THE LOCAL MARINE BIODIVERSITY AND ECOLOGY AT THE SITE OF A SEISMIC SURVEY (PPL 326) BY LARUS ENERGY LIMITED, KUPIANO, CENTRAL PROVINCE

Prepared by:

Augustine J. Mungkaje
Motupore Island Research Centre
School of Natural and Physical Sciences
University of Papua New Guinea
P.O. Box 320, University Post Office
Waigani, N.C.D.
Papua New Guinea

A Consultancy Report prepared for Larus Energy Limited (ABN 16 140 709 360) as part of the Environmental Impact Assessment of the Kupiano Seismic Survey Project.

January 2012

Table of Contents

List of Figures

1. INTRODUCTION

In any biodiversity and ecological study it is important to describe the overall habitat features of the study area and its physical environmental characteristics since these features, together with the biological processes of reproduction, dispersal (and recruitment in terms of aquatic species) and ecological interactions (competition and predation) affect the distribution and abundance patterns of fauna and flora. Thus, aspects of the marine environment within the Papuan Barrier Reef system along the south coast of Papua New Guinea (PNG) that includes the site of the proposed seismic study at Kupiano-Cloudy Bay area, which are relevant to understand the marine biodiversity of the study site, are described below to set the background from which I will attempt to provide an overview of the biodiversity of the study area. This approach is chosen since, given the desktop nature of this biodiversity study and where direct information is limited for the study site, information from similar habitats within the vicinity of the study area may be used as well for the purposes of this study.

1.1. The Papuan Barrier Reef and Lagoon System

The southern PNG coastal environment is classified in terms of its structural geology as part of the *Aure Trough* (Yule Island Area included) and the *South–east Papua Volcanic Province* (Port Moresby and eastwards to Milne Bay) (Löffler, 1977). The inherent features of this structural composition is depicted in the features typical of the *Southern Plains and Lowlands* geomorphological unit that stretches as a 15-20 km belt from its western boundary at the Purari Delta to Mullins Harbour in the East whereby it consists of hilly lowlands and foothills (Löffler 1977) and its associated marine features comprising of beaches and fringing reefs systems, bordered offshore by the extensive discontinuous southern barrier reef system (Whitehouse, 1973; Sullivan, 1994), spanning 500 miles from Yule Island in the west to the tip of Samarai Island and into the Louisiade Archipelago to the east (Whitehouse, 1973). This extensive barrier reef system is separated from the coastline by a lagoon system that runs along its entire length with the depth ranging from 30 m to <50 m in the deeper parts of the lagoon.

At the north-western end of this discontinuous barrier reef system near Port Moresby the barrier reef is located 7.8 km offshore as calculated (*ca.)* from the PNG Hydrographic chart number AUS 621, separated by the Papuan Coastal Lagoon with depths ranging from 20 to 30 m (Australian Hydrographic Service, 2005). At its south-eastern end in the vicinity of the proposed seismic survey site the reef is furthest offshore at Gamoaoru, Kupiano at *ca.* 18 km and closest at Cape Rodney at *ca.* 8 km (Australian Hydrographic Service. 2007) (Figure 1). These distances were calculated from the coastline to the 200 m depth contour and thus, they also indicate the approximate width of the continental shelf. The occurrence of this barrier reef

system relatively close to the coastline is representative of a sinking (though now inactive) continental shelf (Smith, 1990).

The reefs develop from the accumulation of skeletons of reef-building marine flora (calcareous algae) and fauna on top of a parent rock basement. Scleractinean corals are the principal organisms responsible for reef building (Veron, 1986). A detailed description of the Papuan Barrier Reef system and its coral fauna is described in Weber (1973).

1.2. Coral Sea and Lagoon Circulations

The circulation of the waters in this lagoon system near Port Moresby has been described to flow in a counter-clockwise pattern and is largely influenced by tides (Moore, 1981; 1982). The larger scale oceanographic parameters of the waters beyond the barrier reef, is part of the Coral Sea that is traditionally regarded as an area of convergence where water of tropical origin enter either from the east (Scully-Power, 1973; Weber, 1973) under the influence of the Trade Winds in winter or are supplemented in summer by the equatorial waters driven there by the Northwest Monsoon (Scully-Power, 1973); the southeasterly Trade Winds are prevalent along the southern coast from May to October (McAlpine *et al*., 1983). During the Northwest Monsoon (November to April) (McAlpine *et al*., 1983) the dominant surface current in the lagoon flows clock-wise following the main axis of the coastline, exiting at regular intervals (Moore, 1981; 1982) where there are discontinuities (i.e. occurrence of deeper water) on the barrier reef (Weber, 1973).

In the Kupiano-Cloudy Bay area this discontinuous barrier reef system has similar features where reefs are separated by gaps allowing the intrusion of deeper water from the Coral Sea into and out of the lagoon. The Toveli Entrance (off Kupiano) and Rodney Entrance (off Cape Rodney) (Australian Hydrographic Service, 2007) are the two major gaps in the barrier reef in the study area where similar water circulation/exchange patterns relative to seasonal changes in wind patterns as described above for Port Moresby area (Moore, 1981; 1982) may exist.

1.3. Marine Environment and Habitats of the Kupiano-Cloudy Bay Coast

Geologically this area comprises of alluvium deposits and swamp areas closer to the coastline with tonalite, gabbro and granodiorite formations in more inland areas (BMRGGC, 1972). Thus, the southern coastline at the study area is featured by low hills and coastal embayments with mud and sandflats and mangrove areas, especially where creeks and rivers meet the coastline. Major mangrove areas are found near Hood Lagoon, Marshall Lagoon and Kapari areas with smaller patches scattered along the coastline (Royal Australian Survey Corps, 1978). In addition, much of the coastline in comprised of mud and sand flats/beaches extending sub-tidally into the lagoon, with areas of fringing reefs occurring around Kupiano. This is followed by the lagoon system that stretches on average 10-12 km off the coastline and is bordered seaward by the barrier reef system (Figure 1).

2. THIS STUDY AND THE METHODS USED

This report contains the results of a desktop study of the local environment, major habitats and the marine biodiversity and ecology at the site (PPL 326) of a seismic survey by Larus Energy Limited in the Kupiano-Cloudy Bay area, Central Province. Given the desktop nature of this study, its aims were to use existing information from published sources to: 1) describe the general marine environment and habitats for the area, largely based on topographic (Sheet 8577, Edition 2-AAS, Series T601) and hydrographic (Chart Number AUS 621 and Chart Number AUS 506) charts; and 2) to provide a list of reported or likely species in taxonomic groups that could potentially be vulnerable to the impact of the seismic survey using published reports. The taxonomic focus of the second aim was on groups that were thought to be most vulnerable by having either sound receptor organs and gas bladders, known to be soft-bodied, as well as those having brittle calcareous exoskeletons. These taxa included marine mammals (killer whales, dolphins and dugongs), reptiles (turtles and the saltwater crocodile), fish and invertebrates (echinoderms- sea cucumbers and sea urchins; and crustaceans- crabs, shrimps and mantis shrimps).

3. PROJECT SITE AND PROPOSED ACTIVITIES

The study site for this project is the area between Kupiano to the west and Gromen (near Bautumata Point, east of Cloudy Bay) on the east along the southern PNG coastline and extending directly offshore to the edge of the barrier reef (Figure 1). Section 1.3 above describes the general environment and habitat features of this study area.

A 2D seismic survey will be conducted in the area. It will entail transmitting seismic waves using compressed air guns to be discharged at 4 km intervals at right angles to the coastline from a vessel at the edge of the barrier reef within this area (see arrows, Figure 1). It will be an operation spanning a period of about six weeks. The mechanical impact of this activity will result in 2-4 m ripples on the seafloor and the seismic (pressure) waves are bound to affect animals that have sound and vibration detection structures, for example fish (otoliths) and marine mammals (auditory system).

4. MAJOR MARINE HABITATS OF THE STUDY AREA AND REPRESENTATIVE FAUNA

Given the above general physical features of the southern PNG coastline and the adjoining marine environment, one can begin to attain some insight into the diversity of habitats that may be/is present and their biodiversity. As outlined in Section 1.3 above, the coastal environment of the study area is largely comprised of coastal

sand and mud flats, mangroves, fringing reefs (near Kupiano), and deeper water lagoon and barrier reef. Mangroves occur in areas in proximity to major river outflows- the Marshall Lagoon, Kapari (near Cape Rodney, 10,303 ha) and Cloudy Bay (13,700 ha) areas are the major mangrove areas (Raga, 2006) (Figure 1).

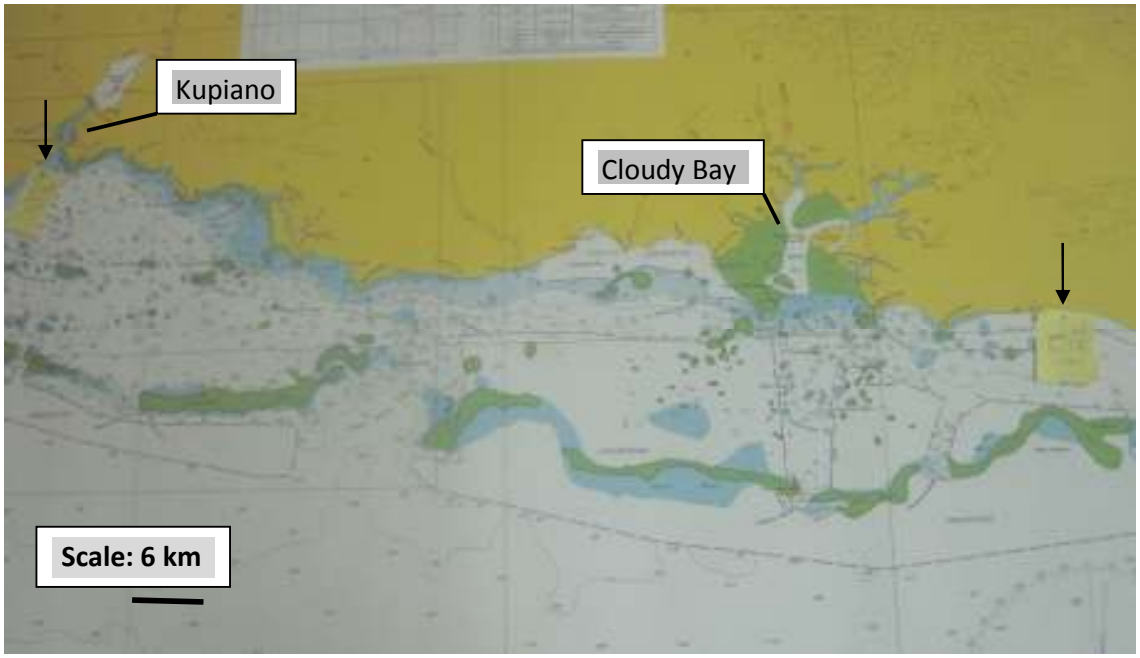

Figure 1. Kupiano seismic survey site. The two arrows show the western (Kupiano) and eastern (Butuma Point, west of Cloudy Bay) borders of the study area along the coast and the offshore border is indicated by the edge of the barrier reef system (offshore green patches). The green patches along the coastline are mangrove areas.

4.1. Mangroves and Mudflats

Mangroves habitats develop where there is freshwater mixing, sedimentation and protection from intense coastal erosion and wave action. Such habitats are associated with areas experiencing inflow of creeks and rivers and in sheltered bays. Marshall Lagoon, Kapari and Cloudy Bay are the locations of major mangrove habitats (Figure 1). Besides many molluscs (mangrove oysters, bivalves (*Geloina coaxans)* and gastropods), the mud crabs (*Scylla serrata*) is an important fishery species collected from mangrove areas. From data collected by my students during class exercises (Mungkaje, unpublished) indicate that the largest crabs (17-18 cm carapace length) sold at Koki Market, Port Moresby were harvested from Kupiano area (near western arrow, Figure 1). Many species of fish also frequent the mangroves when it is high tide. Grey mullets (*Mugil cephalus*), Barramundi (*Lates calcarifer*) (Dunstan, 1961; 1962) and the mangrove jack (*Lutjanus argentimaculatus*) are suitable fishery species that occur in the mangroves (Munro, 1967); these could be potentially harvested in both subsistence and artisanal fisheries.

4.2. Fringing Reefs

The different zones of fringing reefs typically occurring from the high water mark on shore and going seawards to the reef edge providing a variety of microhabitats harbouring a great diversity of species, described in detail (Mungkaje and Maniwavie, 2005) with known species of flora and fauna that are typically known to occur in each zone using examples from the Bootless Bay and the Port Moresby area, are as follows:

1) Intertidal zone. This is a zone that is usually exposed at low tide and depending on the oceanographic regime (refracted wave energy and longshore currents (Sullivan, 1994)) might be constituted of boulders, gravel and sand or comprised of finer substrates such as mud and silt. The substrate has a lot of influence on the epibenthic (surface-dwelling forms) and infaunal (burrowing forms) invertebrates (annelids, echinoderms, crustaceans and molluscs). Mangroves, when present, occur in this zone. This zone is followed by a number of subsequent subtidal zones described below (zone 2-zone 6).
2) Lagoon. This is often the largest zone that may have smaller sub-units within it. It comprises the region between the intertidal zone and the back reef, gently sloping towards the back reef with increasing depth. The substrate is often gravelly-sandy shore wards and muddy-silty seawards. Seagrass species such as *Thalassia hemprichii*, *Syringodium isoetifolium Cymodocea* rotundata, *C. serrulata, Halophila ovalis* and *Enhalus acoroides* are the common species of seagrass that inhabit this zone (Brouns, 1986; Wia, 2005). Echinoderm species, mainly the sea urchin *Tripneustes gratilla*, the starfishes *Protoreaster nodosus* and *Choriaster granulatus* (Maniwavie *et al*., 1998) occur in this zone. The lagoon sea cucumber (Lollyfish) *Holothuria atra*, the Sand fish, *H. scabra*, and the Curryfish, *Stichopus hermanii* are common holothurians in this zone (SPC and NFA, 2003). Commonly occurring in this zone also is the edible gastropod *Strombus luhuanus* (Asigau, 1988). Besides segrasses epibenthic invertebrates a number of fishes are often common residents of this zone viz. the shrimp fish *Aeoliscus strigatus*, the emperor *Lethrinus harak*, the Sharp nose wrasse *Cheilio inermis*, the dash-dot goat fish *Parupeneus barberinus* and the Pipefish *Synganthoides biaculeatus* (Nagai, 2002; Mungkaje *et al*., 2003). The Blue-spotted Stingray (*Dasyatis kuhill*) and the Blue-spotted Fantail Stingray (*Taeniura lymma*) can be found over sandy bottoms in this zone (Appendix 1; Baine and Harasti, 2007).
3) Back reef. This is usually a narrow zone between the lagoon and the reef crest. Some scleractinian (hard) coral and soft coral (*Nepthea* sp. (Allen and Steene, 1994)), as well as anemones, are present here.
4) Reef flat. This zone is usually exposed at spring low tides, and comprises largely of rubble and encrusting and filamentous algae. Macroalgae a common at this zone at certain times of the year; the common species noted in the Joyce Bay area, especially off Pari and Pyramid point were *Sargassum* sp. *Turbinaria* and *Padina* sp. (Maniwavie *et al*., 1998). Stomatopods (Crustacea) abundance and diversity have been found to be very high on reef flats of fringing reefs from islands near Jakarta Bay, Indonesia, due to their strong association as an abundant and mobile component of the cryptofauna of this microhabitat (Erdman and Sisovann, 1998).

5) Reef crest. Also exposed at spring tides, this zone is immediately in front of the reef flat where the percentage of life coral cover begins to increase. Butterflyfishes (Chaetodontidae), damselfishes (Pomacentridae), surgeonfishes (Acanthuridae) and wrasses (Labridae) are the predominant fish fauna at this zone. Two species of butterflyfishes, *Chaetodon trifascialis* and *C. trifasciatus* are obligate coral predators and have the potential to be used as indicator species to assess impacts on coral reefs (Reese, 1981; Oehman *et al*., 1998).
6) Reef slope. This is the outermost section of the fringing reef and due to good wave flushing and suitable depth, coral cover is often highest here; a 44 % life scleractinian (hard) coral cover have been reported in Joyce Bay off Pari Village (Maniwavie *et al*., 1998). Results from a similar technique (Line Intercept Transect or LIT) used on Motupore Island reported slightly lower values viz. 28.5 % (Koren, 2002) and 28.7 % (Karo, 2004). Both these sites are areas with good coral growth so it is reasonable to conclude that levels of healthy hard coral cover under natural conditions in the Papuan Coastal Lagoon would be in the range of 30-40 % and this can assumed also for similar habitats in the Kupiano-Cloudy Bay area too. Regarding the fish fauna, the families listed for the reef crest also occur here with the inclusion of larger predators such as emperors (Letherinidae), cods (Serranidae) and snappers (Lutjanidae). The Cleaner wrasse *Labroides dimidiatus*, that is common in this zone, has a mutual relationship with reef fishes feeding mainly on ectoparasites (Potts, 1973; Grutter, 1995) from host fishes at 'cleaner stations', usually occurring in pairs (Potts, 1973). Unpublished data that I have from Lion and Motupore Islands in Bootless Bay and the Seribu Islands, Indonesia seem to indicate that it has the potential to be used as an indicator species for a decline in fish abundance on coral reefs. Grutter (1995) has showed that parasite load and size of host fish is important to this cleaning interaction from studies done on Lizard Island, Great Barrier Reef, Australia. The Bootless Bay data showed 7-8 such stations along each 100 m transect with an average interval of 12 m among stations whilst much fewer stations were recorded from 22 islands surveyed in the Seribu Islands near Jakarta Bay, Indonesia that have been stressed, largely from anthropogenic causes.

4.3. Deep-water Coastal Lagoons

Deeper waters of the Papuan Coastal Lagoon beyond the reef slope of fringing reefs have average depths of 20-30 m. The benthic habitat there is largely a featureless depositional basin for finer sediments (sand, silt and mud) (Haig, 1988). To the non-specialist it is superficially devoid of life however, many benthic infauna (crustaceans, bivalves, polychaetes, and foraminifera) occur there. Fish species from families such as silverbiddies (Gerreidae), grunts (Terapontidae) slipmouths (Leiognathidae), and trevallies (Carangidae) have been recorded in this habitat (Maniwavie *et al*., 1988). In other areas within the Papua Coastal Lagoon with greater proportion of sand, predatory species on benthic invertebrates, such snappers (Lutjanidae), emperors (Letherinidae), fusiliers (Caesionidae) and coral breams (Nemipteridae) have been recorded (Matsuoka *et al*., 1992; Hansel, *et al.,* 1993).

4.4. Barrier Reef

The physical structure of barrier reefs are very similar to that of fringing reefs, the only difference being that barrier reefs occur offshore and are separated from land by a deep lagoon (see Section 1.1 and Figures 1 & 2). Veron (1986) describes seven major zones on a typical barrier reef. They are:

1) Lower reef slope. This is the outermost zone as one approaches the barrier reef from the open sea (Figure 2). Where water is clear, coral growth may occur here down to 100 m. Corals that occur here are mostly thin, brittle and encrusting plates. At depths around 50 m, coral cover may be dense.
2) Upper reef slope. At depths from 0 m (at low tide) to 20 m, here coral cover may be dense at 20 m, with a mixed coral community where *Acropora* corals may predominate.
3) Reef front. This is a narrow zone that may become exposed at low tide. It is part of the reef that takes much of the force of the ocean swell (Figure 2); most of the stocky forms of *Acropora* occur here.
4) Outer reef flat. This is the zone usually hammered by waves and heavy surf (Figure 2) and is sparsely populated by corals due to this harshness. Calcareous algae (Rhodophyta) and reef fishes such as parrotfishes (Scaridae), surgeonfishes (Acanthuridae), triggerfishes (Balistidae), bufferfishes (Tetraodontidae), rock cod (Serranidae), wrasses (Labridae), butterflyfishes (Chaetodontidae) and damselfishes (Pomacentridae) are predominant taxa in this zone. Pelagic fishes that feed near the surf such as trevalies (Carangidae) and longtoms (Belonidae) may also occur here. Reef crabs and various species of crevice-dwelling sea urchins (Echinometridae) and the starfishes (Ophidiasteridae) may be found in this zone too.
5) Inner reef flat. This zone has high loose rubble substrate, tongues of sand, rubble with partly consolidated substrate (Figure 2). Regarding fishes, wrasses (Labridae) and damselfishes (Pomacentridae) also occur in this zone too.
6) Lagoon. It is an area following the inner reef comprising of sandy seafloor, few meters deep. Usually it is surrounded by small patch reefs and has good water circulation from tidal currents. It may be devoid of corals or may have large stands of branching *Acropora*. Deeper lagoons contain soft sediments and may contain extensive stands of corals such as *Goniopora*, *Leptoseris*, *Pachyseris* and *Montipora*. Fish families most commonly found in such habitats are monocle breams (Nemipteridae), emperors (Letherinidae), goatfishes (Mullidae), rabbitfishes (Siganidae), triggerfishes (Balistidae), wrasses (Labridae), damselfishes (Pomacentridae) and butterfly fishes (Chaetodontidae).
7) Back reef margins. Places of very active coral growth and usually consists of sections of reef flat divided by sandy-floored fissures. The usual coral associated fish species such as squirrelfishes (Holocentridae), parrotfishes,

(Scaridae), fusiliers (Caesionidae), damselfishes (Pomacentridae), butterflyfishes (Chaetodontidae) and angelfishes (Pomacanthidae) and wrasses (Labridae) can be found in this zone.

Figure 2. Aerial photograph of the Papuan Barrier Reef off Port Moresby. Note the Reef front and the Outer reef flat with breaking waves and the Inner reef flat and the Lagoon sections indicated by the differences in substrate, respectively. (Photo by: Mungkaje, May 2009).

5. BIODIVERSITY OF THE PROJECT AREA

It is impossible to provide a complete list of the biodiversity of an area without doing an on-site biodiversity survey. Thus, given the desktop nature of this study I will attempt to provide a list (at both the family and species level) of relevant taxa from published sources for studies done in the study area or from those done in similar habitats from the south-eastern PNG coastal areas.

5.1. Mobile and Wide Ranging Marine Species

1) Marine mammals. A very common species of whale, the killer whale (*Orcinus orca*) has been sighted throughout the country near coastal waters from March to December. They have been seen in association with two other species of cetaceans (sperm whales, *Physeter macrocephalus* and spinner

dolphins, *Stenella longirostris*). Sightings close to the study area was made in April 1989 on two consecutive days in an area southeast of Port Moresby (09^{o} 42' 92" S, 147o 08' 30" E) (Visser and Bonoccoso, 2003). The Bottle-nosed dolphin, *Tursiops truncatus* have been recorded in Barakau (Raga, 2006) and the dugong (*Dugong dugon*) is also known to occur in the study area. It is known to be harvested traditionally between Pari (near Port Moresby) and Marshall Lagoon (near study area) (Pernetta and Hill, 1981).

2) Marine reptiles. Turtles are the most common marine reptiles that are expected to be present in the study area. Of the seven species of marine turtles in the world, six species are known to occur in the South Pacific (Pernetta and Hill, 1981; Hirth, 1993; Logan, 2006). The common species that could be caught in the study area are the Hawsksbill turtle (*Eretmochelys imbricata*), Green Turtle (*Chelonia mydas*) and Loggerhead Turtle (*Caretta caretta*). The Hawsksbill (*E. imbricata*) and Green turtle (*C. mydas*) are widely harvested for meat, eggs and shell (*E. imbricata*) throughout the South Pacific countries (Hirth, 1993) and this has also been reported in subsistence fisheries in the study area as well as other parts Western, Central and Milne Bay Provinces (Pernetta and Hill, 1981). Both species have been recorded on the barrier reef near Barakau (Raga, 2006). *Eretmochelys imbricata* is a critically endangered species and found mainly on reef slopes on both fringing and barrier reefs, where they forage on sponges as their main food source (McLellan *et al*., 2005). The saltwater crocodile (*Crocodylus porosus)* is expected in coastal/mangrove areas (Pernetta and Hill, 1981).
3) Pelagic fish. Tunas, Rainbow runners, Mackerels and Barracudas are common pelagic fish species caught by both subsistence and artisanal fishermen along the Central Province coast and various species of these groups are very common at the city fish markets at Koki, Malaoro and Rainbow. The Barracuda (*Sphyraena genie*), Rainbow runner (*Elagatis bipinnulata*), Spanish Mackerel ((*Scomberomorus commerson*), Skipjack tuna (*Katsuwonus pelamis*), Yellowfin tuna (*Thunnus albacares*), Great barracuda (*Sphyraena barracuda*) and Giant trevally (*Caranx ignobilis*) are some species reported to be caught by fishermen at Barakau Village near Port Moresby and northwest of the study area (Raga, 2006). *C. ignobilis* and the Long-jawed Mackerel, *Rastrelliger kanagurta*, have been recorded from a fisheries catch photograph taken at Alukuni Village near the study area (Timothy-Dandava, 2011). Chondrichthyeans include the common Blacktip reef shark (*Carcharinus melanopterus*), the Spotted eagle ray (*Aetobatus narinari*) and the Manta ray (*Manta birostris*).

5.2. Site-attached/Resident Species

1) Reef fishes. In any tropical coral reef, reef fishes form one of the most conspicuous faunal groups represented on the reef. The most abundant, diverse and speciose groups, also the most conspicuous and easy to identify of reef fishes, are members of the six families: Damselfishes (Pomacentridae); Wrasses (Labridae); Parrotfishes (Scaridae); Surgeonfishes (Acanthuridae); Butterfly fishes (Chaetodontidae) and Angelfishes (Pomacanthidae). An index, Coral Reef Fish Diversity Index (CFDI), based on

the numbers of species of these families present at a site, has been developed to use as a rating system to compare the overall reef fish diversity among localities (Allen, 1998). This tool is useful in assessing reef fish diversity in Rapid Assessment Program (RAP) studies of biodiversity assessments. Two such studies have been carried out to date in Milne Bay Province (Werner and Allen, 1988; Allen *et al*., 2003); these studies contain extensive lists of invertebrates and fish species recorded in the RAP studies of various sites surveyed in the Province. To gain some insight into the range of fish species expected in inshore, fringing reefs and the barrier reefs in the study area refer to Appendix 1, which was adapted from Drew *et al*. (Submitted), highlighting a species list of fishes from Bootless Bay and the Barrier Reef near Port Moresby. Given the proximity of this site to the study area and similarities in habitats, many of the species on this list could be also found in similar habitats in the Kupiano-Cloudy Bay area. Baine and Harasti (2007) is also an excellent reference source for fish and all other marine fauna and flora of Bootless Bay and surrounding areas near Port Moresby.

2) Echinoderms. Many species of echinoderms occur on different microhabitats on all habitats listed above except Mangroves, with different degrees of habitat preference (see Fringing Reef and Barrier Reef sections above). The principal taxa within the Phylum Echinodermata are the classes: Echinoidea (sea urchins); Stellaroidea (starfishes) and Holothuroidea (sea cucumbers). Many of these groups are included in Baine and Harasti (2007); the glossy coloured pictures make it convenient for the non-specialist to easily identify them in the field. Members of the Holothuroidea (sea cucumbers) are of commercial value and a complete list of those with habitat of occurrence and value as a commercial species are given in SPC and NFA (2003). Commercial harvesting and processing of sea cucumbers have been reported in the Kupiano-Cloudy Bay area (Tanaka, 1990). The species recorded from Tarawa Village, Hood Lagoon (at Western border of the study area) were: White teatfish (*Holothuria (Microthele) fuscogilva*), Black fish (*Actinopyga miliaris*) and Surf redfish (*Actinopyga mauritiana*) (Tanaka, 1990).

3) Crustaceans. Many species of crustaceans (crabs, shrimps, prawns and crayfish) occur on coral reefs and coastal waters. The Mud crab (*Scylla serrata*) is a very important fisheries species occurring in the mangroves and coastal areas (Pernetta and Hill, 1981; Mungkaje, unpublished data). Crevices in the reef structure and rubble on both fringing and barrier reefs contain an abundance of crustaceans; stomatopods (mantis shrimps) have been found to be an abundant component of the cryptofauna in the rubble of reef flats on Indonesian reefs (Erdman and Sisovann, 1998). Many of these small species of crustaceans may not be directly important to humans but are a very important prey component to many reef fishes that are exploited by fishermen.

6. POTENTIAL IMPACTS OF SEISMIC WAVES ON MARINE SPECIES

Most coral reef fauna and flora are somewhat resilient and would recover from short term impacts. Since the seismic survey will last only six weeks, and if any destructive impacts occur at all, the natural recovery ability of the marine communities will enable the ecosystem to return to normal condition after the survey. The recovery period will be dependent on the ecology and biology of the various species occurring in the study area.

Sedentary species that are relatively site-attached, mainly because they are territorial or limited in mobility, may suffer shock from pressure waves. Species such as echinoderms and crustaceans occurring directly on the path of the seismic tracks may suffer some mechanical damage due to their brittle/soft exoskeletons. However, on the population and community ecology levels, given the resilient nature of coral reef communities, natural reproductive and recruitment processes will replenish the stocks over time.

Mobile species such as turtles and mammals (dugongs, dolphins and whales) may move out of the area once they experience any interference from the seismic activities. The mammals, especially dolphins and whales use sound in prey location, navigation and to maintain contact with members in a pod (Savage, 1990; Donoghue and Wheeler, 1990), using high frequency sound (0.25-220 kHz) (Donoghue and Wheeler, 1990). For them, the seismic survey may interfere with these functions and may cause temporary alterations/disruption to their social behaviour and possibly cause disorientation.

Dolphins were experimentally found to avoid acoustic signals transmitted by pingers from a boat when dolphins approached in an experiment to determine effective pingers to fit onto gillnets so as to prevent their capture incidentally (Stone *et al*., 2000). The pinger that gave this result had a fundamental frequency of 10 kHz with harmonics up to 160 kHz. A similar experiment done with pingers fitted onto drift gillnets in a fishery in California showed significant reduction in catches of short-beaked common dolphins and California sea lions in the bycatches (Barlow and Cameron, 2003). Obviously this indicates that the acoustic signals negatively impacted these species.

Large pelagic fish such as tunas and mackerels and other actively swimming vertebrates such as dugongs and turtles will be able to move away from the area temporarily during the duration of the study. However, smaller site-attached reef fish, benthic invertebrates such as sea cucumbers and other echinoderms, and mud crabs in the coastal mangrove areas may not be able to move away and may be impacted.

7. SUMMARY AND CONCLUSION

The study area has a great diversity of habitats and microhabitats. They include mangroves, fringing reefs, coastal lagoons and barrier reefs. Thus, one expects a great diversity of species present in these habitats.

Given the desktop nature of this study, these habitats from both the Port Moresby area and the study area were described to lay the foundation from which to discuss species known from published sources to occur in the study area as well as those that were recorded from similar habitats in other areas within the Papua Barrier Reef and Lagoon system, especially the northwestern part of this system near Port Moresby where the it is more well researched than the study site itself.

The biodiversity component of this report focused on marine mammals, reptiles, echinoderms (sea urchins and sea cucumbers) crustacean and fish. Among these taxa, characteristic species of each microhabitat were listed and likely impacts of the seismic survey on the more vulnerable species, especially marine mammals (dolphins and whales) due to their use of sound in echolocation, were briefly discussed.

8. ACKNOWLEDGEMENTS

I wish to thank various staff of the School of Natural and Physical Sciences, University of Papua New Guinea (UPNG) for their help in this study. Professor Hugh Davies of the Discipline of Earth Sciences initially brought the request of this study to my attention and for linking me with Larus Energy Limited for me to discuss the scope and terms of this desktop study. Janet Gagul of Biological Sciences and Roga Gabiobu of Motupore Island Research Centre assisted with accessing/acquiring the required topographic and hydrographic charts, respectively. My thanks also go to Alfred Ko'ou of Biological Sciences and Dulcie Ume of the Physics Discipline for assisting with recovering from virus attack, a key report used in this study. Catherine, Grace, and Martha Mungkaje assisted in various ways to help me access reference materials from internet sources through their respective internet accounts since my office internet connection at UPNG was not working.

9. REFERENCES

Allen, G.R. 1998. Reef and shore fishes of Milne Bay Province, Papua New Guinea. *In:* Werner, T.B. and Allen, G.R. 1998. (Eds.). A rapid biodiversity assessment of the coral reefs of Milne Bay Province, Papua New Guinea. RAP Working Papers 11, Conservation International, Washington, D.C. pp. 39-49.

Allen, G. R., J. P. Kinch, S. A. McKenna, and P. Seeto. (Eds.). 2003. A Rapid Marine Biodiversity Assessment of Milne Bay Province, Papua New Guinea—Survey II (2000). RAP Bulletin of Biological Assessment 29. Conservation International, Washington, DC, USA. 172 p.

Asigau, W. 1988. *Strombus luhuanus* L 1958 (Gastropoda: Mollusca) on reefs near Gabagaba Village, Papua New Guinea. *Science in New Guinea* **14** (1): 40-46.

Australian Hydrographic Service. 2005. Papua New Guinea South Coast: Approaches to Port Moresby (Chart Number AUS 621).

Australian Hydrographic Service. 2007. Papua New Guinea South Coast: Hood Point to Table Bay (Chart Number AUS 506).

Baine, M. and Harasti, D. 2007. The Marine Life of Bootless Bay, Papua New Guinea. Motupore Island Research Centre (MIRC), School of Natural and Physical Sciences, University of Papua New Guinea. 145 p.

Barlow, J. and Cameron, G.A. 2003. Field experiments show that acoustic pingers reduce marine mammal bycatch in the California drift gill net fishery. *Marine Mammal Science*, **19** (2): 265-283.

Brouns, J.J.W.M. 1986. Seagrasses in Papua New Guinea, with notes on their ecology. *Science in New Guinea* **12**(2): 66-92.

Bureau of Mineral Resources, Geology and Geophysics, Canberra (BMRGGC). 1972. Geology of Papua New Guinea, 1:1,000,000. Australian Government.

Donoghue, M. and Wheeler, A. 1990. Save the Dolphins. David Bateman Ltd., Auckland, New Zealand. 119 p.

Drew, J. A., Holmes, D. D., Mandecki, J.L, McCord, C., Mungkaje, A.J., Richardson, A.C. and Westneat, M.W**.** (Submitted). A checklist of the marine fishes of Bootless Bay, Central Province, Papua New Guinea with notes on conservation in the region. *PLoS ONE*.

Dunstan, D.J. 1961. Giant perch in Papua waters. *Fisheries Newsletter*, **March 1961**: 15 and 27.

——. 1962. The barramundi in New Guinea waters. *Papua New Guinea Agricultural Journal* **15** (1-2): 23-31.

Erdmann, M. and Sisovann, O. 1998. Distribution and abundance of reef-flat stomatopods in Teluk Jakarta and Kepulauan Seribu. *In* Subagjo Soemodihardjo (Ed.). *Proceedings, Coral Reef Evaluation Workshop, Pulau Seribu, Jakarta, Indonesia, 11-20 September, 1995.* Contending with Global Change, Study No. 10, UNESCO, Jakarta. pp: 1-24. pp: 66-83.

Grutter, A.S. 1995. Relationship between cleaning rates and ectoparasite loads in coral reef fishes. *Mar. Ecol. Prog. Ser.* **118**: 51-58.

Haig, D.W. 1988**.** Distribution of miliolid foraminifera in marine sediments around Motupore Island, Papua New Guinea. *Science in New Guinea* **14**: 54-94.

Hansel, M., Sundar Rao, K., Matsuoka, T., Rali, T., Burrows, I., and Huber, M.E. 1993. The distribution of fatty acids in flesh and liver of Papua New Guinea fish. *Comp. Biochem. Physiol.,* **106 B** (3): 655-658.

Hirth, H.F. 1993. Marine turtles. *In:* Wright, A. and Hill, L. (Eds.). Nearshore Marine Resources of the South Pacific: Information for fisheries development and management. Institute of Pacific Studies and Forum Fisheries Agency. pp. 329-370.

Karo, M. 2004. Relationship between chaetodontid fishes and live coral cover on the windward fringing reef at Motupore Island. Research Project Report, Division of Biological Sciences, University of Papua New Guinea. 11 p.

Kelly, M. 1986. Systematics and ecology of the sponges of Motupore Island. M. Sc. Thesis, University Auckland, New Zealand.

Koren, L. 2002. The distribution of butterflyfishes (Pisces: Chaetodontidae) in relation to live coral on the fringing reef of southern Motupore Island. Research Project Report, Division of Biological Sciences, University of Papua New Guinea. 12 p.

Löffler, E. 1977. Geomorphology of Papua New Guinea. Australian University Press. 195 p. Reprinted in 1996.

Logan, T. 2006. Pacifi c sea turtle education kit. SPREP. 54 p.

Maniwavie,T., Aitsi, J. and Federizon, R. 1998. Rapid ecological assessment of theWalter and Joyce Bays of Port Moresby (Coral Reef Component). A consultancy report prepared for JICA for the Port Moresby Sewage Study. 54 p.

Matsuoka, T., Mana, R. and Nagaleta, H. 1992. Application of bottom longline fishing in tropical shallow reef water. Fisheries Section Technical Report 1/92. University of Papua New Guinea, Port Moresby.

McAlpine, J.R., Keig, G. and Falls, R. 1983. Climate of Papua New Guinea. Australian National University Press, Canberra, Australia. 200 p.

McLellan, L., Nickson, A. and Benn, J. 2005. Marine turtle conservation in the Asia Pacific region. WWF, Switzerland. 28 p.

Moore, N.H. 1981. The determination of the annual physical hydrographic cycle of tropical coastal lagoons. *Proc. Fourth Internat. Coral Reef Symp.*, Manila, 1981 (1): 361-367.

——. 1982. Physical hydrographic observations in Port Moresby Harbour, Papua New Guinea. Final Research Fellowship Report, prepared on behalf of Maunsell and Partners for Ok Tedi Mining Ltd. 67 pp + 280 pages of data appendices. Data remains the property of Motupore Island Research Department.

Mungkaje, A.J. and Maniwavie, T. 2005. Environmental implications of the Port Moresby Sewage Upgrade Project on the Joyce Bay Marine Ecosystem and surrounding areas. A consultancy report prepared for Ecosystems Management Limited for the Environmental Impact Studies of the Port Moresby Sewerage Upgrade Project. 16 p.

Mungkaje, A.J., Ganiga ,G., Ko'ou, A., Manioli, J., Fabian, V., Yhuanje, K., Vegala, J. and Ben, J. 2003. Incidental brood-hatching during capture in the Double-ended pipefish,*Syngnathoides biaculeatus* (Pisces: Teleostei) with notes on fecundity and juvenile morphometrics. Oral presentation, *5th New Guinea Biological Conference*, 23rd-25th August 2003, Goroka, E.H.P., Papua New Guinea.

Munro, I.S.R., 1967. The Fishes of New Guinea. Dept. Agriculture, Stock & Fisheries, Port Moresby. 651 p. + 78 Plates.

Nagai, J. 2002. Seagrass beds as nursery habitat for marine fish fauna on Motupore Island.Research Project Report, Division of Biological Sciences, University of Papua New Guinea.11 p.

Oehman, M.C., Rajasuriya, A. and Svensson, S. 1998. The use of butterflyfishes (Chaetodontidae) as bio-indicators of habitat structure and human disturbance. *Ambio* **27**(8): 708-716.

Pernetta, J.C. and Hill, L. 1981. A review of marine resource use in coastal Papua. Journal de la Société des Océanistes. N°72-73, Tome 37, 1981: 175-191.

Potts, G.W. 1973. The ethology of *Labroides dimidiatus* (Cuv. And Val.) (Labridae, Pisces) on Aldabra. *Animal Behaviour* **21**(2): 250-291.

Raga, M.N. 2006. Reef and mangrove survey reports, Barakau Village, Central Province, Papua New Guinea. *IWP-Pacific Technical Report (International Waters Project) no. 24*. SPREP, Apia, Samoa. 23 p.

Reese, E.S. 1981. Predation on corals by fishes of the family Chaetodontidae: implications for conservation and management of coral reef ecosystems. *Bull. Mar. Sci*. **31**(3): 594-604.

Royal Australian Survey Corps. 1978. Papua New Guinea Topographic Survey: Kupiano (Sheet 8577, Edition 2-AAS, Series T601).

Savage, S. 1990. Endangered Species: Dolphins and whales. Chartwell Books Inc., New Jersey. 128 p.

Scully-Power, P.D. 1973. Coral Sea flow budgets in winter. *Aust. J. Mar. Freshwat. Res.* **24**: 203-215.

Smith, R.I. 1990. Tertiary plate tectonic setting and evolution of Papua New Guinea. *In*: Carman, G.J. and Carman, Z. (Eds.). Petroleum Exploration in Papua New Guinea. Proceedings of the First PNG Petroleum Convention, Port Moresby, 12-14 February, 1990.

SPC and NFA. 2003. Papua New Guinea sea cucumber and beche-de-mer identification cards. SPC Marine Resource Division Information Section, Noumea, New Caledonia.

Stone, G.S., Cavagnaro, L. Hutt, A., Kraus, S. Baldwin, K. and Brown, J. 2000. Reactions of Hector's dolphins to acoustic gillnet pingers. Published client report on contract 3071, funded by Conservation Services Levy, Department of Conservation, Wellington. 29 p. http://csl.doc.govt.nz/CSL3071.pdf.

Sullivan, M.E. 1994. The coastline of Motupore Island: 360^{o} of processes in low energy tropical environment. *Science in New Guinea* **20**: 59-69.

Tanaka, H. 1990. Pre-feasibility study on aquaculture development potential in the Central Province, Papua New Guinea.FAO South Pacific Aquaculture Development project, Suva, Fiji.

Timothy-Dandava, L.M. 2011. Preliminary Socioeconomic Impact Assessment of the Marine Aquarium Trade on Fishing Communities: A Papua New Guinea Case Study. Master's Thesis, University of Bremen, Germany. 81 p.

Veron, J.E.N. 1986. Corals of Australia and the Indo-Pacific. University of Hawaii Press, Honolulu. 644 p.

Visser, I.N. and Bonoccoso, F. 2003. New observations and a review of killer whale (*Orcinus orca*) sightings in Papua New Guinea waters. *Aquatic Mammals* **29** (1):150-172.

Weber, J.N. 1973. Reef corals and coral reefs in the vicinity of Port Moresby, south coast of Papua New Guinea. *Pacific Science* **27**: 377-390.

Werner, T.B. and Allen, G.R. 1998. (Eds.). A rapid biodiversity assessment of the coral reefs of Milne Bay Province, Papua New Guinea. RAP Working Papers 11, Conservation International, Washington, D.C.110 p.

Whitehouse, F.W. 1973. Coral reefs of the New Guinea region. *In* Jones, A.D. and Endean, R. (Eds.). Biology and Geology of Coral Reefs, Vol. 1. Academic Press, New York. Pp. 169-186.

Wia, J. 2005. The effect of sediment type on the distribution and abundance of seagrass species at selected sites around Motupore Island. Research Project Report, Division of Biological Sciences, University of Papua NewGuinea.13 p.

APPENDIX 1. Reef and coastal fishes from Bootless Bay and the Papuan Barrier Reef, Port Moresby. Drew *et al.* (Submitted).

Class	Order	Family	Species
Chondrichthyes			
	Orectolobiformes		
		Stegostomatidae	
			Stegostoma fasciatum (Hermann 1783)
		Hemiscyllidae	
			Hemiscyllium hallstromi Whitley, 1967
		Orectolobidae	
			Eucrossorhinus dasypogon (Bleeker 1867)
	Carcharhiniformes		
		Carcharhinidae	
			Carcharinus melanopterus (Quoy and Gaimard, 1824)
			Triaenodon obesus (Rüppell 1837)
	Rajiformes		
		Dasyatidae	
			Dasyatis kuhlii (Muller and Henle, 1841)
			Taeniura lymma (Bennett, 1830)
		Myliobatidae	
			Aetobatus narinari (Euphrasen 1790)
		Mobulidae	
			Manta birostris (Walbaum, 1792)
Osteichthyes			
	Elopiformes		
		Megalopidae	
			Anguilliformes *Megalops cyprinoides* (Broussonet, 1782)
		Congridae	
			Heteroconger hassi (Klausewitz & Eibl-Eibesfeldt, 1959)
			Congridae sp.
		Ophichthidae	
			Callechelys marmorata (Bleeker, 1853)
			Kaupichthys sp.
		Ophichthidae	
			Ophichthus bonaparti (Kaup, 1856)

Class	Order	Family	Species
Osteichthyes			
	Elopiformes		
		Anguilladae	*Anguilla obscura* Günther, 1872
		Muraenidae	*Echidna nebulosa* (Ahl, 1789) *Gymnothorax cf. chilospilus* Bleeker, 1864 *Gymnothorax elegans* Bliss, 1883 *Gymnothorax favagineus* Bloch & Schneider, 1801 *Gymnothorax fimbriatus* (Bennett, 1832) *Gymnothorax flavimarginatus* (Rüppell, 1830) *Gymnothorax herrei* Beebe & Tee-Van, 1933 *Gymnothorax javanicus* (Bleeker, 1859) *Gymnothorax richardsoni* (Bleeker, 1852) *Gymnothorax thyrsoidea* (Richardson, 1845) *Gymnothorax undulatus (Lacépède, 1803)* Gymnothorax zonipectis Seale, 1906 *Moringua* sp. *Pseudoechidna brummeri* (Bleeker, 1859) *Rhinomuraena quaesita* Garman, 1888
	Clupeiformes	Clupeidae	Clupeidae sp.
	Siluriformes	Plotosidae	*Plotosus lineatus* (Thunberg, 1787)
	Aulopiformes	Synodontidae	*Saurida gracilis* (Quoy & Gaimard 1824) *Synodus rubromarmoratus* Russell & Cressey 1979

Class	Order	Family	Species
Osteichthyes	Aulopiformes	Synodontidae*, Cont'd.*	*Synodus variegatus (Lacépède 1803)* *Synodus dermatogenys* Fowler, 1912
	Lophiiformes	Antennariidae	*Antennarius pictus* (Shaw, 1794) *Histrio histrio* (Linnaeus, 1758)
	Mugiliformes	Mugilidae	*Moolgarda seheli* (Forsskål, 1775)
	Beloniformes	Belonidae	*Tylosurus crocodilus* (Péron & Lesueur, 1821) *Zenarchopterus gilli* Smith 1945
		Hemiramphidae	*Hemiramphus archipelagicus* Collette & Parin 1978 *Hemiramphus far* (Forsskål, 1775) *Hyporhamphus quoyi* (Valenciennes, 1847)
	Beryciformes	Holocentridae	*Myripristis berndti* Jordan and Evermann, 1903 *Myripristis kuntee* Valenciennes, 1831 *Myripristis murdjan* (Forsskål, 1775) *Myripristis violacea* Bleeker, 1851 *Myripristis vittata* Valenciennes, 1831 *Neoniphon argenteus* (Valenciennes, 1831) *Neoniphon sammara* (Forsskål, 1775) *Plectrypops lima* (Valenciennes, 1831) *Sargocentron caudimaculatum* (Rüppell 1838) *Sargocentron cornutum* (Bleeker 1853) *Sargocentron ensifer* (Jordan & Evermann 1903) *Sargocentron cf. iota* Randall 1998 *Sargocentron rubrum* (Forsskål, 1775)

Class	Order	Family	Species
Osteichthyes			
	Beryciformes		
		Holocentridae, *Cont'd.*	
			Sargocentron spiniferum (Forsskål 1775)
			Sargocentron tiereoides (Bleeker, 1853)
			Sargocentron violaceum (Bleeker, 1853)
	Gasterosteiformes		
		Aulostomidae	
			Aulostomus chinensis (Linnaeus, 1766)
		Fistulariidae	
			Fistularia commersonii (Rüppell, 1838)
		Pegasidae	
			Eurypegasus draconis (Linnaeus 1766)
		Solenostomidae	
			Solenostomus cyanopterus Bleeker 1854
			Solenostomus halimeda Orr, Fritzsche & Randall 2002
			Solenostomus paegnius Jordan & Thompson 1914
			Solenostomus paradoxus (Pallas 1770)
		Syngnathidae	
			Corythoichthys amplexus Dawson & Randall 1975
			Corythoichthys haematopterus (Bleeker 1851)
			Corythoichthys intestinalis (Ramsay 1881)
			Corythoichthys ocellatus Herald 1953
			Corythoichthys polynotatus Dawson 1977
			Corythoichthys schultzi Herald 1953
			Doryrhamphus dactyliophorus (Bleeker, 1853)
			Hippocampus sp.
			Sygnathidae sp.
			Syngnathoides biaculeatus (Bloch 1785)
			Trachyrhamphus bicoarctatus (Bleeker 1857)
	Scorpaeniformes		
		Scorpaenidae	
			Ablabys taenianotus (Cuvier, 1829)
			Dendrochirus brachypterus (Cuvier, 1829)
			Dendrochirus zebra (Cuvier, 1829)

Class	Order	Family	Species
Osteichthyes			
	Scorpaeniformes		
		Scorpaenidae*, Cont'd.*	
			Pterois antennata (Bloch, 1787)
			Pterois volitans (Linnaeus, 1758)
			Rhinopias aphanes Eschmeyer, 1973
			Scorpaenodes albaiensis (Evermann & Seale, 1907)
			Scorpaenodes guamensis (Quoy and Gaimard, 1824)
			Scorpaenodes hirsutus (Smith, 1957)
			Scorpaenodes parvipinnis (Garrett, 1864)
			Scorpaenodes sp. 1
			Scorpaenodes sp. 2
			Scorpaenopsis diabolus (Cuvier, 1829)
			Scorpaenopsis macrochir Ogilby, 1910
			Scorpaenopsis oxycephala (Bleeker, 1849)
			Scorpaenopsis possi Randall & Eschmeyer, 2001
			Scorpaenopsis venosa (Cuvier, 1829)
			Sebastapistes sp.
			Sunagocia sp.
			Taenianotus triacanthus Lacépède, 1802
		Synanceia	
			Synanceia verrucosa Bloch & Schneider 1801
		Platycephalidae	
			Cymbacephalus beauforti (Knapp 1973)
	Perciformes		
		Serranidae	
			Anyperodon leucogrammicus (Valenciennes 1828)
			Cephalopholis argus Schneider 1801
			Cephalopholis boenak (Bloch 1790)
			Cephalopholis leopardus (Lacépède 1801)
			Cephalopholis miniata (Forsskål 1775)
			Cephalopholis urodeta (Forster 1801)
			Cromileptes altivelis (Valenciennes 1828)
			Diploprion bifasciatum Cuvier 1828
			Epinephelus fasciatus (Forsskål 1775)

Class	Order	Family	Species
Osteichthyes	Perciformes	Serranidae*, Cont'd.*	
			Epinephelus fuscoguttatus (Forsskål 1775)
			Epinephelus maculatus (Bloch 1790)
			Epinephelus merra Bloch 1793
			Epinephelus polyphekadion (Bleeker 1849)
			Grammistes sexlineatus (Thunberg 1792)
			Plectropomus laevis (Lacépède 1801)
			Plectropomus leopardus (Lacépède 1802)
			Pseudanthias fasciatus (Kamohara 1954)
			Pseudanthias hypselosoma Bleeker 1878
			Pseudanthias luzonensis (Katayama & Masuda 1983)
			Pseudanthias pleurotaenia (Bleeker 1857)
			Pseudanthias squamipinnis (Peters 1855)
			Pseudanthias tuka (Herre & Montalban 1927)
		Pseudogramminae	
			Pseudogramma polyacantha (Bleeker 1856)
			Suttonia lineata Gosline 1960
		Cirrhitidae	
			Cirrhitichthys aprinus (Cuvier, 1829)
			Cirrhitichthys falco Randall, 1963
			Cirrhitichthys oxycephalus (Bleeker, 1855)
			Oxycirrhites typus Bleeker, 1857
			Paracirrhites forsteri (Schneider, 1801)
			Paracirrhites arcatus (Cuvier, 1829)
		Priacanthidae	
			Priacanthus hamrur (Forsskål 1775)
		Psuedochromidae	
			Pictichromis aurifrons (Lubbock 1980)
			Pseudochromis fuscus Müller & Troschel 1849
			Pseudochromis marshallensis Schultz 1953
			Pseudochromis sp.
		Plesiopidae	
			Calloplesiops altivelis (Steindachner 1903)

Class	Order	Family	Species
Osteichthyes	Perciformes	Plesiopidae	*Plesiops caeruleolineatus* Rüppell, 1835
		Apogonidae	*Apogon aureus (Lacépède, 1802)*
			Apogon crassiceps Garman, 1903
			Apogon cyanosoma Bleeker 1853
			Apogon exostigma (Jordan and Starks, 1906)
			Apogon fraenatus Valenciennes, 1832
			Apogon fucata (Cantor, 1849)
			Apogon kallopterus Bleeker, 1856
			Apogon nigrofasciatus Lachner, 1953
			Apogon perlitus Fraser and Lachner, 1985
			Apogon rhodopterus Bleeker, 1852
			Apogon sp. 1
			Apogon sp. 2
			Apogon sp. 3
			Archamia zosterophora (Bleeker, 1856)
			Cheilodipterus alleni Gon, 1993
			Cheilodipterus isostigmus (Schultz, 1940)
			Cheilodipterus macrodon (Lacépède, 1802)
			Cheilodipterus parazonatus Gon, 1993
			Cheilodipterus quinquelineatus Cuvier, 1828
			Cheilodipterus sp.
			Fowleria marmorata (Alleyne and MacLeay, 1877)
			Fowleria variegata (Valenciennes, 1832)
			Pseudamia hayashii (Lachner & Fraser, 1985)
			Rhabdamia cypselurus (Weber, 1909)
			Siphamia elongata Lachner, 1953
			Siphamia versicolor (Smith & Radcliffe, 1911)
			Sphaeramia nematoptera (Bleeker, 1856)
			Sphaeramia orbicularis (Cuvier, 1828)

Class	Order	Family	Species
Osteichthyes	Perciformes	Carangidae	*Carangoides plagiotaenia* Bleeker, 1857
			Caranx melampygus Cuvier, 1833
			Caranx sexfasciatus Quoy and Gaimard, 1825
		Lutjanidae	*Lutjanus argentimaculatus* (Forsskål, 1775)
			Lutjanus biguttatus (Valenciennes, 1830)
			Lutjanus gibbus (Forsskål, 1775)
			Lutjanus semicinctus Quoy and Gaimard, 1824
			Macolor macularis Fowler, 1931
			Symphorichthys spilurus (Günther, 1874)
		Caesionidae	*Caesio caerulaurea* Lacépède, 1801
			Caesio cuning (Bloch, 1791)
			Caesio teres Seale, 1906
			Pterocaesio digramma (Bleeker, 1864)
			Pterocaesio pisang (Bleeker,1853)
		Haemulidae	*Plectorhinchus chaetodontoides Lacépède 1801*
			Plectorhinchus chrysotaenia (Bleeker, 1855)
			Plectorhinchus lineatus (Linnaeus, 1758)
			Plectorhinchus vittatus (Linnaeus, 1758)
		Sciaenidae	*Sciaenops sp.*
		Lethrinidae	*Lethrinus erythracanthus* Valenciennes, 1830
			Lethrinus harak (Forsskål, 1775)
			Lethrinus variegatus (Valeciennes, 1830)
			Monotaxis grandoculis (Forsskål, 1775)
		Nemipteridae	*Pentapodus trivittatus* (Bloch, 1791)
			Scolopsis bilineata (Bloch 1793)
			Scolopsis ciliatus (Lacépède, 1802)

Class	Order	Family	Species
Osteichthyes	Perciformes	Nemipteridae*, Cont'd.*	
			Scolopsis lineata Quoy & Gaimard 1824
			Scolopsis margaritifera (Cuvier 1830)
			Scolopsis monogramma (Cuvier, 1830)
		Mullidae	
			Parupeneus barberinoides (Bleeker, 1852)
			Parupeneus crassilabris (Valenciennes, 1831)
			Parupeneus indicus (Shaw, 1803)
			Parupeneus multifasciatus (Quoy and Gaimard, 1852)
			Upeneus tragula Richardson, 1846
		Pempheridae	
			Parapriacanthus ransonneti Steindachner, 1870
		Kyphosidae	
			Kyphosus cinerascens (Forsskål 1775)
		Chaetodonitdae	
			Chaetodon auriga Forsskål, 1775
			Chaetodon baronessa Cuvier, 1829
			Chaetodon bennetti Cuvier, 1831
			Chaetodon citrinellus Cuvier, 1831
			Chaetodon ephippium Cuvier, 1831
			Chaetodon kleinii Bloch, 1790
			Chaetodon lunulatus Quoy and Gaimard, 1825
			Chaetodon melannotus Bloch and Schneider, 1801
			Chaetodon ornatissimus Cuvier, 1831
			Chaetodon pelewensis Kner, 1868
			Chaetodon plebeius Cuvier, 1831
			Chaetodon rafflesi [Bennett], 1830
			Chaetodon speculum Cuvier, 1831
			Chaetodon trifascialis Quoy and Gaimard, 1825
			Chaetodon ulietensis Cuvier, 1831
			Chaetodon unimaculatus Bloch, 1787
			Chaetodon vagabundus Linnaeus, 1758
			Chelmon rostratus (Linnaeus, 1758)

Class	Order	Family	Species
Osteichthyes	Perciformes	Chaetodonitdae, *Cont'd.*	*Forcipiger flavissimus* Jordan and McGregor, 1898
			Forcipiger longirostris (Broussonet, 1782)
			Heniochus varius (Cuvier, 1829)
			Hemitaurichthys polylepis (Bleeker, 1857)
			Heniochus acuminatus (Linnaeus, 1758)
			Heniochus chrysostomus Cuvier, 1831
			Heniochus singularis (Smith and Radcliffe, 1911)
		Pomacanthidae	*Apolemichthys trimaculatus* (Cuvier 1831)
			Centropyge bicolor (Cuvier 1831)
			Centropyge bispinosa (Günther 1860)
			Centropyge vrolikii (Bleeker 1853)
			Genicanthus melanospilos (Bleeker 1857)
			Pomacanthus imperator (Bloch 1787)
			Pomacanthus sexstriatus (Cuvier 1831)
			Pomacanthus xanthometopon (Bleeker 1853)
			Pygoplites diacanthus (Boddaert 1772)
		Pomacentridae	*Abudefduf lorenzi* Hensley & Allen 1977
			Abudefduf sexfasciatus (Lacépède 1801)
			Abudefduf vaigiensis (Quoy & Gaimard 1825)
			Amblyglyphidodon aureus (Cuvier 1830)
			Amblyglyphidodon curacao (Bloch 1787)
			Amblyglyphidodon leucogaster (Bleeker 1847)
			Amphiprion clarkii (Bennett 1830)
			Amphiprion melanopus Bleeker 1852
			Amphiprion percula (Lacépède 1802)
			Amphiprion perideraion Bleeker 1855
			Amphiprion polymnus (Linnaeus 1758)
			Chromis amboinensis (Bleeker 1871)
			Chromis atripectoralis Welander & Schultz 1951
			Chromis atripes Fowler & Bean 1928

Class	Order	Family	Species
Osteichthyes	Perciformes	Pomacentridae, *Cont'd.*	*Chromis margaritifer* Fowler 1946
			Chromis retrofasciata Weber 1913
			Chromis ternatensis (Bleeker 1856)
			Chromis viridis (Cuvier 1830)
			Chromis weberi Fowler & Bean 1928
			Chrysiptera rollandi (Whitley 1961)
			Chrysiptera talboti (Allen 1975)
			Dascyllus aruanus (Linnaeus 1758)
			Dascyllus melanurus Bleeker 1854
			Dascyllus reticulatus (Richardson 1846)
			Dascyllus trimaculatus (Rüppell 1829)
			Dischistodus chrysopoecilus (Schlegel & Müller 1839)
			Dischistodus prosopotaenia (Bleeker 1852)
			Neoglyphidodon melas (Cuvier 1830)
			Neoglyphidodon nigroris (Cuvier 1830)
			Neoglyphidodon oxyodon (Bleeker 1858)
			Neopomacentrus azysron (Bleeker 1877)
			Neopomacentrus taeniurus (Bleeker 1856)
			Plectroglyphidodon lacrymatus (Quoy & Gaimard 1825)
			Pomacentrus amboinensis Bleeker 1868
			Pomacentrus armillatus Allen 1993
			Pomacentrus bankanensis Bleeker 1854
			Pomacentrus cf. amboinensis Bleeker, 1868
			Pomacentrus colini Allen 1991
			Pomacentrus grammorhynchus Fowler 1918
			Pomacentrus moluccensis Bleeker 1853
			Pomacentrus nagasakiensis Tanaka 1917
			Pomacentrus nigromanus Weber 1913
			Pomacentrus pavo (Bloch 1787)
			Pomacentrus reidi Fowler & Bean 1928
			Pomacentrus cf. wardi Whitley 1927
			Premnas biaculeatus (Bloch 1790)

Class	Order	Family	Species
Osteichthyes	Perciformes	Pomacentridae, *Cont'd.*	*Stegastes fasciolatus* (Ogilby 1889)
			Stegastes nigricans (Lacépède 1802)
			Stegastes albifasciatus (Schlegel & Müller 1839)
		Labridae	*Anampses neoguinaicus* Bleeker, 1878
			Bodianus anthioides (Bennet, 1832)
			Bodianus axillaris (Bennet, 1832)
			Bodianus bimaculatus Allen, 1973
			Bodianus diana (Lacépède, 1801)
			Bodianus mesothorax (Bloch and Schneider, 1801)
			Oxycheilinus bimaculatus (Valenciennes 1840)
			Cheilinus chlorourus (Bloch, 1791)
			Cheilinus digrammus (Lacépède, 1801)
			Cheilinus fasciatus (Bloch, 1791)
			Cheilinus oxycephalus Bleeker 1853
			Cheilinus trilobatus Lacépède, 1801
			Cheilinus undulatus Rüppell, 1835
			Choerodon anchorago (Bloch, 1791)
			Cirrhilabrus punctatus Randall and Kuiter, 1989
			Coris batuensis (Bleeker, 1856-57)
			Coris gaimard (Quoy and Baimard, 1824)
			Epibulus insidiator (Pallas, 1770)
			Gomphosus varius Lacépède, 1801
			Halichoeres argus (Bloch and Schneider, 1801)
			Halichoeres biocellatus Schutlz, 1960
			Halichoeres chloropterus (Bloch, 1791)
			Halichoeres hortulanus (Lacépède, 1801)
			Halichoeres leucurus (Walbaum, 1792)
			Halichoeres melanurus (Bleeker, 1851)
			Halichoeres prosopeion (Bleeker, 1853)
			Halichoeres richmondi Fowler and Bean, 1928
			Halichoeres trimaculatus (Quoy and Gaimard, 1834)

Class	Order	Family	Species
Osteichthyes	Perciformes	Labridae, *Cont'd.*	*Hemigymnus fasciatus* (Bloch, 1792)
			Hemigymnus melapterus (Bloch, 1791)
			Hologymmnosus annulatus (Lacépède, 1801)
			Labrichthys unilineatus (Guichenot, 1847)
			Labroides dimidiatus (Valenciennes, 1839)
			Labropsis micronesica Randall, 1981
			Macropharyngodon meleagris (Valenciennes, 1839)
			Novaculichthys taeniourus (Lacépède, 1801)
			Oxycheilinus digramma (Lacépède, 1801)
			Pseudocheilinus evanidus Jordan and Evermann, 1903
			Pseudocheilinus octotaenia Jenkins, 1901
			Pseudocheilinus sp.
			Stethojulis bandanensis (Bleeker, 1851)
			Thalassoma hardwicke (Bennett, 1830)
			Thalassoma lunare (Linnaeus, 1758)
			Thalassoma lutescens (Lay and Bennett, 1839)
			Wetmorella nigropinnata (Seale, 1901)
		Scaridae	*Calotomus carolinus* (Valenciennes 1840)
			Calotomus spinidens (Quoy & Gaimard 1824)
			Cetoscarus bicolor (Rüppell 1829)
			Chlorurus bleekeri (de Beaufort 1940)
			Chlorurus microrhinos (Bleeker 1854)
			Chlorurus sordidus (Forsskål 1775)
			Hipposcarus longiceps (Valenciennes 1840)
			Leptoscarus vaigiensis (Quoy & Gaimard 1824)
			Scarus chameleon Choat & Randall 1986
			Scarus flavipectoralis Schultz 1958
			Scarus frenatus Lacépède 1802
			Scarus ghobban Forsskål 1775
			Scarus niger Forsskål 1775
			Scarus quoyi Valenciennes 1840

Class	Order	Family	Species
Osteichthyes	Perciformes	Scaridae, *Cont'd.*	*Scarus rivulatus* Valenciennes 1840
			Scarus schlegeli (Bleeker 1861)
			Scarus spinus (Kner 1868)
		Pinguipedidae	*Parapercis clathrata* Ogilby, 1910
			Parapercis hexophtalma (Cuvier 1829)
			Parapercis lineopunctata Randall, 2003
			Parapercis millepunctata (Günther, 1860)
			Parapercis xanthozona (Bleeker, 1849)
		Trichonotidae	Trichonotus setiger Bloch & Schneider 1801
		Tripterygiidae	*Enneapterygius sp.*
			Helcogramma sp. 1
			Helcogramma sp. 2
			Helcogramma striatum Hansen, 1986
		Blenniidae	*Aspidontus taeniatus* Quoy and Gaimard, 1834
			Blenniella cf. gibbifrons (Quoy and Baimard, 1824)
			Crossosalarias macrospilus Smith-Vaniz and Springer, 1971
			Ctenogobiops sp.
			Ecsenius namiyei (Jordan and Evermann, 1902)
			Ecsenius yaeyamaensis (Ayoagi, 1954)
			Meiacanthus grammistes (Valenciennes, 1836)
			Meiacanthus vittatus Smith-Vaniz, 1976
			Plagiotremus laudandus (Whitley, 1961)
			Plagiotremus rhinorhynchos (Bleeker, 1852)
		Gobiesocidae	*Diademichthys lineatus* (Sauvage, 1883)
			Discotrema crinophila Briggs, 1976

Class	Order	Family	Species
Osteichthyes	Perciformes	Callionymidae	*Callionymus enneactis* Bleeker, 1879
			Dactylopus dactylopus (Valenciennes, 1837)
			Synchiropus stellatus Smith, 1963
		Gobiidae	*Amblyeleotris arcupinna* Mohlmann and Munday, 1999
			Amblyeleotris guttata (Fowler, 1938)
			Amblyeleotris randalli Hoese and Steene, 1978
			Amblygobius decussatus (Bleeker, 1855)
			Amblygobius phaelena (Valenciennes, 1837)
			Amblygobius rainfordi Whitley, 1940
			Bryaninops amplus Larson, 1985
			Bryaninops loki Larson, 1985
			Calumia sp. 1
			Calumia sp. 2
			Cryptocerus sp.
			Eviota sp.
			Exyrias belissimus (Smith, 1959)
			Fusigobius inframaculatus (Randall, 1994)
			Fusigobius signipinnis Hoese & Obika 1988
			Fusigobius sp.
			Gobidae sp. 1
			Gobidae sp. 2
			Gobidae sp. 3
			Gobiodon okinawae Sawada, Arai & Abe, 1972
			Istigobius goldmanni (Bleeker, 1852)
			Istigobius ornatus (Rüppell, 1830)
			Istigobius rigilius (Herre, 1953)
			Oplopomus oplopomus (Valenciennes, 1837)
			Oxudercinae sp.
			Paragobiodon xanthosomus (Bleeker, 1852)
			Periophthalmus argentilineatus Valenciennes, 1837

Class	Order	Family	Species
Osteichthyes	Perciformes	Gobiidae, *Cont'd.*	*Pleurosicya bilobata* (Koumans, 1941)
			Pleurosicya micheli Fourmanoir, 1971
			Pleurosicya mossambica Smith, 1959
			Priolepis sp.
			Signigobius biocellatus Hoese & Allen 1977
			Trimma sp. 1
			Trimma sp. 2
			Trimma sp. 3
			Trimma caesiura Jordan & Seale 1906
			Trimma macrophthalma (Tomiyama, 1936)
			Trimma okinawae (Aoyagi, 1949)
			Trimma striatum (Herre 1945)
			Valenciennea helsdingenii (Bleeker 1858)
			Valenciennea puellaris (Tomiyama 1956)
			Valenciennea strigata (Broussonet, 1782)
		Xenisthmidae	*Xenisthmus cf. polyzonatus* (Klunzinger 1871)
		Pterelotridae	*Nemateleotris decora* Randall & Allen 1973
			Nemateleotris magnifica Fowler 1938
			Ptereleotris evides (Jordan & Hubbs 1925)
		Ephippidae	*Platax orbicularis* (Forsskål, 1775)
			Platax pinnatus (Linnaeus, 1758)
			Platax teira (Forsskål, 1775)
		Zanclidae	*Zanclus cornutus* (Linnaeus 1758)
		Acanthuridae	*Acanthurus auranticavus* Randall, 1956
			Acanthurus fowleri de Beaufort, 1951
			Acanthurus grammoptilus Richardson, 1843
			Acanthurus lineatus Linnaeus, 1758

Class	Order	Family	Species
Osteichthyes			
	Perciformes		
		Acanthuridae, *Cont'd.*	
			Acanthurus nigrofuscus (Forsskål, 1775)
			Acanthurus nigroris Valenciennes, 1835
			Acanthurus olivaceus Bloch and Schneider, 1801
			Acanthurus pyroferus Kittlitz, 1834
			Acanthurus triostegus (Linnaeus, 1758)
			Ctenochaetus striatus (Quoy and Baimard, 1825)
			Ctenochaetus binotatus Randall, 1955
			Naso brevirostris (Cuvier, 1829)
			Naso lituratus (Forster, 1801)
			Naso vlamingii (Valenciennes, 1835)
		Siganidae	
			Siganus argenteus (Quoy & Gaimard 1825)
			Siganus javus (Linnaeus 1766)
			Siganus spinus (Linnaeus 1758)
			Siganus vulpinus (Schlegel & Müller 1845)
			Siganus puellus (Schlegel 1852)
		Sphyraenidae	
			Sphyraena flavicauda Rüppell 1838
			Sphyraena qenie Klunzinger 1870
		Scombridae	
			Euthynnus affinis (Cantor 1849)
			Katsuwonus pelamis (Linnaeus 1758)
			Rastrelliger kanagurta (Cuvier 1816)
			Scomberoides lysan (Forsskål 1775)
			Scomberoides tol (Cuvier 1832)
	Pleuronectiformes		
		Bothidae	
			Bothus mancus (Broussonet, 1782)
		Soleidae	
			Pardachirus pavoninus (Lacépède 1802).
			Pardachirus sp.

Class	Order	Family	Species
Osteichthyes	Tetraodontiformes	Balistidae	*Abalistes stellatus* ([Lacépède, 1798])
			Balistapus undulatus (Park, 1797)
			Balistoides conspicillum (Bloch and Schneider, 1801)
			Balistoides viridescens (Bloch and Schneider, 1801)
			Melichthys vidua (Richardson, 1845)
			Pseudobalistes flavimarginatus (Rüppell, 1829)
			Rhinecanthus aculeatus (Linnaeus, 1758)
			Rhinecanthus verrucosus (Linnaeus, 1758)
			Sufflamen bursa (Bloch and Schneider, 1801)
			Sufflamen chrysopterus (Bloch and Schneider, 1801)
		Monacanthidae	*Aluterus scriptus* (Osbeck 1765)
			Cantherhines dumerilii (Hollard 1854)
			Cantherhines pardalis (Rüppell 1837)
			Monacanthus chinensis (Osbeck, 1765)
			Oxymonacanthus longirostris (Bloch & Schneider, 1801)
			Pervagor janthinosoma (Bleeker, 1854)
			Pervagor cf. melanocephalus (Bleeker, 1853)
			Rudarius minutus Tyler, 1970
		Ostraciidae	*Lactoria cornuta* (Linnaeus, 1758)
			Ostracion cf. cubicus Linnaeus, 1758
			Ostracion meleagris Shaw, 1796
			Ostracion solorensis Bleeker, 1853
		Tetradontidae	*Arothron caeruleopunctatus* Matsuura 1994
			Arothron hispidus (Linnaeus 1758)
			Arothron manilensis (Marion de Procé 1822)
			Arothron mappa (Lesson 1831)
			Arothron nigropunctatus (Bloch & Schneider 1801)
			Arothron stellatus (Anonymous 1798)
			Canthigaster compressa (Marion de Procé 1822)

Class	Order	Family	Species
Osteichthyes	Tetraodontiformes	Tetradontidae, *Cont'd.*	
			Canthigaster janthinoptera (Bleeker, 1855)
			Canthigaster papua (Bleeker 1848)
			Canthigaster valentini (Bleeker 1853)
			Tetradontidae sp.
		Diodontidae	
			Diodon hystrix Linnaeus, 1758