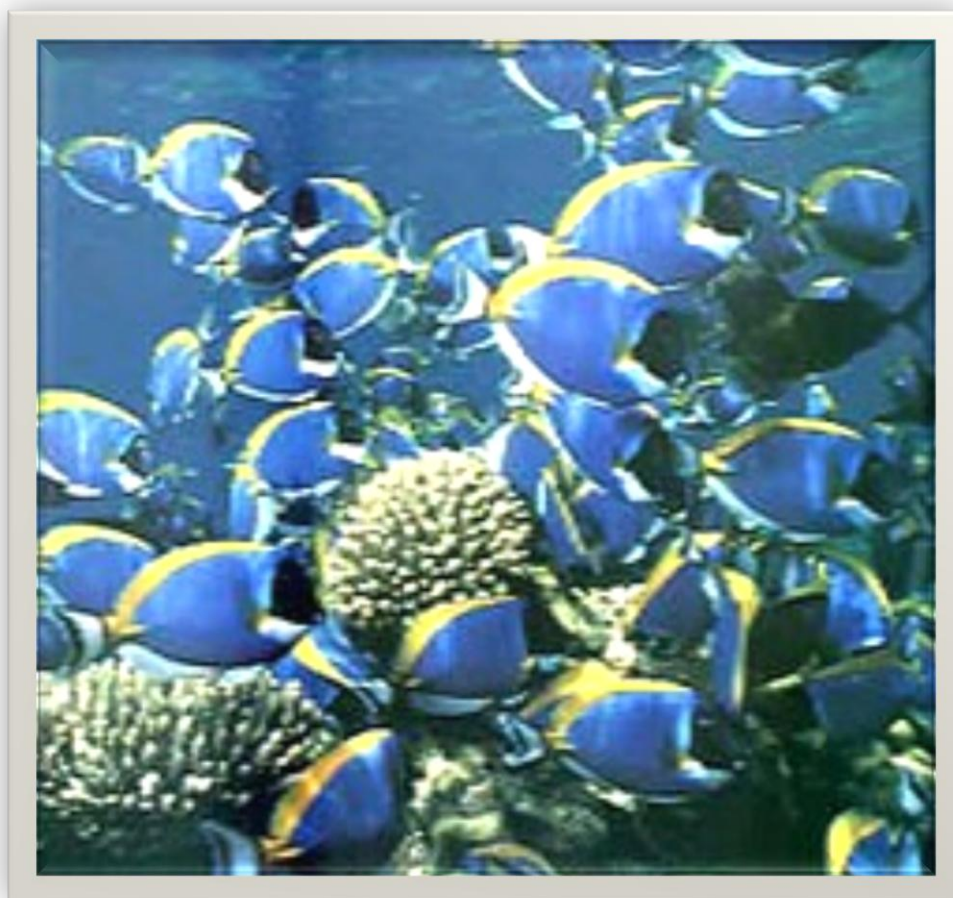


# NATURAL RESOURCE INVENTORY REPORT OF THE FIJI ISLANDS 2010

## VOLUME 2: MARINE RESOURCES INVENTORY OF THE FIJI ISLANDS



Prepared by: Professor Biman Chand Prasad  
Dean  
Faculty of Business and Economics  
University of the South Pacific  
Suva  
Fiji

## ACKNOWLEDGEMENTS

The preparation of the Natural Resource Inventory (NRI) report was a challenging task and the contribution of the following people cannot be left unmentioned. The following organisations and government departments who actively contributed in making the Natural Resource Inventory a success are:

- Department of Energy
- Fiji Electricity Authority
- Fiji Locally Managed Marine Areas
- Fisheries
- Food Agriculture Organisation
- Hydrology department
- Institute of Applied Science
- Mareqeti Viti
- Meteorological Office
- Mineral Resource Department
- Ministry of Agriculture
- Ministry of Lands
- Ministry of Primary Industries
- Ministry of Town Planning
- National Trust
- Native Land Trust Board
- Non Government Organisations
- Secretariat for the Pacific Islands Applied Geoscience Commission
- Secretariat of the Pacific Community
- South Pacific Regional Environment Programme
- University of the South Pacific
- Wetland International
- Wildlife Conservation Society

## **ABBREVIATIONS**

AIMS	Australian Institute of Marine Science
DoF	Department of Fisheries
EEZ	Economic Exclusive Zone
EOI	Expression of Interest
GoF	Government of Fiji Islands
MPA	Marine Protected Areas
NWVL	Natural Waters of Viti Ltd
PIFS	Pacific Islands Forum Secretariat
SE	South East
W/NW	West/North West

## **EXECUTIVE SUMMARY**

The preparation of the Natural Resource Inventory Report (NRI) is a requirement under the Environment Management Act (2005). Under the Environment Management Act (2005) s.13, the resource management unit is required to prepare the NRI report after consulting the important stakeholders such as the resource owners. Notably, this is the first NRI that has been prepared for Fiji. It is divided into six chapters and each chapter focuses on important aspects of the natural resources in Fiji. The major sub categories of NRI are the:

- Freshwater Resources
- Marine Resources
- Agricultural Resources
- Energy Resources
- Mineral Resources

Chapter 2 focused on marine resources in Fiji. The introductory section of this chapter focused on coral reefs, other marine habitats, mangroves, traditional fishing grounds, marine protected areas and buffer zones. The subsequent section of this chapter analysed marine flora and fauna. The concluding section of this chapter focused on state of current research and gaps in existing literature in the field of marine resource inventory of Fiji.

## TABLE OF CONTENTS

ACKNOWLEDGEMENTS .....	2
ABBREVIATIONS .....	3
DEFINITIONS: CHAPTER 2 .....	7
CHAPTER 2: MARINE RESOURCES INVENTORY OF FIJI .....	8
2.0 INTRODUCTION .....	8
2.1 CORAL REEFS .....	8
2.1.1 HARD CORALS OF FIJI .....	8
2.2 OTHER MARINE HABITATS .....	11
2.3 TRADITIONAL FISHING GROUNDS .....	11
2.4 MARINE PROTECTED AREAS (MPA's) .....	12
2.5 BUFFER ZONES .....	12
2.6 MARINE FLORA AND FAUNA .....	12
2.6.1 BIODIVERSITY HOTSPOT FOR MARINE ALGAE .....	14
2.6.2 THE MARINE AND ESTUARINE FISHES OF FIJI .....	16
2.6.3 CETACEAN BIODIVERSITY OF THE FIJI ISLANDS .....	17
2.6.4 SEAGRASSES OF THE FIJI ISLANDS .....	19
2.6.5 MOLLUSCS OF FIJI .....	21
2.6.6 BIVALVES OF FIJI .....	22
2.6.7 BRACHIOPODS OF THE FIJI ISLANDS .....	23
2.6.8 GASTROPODS .....	25
2.6.9 CHITONS OF FIJI .....	27
2.6.10 CONE SHELLS – CONIDAE .....	28
2.6.11 COWRIES (CYPRAEIDAE) OF FIJI .....	28
2.7 REEF FISHES .....	29
2.8 INTRODUCED SPECIES .....	29
2.9 MIGRATORY SPECIES .....	29
2.10 INVASIVE/INTRODUCED SPECIES .....	30
2.11 ENDANGERED SPECIES .....	30
2.12 ENDEMIC SPECIES .....	31
2.13 INDICATOR SPECIES .....	31
2.14 TRADED SPECIES .....	32

2.15	CURRENT STATE OF RESEARCH AND GAPS IN EXISTING LITERATURE .....	33
2.16	CONCLUSION.....	33

## DEFINITIONS: CHAPTER 2

1. Marine Protected Areas (MPAs)- is an ocean boundary which is protected.
2. Buffer Zone- is any zonal area that serves the purpose of keeping two or more areas distant from one another for whatever reason.
3. Traditional Fishing Grounds- were those special area where cultural rules were strictly adhered to.
4. Estuaries (gusu ni wai) – The lower usually tidal sections of rivers where the freshwater meets the seawater.
5. Intertidal Zone (dela ni wasa, tavola/vei vutia) – These are the areas of old fringing reefs or tidal flats that are above sea level during low tide but goes under water at high tide.
6. Lagoons (namo, lomaloma/toba) – These are the bodies of saltwater or brackish water more or less separated from the open sea by reefs, islets or other barriers.
7. Fishponds/Maricultural Areas (tobu ni ika) – These are the artificially constructed fish ponds or other forms of development primarily for the purpose of fishfarming or mariculture.
8. Coral reefs/Outer reef (cakau/batilili) – These include coral reefs, algal reefs, barrier reefs, fringing reefs and lagoon/patch reefs.
9. Island Shelf/Reef Platform (boto ni sauloa) – These include areas of 50-200m adjacent to islands.
10. Open Ocean (waituiloa, wasa) – These are the areas deeper than 200m that are found within Fiji's Economic Exclusive Zone (EEZ). Notably, these are very crucial pelagic fishing areas.

## **CHAPTER 2: MARINE RESOURCES INVENTORY OF FIJI**

### **2.0 INTRODUCTION**

Fiji has a diverse range of marine resources and the wise use of these resources is essential for the growth of the Fiji's economy. Sustainable use of marine resources is essential for the growth of Fiji and to ensure that enough is leftover for the future generation. Notably, Fiji's continental marine zone is under threat and it is important to determine the variations that are taking place in the marine resources inventory of Fiji. In regards to this, argument this chapter will analyse the marine resource inventory of Fiji. The introductory section of this paper will focus on coral reefs, other marine habitats, mangroves, traditional fishing grounds, marine protected areas and buffer zones. The subsequent section of this chapter will analyse marine flora and marine fauna. The concluding section of this chapter will focus on state of current research and gaps in existing literature in the field of marine resource inventory of Fiji.

### **2.1 CORAL REEFS**

Coral reefs are one of the essential features of the marine ecosystem. Hence, discussion on the inventory of marine resources in Fiji is not complete without proper analysis of inventory of coral habitat in Fiji. Notably, Fiji has an extensive range of coral formation. Coral reefs are a highly integrated marine ecosystem that supports the biodiversity of organisms (Morris and Pratt, 1997:9). A close analysis of collection research of Fiji's coral reefs recorded 50 genera and 144 species of coral (Morris and Pratt, 1997:9). These estimates are for coral reef biodiversity that is for 6 locations that has major reef systems (Morris and Pratt, 1997:9).

#### **2.1.1 HARD CORALS OF FIJI**

Corals are grouped under the Phylum Coelenterata in the Class Anthozoa, which are divided into two sub-classes, depending on the number of tentacles. Those with eight tentacles are called the octocorallia or Alcyonaria, which include soft corals, blue coral, sea fans and sea pens. Those with six or a multiple of six tentacles are called the Hexacorallia or Zoantharia. This group comprises the reef-building corals, sea anemones, and zoanthids. This account deals with the hard or stony corals which represent the reef building corals of Fiji. They mostly belong to the Order Scleractinia but also several other taxonomic entities within the Coelenterates which secrete hard skeletons. Hard corals usually dominate the reef community providing habitat both in terms of morphologic relief and material for reef construction (Morris and Pratt, 1998).

In addition to the hard corals, crustose coralline algae play a fundamental role in reef formation through cementing the corals together. Coral reefs are among the most biologically diverse of communities on earth. They play an important role in coastal protection, as a source of food security for local communities, as an important resource for tourism, and as a potential source of biologically active compounds for the production of pharmaceuticals.



A reference collection of Fijian stony corals is housed at the University of the South Pacific. It was commenced by Carlson, Beveridge and Gawel in 1974. A total of 212 species are represented by voucher specimens in the USP collections. The identifications of these corals were later revised in 1980 by Pichon to conform to the taxonomy in the Australian Institute of Marine Science (AIMS) monograph series, *Scleractinia* of Eastern Australia (Veron and Pichon 1976, 1979, 1982; Veron Pichon & Wijsman – Best 1977; Veron & Wallace, 1984). Identifications of the genera *Acropora*, *Montipora*, *Anacropora* and *Astreopora* are incomplete and the Acroporidae has yet to be revised. However Veron (1990) described 50 genera and 144 species (Morris and Pratt, 1998).

From the reference collection and field survey, Lovell and McLardy (2008) recorded 342 species within 72 genera of Scleractinian hard corals in Fiji. Of these, ahermatypic (non reef building corals) Scleractinia comprise six species within four genera; the remainders are hermatypic (reef building corals). A further 12 non-Scleractinian species within five genera also occur in Fiji. Fiji is the type locality for 47 species which is largely the result of collections made by Dana (1846) during the United States Exploring Expedition 1838-1842, the specimens of which are currently held at the Smithsonian Museum in Washington DC, USA (Lovell and McLardy, 2008).

The following list was abstracted from the CITES administered corals of Fiji and summarizes information drawn from publications, reports and coral export records (Lovell, 2002a; Obura and Mangubhai, 2003; Lovell, 2005; Fenner, 2006; Bonito (in prep), Fiji Fisheries records (unpublished); Veron, 1993; 2000; Wallace, 1999) and museum voucher specimens from the University of the South Pacific marine collection and the Museum of Tropical Queensland (Wallace 1999; Pichon 1980; Lovell 2005), with additions from the Smithsonian National Museum of Natural History (NMNH). Unregistered specimens represent identified material from the Cakaulevu/North Vanua Levu expedition (Jenkins *et al.*, 2004), which will be incorporated into the collections of the University of the South Pacific. Zann and Boulton (1985) described the distribution of the blue coral, *Heliopora coerulea*, which is common in the isolated northern Fijian island of Rotuma (approx. 300 km north of the main island group) and which was recently found in the main archipelago (Lovell and McLardy, 2008).

The Fiji hard coral list also includes a compilation of data derived from species surveys from around Viti Levu and includes locations to the west and north of Vanua Levu (Lovell and McLardy, 2008). Important areas such as Rotuma (Gardiner, 1898) and the extensive Lau Group (Hoffmeister, 1945; Phipps and Preobrazhensky 1977; Salvat *et al.*, 1997) have received limited study with regard to species occurrence. Viti Levu is the centre of the aquarium trade collection where most of the surveys were undertaken, so table 2.1 is considered to include all those species that could be potentially traded within the quota framework.

The presence of a voluntary export quota, submitted to the CITES Secretariat by an exporting party, can be an important component of a non-detriment finding for both the exporting country and for an importing party (should one be required by their stricter measures). Additionally, two resource surveys assessing the number of corals within CITES categories were undertaken.

Scleractinian coral species number found in Fiji were observed to approach that predicted by Veron (2000) totaling 354 species. There have been numerous predictions with relevant field records to support them. However, there remain some predictions which are unsupported by field records and some records of species presence which were not predicted by Veron (Lovell and McLardy, 2008). Of those predictions of species occurrences in Fiji (without field records), 27 are also not found in adjacent countries in the Central Southwest Pacific and so are unlikely to occur in Fiji (see table 2.1).

Table 2.1: Summary of Records from Fiji of CITES-Listed Hard Corals

Class	No. Orders	No. Families	No. Genera	No. Species
Anthozoa	3	19	74	344
Hydrozoa	2	3	3	10
Totals	5	22	79	354

Source: Created by Tikoca and Skelton, (2010).

Furthermore, Ministry of Marine Resources (2010) also provided a list of coral genus. This list includes the following; namely:

- Acropora
- Anacropora
- Montipora
- Pocillopora
- Diploastrea
- Cyphastrea
- Cosaenarea
- Porites
- Favites
- Favia
- Turbipora
- Turbinaria
- Tubastrea
- Symphyllia
- Euphyllia
- Trachyphyllia
- Goniastrea
- Gonipora
- Alveopora
- Astreopora
- Acanthastrea
- Monitpora
- Fungia
- Ctenactis
- Polyphyllia
- Hydnophora
- Stylophora

- Seriatopora
- Lobophyllia
- Oluophyllia
- Gardinoseris
- Montastrea
- Galaxea
- Plerogyra
- Echinopora
- Oxypora
- Echniophyllia

## **2.2 OTHER MARINE HABITATS**

Some of the common marine habitats include the following:

- Estuaries (gusu ni wai) – The lower usually tidal sections of rivers where the freshwater meets the seawater.
- Intertidal Zone (dela ni wasa, tavola/vei vutia) – These are the areas of old fringing reefs or tidal flats that are above sea level during low tide but goes under water at high tide.
- Lagoons (namo, lomaloma/toba) – These are the bodies of saltwater or brackish water more or less separated from the open sea by reefs, islets or other barriers.
- Fishponds/Maricultural Areas (tobu ni ika) – These are the artificially constructed fish ponds or other forms of development primarily for the purpose of fishfarming or mariculture.
- Coral reefs/Outer reef (cakau/batilili) – These include coral reefs, algal reefs, barrier reefs, fringing reefs and lagoon/patch reefs.
- Island Shelf/Reef Platform (boto ni sauloa) – These include areas of 50-200m adjacent to islands.
- Open Ocean (waituiloa, wasa) – These are the areas deeper than 200m that are found within Fiji's Economic Exclusive Zone (EEZ). Notably, these are very crucial pelagic fishing areas. (Thaman et al., 1998 : 92-93)

## **2.3 TRADITIONAL FISHING GROUNDS**

Traditional management understanding was entrenched in the wider communal structure in which the traditional authority prevailed and the structure of retribution ensured fulfillment. Traditional fishing grounds were those special area where cultural rules were strictly adhered to (Veitayaki, 1997). Fishing at the traditional fishing grounds were conducted with the permission of a bete, or traditional priest or when special requirements were met (Veitayaki, 1997). Furthermore, in Qoma today, the people going to Cakau Davui, the sacred fishing ground are expected to obtain permission to perform the rituals of an arrival party at the reef and to fish according to the rules (Veitayaki, 1997). Notably, among the turtle fisherman of Qoma, the belief is that their gods will provide a catch enough for the purpose for which the fishing was asked for (Veitayaki, 1997). In Kaba, the traditional swimming spot for the paramount chief is only fished at the request of the chief (Veitayaki, 1997).

## 2.4 MARINE PROTECTED AREAS (MPA's)

In 1997, the technical report prepared by Morris and Pratt (1997:9) states that no recognised marine protected areas have been successfully established in Fiji to date. The primary reason behind this failure is lack of adequate local community involvement throughout the process of programme development (Morris and Pratt, 1997:9). Against this backdrop, it is essential to ensure that the rights of traditional fishing owners are recognised.

## 2.5 BUFFER ZONES

A buffer zone is any zonal area that serves the purpose of keeping two or more other areas distant from one another for whatever reason (Wikipedia Foundation Incorporation, 2010a). The field of buffer zones in Fiji is under researched. However, few newspaper articles have been written on government granting permit to Natural Waters of Viti Limited (NWVL) for the introduction of a ground water protection zone for the Yaqara Basin in Rakiraki, Ra (Fiji Government Online, 2005). The field of marine buffer zones has been under researched in Fiji and further studies needs to be carried out in this discipline.

## 2.6 MARINE FLORA AND FAUNA

The contemporary knowledge of most taxa is incomplete in Fiji, however it is evident from the analysis of current literature that Fiji has high species diversity. Flora and fauna inventory of Fiji is summarised in the following table.

Table 2.2: Flora and Fauna Inventory of Fiji

<b>Marine Plants</b>	
Algae (seaweeds)	South and Kasahara (1992) as cited in (Morris and Pratt, 1997:2) published the first major algal checklist for the Fiji Group, listing 314 taxa and revising the nomenclature and taxonomy up to date. The most complete list of the Fijian flora to date is the revised checklist by N'Yert et al. (1996) as cited in (Morris and Pratt, 1997:2), listing 422 taxa (39 Cyanophyceae, 113 Chlorophyceae, 42 Phaeophyceae and 288 Rhodophyceae).
Seagrasses	Four species of seagrasses are common in Fiji. This compares with 14 species in the Philippines, nine in Papua New Guinea, New Caledonia and Vanuatu, two in Samoa and Tonga and one in Tahiti. The studies of the Great Astrolabe Lagoon (Dravuni Island Field Station of the USP) by Dr Mukai, Koike and colleagues from Japan during the past 5 years have been the principal work on Fijian seagrasses (Morris and Pratt, 1997:4).
Mangroves	Pillai (1985) as cited in (Morris and Pratt, 1997:4) identified 33 species including mangroves and important mangrove tracheophytes represented in Fiji mangrove areas.

<b>Marine Invertebrates</b>	
Coral	According to Zann (1992) as cited in (Morris and Pratt, 1997:5), there are around one thousand coral reefs in Fiji. Pichon (1980) as cited in (Morris and Pratt, 1997:5) identifies 230 forms about 200 of which to the species level. Notably, about 100 species have been identified by Paulay (1990) as cited in (Morris and Pratt, 1997:6) from the Astrolabe reef. Fiji's National Environment Strategy project by E, Lovell provided a detailed description of corals in a preliminary listing of 198 species from the Manamucas and Southern Viti Levu (Zann and Lovell, 1992 as cited in Morris and Pratt, 1997:6). There were 17 genera and 45 species identified from Ovalau (Lovell, 1997 as cited in Morris and Pratt, 1997:6).
Lower Invertebrates	The area of lower invertebrates of Fiji has been under researched in Fiji. Some of the studies that are conducted concerning lower invertebrates include Morton (1990), Brock (1985) and J. Ryland (Morris and Pratt, 1997:6).
Molluscs	K. Gilchrist compiled 7000 species including around 760 species of Fijian gastropods bivalves (Morris and Pratt, 1997:7).
Gastropods	Brodie and Brodie (1990) as cited in (Morris and Pratt, 1997:7) listed 253 species of shell – less molluscs mainly collected from southern Viti Levu.
Bivalves	Parkinson (1982) as cited in (Morris and Pratt, 1997:7) listed 102 species of bivalves form 25 families from Viti Levu and adjacent islands.
Crustaceans	The crustaceans (crabs, lobsters, barnacles etc) are moderately studied in Fiji. Some of studies conducted on crustaceans include Myers (1985), Morton (1990), Wells (1977), Yeatman (1983) and Bruce (1984) (Morris and Pratt, 1997:8). The shrimps are relatively well studied. Some of studies conducted on shrimps include Choy (1981), Choy (1983), Bruce (1980), King (1983) and Shokita et al., (1984) identified 26 species on 4 families (Morris and Pratt, 1997:8).
Echinoderms	The echinoderms are not well known. The inventory of echinoderms is under researched.
Ascidians	Kott (1981) as cited in (Morris and Pratt, 1997:8) and Ryland et al., (1984) as cited in (Morris and Pratt, 1997:8) have described 60 species from reefs in Viti Levu and Kadavu.
<b>Marine Vertebrates</b>	
Fishes	Fiji's fish fauna is moderately well known. Fowler (1959) as cited in (Morris and Pratt, 1997:9) described 439 species from a listing by Gilbert Whitley. In a study conducted by Carlson (1975) as cited in (Morris and Pratt, 1997:9), a collection of 147 species from 39 families of reefal species was made which is now based at the

	University of the South Pacific Marine Collection. Morris and Pratt (1997:9) referred to the study conducted by Baldwin and Seeto (1986). These authors mentioned a preliminary listing of reefal, pelagic and deepwater bottom fish which comprised a total of 1198 species from 162 families. An interview with J. Seeto stated that this listing would be substantially increased perhaps to 1,500 species when the Springer, Emery and Winterbottom collections are fully identified (Morris and Pratt, 1997:9). Notably, smaller collections have been initiated on the Astrolabe reef by Emery and Winterbottom (1991) and Bandy (1989) as cited in (Morris and Pratt, 1997:9).
Reptiles	2 species of turtles are found in Fiji. They include Chekonia mydas and the hawksbill turtle Eretmochelys imbricata (Bustard, 1970 as cited in Morris and Pratt, 1997:10). Loggerheads (Caetta caretta) are present but uncommon. Flatbacks (Chelonia depressa), Ridelys (Lepidochelys olivacea) and leather backs are occasional to rare visitors to Fijian waters (Morris and Pratt, 1997:10). Three species of sea snake breed in the Fiji Group: Laticauda colubrine, L. laticauda and Hydrophus melanocephalus. The oceanic bellied sea snake Pelamis platuris is an occasional visitor as cited in (Morris and Pratt, 1997:10).
Seabirds	Seabirds nesting in the ringgold island of Fiji include reef herons (Egretta sacra), black noddies (Anous stolidus), black-naped terns (Sterna sumatrana), white terns (Gygis alba), sooty terns (Sterna fuscata), brown bobbies (Sula leucogaster), red-footed boobies (Sula sula), lesser frigate birds (Fregata ariel) and White tailed tropic birds (Phaethon leperus) (Clunie, 1985 as cited in Morris and Pratt, 1997:10).
Marine Mammals	The marine mammals in Fiji are not well known. The smaller whales are uncommon. Some of the marine mammals common in Fiji include the bottlenose dolphins, pilot whales, humpback whales and sperm whales (Morris and Pratt, 1997:10).

Source: Created by Author, 2010.

### 2.6.1 BIODIVERSITY HOTSPOT FOR MARINE ALGAE

For purposes of this report, the benthic marine macro algae comprise members of the phyla Chlorophyta, Ochrophyta (Class Phaeophyceae) and Rhodophyta. There are many other phyla of algae represented in the Fijian marine algal flora, but these are so poorly known that it would be presumptuous and meaningless to attempt to list them at this time. This includes the Cyanobacteria, which are strongly represented in the flora, but which provide many challenges regarding their taxonomy and nomenclature. South and Kasahara (1992) provided a detailed account of earlier work on the benthic marine macro algae of the Fiji Islands, and this was updated by N'Yeurt et al. (1996) and South and Skelton (2003b). Payri et al. (2007) substantially

increased the known number of species from their deep-water surveys conducted on the Great Sea Reef, Gau, the remote Ringgold Islands, and Kadavu.

The earliest reports of Fijian algae were those of Grunow (1874), Dickie (1876) and Askenasy (1888), and it was almost a century later before the next additions to the flora were reported by Chapman (1971,1977) and Kapraun and Bowden (1978). Japanese contributions added greatly to our knowledge of the flora starting in the mid 1980s (Enemoto and Ajisaka, 1983; Itono and Ajisaka, 1984; Ajisaka and Enomoto, 1985; Itono 1985a, 1985b; Kasahara 1985, 1988), and these were followed by the list of species reported by Garbary et al. (1991) from various sites around Viti Levu and Taveuni.

Since the phycological research laboratory was established at the University of the South Pacific in 1990, extensive studies of the marine algae have taken place. The Phycological Herbarium (SUVA-A) was established and is now a regional depository of algae from the Pacific islands, housing approximately 8,000 specimens. Publications since that time include those by South (1991, 1992, 1993, 1995) and collaborators (N'Yeurt, 1993a, 1993b, 1995, 1996, 2001, 2002; South and N'Yeurt 1993; South et al., 1993; N'Yeurt and South 1997). Keats (1995,1997) and Keats and Chamberlain (1994) contributed to our understanding of Fiji's non-geniculate coralline algae. Several new taxa have been described (South and Skelton, 2000, 2003; N'Yeurt and Payri, 2009; and N'Yeurt et al. 2006,2008) and many more are awaiting description e.g. Great Sea Reef (Skelton, unpubl.; Payri et al., 2007).

Within the regional context, there is a great need for monographic studies, such as those by South and Skelton (2000) for *Ceramium*, Skelton and South (2003a) for *Caulerpa* and Mattio (2007) for *Sargassum*. Only through such comparative studies can we learn more about Fiji's benthic macro algae and their relationships with those in the Southwest Pacific Region and beyond. For some highly complex and widespread genera such as *Hypnea* (South, 2003) the naming of species from Fiji is at best superficial, since we will not understand the genus until a major regional review, supported by molecular evidence has been completed.

Large areas of Fiji remain scarcely explored or unexplored for algae, including most of the Yasawa Islands, the Lau Group, Taveuni Island, remote parts of northern Vanua Levu and elsewhere, with only about 15% of the islands collected. As predicted in South and Skelton (2003) the richest discoveries remain to be made from deep sampling and from reef fronts; this was clearly demonstrated by Payri et al. (2007) who reported 58 new records from their deep water surveys of the Great Sea Reef and Kadavu, with an additional 22 taxa awaiting description. There are many other areas to be explored, including those where seasonal upwelling is known to occur, such as the Yasawa. It might not be necessary to travel far and wide, as there is one site as yet poorly collected, at Namada on the Coral Coast, some 2 hours drive from Suva, where deep collections on what is essentially a reef front close to the main highway, are likely to reveal many new records. Similarly, the Suva Barrier Reef yielded many new records, thanks to the dive surveys made by Derek Keats during the early 1990s, and more could be expected from

similar work. Table 2.3 summarises the currently-known species biodiversity for Fiji’s benthic macro algae.

Table 2.3: Summary of Species Biodiversity of Marine Benthic Macro Algae of the Fiji Islands (including Rotuma)

Division/Class	No. Species	No. Genera	No. Undescribed taxa
Chlorophyta	217	40	7
Ochrophyta (Phaeophyceae)	49	22	1
Rhodophyta	310	115	20
TOTALS	576	177	28

*Sources:* N’Yeurt (1996), South & Skelton (2003b); Payri *et al.* (2007), as well as subsequent new records as cited in the text, and species *inedit.* Held at the Phycological Herbarium, University of the South Pacific (SUVA-A) and the Herbarium, IRD, Nouméa.

This latest count on the species biodiversity of benthic macro-algae in Fiji yields a total of 576 taxa, from 177 genera, and with at least an additional 28 more to be described. This total is higher than that for Micronesia (Skelton and South, 2007), with the likelihood of many more new distribution records and new taxa to be described from Fiji in the future. It is evident that Fiji has the highest species biodiversity of macro algae in the Pacific islands, and should be classified as a biodiversity centre of high importance and a biodiversity hotspot.

## 2.6.2 THE MARINE AND ESTUARINE FISHES OF FIJI

Marine and freshwater fishes include all those fishes that inhabit Fiji’s coastal and lagoonal habitats, deepsea fishes, and those species that are principally marine but may spend at least some of their life cycle in estuarine environments where they are subjected to fluctuations in salinity. As stated by Jenkins *et al.*, (2010) deciding what is a 'freshwater' fish, and how it differs from an 'estuarine' fish is problematic, yet we acknowledge the accepted ecological classification of fishes in freshwater is summarised by Tim Berra (2001). Tim Berra (2001) stated that there are three divisions of freshwater fishes (primary, secondary and peripheral), based on their tolerance to salt water. This summary is based on Seeto’s (2010) checklist of Fiji’s fishes, where he lists 2,031 species, plus an additional 275 doubtful records, from a total of 200 families. Seeto’s list includes freshwater and estuarine species. Jenkins *et al.* (2010), listed 203 freshwater and estuarine species. Notably, no attempt has been made here to analyse overlaps between these two lists, but is worth noting that Jenkins *et al.* (2010) state that only 5% of the species in the report can be considered exclusively freshwater. Thus, it would seem that more than 2000 species fall into the marine and estuarine categories in the Fiji Islands.



For a full description of the historical aspects of fish collections in Fiji refer to Seeto (2010). Previous scientific expeditions have collected fish in Fiji and they included the Challenger Expedition (Günther, 1889) which conducted a deep sea survey in Fiji; namely, the Fiji-New Zealand Expedition (Nutting, 1924); the Templeton-Crocker Expedition to Western Polynesia and Melanesia (Seale, 1935); the fish collected by the yacht “Alva” (Borodin, 1932); the Wilkes Expedition (Fowler, 1940a); the Crane Expedition (Herre, 1935); and the scientific expedition of the tropical Pacific on the steamer “Albatross” (Kendall and Goldsborough, 1911). Günther (1857-1910) also listed many Fijian fishes. Other fish collections were reported by Boulenger (1897) on a collection of fish at Rotuma by J. Stanley Gardener; Jordan and Dickerson (1908) on a collection of fish from Fiji; Whitley (1927) reported on a checklist of the fishes in Fiji; Fowler (1932) listed fish obtained in Fiji and Fowler (1955a) wrote about fish collected by Dr. and Mrs. Marshall Laird in Fiji. The first book that described the Fijian fish fauna was written by Henry W. Fowler (1959) and it covered only about 560 species. Carlson (1975) wrote a checklist of 575 Fijian fish species (107 families) based mainly on collections he made with Mike Gawel while setting up the University of the South Pacific marine reference collection.

Present day fish collections have included those of R. Winterbottom and A. Emery (1983) from the Royal Ontario Museum, Canada and V. G. Springer’s team (1982) from the Smithsonian Institute, Washington. Their collection data were incorporated in Seeto’s list. Zug *et al.*, (1989) listed the vertebrates of Rotuma (including fish) after a visit in 1988 and Blaber *et al.*, (1993b) listed 355 species of fishes from their baitfish research in Fiji from 1991 to 1993. David Greenfield and his team from the University of Hawaii collected fish in Fiji in May, 1999. IRD collected deepsea fauna from Fiji 5 years ago. The marine reference collection housed in the Division of Marine Studies at USP is an important reference source for Fiji’s marine fishes.

Overfishing is the major threat to some species (e.g. *Cheilinus undulates*), whereas habitat destruction or loss is also a contributing factor to loss of biodiversity in areas where mangroves have been destroyed, in urban or heavily polluted areas, or those areas subject to significant infrastructure development such as tourism sites, road construction, etc. For the future, it will be important for Fiji to maintain close vigilance on the potential introduction of invasive species, such as through the aquarium trade, or through aquaculture.

### **2.6.3 CETACEAN BIODIVERSITY OF THE FIJI ISLANDS**

Cetaceans are aquatic mammals (phylum Mammalia) are characterised by having a fusiform (streamlined) body shape, paddle-shaped front limbs and vestigial hind limbs. Their tails have evolved and have been flattened into a fluke to aid propulsion or movement through the water. The name ‘cetacean’ comes from the Latin word ‘cetus’ meaning large sea animal combined with the ancient Greek word ‘kotos’ meaning ‘sea monster’ (Carwardine, 2002).

The order Cetacea includes whales, dolphins, and porpoises. It has just over eighty living species, grouped into the suborders Odontoceti (the toothed whales, including dolphins and porpoises) and Mysticeti (the baleen whales). There are numerous extinct species discovered and

identified through fossil records. A recent review confirmed twelve cetacean species records in Fijian waters as well as six additional unconfirmed species records (Miller, 2009). A majority of these records came from anecdotal and opportunistic sightings (Ohsumi 1979; Kasamatsu *et al.* 1995; Jefferson *et al.* 1993; Paton and Gibbs 2002) and therefore this listing represents a relatively limited and conservative understanding of cetacean diversity, ecology and population status in Fijian waters. Nevertheless, these records do suggest that suitable habitat and prey conditions are available in the Fijian EEZ for a wide variety of cetacean species.

Some of the interesting whales found in Fiji waters include:

- Sperm whales (*Physeter macrocephalus*) have been well documented in Fijian waters. Townsend (1931,1935) indicated that individuals were seen year-round although more so during the winter and spring months (June-November). Unpublished surveys of Dawbin (reported in Paton and Gibbs 2002) in the mid-1950s also reported sperm whales. Sperm whales are still seen in Fijian waters today, and have been known to strand on several occasions in shallow waters (Fiji Times, 2009).
- Dawbin (1959) observed and tagged seven Sei whales in Fijian waters between 1956 and 1958. These researchers differentiated these animals from a very similar species, the Bryde's whale (*Balaenoptera brydei*), whose presence in Fiji has since been confirmed genetically (Kanda *et al.* 2007) as well as by recent footage from a dive operator near Savusavu (C. Miller, pers. comm.).
- Ohsumi (1979) further noted the presence of minke whales (*Balaenoptera spp.*), as did more recent Japanese sighting surveys (Kasamatsu *et al.* 1995). Dwarf minke whales have also been confirmed within Fijian waters after two individuals were observed at close range during a prolonged stay in a coastal lagoon near Koro Island (C. Miller, pers. comm.).
- Blue whales (*Balaenoptera musculus*) may also be occasional visitors to Fiji as a survey by Ohsumi (1979) indicated that a pair of blue whales was sighted west of Tonga. This species is the largest living cetacean and can reach 35m in length.
- Paton and Gibbs (2002) stated that anecdotal reports indicated that fin whales (*Balaenoptera physalus*) had been sighted in waters just south of Fiji, which was supported by Japanese whaling ship records (Ohsumi 1979).
- Species confirmation of a stranded female Blainville's beaked whale near Viti Levu was confirmed by genetic analysis (Leslie *et al.* 2005).
- Critical resting habitat of spinner dolphins (*Stenella longirostris*) has been documented in a small coral reef system off the north-east coast of Viti Levu. In addition, it appears that the pod using this day-time resting area is resident (C. Miller, pers. comm.).
- Additional species sighted in Fijian waters include short-finned pilot whales, false killer whales, pantropical spotted dolphins, orca, rough-toothed dolphin, and bottlenose dolphins (Gibbs and Paton 2003 in Bourke and Powell 2004; Reeves *et al.* 1999; Miller, 2009). Less reliable records have also been collated for Fraser's dolphin, common dolphin, and the pygmy sperm whale (Reeves *et al.*, 1999, UNEP-WCMC 2003).

Table 2.4: Summary of Cetacean Species Reported in Fijian Waters

Family	Scientific name	Common name
Suborder Mysticeti (baleen whales)		
Balaenopteridae	<i>Balaenoptera musculus</i>	Blue whale
	<i>Balaenoptera physalus</i>	Fin whale
	<i>Balaenoptera</i> spp.	Minke whales <sup>1</sup>
	<i>Balaenoptera</i> sp. 2	'Bryde's-like' whales <sup>2</sup>
	<i>Megaptera novaeangliae</i>	Humpback whale
Suborder Odontoceti (toothed whales)		
Physeteridae	<i>Physeter macrocephalus</i>	Sperm whale
Kogiidae	<i>Kogia breviceps</i>	Pygmy sperm whale
Delphinidae	<i>Steno bredanensis</i>	Rough-toothed dolphin
	<i>Tursiops</i> sp.	Bottlenose dolphin – (could have been <i>T. tursiops</i> or <i>T. aduncus</i> )
	<i>Stenella attenuata</i>	Pantropical spotted dolphin
	<i>Stenella longirostris</i>	Spinner dolphin
	<i>Delphinus</i> sp.	Common dolphin – ( could have been a long – beaked or short – beaked common dolphin)
	<i>Lagenodelphis hosei</i>	Fraser's dolphin
	<i>Pseudorca crassidens</i>	False killer whale
	<i>Orcinus orca</i>	Killer whale
	<i>Globicephala macrorhynchus</i>	Short-finned pilot whale
Ziphiidae	<i>Mesoplodon densirostris</i>	Blainville's beaked whale

Source: Created by Tikoca and Skelton, (2010).

#### 2.6.4 SEAGRASSES OF THE FIJI ISLANDS

Seagrasses are flowering plants (angiosperms) that grow exclusively in the marine environment. Although some seagrasses resemble terrestrial grasses, they are not related. Seagrasses are polyphyletic and may have derived from land directly, or via rivers and other freshwater bodies. For a plant to be able to survive in saline environment it needs to be able to grow fully submerged in water, adapt to varying salinity levels, have an anchoring system, aquatic-adapted pollination, flowering and seed dispersal system, and to be able to compete with other species. Seagrass species often form dense meadows that are nursery and foraging grounds for many commercially important species. The meadows are often inter-linked with other ecological systems such as coral reefs, mangroves and salt-marshes, enabling an incredible flow of energy through the systems. Some seagrass species are preferred food for many culturally important species such as dugongs, marine turtles and waterfowls. Seagrass leaves provide habitats for

<sup>1</sup> Due to difficulties in at sea species subspecies identification and historical differences in taxonomic classification – all Minke whale species and subspecies are listed together.

<sup>2</sup> Due to difficulties in at sea species and subspecies identification and recent changes to taxonomic classifications – all Bryde's whales, Eden's whales, and Sei whales are listed together.

countless animals and plants, and assist in filtering the water column. Dead seagrass contributes to nutrient cycles.

The most comprehensive taxonomic account of the seagrasses of Fiji was provided by Den Hartog (1970) as part of his global review of seagrasses. He listed five taxa (*H. ovalis* ssp *ovalis*, *H. ovalis* ssp *bullosa*, *Halodule pinifolia*, *H. uninervis* and *Syringodium isoetifolium*). A.C. Smith (1979) recognised den Hartog's subspecies at the species level; merging *H. ovalis* ssp *bullosa* with *H. minor*. He also recorded *H. pinifolia*, *H. uninervis* and *S. isoetifolium* as well as the brackish-water *Ruppia maritima* var. *pacifica*. McMillan & Bridges (1982) noted the distinctiveness of *Halophila ovalis* ssp *bullosa* suggesting that it may warrant a species ranking. Recently, Skelton and South (2006) updated the nomenclature of seagrasses of Fiji recognising three *Halophila* taxa [*H. ovalis*, *H. ovalis* ssp. *bullosa*, *H. decipiens*], two *Halodule* species [*H. pinifolia*, *H. uninervis*] and *Syringodium isoetifolium*.

The polyphyletic nature of seagrasses can be seen by their diverse range in shapes and sizes, including strap-like blades found in *Halodule*, the cylindrical strands of *Syringodium* and paddle-shaped leaves (*Halophila*). There are 60 seagrass species recognised globally, of which only six are found in Fiji. While most Fijian seagrass species have been known since the early 1960s, the presence of *Halophila decipiens* was only confirmed in 2004. Some seagrass species reported by Spalding *et al.* (2003) and Littler and Littler (2002) from Fiji (*Thalassia*, *Cymodocea*, *Halophila minor* and *H. ovata*) remain doubtful, as they lack any voucher specimens. *Halophila ovalis* subspecies *bullosa* is the only endemic seagrass found only in Fiji, Tonga and Samoa.

The seagrass flora of the Fiji islands has an Indo-West Pacific affiliation. Fiji and Tonga are the eastern-most limits for *Halodule* species. *Syringodium isoetifolium* and *Halophila decipiens* have a Pacific wide distribution (as far east as French Polynesia and Hawaii), although the latter remains to be recorded for Tonga and Samoa. The geographic distribution of seagrass in Fiji remains to be adequately documented. A summary of Fiji's seagrass distribution is found in McKenzie and Yoshida (2007). Only a few sites have been studied, mostly by researchers associated with the University of the South Pacific, including students, and visiting scientists. Seagrass are also noted in environmental impact assessment reports undertaken by consultants, research by non-governmental organisations and also during coral reef monitoring work (Fiu, 2004, 2005; Skelton and South 2006; Solandt *et al.* 2002; Solomona *et al.*, 2002; Sykes 2003; Vuki 1994).

Seagrass species zonation is highly variable in that shallow water species can be found in deep waters, and *vice versa*. *Halophila decipiens* recently discovered in 2004 is perhaps the only truly deep water species in Fiji, and it grows in 10-25 m water. So far it has only been collected from the Cakaulevu Reef. *Halophila ovalis* ssp *bullosa* is often found in the intertidal zones (exposed during low-tides, but submerged at high tides). This species either grows in patches, or intermixed with *Halodule* species in the upper subtidal areas. *Halodule pinifolia* is found mostly in the intertidal, often exposed during low tides but also grows in subtidal areas. *Halodule uninervis* grows from upper-subtidal to deep waters (30 m). *Syringodium isoetifolium* is mostly subtidal usually in calm places.

## 2.6.5 MOLLUSCS OF FIJI

The phylum Mollusca represents a large group of organisms inhabiting areas ranging from freshwater, marine and terrestrial environments. Molluscs are a highly diverse in size, anatomical structures and behavior that it is difficult to class them under similar characteristics that would define all of its members. Gilchrist, over the past 40 years had collected and compiled over 7,000 specimens including 760 species of Fijian bivalves and gastropods which are held at the Smithsonian Institute (Morris, 1998) and the most recent information on bivalves from the Great Astrolabe Reef was compiled by Joan Koven. As molluscs classification is relatively well known it is briefly summarised below. Molluscas contains ten classes of which two are extinct (*Heliconellouda* and *Rostroconchia*) (see table 2.5). The gastropods (class *Gastropoda*) are by far the most numerous group accounting for 80% of the phylum. The cephalopods (*Cephalopoda*) including squids, cuttlefish and octopus are among the most advanced in terms of their anatomical structure.

Table 2.5: Ten Molluscan Classes and Their Key Characteristics and Distribution

Class	Major organisms	Distribution
Caudofoveata	They are small, worm-like, lacking shells or distinct muscular foot, have scales and calcareous spines called sclerites for movement.	seabed 200–3,000 meters (660–9,800 ft)
Aplacophora	Solenogasters, small, shell-less worm-like marine organisms.	seabed 200–3,000 meters (660–9,800 ft)
Polyplacophora	Chitons has shells which is composed of eight separate shell plates or valves.	rocky tidal zone and seabed
Monoplacophora	They have cap-like shells i.e. single, flat, rounded bilateral shell that is often thin and fragile (a limpet-like organisms).	seabed 1,800–7,000 meters (5,900–23,000 ft); one species 200 meters (660 ft)
Gastropoda	Are the most diversified class accounting for 80% of the whole phylum. Includes abalone, limpets, conch, nudibranchs, sea hares, sea butterfly, snails and slugs.	Marine and freshwater land
Cephalopoda	Characterised by bilateral body symmetry, a prominent head, and a modification of the muscular foot into arms or tentacles. Includes squid, octopus, cuttlefish and nautilus.	Marine
Bivalvia	Marine and freshwater mollusc species, including scallops, clams, oysters and mussels. They possess a shell consisting of two rounded plates called valves joined at one edge by a flexible ligament called the hinge.	Marine and freshwater
Scaphopoda	Marine molluscs-molecular data suggests that the scaphopods are a sister group to the cephalopods which includes tusk shells.	marine 6–7,000 meters (20–22,970 ft)

Rostroconchia	Extinct molluscs dating from the early Cambrian to the late Permian. Fossils suggests that they are probable ancestors of bivalves.	Marine
Helcionelloida	Extinct group of ancient molluscs which are the oldest known conchiferan molluscs fossils; snail-like organisms such as Latouchella.	Marine

Source: Created by Tikoca and Skelton, (2010).

The term mollusc is derived from the French mollusque, which originated from the Latin. Molluscus was itself an adaptation of Aristotle's τὰ μαλάκια, ‘the soft things’, which he applied to cuttlefish (Wikipedia Projects, 2009). Gubanov *et al* (2003) stated that molluscs are generally regarded as members of Lophotrochozoa (including Brachiopods), a group defined by having trochophore larvae and, in the case of living Lophorata, a feeding structure called a lophophore. The other members of the Lophotrochozoa are the annelid worms and seven marine phyla.

## 2.6.6 BIVALVES OF FIJI

Bivalves are marine and freshwater molluscs that include scallops, clams, oysters and mussels. They possess a shell consisting of two rounded plates called valves joined at one edge by a flexible ligament called the hinge (Wikipedia projects, 2009). A list compiled by Parkinson in 1982 comprised 102 species of bivalves from 25 families from Viti Levu and its adjacent Islands. An investigation regarding their biogeographic distribution in the region showed a total of 145 species belonging in 18 families (Morris, 2006). However, the latest study done by Koven in 1992 in the Great and North Astrolabe Reef indicated a total of 28 families, 68 genera and 181 species.

Table 2.6: Taxonomic Classifications and the Number of Bivalve Species

Class	Order	Family	Genus	Species
Bivalvia	Arcoida	Acteonidae	3	14
		Glycymerididae	2	3
	Limoida	Limidae	2	6
	Mytiloida	Mytilidae	4	8
	Ostreoida	Gryphaeidae	2	2
		Ostreidae	3	4
		Plicatulidae	1	3
		Placunidae	1	1
		Pectinidae	8	13
		Spondylidae	1	15
		Pterioda	Pinnidae	3
		Isognomonidae	1	2
		Malleidae	1	1
		Pteriidae	3	10

	Veneroida	Trapeziidae	1	5
		Cardiidae	5	11
		Carditidae	1	1
		Chamidae	1	7
		Fimbriidae	1	1
		Lucinidae	4	7
		Mactridae	1	1
		Mesodesmatidae	1	1
		Donacidae	1	2
		Psammobiidae	2	7
		Semelidae	2	2
		Tellinidae	2	21
		Tridacnidae	2	4
		Veneridae	9	26
Total			68	182

Source: Created by Tikoca and Skelton, (2010).

## 2.6.7 BRACHIOPODS OF THE FIJI ISLANDS

Brachiopods are one of the oldest groups of marine invertebrates dating back to the Cambrian period (550 million years ago). About 350 living species have been described, in contrast to over 26,000 fossil species known. They are exclusively marine species that resemble bivalves in having two shells. The earliest brachiopod records from Fiji were those of Woodward (1855), Davidson (1880) and Thomson (1927), who reported *Lingula anatina* Lamarck, 1801 and *Rhynchonella grayi* [*Basiliolella grayi*] (Woodward, 1855). Other notable reports of Fiji brachiopods were of Cooper (1978), Ladd (1934), Eliot (1961) and more recently the work of French researchers on Musorstom 10 and Bordau 1 from 1998 to 1999. Brachiopods from the French research was identified and published by Bitner (2006, 2008). A total of 27 Brachiopod species are attributed to the Fiji fauna (Table 2.7), of which nine have type localities in Fiji. Whether these nine species are exclusive to the Fiji fauna remains to be validated by pending further research of neighbouring countries. The remaining species have a South-West Pacific biogeographic distribution.

Table 2.7: Brachiopods of Fiji

Phylum	Class	Order	Family	Genus	Species	Authority	Comments
Brachiopoda	Lingulata	Lingulida	Lingulidae	<i>Lingula</i>	<i>anatina</i>	Lamarck, 1801	Include <i>Lingula</i> sp. reported by Bitner 2008
		Craniida	Craniidae	<i>Novocrania</i>	<i>sp.</i>		May prove to be a new species (cf. Bitner 2008)
	Rhynchonellata	Rhynchonellida	Cryptoporidae	<i>Cryptopora</i>	<i>maldivensis</i>	Muir-Wood, 1959	Bitner (2008)

			Basiliolidae	<i>Basiliola</i>	<i>lucida</i>	(Gould, 1862)	Bitner (2008)
				<i>Basiliola</i>	<i>roddai</i>	Cooper, 1978	
				<i>Basiliola</i>	<i>beecheri</i>	(Dall, 1895)	Bitner (2008)
			Dyscoliidae	<i>Abyssothyris</i>	<i>wyvillei</i>	(Davidson, 1878)	Bitner (2008)
				<i>Abyssothyris</i>	<i>briggsi</i>	Cooper, 1978	
				<i>Xenobrochus</i>	<i>rotundus</i>	Bitner, 2008	Type locality: Lau Ridge
			Terebratulidae	<i>Dallithyris</i>	<i>pacifica</i>	Bitner, 2006	Type locality: Bligh Water
			Cancellothyrididae	<i>Terebratulina</i>	<i>japonica</i>	(GB Sowerby, 1846)	Bitner (2008)
				<i>Terebratulina</i>	<i>waimanensis</i>	Ladd, 1934	
				<i>Terebratulina</i>	<i>australis</i>	Bitner, 2006	Type locality: Lau Ridge
				<i>Terebratulina</i>	<i>reevei</i>	Dall, 1920	Bitner (2008)
			Chlidonophoridae	<i>Eucalathis</i>	<i>rugosa</i>	Cooper, 1973	Bitner (2008)
			Aulacothyropsidae	<i>Falla</i>	<i>neocaledonensis</i>	Laurin, 1997	Bitner (2008)
				<i>Septicollarina</i>	<i>sp.</i>		According to Bitner (2008) - need more material
			Frenulinidae	<i>Frenulina</i>	<i>sanguinolenta</i>	(Gemlin, 1791)	Bitner (2008)
			Megathyrididae	<i>Argyrotheca</i>	<i>sp.</i>		Bitner (2008)
			Platidiidae	<i>Amphithyris</i>	<i>buckmani</i>	Thomson, 1918	Bitner (2008)
				<i>Leptothyrella</i>	<i>fijiensis</i>	Bitner, 2008	Type locality: Bligh Water
			Daliinidae	<i>Dallina</i>	<i>triangularis</i>	Yabe & Hatai, 1934	Bitner (2008)
				<i>Dallina</i>	<i>vitilevensis</i>	Ladd, 1934	
<i>Nipponithyris</i>	<i>lauensis</i>	Bitner, 2008		Type locality: Lau Ridge			
<i>Nipponithyris</i>	<i>fijiensis</i>	(Elliott, 1961)		Homonym: <i>Abyssothyris fijiensis</i>			
<i>Campages</i>	<i>ovalis</i>	Bitner, 2008		Type locality: Lau Ridge			



		Thecideida	Thecidellinidae	<i>Thecidellina</i>	<i>maxilla</i>	(Hedley, 1899)	May include species <i>Thecidellina</i> sp. reported by Cooper (1978) from Fiji
--	--	------------	-----------------	---------------------	----------------	----------------	---

Source: Created by Tikoca and Skelton, (2010).

## 2.6.8 GASTROPODS

Gastropods are the most diversified class accounting for 80% of the whole phylum. This class includes abalone, limpets, conch, nudibranchs, sea hares, sea butterfly, snails, slugs. They acquire habitats in freshwater, estuarine and marine habitats. Studies carried out in 1990 by Brodie and Brodie listed a total of 253 species of opisthobranchs (shell – less molluscs) mainly collected from southern Viti Levu. Out of which the major orders were: Nudibranchia with 162 species, Cephalaspidae with 43 species, Sacoglossa with 27 species, Notospida with 7 species, orders Entomotaeniata with 6 species and Anaspida with 6 species (Morris, 2006). Recent studies carried out in the Great Astrolabe Reef by Koven from 1986 – 2006 has the records of the following gastropods on the reef which totalled up to 536 of marine gastropod species from 141 genera as shown in table 2.8 below. The data represented in the table does not include terrestrial gastropods.

Table 2.8: Marine Gastropods of Fiji

Class	Order	Family	Genus	Species
Gastropoda	Patellogastropoda	Patellidae	2	2
	Docoglossa	Haliotidae	1	5
	Vetigastropoda	Fissurellidae	4	5
		Neritidae	1	5
		Neritopsidae	1	1
		Stomatellidae	3	5
		Trochidae	9	18
		Turbinidae	6	14
	Sorbeoconcha	Strombidae	4	22
	Neotaenioglossa	Cerithiidae	1	1
		Modulidae	1	2
		Planaxidae	1	2
		Siliquariidae	2	4
		Vermetidae	2	4
		Littorinidae	1	3
		Vanikoridae	2	2
		Rissoidae	1	2
		Triphoridae	1	1
		Eulimidae	1	1
		Thycidae	1	1

		Epitoniidae	3	20
	Neogastropoda	Buccinidae	1	19
		Nassariidae	3	12
		Columbellidae	6	26
		Fasciolaridae	1	76
		Conidae	2	6
		Drillidae	2	19
		Terebridae	8	19
		Turridae	1	2
		Cancellariidae	1	38
		Costellariidae	5	44
		Mitridae	1	8
		Olividae	23	6
		Muricidae	1	2
		Harpidae	1	3
		Turbinellidae	2	14
	Neomesogastropoda	Naticidae	1	50
		Cypraeidae	2	2
		Ovulidae	2	10
		Bursidae	1	2
		Cassidae	3	15
		Ranellidae	2	2
		Tonnidae	1	1
		Capulidae	3	5
		Hipponicidae	2	2
		Ficidae	1	1
		Lamellaridae	3	5
		Trividae	1	1
	Heterostropha	Architectonicidae	1	1
	Pyramidelloida	Pyramidellidae	1	1
	Cephalaspidea	Acteonidae	2	4
		Haminoeidae	2	4
		Hydatinidae	2	3
		Bullidae	1	2
	Archaeopulmonata	Ellobiidae	1	2
	Besommatophora	Siphonariidae	1	2
	Nautilida	Nautilidae	1	2
	Sepioida	Spirulidae	1	5
Total			141	536

Source: Created by Tikoca and Skelton, (2010).

## 2.6.9 CHITONS OF FIJI

Chitons are small to large, primitive marine molluscs in the class Polyplacophora. Chitons are exclusively marine species, unlike the bivalves that adapt to brackish water and gastropods, which are freshwater and terrestrial tolerant. Chitons shells are composed of eight separate shell plates or valves. These plates overlap somewhat at the front and back edges, and yet the plates articulate well with one another. Because of this, although the plates provide good protection for impacts from above, they nonetheless permit the chiton to flex upward when needed for locomotion over uneven surfaces, and also the animal can slowly curl up into a ball when it is dislodged from the underlying surface. The shell plates are surrounded by a structure known as a girdle. Chitons live worldwide, in cold water and in the tropics. Most of them inhabit intertidal or sub tidal zones and do not extend beyond the photic zone. According to Schwabe, *et al.*, (2008), a total of 20 species out of 9 genera are found in Fiji (see table 1.6). Chitons are a delicacy of the locals and are often seen for sale at the market.

Table 2.9: Taxonomic Classifications and the Total Number of Polyplacophora Species

Phylum	Division / Class	Genus	Species
Mollusca	Polyplacophora	<i>Parachiton</i>	<i>acuminatus</i>
		<i>Parachiton</i>	<i>puppis</i>
		<i>Nierstraszella</i>	<i>lineata</i>
		<i>Callochiton</i>	<i>neocaledonicus</i>
		<i>Chiton</i>	<i>tuberculatus</i>
		<i>Chiton</i>	<i>affinis</i>
		<i>Chiton (Rhyssoplax)</i>	<i>ectypus</i>
		<i>Chiton (Rhyssoplax)</i>	<i>pulcherrimus</i>
		<i>Chiton (Rhyssoplax)</i>	<i>subassimilis</i>
		<i>Chiton (Tegulapax)</i>	<i>hululensis</i>
		<i>Acanthopleura</i>	<i>gemmata</i>
		<i>Lucilina</i>	<i>lamellosa</i>
		<i>Lucilina</i>	<i>nigropunctata</i>
		<i>Lucilina</i>	<i>novemrugata</i>
		<i>Onithochiton</i>	<i>societatis</i>
		<i>Cryptoplax</i>	<i>elioti</i>
		<i>Cryptoplax</i>	<i>larvaeformis</i>
		<i>Cryptoplax</i>	<i>striata</i>
		<i>Cryptoplax</i>	<i>menkrawitensis</i>
		<i>Choneplax</i>	<i>littlerorum</i>

Source: Created by Tikoca and Skelton, (2010).

## **2.6.10 CONE SHELLS – CONIDAE**

Cone shells belong to the family of Conidae. They are part of the marine gastropods (or snails) that predate on other invertebrates. The shell resembles a cone, with the narrow end being the anterior and the wider side having the spire of the animal. The genus *Conus* contains the largest number of species with over 500 living species.

There have been numerous publications on Fiji's cone shells including Cernohosky (1964, 1978) where he listed 80 species. Lewis (1973) added five species. Joan Koven (1991, 1997) provided a listing of cone species from the Great Astrolabe. In 1998, Seeto published the latest compilation of the cone shells of Fiji, which included 99 living species and 29 fossils (Seeto, 1998). The fossil cones of Fiji were recorded by numerous authors Ladd (1934), Salvat *et al.* (1976), Cernohorsky (1978) and Gilchrist (1984; 1987).

## **2.6.11 COWRIES (CYPRAEIDAE) OF FIJI**

Cowries are gastropods (snails) in the family Cypraeidae. The family is distinguished by having shells that are rounded, almost like an egg, smooth and shiny. The smooth and shiny shell is attributed to the mantle of the animal that envelopes the shell. Species of the Cypraeidae were once placed in a single genus, *Cypraea*, but results of recent research have shown that this treatment is not accurate, and therefore new genera and even sub-genera were recognised. Many studies have been carried out on Fijian cowries (Schilder and Schilder 1939; Steadman and Cotton 1943; Cernohosky, 1964, 1967, 1978; Iredale 1935).

Cowries or cowry shells are the common name given to Cypraeidae which is a taxonomic family of small to large sea snails. These are marine gastropod molluscs in the superfamily Cypraeoidea (Wikipedia projects, 2009). Cypraeidae have adult shells which are very rounded, almost like an egg; they do not look like a typical gastropod shell. In virtually all of the species in the family Cypraeidae, the shells are extremely smooth and shiny. This is because in the living animal, the shell is nearly always fully covered with the mantle. For nearly 200 years, every species in the family Cypraeidae was placed in one genus, *Cypraea*, but recently the cowries have been divided into many different genera (Wikipedia projects, 2009). However according to Seeto (pers Comm, 2009) the various cowries have been divided into different sub genus according to their shapes however they all still come under just one genus.

Many studies have been carried out on molluscs (including cowries) in the Pacific and also including Fiji. The most recent study of cowries would be the annotated checklist of living and fossilized cowries in Fiji by Johnson Seeto in 2001 mostly from his own shell collections and from literature. Seeto (2001) described 75 species of cowries which he believes is or was found in Fiji at a certain time (confirmed species), and he also mentions 18 other cowries that could possibly be in Fiji or the ones that he believes were probably mistakenly identified (unconfirmed species). However, prior to the mentioned study, there were many other previous studies conducted on cowries in Fiji and the Pacific. Such studies include that done by Schilder and Schilder in the year 1939 (describing 49 species in the Samoa – Fiji region), whereas Steadman and Cotton in 1943 described 61 species and re-described many of the cowries found in Fiji putting them in different subspecies names. Cernohosky in years 1964, 1967 and 1978 described

57 species (he had an extensive collection of marine molluscs including cowries from the group) and Iredale (1935).

The summary of the number of total living and fossilized cowries recorded by Seeto in 2001 is summarized in Table 1.8 below.

Table 2.10: Illustrates the different taxonomic classifications and the total number of individuals (species) of molluscs that fall under the genera *Cypraea*.

Division/Class	Family	Genera	No.sp. confirmed living and fossilized Species	of and	No. sp. Possibly Found or mistakenly identified in Fiji	TOTAL
Gastropoda	Cypraeidae	<i>Cypraea</i>	75		18	93

## 2.7 REEF FISHES

Fiji's reef fishes are moderately well known. In a study conducted by Carlson (1975) as cited in (Morris and Pratt, 1997:9), a collection of 147 species from 39 families of reefal species was made which is now based at the University of the South Pacific Marine Collection. Morris and Pratt (1997:9) referred to the study conducted by Baldwin and Seeto (1986, unpubl.) as cited in (Morris and Pratt, 1997:9). These authors mentioned a preliminary listing of reefal, pelagic and deepwater bottom fish which comprised a total of 1198 species from 162 families. An interview with J. Seeto stated that this listing would be substantially increased perhaps to 1500 species when the Springer, and Emery and Winterbottom collections are fully identified (Morris and Pratt, 1997:9). Notably, smaller collections have been initiated on the Astrolabe reef by Emery and Winterbottom (1991) and Bandy (1989) (Morris and Pratt, 1997:9).

## 2.8 INTRODUCED SPECIES

Some of the introduced species of marine flora and fauna include the following:

- At least 21 species of fish (brown trout, bass, mollies, guppies, swordtails, mosquitofish, carps, tilapia, grunters, Australian bass, herrings etc).
- Four species of prawns (*Macrobrachium*, *Penaeus*)
- Six species of bivalves (oysters and mussels)
- One seaweed (*Eucheuma*)
- The Tilapia *Oreochromis mossambica* has thrived in every river to which it has been introduced and is considered to have had a detrimental effect on the status of certain native species, in particular, the Ika ni Vatu *Kuhlia rupestris*.

(Department of Environment, 1997:12).

## 2.9 MIGRATORY SPECIES

Some of the marine flora and fauna that is migratory include the following:

- Pelagic dolphins of the genus *Stenell*.

- Turtles
- Tuna
- Billfish
- Mahi Mahi
- Swordfish
- Cetaceans (Whales & Dolphins)
- Sharks (Bulls - River to sea migration is more common)
- Tuna
- Groupers (Kawakawa - for spawning aggregation)
- 

(World Wildlife Fund, 2010; South Pacific Regional Environment Programme: 2010)

## 2.10 INVASIVE/INTRODUCED SPECIES

Studies conducted by Wildlife Conservation Society and other groups underline that tilapia is a problematic invasive species to the native fish of the islands. Scientists suspect that tilapia introduced to the waterways of the Fiji Islands may be gobbling up the larvae and juvenile fish of several native species of goby fish that live in both fresh and salt water and begin their lives in island streams (Science Daily Incorporation, 2010).

## 2.11 ENDANGERED SPECIES

Some of the fish species of Fiji that are severely under threat include *Cheilinus undulatus* – listed as Endangered under the IUCN Red List. *Thunus obesus* (Bigeye tuna) – Vulnerable; *Epinephelus coioides* (Orange spotted grouper) near threatened; *Epinephelus fuscoguttatus* (Brown marbled grouper) – near threatened; *Epinephelus lanceolatus* (Queensland grouper) – Vulnerable; *Epinephelus malabaricus* (Malabar grouper) – Near Threatened; *Epinephelus polyphkadion* (Camouflage grouper) – Near Threatened; *Plectropomus areolatus* (Squaretail grouper) – Vulnerable; *Plectropomus laevis* (black saddle grouper) – Vulnerable; *Hipocampus kuda* (common seahorse) Vulnerable; *Carcharhinus longimanus* (Oceanic white tip) – Vulnerable; *Negaprion acutidens* (Sharp tooth lemonshark) – Vulnerable; *Carcharodon carcharias* (Great White shark) – Vulnerable; *Rhincodon typus* (Whale Shark) Vulnerable; and *Urogymnus asperrimus* (Porcupine Ray) – Vulnerable. The Oceania sub-population of humpback whales (*Megaptera novaeangliae*) has recently been classified as endangered on the IUCN red list. This classification was largely based on the small number of individuals visible on tropical breeding grounds in comparison to pre-whaling abundance estimates, including comparisons between historical and recent land-based counts conducted in Levuka, Ovalau (Paton et al. 2009). During the past year, land-based surveys have also been initiated from Makogai Island during the peak migration period to further assess the status of this species in Fijian waters.

According to Minsitry of Marine Resources (2010) and Nature Fiji (2010), the following are the endangered species and near threatened species for Fiji:

- Turtles - Research undertaken in collaboration with NGOs has been extended to 2018 (Leatherback turtle, Green turtle , Hawksbill turtle).
- Whales and Dolphins (Cetaceans) - focus for the region due to decline in population, research undertaken in the form of yearly monitoring activities from Makogai Island, cetacean forms distributed to all member organisations and committee representatives.
- Sharks - research undertaken, management plan drafted by the Department of Fisheries.
- Humphead wrasse
- Bumphead parrot fish
- Triton
- Giant clams
- Redigobius New Species

## 2.12 ENDEMIC SPECIES

Some of the species of endemic marine flora and fauna include the following:

- Uspi Rabbitfish
- Yellow Poison Fang Blenny and Poison.
- Fang-blenny Mimic

(Andrewartha, 2010)

Thirty-three of the 2031 marine fishes recorded from Fiji are considered marine endemics (Seeto, 2010). This is a low level of endemism compared with, for example, terrestrial fauna and flora in Fiji.

## 2.13 INDICATOR SPECIES

Analysis of the contemporary literature suggests that the field of indicator species is under researched in Fiji. As mentioned in the literature Butterflyfishes are indicator species in Fiji (Crosby and Reese, 1996:1). According to Ministry of Marine Resources (2010), indicator species differs with the inshore and off shore zonation. First, the ‘Seagrass Bed Indicator’ species are Gobies and Gudgeons. Second, the ‘Mangrove Zones Indicator’ species are Mangrove snappers, Mangrove gobies, Mangrove shrimps, Mud crab and Sliverstripe Mud skippers. Third, the ‘Forereef Zone Indicator’ species are Sweetlips, Wrasses, Parrotfish, Emperor and Triggerfish. Fourth, the ‘Reefflat Zone Indicators’ are Butterflyfish, Angelfish, Damsels and Surgeonfish. Fifth, ‘Backreef Zone Indicator’ species are Trevally, Baraccuda, Reef sharks, Snappers and Groupers. Fourth, the ‘Offshore Zone Indicators’ are Tuna, Trevally, Deep sea snapper, Sharks (Tiger, bulls), Spanish Makerel (Walu) and Wahoo. Fifth, the ‘Reef Health Indicator’ species are Reef Sharks (Whitetips, Grey reefs, Blacktips, Lemon, Nurse), Butterflyfish, Parrotfish (Bumphead and Steephead) and Batfish. Sixth, the ‘Nutrient Indicator’ species are Gudgeons and Holothurians (synapta).

## 2.14 TRADED SPECIES

The marine species trade industry contributes to source of income and living for the local communities. This industry contributes to Gross Domestic Product (GDP) and contributes to foreign exchange earnings. Some of the species of fish that is traded in Fiji include:

- Black marlin
- Blue marlin
- Sail fish
- Occasional striped marlin
- Broadbill
- Wahoo
- Dolfini
- Barracuda
- Shark fin
- Jack Cravelle
- King Mackerel
- Yellow fin tuna
- Sea breem
- Salmon cod
- Mangrove snapper
- Jack
- Yellow Fin Tuna
- Dolpin fish
- Tilapia
- Pearl
- Lobsters
- Liverock
- Tabua (Whales Tooth)
- Coral Species - research undertaken by Government (DoF) as well as NGOs, permanent monitoring sites set in Makogai for coral bleaching and disease monitoring by DoF.
- Ornamental Fish
- BDM (Beach-de-mer)
- Reef fish
- Pelagic Fish
- Trochus
- Prawns/shrimps

(Fiji Escapes Travel, 2010)

Seven taxa of seaweeds feature the diet of Fijians. These are the seaweeds sold in Fiji. Species of coral trade in Fiji include *Acropora* spp., *Catalaphyllia* spp., *Euphyllia* spp., *Goniopora* spp. , *Helioungia* spp. , *Lobophyllia* spp., *Nemanzophyllia* spp. , *Plerogyra* spp., *Porites* spp. , *Trachyphyllia* spp., live rock. Sea cucumbers are also traded in Fiji (South, 1993).



## 2.15 CURRENT STATE OF RESEARCH AND GAPS IN EXISTING LITERATURE

As noted by Seeto (2010) it is likely that new records will continue to turn up in the marine fish fauna. The deep sea samples collected by IRD revealed new records and it is likely that many more will be discovered as further investigations are made in the future. For many families, there is a need for detailed taxonomic investigations, especially those with large numbers of species. There are many areas of Fiji that are yet to be surveyed to determine species diversity and population. These areas will need to be mapped and this information utilised for decision making, especially with regards to use and conservation. Despite their important role in the marine ecosystem, very little is known in terms of their condition. With threats from climate change, natural disasters (tsunami and earthquakes) and anthropogenic activities it is important that monitoring of seagrass beds be undertaken, as they can provide early-warning to managers and communities on the state of the coast. Molecular research is needed to support morphological research in confirming species delimitation. Two genera are particularly important – *Halodule* and *Halophila* that require further research. Waycott *et al.* (2004) suggested that *Halodule uninervis* and *H. pinifolia* are con-specific. While their observation was based on Australian material, the Fijian populations of the two species appear quite distinct so that it makes sense to keep them separate. *Halophila ovalis* ssp *bullosa* is quite distinct by the blister-like character on the leaves. Another character is the fewer paired veins (to 7) compared to *H. ovalis sensu stricto* (> 7).

## 2.16 CONCLUSION

In this chapter, I have examined the following issues. First the coral reefs, other marine habitats, mangroves, traditional fishing grounds marine protected areas and buffer zones. Second, the subsequent section of this chapter analysed marine flora and marine fauna. Third, the state of current research and gaps in existing literature in the field of marine resource inventory of Fiji.

The next chapter will examine land resources inventory of Fiji.

## 7.0 BIBLIOGRAPHY

- Ajisaka, S., and Enomoto, S. (1985). *Dictyota Lamouroux (Dictyotales, Phaeophyceae) of the Fiji and Solomon Islands*. Kagoshima University Research Centre for the South Pacific. Fiji: Suva.
- Andrewartha, B. (2010). *Unique Marine Species of the Fiji Islands*. Fiji: Suva. Retrieved February 23, 2010 from <http://www.bulafijinow.com/dive/Fiji-map-DG.pdf>
- Andrews, S. (1985). Aquatic Species Introduced to Fiji. *Journal of the Fiji Museum*, 3 (2), 67-81.
- Askenasy, E. (1888). *Algen. In: Forschungsreise S.M.S. Gazelle. IV. Theil, Botanik*. Germany: Berlin.
- AusAid. (2009). *The Use of Seasonal Climatic Forecasts for Management of Water Supply: Vaturu Dam Case Study*. Fiji: Vaturu. Retrieved February 23, 2010, from [http://www.bom.gov.au/climate/pi-cpp/pilot\\_projects/fiji-progress-200908.pdf](http://www.bom.gov.au/climate/pi-cpp/pilot_projects/fiji-progress-200908.pdf)
- Bailey-Brook, J. (1985). Polychaetes from Fijian Coral Reefs. *Pacific Science*. Fiji: Suva.
- Baker, G. (2005). *Priorities for Additions to the Fijian Protected Natural Areas Network: An Assessment Based on Complementarity in Land Snail Assemblages*. New Zealand Landcare Research Contract. Wildlife Conservation Society. Suva: Fiji.
- Baldwin, W. and Seeto, J. (1986). *A Checklist of the Fishes of Fiji*. Unpublished Manuscript. University of the South Pacific. Fiji: Suva.
- Balgooy, M. (1971). *Plant Geography of the Pacific*. Fiji: Suva.
- Bandy, M. (1989). *A Survey of Astrolobe Reef and Lagoon*. Unpublished Manuscript. University of the South Pacific. Fiji. Suva.
- Beumer, J.P. (1985). *The Eel Resource of Fiji*. Queensland Department of Primary Industries. Australia: Queensland.
- Bitner, M.A. (2006). Recent Brachiopoda From the Fiji and Wallis and Futuna Islands, South-West Pacific. In R.D. Forges and J.L. Justine (Eds.), *Tropical Deep-Sea Benthos*, 24(193), 15-32.
- Bitner, M.A. (2008). New Data on the Recent Brachiopods From the Fiji and Wallis and Futuna Islands. South-West Pacific. *Zoosystema*, 30(2), 419-461.
- Blaber, S. J. M., Milton, D. A., Rawlinson, N. J. F., and Sesawa, A. (1993). A Checklist of Fishes Recorded by the Baitfish Research Project in Fiji from 1991 to 1993. In Blaber, Milton and Rawlinson (Eds.), *Australian Centre for International Agricultural Research Proceedings*, No. 52.

- Bonito, V. (2008). *Coral Species Listing: Enhancement of Marine Biodiversity Conservation Efforts in Votua Village, Fiji Islands*. Regional Natural Heritage Programme. Department of Environment and Water Resources. Fiji: Suva.
- Bordie, G.D and Brodie, J.E. (1990). A Checklist of the Opisthobranch Molluscs of Fiji. *Malac. Soc. Australia*, 11(53), 63.
- Borodin, N. A. (1932). Scientific Results of the Yacht “Alva” World Cruise. *Bull. Vanderbilt Mar. Mus.*, 1(3), 65-101.
- Boseto, D. (2006). *Diversity, Distribution and Abundance of Fijian Freshwater Fishes*. Master of Science Thesis. The University of the South Pacific. Fiji: Suva.
- Boulenger, G. A. (1897). A List of the Fishes Obtained by Mr. J. Stanley Gardener From Rotuma. South Pacific Ocean. *Ann. Mag. Nat. Hist.*, 6 (20), 371 -374.
- Bourke, D., and S, Powell. (2004). *Australia Progress Report on Cetacean Research*. Australia: Australian Marine Mammal Center. Retrieved June 13, 2010, from [http://iwcoffice.org/\\_documents/sci\\_com/2009progreports/SC-61-ProgRep%20Australia.pdf](http://iwcoffice.org/_documents/sci_com/2009progreports/SC-61-ProgRep%20Australia.pdf)
- Brescia, F., Pollabauer, C.M., Potter, M.A., and Robertson, A.W. (2008). A Review of the Ecology and Conservation of *Placostylus* (Mollusca: Gastropoda: Bulimulidae) in New Caledonia. *Molluscan Research*, 28(2), 111-122.
- Brodie, G. (2002). Preliminary Observations of Terrestrial Gastropods of the Nakauvadra Range and Rakiraki Province in Fiji. In Morrison, C. (Eds.), *Nakauvadra Biodiversity Baseline Study*. Institute of Applied Sciences. University of the South Pacific. Conservational International RAP Report. Fiji: Suva.
- Bruce, A.J. (1980). *Pontonine Shrimps from the Astrolobe Reef*. Fiji Pacific Science, 34:389.
- Bruce, N.L. (1984). A New Family for the Isopod Crustacean Genus *Tridentella* Richardson, *Zool.J.Lin. Soc.*, 80:447-455.
- Brusca, R.C., and Brusca, G.J. (2003). *Invertebrates*. Sinauer Associates. Massachusetts: Saunderland.
- Bustard, H.R. (1970). *Turtles and an Iguana in Fiji*. *Oryx.*, 10, 317-322.
- Carlson, B. A. (1975). *A Preliminary Check-List of the Fishes of Fiji*. University of the South Pacific. Fiji: Suva.
- Carwardine, M. (2002). *Whales, Dolphins and Porpoises*. New York: Dorling Kindersley Publishing Incorporation.
- Chapman, V.J. (1971). The Marine Algae of Fiji. *Revue Algologique*, 2, 164-171.

Chapman, V.J. (1977). Marine Algae of Norfolk Island and the Cook Islands. *Botanica Marina*, 20, 161-165.

Chatham. (2010). *Department of International Development*. United Kingdom Aid: United Kingdom. Retrieved 12 July, 2010, from [http://www.illegal-ogging.info/approach.php?a\\_id=173](http://www.illegal-ogging.info/approach.php?a_id=173)

Cooper, G.A. (1978). Tertiary and Quaternary Brachiopods from the Southwest Pacific. *Smithsonian Contributions to Paleobiology*, 38, 1-23.

Cowie, R.H. (2000). Non-Indigenous Land and Freshwater Molluscs in the Islands of the Pacific: Conservation Impacts and Threats. In G. Sherley (Ed.), *Invasive Species in the Pacific: A Technical Review and Draft Regional Strategy*. Fiji: Suva.

Cowie, R.H. (2004). Disappearing Snails and Alien Invasions: The Biodiversity/Conservation Interface in the Pacific. *Journal of Conchology Special Publications*, 3, 23-37.

Cowie, R.H. (2005). Alien Non-Marine Molluscs in the Islands of the Tropical and Subtropical Pacific: A Review. *American Malacological Bulletin*, 20(1/2), 95-103.

Cowie, R.H., Hayes, K.A., Tran, C.T., and Meyer, W.M.. (2008). The Horticultural Industry as a Vector of Alien Snails and Slugs: Widespread Invasions in Hawaii. *International Journal of Pest Management*, 54(4), 267-276.

Cowie, Robert H. (1998). Catalog of the Non-marine Snails and Slugs of the Samoan Islands. *Bishop Museum Bulletin in Zoology*, 1-122.

Crosby, M.P and Reese, E.S. (1996). *Butterflyfishes as Indicator of Change on Indo-Pacific Reefs*. Hawaii: Honolulu. Retrieved February 23, 2010, from <https://dspace.mote.org/dspace/bitstream/2075/120/1/manualformonitoringcoralreefswithindicatorspecies.pdf>

Dana, J.D. (1846). *Zoophytes, United States Exploring Expedition 1838-1842*. Smithsonian Museum. Retrieved June 30, 2007, from <http://www.sil.si.edu/DigitalCollections/usexex>

Davidson, T. (1880). Report on the Brachiopoda Dredged by H.M.S. Challenger During the Years 1873-1876. *Zoology*, 1, 1-67.

Dawbin, W. H. (1956). Whale Marking in South Pacific Waters. *Norsk Hvalfangsttidende*, 9, 485-508.

Dawbin, W. H. (1959). New Zealand and South Pacific Whale Marking and Recoveries to the End of 1958. *Norsk Hvalfangsttidende*, 48(5), 213-238.

Department of Environment. (1997). *Convention on Biological Diversity 1997 National Report to the Conference of the Parties*. Fiji: Suva. Retrieved February 23, 2010, from <http://www.sprep.org/att/IRC/eCOPIES/Countries/Fiji/28.pdf>

- Dickie, G. (1876). Notes on Algae. *Journal of the Linnean Society London*, 15, 446-455.
- Doyle, M.F. (1998). Gymnosperms of the South Western Pacific. Fiji. Endemic and Indigenous Species: Changes in Nomenclature, Key, Annotated Checklist, and Discussion. *Harvard Papers in Botany*, 3, 101-106.
- Doyle, M.F. and Fuller, D. (1998). Palms of Fiji—I. Endemic, Indigenous, and Naturalized Species: Changes in Nomenclature, Annotated Checklist, and Discussion. *Harvard Papers in Botany*, 3, 95-100.
- Elliott, G.F. (1961). A Fossil Species Referred to *Abyssothyris*. In H. Muir-Wood (Eds.), *Homeomorphy in Recent Brachiopoda: Abyssothyris and Neorhynchia*. *Annals and Magazine of Natural History*, 13(3), 526.
- Emery, A.R., and Winterbottom, R. (1991). *Lagoonal Fish and Fisheries of Dravuni, Great Astrolabe Reef, Fiji, South Pacific*. Marine Studies Programme Technical Report No.3. The University of the South Pacific. Fiji: Suva.
- Enomoto, S., and Ajisaka, T. (1983). *Marine Algae of Viti Levu, the Fiji Islands: Chlorophyceae*. Oceanography and Biological Sciences, Prompt Report of 2<sup>nd</sup> Scientific Survey of South Pacific. Kagoshima University. South Pacific Regional Herbarium. Fiji: Suva.
- Fenner, D. (2006). *Coral Diversity Survey: Mamanuca Islands, Coral Coast and Fiji*. Institute of Applied Science. The University of the South Pacific. Fiji: Suva.
- Fiji Electricity Authority. (2010). *Major Projects*. Marlow Street. Fiji: Suva. Retrieved February 5, 2010, from <http://www.fea.com.fj/>
- Fiji Escapes Travel. (2010). *Dream Vacation Planning Since 1986*. Hawaii. Retrieved February 23, 2010, from <http://www.fiji-islands.com/fishing.html>
- Fiji Government online. (2005). *Natural Waters of Viti Ltd*. Press Release. Fiji: Suva. Retrieved February 23, 2010 from <http://www.fiji.gov.fj/cgi-bin/cms/exec/view.cgi/49/4043/printer>
- Fiji Islands Bureau of Statistics. (2006). *Quick Reference 2006 Facts & Figures: Fiji Islands Bureau of Statistics*. Fiji: Suva. Retrieved February 7, 2010, from <http://www.statsfiji.gov.fj/Fiji Facts Figures As At Jul 06.pdf>.
- Fiji Pine Limited. (2006). *Pine Plantation Area at December 2006*. Fiji: Lautoka.
- Fiu, M. (2004). *Kabara Marine Baseline Biological Survey Report*. World Wide Fund for Nature. Fiji: Suva.
- Fiu, M. (2005). *Tikina Sawaike-Gau: Marine Baseline Biological Survey Report*. Fiji: Suva.
- Fowler, H.W. (1928). The Fishes of Oceania. *Memoirs of the Bernice P. Bishop Museum*, 10, 1-540.

- Fowler, H. W. (1932). Fishes Obtained at Fiji in 1929. *Occ. Paps. B. P. Bishop Mus.*, 9 (920), 13.
- Fowler, H. W. (1955). A Collection of Coral-Reef Fishes of Fiji. *Trans. Roy. Soc. New Zealand*, 83(2), 373 - 381.
- Fowler, H. W. (1959). *Fishes of Fiji*. Government of Fiji. Fiji: Suva.
- Fowler, H.W. (1931). The Fishes of Oceania: Supplement 1. *Memoirs of the Bernice P. Bishop Museum*, 11(5), 313-381.
- Fowler, H.W. (1934). The Fishes of Oceania: Supplement 2. *Memoirs of the Bernice P. Bishop Museum*, 11(6), 385- 466.
- Fowler, H.W. (1949). The Fishes of Oceania: Supplement 3. *Memoirs of the Bernice P. Bishop Museum*, 12(2), 37-186.
- Fowler, H.W. (1959). *Fishes of Fiji*. Government of Fiji. Fiji: Suva.
- Fowler, H.W. (1959). *Fishes of Fiji*. New Plymouth. New Zealand: Avery Press Limited.
- Garbary, D.J., Oliveira, J.C., Scagel, R.F., and Villeneuve, S. (1991). Notes and Distribution Records for the Marine Algae of Fiji. *Micronesica*, 24, 249-260.
- Gardiner, J.S. (1898). The Coral Reefs of Funafuti, Rotuma and Fiji. *Proc. Cambridge Phil. So*, 9, 417-503.
- Garratt, A. (1887). On the Terrestrial Molluscs of the Viti Islands. *Proceedings of the Zoological Society*, 1, 164 – 184.
- Germain, L. (1932). La Faune Malacologique des îles Fiji. *Annales de L'institut Oceanographique*, 12(2), 39-63.
- Gibbs, N., and Paton, D. (2003). *Preliminary Report on the Survey of Whales and Dolphins in the Lomaiviti Island Group of Fiji*. Australian Department of Environment and Heritage and Fijian Department of Environment. Fiji: Suva.
- Giribet, G., Okusu, A., Lindgren, A.R., Huff, S.W., Schrödl, M., and Nishiguchi, M.K. (2006). Evidence for a Clade Composed of Molluscs with Serially Repeated Structures: Monoplacophorans are Related to Chitons. *Proceedings of the National Academy of Sciences of the United States of America*, 103 (20), 7723–7728.
- Global Trade Media Ltd. (2010). *Wainikasau Project Fiji*. UK. Retrieved February 23, 2010 from <http://www.waterpowermagazine.com/story.asp?storyCode=2053633>
- Government of Fiji Islands. (1997). *Fiji Today*. Ministry of Information. Fiji: Suva.

- Gray, A. (1854). *United States Exploring Expedition*. Phanerogamia. USA: New York.
- Grunow, A. (1874). Algen der Fidschi-, Tonga- und Samoa-Inseln, gesammelt von Dr. E. Graeffe. Erst Folge: Phaeosporeae, Fucoideae und Florideae. *Journal Museum Godeffroy*, 4(1), 23–50.
- Gubanov, A.P., and Peel, J.S. (2003). The Early Cambrian Helcionelloid Mollusc *Anabarella Vostokova*. *Palaeontology*, 46 (5), 1073–1087.
- Günther, A. (1873 – 1910). Andrew Garrett's Fische der Südsee. *Journal Mus. Godeffroy*, 1(9), 515.
- Günther, A. (1889). *Report on the Pelagic Fishes Collected by H. M. S. Challenger During the Years 1873-76*, 31(78), 1 - 47.
- Haase, M., Ponder, W.F., and Bouchet, P. (2006). The Genus *Fluviopupa* Pilsbry from Fiji. *Journal of Molluscan Studies*, 72, 119-135.
- Hadfield, M.G. (1986). Extinction in Hawaiian Achatinelline Snails. *Malacologia*, 27, 67-81.
- Haynes, A. (1985). The Ecology and Local Distribution of Non-Marine Aquatic Gastropods in Viti Levu Fiji. *The Veliger*, 28, 204-210.
- Haynes, A. (1988a). The Gastropods in the Streams and Rivers of Five Fiji Islands: Vanua Levu, Ovalau, Gau, Kadavu and Taveuni. *The Veliger*, 30, 377-383.
- Haynes, A. (1988b). A Population Study of the Fijian Freshwater Thiarid Gastropod *Fijidoma Maculata* (Mousson). *Archiv fr Hydrobiologie*, 113, 27-39.
- Haynes, A. (1990). The Number of Freshwater Gastropods In Pacific Islands and the Theory of Island Biogeography. *Malacologia*, 31, 237-248.
- Haynes, A. (1998a). *Fiji Biodiversity Strategy and Action Plan, Technical Group 2 – Terrestrial Vertebrates and Invertebrates*. Unpublished Manuscript. Fiji: Suva.
- Haynes, A. (1998a). *Freshwater Invertebrates of Fiji*. Fiji Biodiversity Strategy and Action Plan. Fiji: Suva.
- Haynes, A. (2001). *Freshwater Snails of the Tropical Pacific Islands*. The University of the South Pacific. Institute of Applied Sciences. Fiji: Suva.
- Haynes, A., and Kenchington, W. (1991). *Acochlidium Fijiense* Sp. Nov. (Gastropoda: Opisthobranchia: Acochliidae) From Fiji. *The Veliger*, 34, 166-171.
- Herre, A. (1935). New Fishes Obtained by the Crane Pacific Expedition. *Field Mus. Nat. Hist.*, 18 (12), 383 - 438.

Herre, A. (1936). Fishes of the Crane Pacific Expedition. Reports on Results of the Crane Pacific Expedition. *Field Museum of Natural History, Zoological Series*, 21(353), 472.

Hill, J.E., and Beckon, W.N. (1978). A New Species of Pteralopex Thomas (Chiroptera: Pterodidae) from the Fiji Islands. *Bulletin of the British Museum of Natural History (Zool.)*, 34(2), 65-82.

Hinds, R.B. (1842). Remarks on the Vegetation of the Feejee Islands, Tanna, New Ireland and New Guinea. *London Journal of Botany*, 1, 669-676.

Hoffmeister, J.E. (1945). Corals. In Hoffmeister, J.E. and Ladd, H.S. Geology of Lau, Fiji: *Bulletin Bernice P. Bishop Museum*, 81(171), 70-159.

International Union for Conservation of Nature and Natural Resources. (2010). *The IUCN Red List of Threatened Species*. United Kingdom: Cambridge. Retrieved June 12, 2010, from <http://www.iucnredlist.org/>

Itono, H. (1985a). *Some Noteworthy Species of Galaxaura (Chaetangiaceae, Rhodophyta) from Fiji*. Kagoshima University Research Center for the South Pacific. Fiji: Suva.

Itono, H. (1985b). *Rhodolachne Radicosa, A New Species of Red Alga (Rhodophyceae, Ceramiales) from Fiji and Southern Parts of Japan*. Kagoshima University Research Center for the South Pacific. Fiji: Suva.

Itono, H., and Ajisaka, T. (1984). *Taxonomic Study of the Marine Algae From Fiji*. Prompt Rep. 1<sup>st</sup> Scientific Survey of the South Pacific. Marine Science and Fisheries. Research Center for the Pacific, Kagoshima University. Institute of Marine Resources. University of the South Pacific. Fiji: Suva.

Jenkins, A., Sykes, H., Skelton, P., Fiu, M., and Lovell, E. (2004). *Fiji's Great Sea Reef: The First Marine Biodiversity Survey of Cakaulevu and Associated Coastal Habitats*. WWF Fiji Country Programme. Fiji: Suva.

Jenkins, A.P. (2001). *Freshwater Fishes of Fiji: Advanced Taxonomy, Identification and Applications for Wetland Management*. Asia Pacific Wetland Managers' Training Program. Wetlands International Oceania. The University of the South Pacific. Fiji: Suva.

Jenkins, A.P. (2004). *Freshwater Fishes of Waisai Creek and Allied Hotsprings Systems*. Unpublished Manuscript. Wetlands International. Fiji Islands: Suva.

Jenkins, A.P. (2005). *A Preliminary Study of Freshwater Fauna and Water Quality of Kubuna River and Tributaries with Recommendations for Conservation Action*. Wetlands International Oceania. Canberra: John Gorton Building.



- Jenkins, A.P., and Boseto, D. (2003). *A Preliminary Investigation of Priority Ichthyofaunal Areas and Watershed Ecosystem Services for Assessing Representation in Fiji's Forest Reserve Network*. Wetlands International Oceania. Fiji: Suva.
- Jenkins, A.P., and Boseto, D. (2005). *Schismatogobius Vitiensis: A New Freshwater Goby (Teleostei: Gobiidae) From the Fiji Islands*. *Ichthyological Explorations of Freshwaters*, 16(1), 75-82.
- Jenkins, A.P., and Mailautoka, K. (2009). *Occurrence Records and Conservation Status of Fiji's Rare, Endemic and Endangered Freshwater and Estuarine Fishes*. Fiji National Protected Areas Committee. Fiji: Suva.
- Jenkins, A.P., Jupiter, S.D., Qauqau, I., and Atherton, J. (2004). *The Importance of Ecosystem-Based Management for Conserving Aquatic Migratory Pathways on Tropical High Islands: A Case Study from Fiji*. *Aquatic Conservation: Marine and Freshwater Ecosystems*. Fiji: Suva.
- Jenkins, A.P., Kailola, P.J., Boseto, D., and Kinikoto, M. (2010). *Freshwater Fishes of the Fiji Islands*. Fiji: Suva.
- Jordan, D. S., and Dickerson, M. C. (1908). On a Collection of Fishes From Fiji. *Proc. U. S. Nat. Mus.*, 34(1625), 603 - 617.
- Joyce, C. (2007). Fiji Mangroves, Coral under Assault. NPR Station. Washington: Massachusetts. Retrieved 12 July, 2010, from <http://www.npr.org/templates/story/story.php?storyId=10983906>
- Kailola, P.J. (2001). *The Freshwater and Estuarine Fishes of Fiji: An Annotated Checklist*. Unpublished Checklist. Fiji: Suva.
- Kanda, N., Goto, M., Kato, H., McPhee, M.V., and Pastene, L.A. (2007). Population Genetic Structure of Bryde's Whales (*Balaenoptera brydei*) at the Inter-Oceanic and Trans-equatorial Levels. *Conservation Genetics*, 8, 853-864.
- Kapraun, D.F., and Bowden, W.A. (1978). Additions to the Benthic Marine Algal Flora of Fiji. *Micronesica*, 14, 199-207.
- Kasahara, H. (1985). *Marine Green and Red Algae Collected at Viti Levu and Ndravuni Islands of Fiji*. Master of Science Thesis. Japan: Kagoshima University.
- Kasahara, H. (1988). *In Japanese: Description and Illustrations of Marine Chlorophyceae Collected at Viti Levu, Suva, Makaluva, Ovalau and Fiji*. Fiji: Suva.
- Kasamatsu, F., Nishiwaki, S., and Ishikawah, H. (1995). Breeding Areas and Southbound Migrations of Southern Minke Whales *Balaenoptera acutorostrata*. *Marine Ecology Progress Series*, 119(1-3), 1-10.

- Kawamura, A. (1980). Food Habits of the Bryde's Whales Taken in the South Pacific and Indian Oceans. *Scientific Reports of the Whales Research Institute*, 32, 1-23.
- Keats, D.W. (1995). *Lithophyllum cuneatum* sp. nov. (Corallinaceae, Rhodophyta), A New Species of Non-Geniculate Coralline Alga Semi-Endophytic in Hydrolithon Onkodes (Heydrich) Penrose et Woelkerling and Neogoniolithon sp. from Fiji, South Pacific. *Phycological Research*, 1, 151-160.
- Keats, D.W. (1997). *Lithophyllum insipidum* Adey, Townsend et Boykins and *L. flavescens* sp. nov.: Two Flat Lithophylloid Coralline Algae (Corallinales, Rhodophyta) Abundant in Shallow Reef Environments in Fiji. *Phycologia*, 36, 351-365.
- Keats, D.W., and Chamberlain, Y.M. (1994). Three Species of Hydrolithon (Rhodophyta, Corallinaceae): *Hydrolithon onkodes* (Heydrich) Penrose and Woelkerling, *Hydrolithon superficiale* sp. nov., and *H. samoëense* (Foslie) comb. nov. from South Africa. *South African Journal of Botany*, 60, 8-21.
- Kendall, W. C. and Goldsborough, E. L. (1911). The Shore Fishes. *Mem. Mus. Comp. Zool., Harvard Coll.*, 26(7), 241-337.
- King, M. (1983). *The Ecology of deepwater Caridean Shrimps (Crustacea: Decapoda: Caridea) nea; Tropical Pacific Islands with Particular Emphasis on the Relationships of Life History Patterns to Depth*. Doctoral of Philosophy Thesis. The University of the South Pacific. Fiji. Suva.
- Kott, P. (1981). The Ascidians of the Reef Flats of Fiji. *Proc. Linn. Soc. New South Wales*. 105: 147-212.
- Koven, J. F. (2006). *Molluscan Biodiversity of Fiji's Great and North Astrolabe Reefs from 1986 – 2006*. School of Marine Studies Collection, University of the South Pacific, Fiji: Suva.
- Ladd, H.S. (1934). Geology of Vitilevu, Fiji. *Bernice P. Bishop Museum Bulletin*, 119, 1-263.
- Leslie, D.M. (1997). *Soils of Fiji*. Soils and Crops Evaluation Project. Research Division of Ministry of Agriculture and Fisheries and ALTA. Fiji: Nausori.
- Leslie, M S., Batibasaga, A., Weber, D.S., Olson, D., and Rosenbaum, H.C. (2005). First Record of Blainville's Beaked Whale *Mesoplodon densirostris* in Fiji. *Pacific Conservation Biology*, 11(4), 302-304.
- Lewis, A.D., and Pring, C.K. (1986). Freshwater and Brackish Water Fish and Fisheries of Fiji. In T. Petr (Eds.), *Indo-Pacific Fishery Commission Expert Consultation*. Thailand: Bangkok.
- Little, L., Fowler, H.W., Coulson, J., and Onions, C.T. (Eds.) (1964). *Malacology*. Shorter Oxford English Dictionary. Oxford University press.

- Lovell, E.R. (1997). *The Coral Reefs of Ovalau Island in Fiji*. Composition of Environment Assessment. Department of Environment. Fiji: Suva.
- Lovell, E.R. (2002a). *The Coral Reefs of Yadua Island, Bua, Fiji*. Unpublished Manuscript. National Trust of Fiji. Fiji: Suva.
- Lovell, E.R., and McLardy, C. (2008). *Annotated Checklist of the CITES-Listed Corals of Fiji with Reference to Vanuatu, Tonga, Samoa and American Samoa*. JNCC Report. Fiji: Suva.
- Lowery, R. (1997). The Biology of *Batissa violacea* Lamarck, 1818 (Bivalvia: Corbiculoidea) in Fiji. *The South Pacific Journal of Natural Science*, 15, 37-52.
- Lydeard, C., Cowie, R.H., Ponder, W.F., Bogan, A.E., Bouchet, P., Clark, S.A., et al. (2004). The Global Decline of Nonmarine Mollusks. *BioScience*, 54(4), 321-330.
- Macfarlane, D.C. (2009). *Country Pasture/Forage Resource Profiles*. Australia: Brisbane. Retrieved February 13, 2010, from <http://www.fao.org/ag/AGP/AGPC/doc/counprof/southpacific/fiji.htm>
- Mattio, L. (2007). *Revision of the Brown Algal Genus Sargassum (Phaeophyta, Fucales) in Fiji*. New Caledonia: Noumea.
- McGinley, M. (2007). *Fiji Tropical Moist Forests*. USA: Washington. Retrieved February 23, 2010, from [http://www.eoearth.org/article/Fiji\\_tropical\\_moist\\_forests](http://www.eoearth.org/article/Fiji_tropical_moist_forests)
- McKenzie, L.J., and Yoshida, R.L. (2007). Seagrass-Watch: Guidelines for Monitoring Seagrass Habitats in the Fiji Islands. *Proceedings of a Training Workshop*. Corpus Christi Teachers College, Laucala Bay, Fiji: Suva.
- McMillan, C., and Bridges, K.W. (1982). *Systematic Implications of Bullate Leaves and Isozymes for Halophila from Fiji and Western Samoa*. *The South Pacific Journal of Natural Science*, 12, 73-188.
- Miller, C. (2009). Current State of Knowledge of Cetacean Threats, Diversity and Status in the Pacific Islands Region. Convention of Migratory Species Memorandum of Understanding for the Conservation of Cetaceans and their Habitats in the Pacific Islands Region. New Zealand: Auckland.
- Morris, C.W. (1998). Marine Biodiversity Technical Report. Fiji Biodiversity Strategy and Action Plan. Unpublished Manuscript. Suva: Fiji.
- Morris, C.W. and Pratt, C. (1998). Fiji Biodiversity Strategy and Action Plan. Marine Biodiversity Technical Group Report. Unpublished Manuscript. Fiji: Suva.
- Morris, C.W. and Pratt, C. (1997). *Marine Biodiversity Technical Group Report*. University of the South Pacific. Fiji: Suva.

- Morton, J. (1990). *The Shore Ecology of the Tropical Pacific*. UNESCO. Jakarta.
- Mousson, A. (1870). Faune Malacologique Terrestre Et Fluviale Des îles Viti, d'après envois de M. le Dr Edouard Graeffe. *Journal de Conchyliologie*, 109-135.
- Nature Fiji. (2010). *Endangered Species*. Fiji: Suva. Retrieved February 23, 2010, from <http://www.naturefiji.org/>
- Nutting, C. C. (1924). The Fishes in the Fiji- New Zealand Expedition. *Univ. Iowa Studies Nat. Hist.*, 10(5), 57 - 67.
- N'Yeurt, A.D.R. (1993a). *A Floristic Survey of the Intertidal and Shallow Benthic Marine Algae of Rotuma*. Master of Science Thesis. The University of the South Pacific. Fiji: Suva.
- N'Yeurt, A.D.R. (1993b). *A Preliminary Checklist of the Marine Benthic Algae of Rotuma*. The University of the South Pacific Marine Studies Programme Technical Reports, 93(2), 1-14.
- N'Yeurt, A.D.R. (1995). *Meristotheca Procumbens* P. Gabrielson et Kraft (Gigartinales, Solieriaceae): An Edible Seaweed from Rotuma Island. *South Pacific Journal of Natural Science*, 14, 242-250.
- N'Yeurt, A.D.R. (1996). A Preliminary Floristic Survey of the Intertidal and Shallow-subtidal Benthic Marine Algae of Rotuma Island. *Australian Systematic Botany*, 9, 361-490.
- N'Yeurt, A.D.R. (2001). Marine Algae from the Suva Lagoon and Reef, Fiji. *Australian Systematic Botany* 14(5), 689-869.
- N'Yeurt, A.D.R. (2002). A Revision of *Amansia Glomerata* C. Agardh, *Amansia rhodantha* (Harvey) J. Agardh and *Melanamansia glomerata* (C. Agardh) R.E. Norris (Rhodophyta: Rhodomelaceae). *Botanica Marina*, 45, 231-242.
- N'Yeurt, A.D.R., and Payri, C. (2008). *Sebdenia Cerebriformis* sp. nov. (Sebdeniaceae, Sebdeniales) From the South Western Pacific Ocean. *Phycological Research*, 56, 113-120.
- N'Yeurt, A.D.R., and Payri, C. (2009). Four New Species of Rhodophyceae from Fiji, Polynesia and Vanuatu. South Pacific. *Phycological Research*, 57, 12-24.
- N'Yeurt, A.D.R., and South, G.R. (1997). Biodiversity and Biogeography of Marine Benthic Algae in the Southwest Pacific: Cases of Rotuma and Fiji. *Pacific Science*, 51, 18-28.
- N'Yeurt, A.D.R., Payri, C., Gabrielson, P.W., and Fredericq, S. (2006). *Pennatiphycs menouana* gen. Et sp. nov. (Rhodophyta, Dicranemataceae) from New Caledonia and Fiji (South Pacific): Vegetative and Reproductive Morphology and Molecular Phylogeny. *Phycologia*, 45, 422-431.

- N'Yeurt, A.D.R., South, G.R., and Keats, D.W. (1996). A Revised Checklist of the Benthic Marine Algae of the Fiji Islands, South Pacific (including the Island of Rotuma). *Micronesica*, 29(1), 49-98.
- Obura, D., and Mangubhai, S. (2003). *Marine Biological Survey Report of the Great Astrolabe Reef, Ono Kadavu*. Fiji Barrier Reef Ecoregion. WWF South Pacific Programme. Fiji: Suva.
- Ohsumi, S. (1978). *Provisional Report on the Brydes Whales Caught Under Special Permit in the Southern Hemisphere*. Report of the International Whaling Commission, 28, 281-287.
- Ohsumi, S. (1979a). Bryde's Whales in the North Pacific in 1977. *Report of the International Whaling Commission*, 29, 265-266.
- Ohsumi, S. (1979b). Provisional Report of the Bryde's Whales Caught Under Special Permit in the Southern Hemisphere in 1977/78 and a Research Programme for 1978/79. *Report of the International Whaling Commission*, 29, 267-273.
- Parkinson, B. (1988). *Collecting in Fiji*. Fiji: Suva.
- Parkinson, B. (1990). *Notes on the Fiji Land Snail Fauna*. Fiji: Suva.
- Parkinson, B. (1982). *The Specimen Shell Resources of Fiji*. South Pacific Commission. New Caledonia: Noumea.
- Paterson, R.A., Paterson, P., and Cato, D.H. (2001). Status of Humpback Whales, *Megaptera novaeangliae*, in East Australia at the End of the 20th century. *Memoirs of the Queensland Museum*, 47, 579-586.
- Paton, D., and Gibbs, N.J. (2002). *Documented and Anecdotal Cetacean Sightings from 1761-2001 in the Samoa, Fiji, Vanuatu and Solomon Island regions*. Fiji: Suva.
- Paton, D., Batibasaga, A., Sharma, S., O'Connor, W., and Nand, Y. (2009). *Report of the Whale and Dolphin Survey Undertaken in the Lomaiviti Island Group, Fiji 2008*. Unpublished Manuscript. Fiji: Suva.
- Paulay, G. (1990). *Astrolabe Corals*. Unpublished Data. University of the South Pacific. Fiji: Suva.
- Payri, C., Petek, S., Menou, J-L., Lasne, G., and Butsche, J. (2007). *Biodiversity and Marine Substances from the Fiji Islands. Algae/Sponges/Ascidians/Echinoderms*. New Caledonia: Noumea.
- Pernetta, J.C. and Watling, D. (1978). The Introduced and Native Terrestrial Vertebrates of Fiji. *Pacific Science*, 32, 223-224.

- Phipps, C.V.G., and Preobrazhensky, B.V. (1977). Morphology, Development and General Coral Distribution of Some Reefs of the Lau Islands, Fiji. *Memoirs du Bureau de Recherches Géologiques et Minières*, 89, 440- 445.
- Pichon, M. (1980). *University of the South Pacific Coral Collection*. Unpublished Manuscript. Institute of Marine Resources. Fiji: Suva.
- Pichon, M. (1980). *USP Coral Collection*. Speciman Catalogue. Unpublished Data. University of the South Pacific. Fiji: Suva.
- Pillai, G. (1982). *Aspects of the Biology of Thalassina Anomala*. Master of Science Thesis. University of the South Pacific. Fiji: Suva.
- Potter, D. (1989). *Fijian Land Snails: A Check List for Mana Island Fiji*: Suva.
- Ralogaivau, T. (2009). *Giant Whale Dies, Villagers Share 34 Tabua*. Fiji Times. Fiji: Suva. Retrieved September 15, 2009, from [www.fijitimes.com/story.aspx?id=127899](http://www.fijitimes.com/story.aspx?id=127899)
- Reeves, R. R., Leatherwood, S., Stone, G.S., and Eldredge, L.G. (1999). *Marine Mammals in the Area Served by the South Pacific Regional Environment Programme (SPREP)*. South Pacific Regional Environment Programme (SPREP). Samoa: Apia.
- Robinson, G.S. (1978). *The Macrolepidoptera of Fiji and Rotuma*. UK: E.W. Classey.
- Ruppert, E.E., Fox, R.S., and Barnes, R.D. (2004). *Invertebrate Zoology* (7<sup>th</sup> Ed.). United Kingdom: Oxford Press.
- Ryan, P. (2000). *Fiji's Natural Heritage*. New Zealand: Exisle Publishing Limited.
- Ryan, P.A. (1980). A Checklist of the Brackish and Freshwater Fish of Fiji. *South Pacific Journal Natural Science*, 1, 58-73.
- Ryan, P.A. (1981). Records of the Three New Freshwater Fishes of the Fiji Islands. *Pacific Science*, 35(1), 93 – 95.
- Ryan, P.A. (1981). Records of Three New Freshwater Fish From the Fiji Islands. *Pacific Science*, 35(1), 93-95.
- Ryland, J.S., Wrigley, R.A., and Murihead, A. (1984). Ecology and Colonial Dynamics of Some Pacific Reef-Flat Didemnidae (Ascidiacea). *Zool. J. Linnean. Soc.*, 80, 261-282.
- Salvat, B., Richard, G., Toffart, J.L., Ricard, M., and Galzin, R. (1977). Reef Lagoon Complex of Lakeba Island (Lau Group, Fiji) Geomorphology, Biotic Associations and Socio-Ecology. *Proceedings of the Third International Coral Reef Symposium*. Fiji: Suva.

Schwabe, E., Sirenko, B. I., and Seeto, J. (2008). A Checklist of Polyplacophora (Mollusca) From the Fiji islands. *Zootaxa*, 1777, 1–52.

Science Daily Incorporation. (2010). *Tilapia Feeds on Fiji's Native Fish*. USA: New York. Retrieved February 23, 2010, from <http://www.sciencedaily.com/releases/2010/01/100112135044.htm>

Seale, A. (1935). The Templeton Crocker Expedition to Western Polynesia and Melanesian islands. *Proc. Calif. Acad. Sci.*, 21(27), 337-378.

Seale, A. (1935). The Templeton Crocker Expedition in Western Polynesian and Melanesian Islands. *Pacific Science*, 21(27), 337-378.

Seemann, B. (1865-1873). *Flora Vitiensis: A Description of the Plants of the Viti or Fiji Islands with an Account of their History Uses and Properties*. London: United Kingdom.

Seeto, J. (1998). *An Update on the Living and Fossil Cone Shells (Gastropoda: Conidae) of Fiji*. University of the South Pacific. Fiji: Suva.

Seeto, J. (2010). A Checklist of the Fishes of Fiji and a Bibliography of Fijian Fish. *The University of the South Pacific Marine Studies Technical Report*, 2010(1), 220.

Seeto, J. (1998). *An Annotated Checklist of the Living and Fossil Cowries (Gastropoda: Cypraeidae) of Fiji*. University of the South Pacific. Fiji: Suva.

Shokita, S., Takano, L., La, S., and Vereivalu, T. (1984). *Environment Survey of Rivers and Biology of Inland Water and Prawns in Fiji*. Unpublished Report. Ministry of Fisheries. Fiji: Lami.

Skelton, P.A., and South, G.R. (2006). Seagrass Biodiversity of the Fiji, Samoa Islands and South Pacific. *New Zealand Journal of Marine and Freshwater Research*. 40, 345-356.

Skelton, P.A., and South, G.R. (2007). The Benthic Marine Algae of the Samoan Archipelago, South Pacific, with Emphasis on the Apia District. *Nova Hedwigia Beiheft*, 132, 1-350.

Smith, A.C. (1934). Plant Collecting in Fiji. *Journal of New York Botanical Garden*, 35, 261-280.

Smith, A.C. (1935). Botanical Exploration of the Fiji Islands. *Topical Woods*, 41, 1-5.

Smith, A.C. (1936). Fijian Plant Studies. *Bishop Museum Bulletin*, 141, 1-166.

Smith, A.C. (1942). Fijian Plant Studies II. *Sargentia*, 1, 1-148.

Smith, A.C. (1950). Studies of Pacific Island Plants, VI. New and Noteworthy Flowering Plants from Fiji. *Journal Arnold Arb.* 31, 137-171.

- Smith, A.C. (1955). Botanical Studies in Fiji. *Smithsonian Report*, 305-315.
- Smith, A.C. (1970). The Pacific as a Key to Flowering Plant History. H.S. Lyon AQRb. Lecture 1: 1-26. In B.J. Meggers (Eds.), *Tropical Forest Ecosystems in Africa and South America: A Comparative Review*. Smithsonian Press.
- Smith, A.C. (1978). A Precursor to a New Flora of Fiji. *Allertonia*, 1, 331- 414.
- Smith, A.C. (1979). Flora Vitiensis Nova. A New Flora of Fiji (Spermatophytes only). 1, 495.
- Solandt, J., Harding, S., Walker, D., Slater, J., and Raines, P. (2002). *Fiji: Castaway Island Progress Report: Baseline Survey Data March-May 2002*. Coral Cay Conservation Ltd. United Kingdom: London.
- Solem, A. (1959). Systatics and Zoogeography of the Land and Freshwater Mollusca of the New Hebrides. *Zoology*, 43 (1), 1-359.
- Solem, A. (1978). Land Snails from Mothe, Lakemba and Karoni Islands, Lau Archipelago, Fiji. *Pacific Science*, 32(1), 39-45.
- Solem, G.A. (1974). *The Shell Makers: Introducing Mollusks*. Wiley. USA: New York.
- Solomona, P., Wilson, L., Afzal, D., Areki, D., Cerelala, A., Fiu, M., et al. (2002). *A Preliminary Baseline Assessment of the Malomalo i Qoliqoli*. Fiji: Suva.
- South Pacific Regional Environment Programme. (2000). *Invasive Species in the Pacific: A Regional Strategy*. Samoa: Apia. Retrieved February 23, 2010 from <http://www.sprep.org/legal/documents/IS.pdf>
- South Pacific Regional Environment Programme. (2010). *Fiji Islands*. Samoa; Apia. Retrieved February 23, 2010 from <http://www.sprep.org/att/IRC/eCOPIES/Countries/Fiji/23.pdf>
- South Pacific Regional Environment Programme. (2010). *Marine Species in the Pacific*. Samoa: Apia. Retrieved February 23, 2010 from <http://www.sprep.org/legal/documents/IS.pdf>
- South Pacific Whale Research Consortium. (2009). *Report of the Annual Meeting of the South Pacific Whale Research Consortium*. New Zealand: Auckland. Retrieved February 12, 2009, from IWC Scientific Document SC/61/SH15.
- South, G.R. (1991). Benthic Marine Algae from Dravuni Island, Astrolabe Islands, Kadavu, Fiji. *University of the South Pacific Marine Studies Programme Technical Report 1991*, 5, 1-13.
- South, G.R. (1992). Contributions to a Catalogue of the Marine Algae of Fiji. Halimeda (Chlorophyceae). *University of the South Pacific Marine Studies Programme Technical Report 1992*, 2, 1-19.



- South, G.R. (1993). *Edible Seaweeds of Fiji: An Ethnobotanical Study*. Botanical Marina, 36(40), 355. Retrieved February 23, 2010 from <http://www.reference-global.com/doi/abs/10.1515/botm.1993.36.4.335>
- South, G.R. (1995). *Gracilaria maramae* sp. nov. (Gracilariaceae, Gracilariales, Rhodophyta), An Economically Important Species from the Fiji Islands, South Pacific. In I.A. Abbott (Eds.). *Taxonomy of Economic Seaweeds with Reference to Some Pacific Species*, 3, 177-184.
- South, G.R., and Kasahara, H. (1992). A Preliminary Checklist of the Benthic Marine Algae of the Fiji Islands, South Pacific. *Micronesica*, 25(1), 41-70.
- South, G.R., and N'Yeurt, A.D.R. (1993). Contributions to a Catalogue of Benthic Marine Algae of the Fiji Islands. II. *Caulerpa* and *Caulerpella* (Chlorophyta – Caulerpales). *Micronesica*, 26, 107-136.
- South, G.R., and Skelton, P. (2003a). Catalogue of the Marine Benthic Macroalgae of the Fiji Islands, South Pacific. *Australian Systematic Botany*, 16, 699-758.
- South, G.R., and Skelton, P.A. (2000). A Review of *Ceramium* (Ceramiales, Rhodophyceae) from Fiji and Samoa, South Pacific. *Micronesica*, 33(1/2), 45-99.
- South, G.R., and Skelton, P.A. (2003b). Revisions and Additions to *Caulerpa* (Chlorophyta, Caulerpaceae) from the Fiji Islands, South Pacific, including *Caulerpa reniformis* sp. nov. *Australian Systematic Botany*, 16, 539-548.
- South, G.R., N'Yeurt, A.D.R., and Raj-Prasad, R.A. (1993). Additions and Amendments to the Benthic Marine Algal Flora of Fiji, Including the Island of Rotuma. *Micronesica*, 26, 175-196.
- South, G.R. and Kasahara, H. (1992). A Preliminary Checklist of the Marine Algae of the Fiji Islands, South Pacific. *Marine Studies Programme Technical Report*. University of the South Pacific. Fiji: Suva.
- Springer, V. G. (1982). Pacific Plate Biogeography with Special Reference to Shorefishes. *Smith. Contr. Zool.*, 367,182.
- Springer, V.G. (1982). Pacific Plate Biogeography: with Special Reference to Shorefishes. *Smithsonian Contributions to Zoology*, 367, 182.
- Stanton, W. (1975). *The Great United States Exploring Expedition of 1838-1842*. Berkeley: University of California Press.
- Starmühlner, F. (1976). Beiträge zur Kenntnis der Süsse- Gastropoden Pazifischer Inseln. *Annalen des Naturhistorischen Museum in Wien*, 80, 473-656.

Sykes, H.R. (2003). *Report on Surveys Carried out at Robinson Crusoe Resort on Likuri Island, Viti Levu*. Fiji: Suva.

Tate, G.H. (1934). Rodents of the Genera *Rattus* and *Mus* from the Pacific Islands. *Bulletin of American Museum of Natural History*, 63, 145-178.

Thaman, R.R., Aalbersberg, W., Kuridrani, L., Savou, S., Tuivage, J., Vatucawaqa, P., et al. (1998). *Traditional Ethnobiological Knowledge, Resource Use and Community Based Biodiversity Conservation in Fiji*. Department of Environment. Fiji: Suva.

Townsend, C. H. (1931). Where the Nineteenth Century Whaler Made His Catch. *New York Zoological Society*, 34(6), 173-179.

Townsend, C. H. (1935). The Distribution of Certain Whales as Shown by Logbook Records of American Whaleships. *Zoologica*, 19, 1-50.

Tregenza, K. (2001). *Variations in Fijian Placostylus*. Fiji: Suva.

Tsuchida, E., and Shimura, S. (1995). *Some Commercial Mollusks Collected at Suva Market*. Fiji: Suva.

United Nations Environment Programme World Conservation Monitoring Centre. (2003). *Checklist of Mammals Listed in the CITES Appendices and in EC Regulation 338/97* (6<sup>th</sup> ed.). JNCC Report No. 342. Fiji: Suva.

Veitayaki, J. (1997). *Fisheries Resource Use Culture in Fiji and its Implications*. UNESCO Conference. Fiji: Suva.

Veron, J.E.N. (2000). *Corals of the World*. Australian Institute of Marine Science. Australia: CRR Qld. Pty. Ltd.

Veron, J.E.N. (1993). A Biogeography Database of Hermatypic Corals. Species of the Central Indo-Pacific Genera of the World. *Australian Institute of Marine Science Monographic Series*, 10.

Veron, J.E.N. and Pichon, M. (1976). Scleractinia of Eastern Australia, Part 1: Families Thamnasteriidae, Astrocoenidae, Pocilloporidae. *Australian Institute Marine Science Monograph Series*, 1, 86.

Veron, J.E.N. and Pichon, M. (1982). Scleractinia of Eastern Australia. *Monograph Series 4*. Australia: Australian Institute of Marine Science.

Veron, J.E.N., and Pichon, M. (1979). Scleractinia of Eastern Australia. *Monograph Series 4*. Australia: Australian Institute of Marine Science.

Veron, J.E.N., Pichon, M., and Wijsman-Best, M. (1977). Scleractinia of Eastern Australia. *Monograph Series 3*. Australia: Australian Institute of Marine Science.

Vuki, V.C. (1994). *Long-Term Changes of Suva Reef Flat Communities from Conventional in situ Survey and Remote Sensing Methods*. PhD Thesis. Southampton: University of Southampton.

Wallace, C.C. (1999). *Staghorn Corals of the World. A Revision of the Coral Genus Acropora Worldwide with Emphasis on Morphology, Phylogeny and Biography*. Australia: Collingwood.

Waqairatu, S.S. (2003). *An Inter and Intra-Creek Study of Tilapia Introduction to Fiji Fresh and Brackish Waters: Determining Salinity Tolerance Range of Oreochromis Mossambicus and its Possible Ecological Impacts*. Unpublished Manuscript. Marine Studies programme. The University of the South Pacific. Fiji: Suva.

Waycott, M., McMahon, K., Mellors, J., Calladine, A., and Keline, D. (2004). *A Guide to Tropical Seagrasses in the Indo-West Pacific*. James Cook University. Australia: Townsville.

Wells, J. (1977). *A Preliminary Report on the Littoral Copepods of Moce Island*. Fiji: Lau group.

Whale and Dolpin Conservation Society. (2009). *Convention on Migratory Species: Memorandum of Understanding for the Conservation of Cetaceans and Their Habitats in the Pacific Islands Region*. NZ: Auckland. Retrieved February 23, 2010 from [http://www.cms.int/species/pacific\\_cet/2nd\\_Mtg\\_July09\\_NewZealand/Docs/PIC2\\_Inf5\\_02\\_ImplementationReportsCollaboratingOrgs\\_WDCS.pdf](http://www.cms.int/species/pacific_cet/2nd_Mtg_July09_NewZealand/Docs/PIC2_Inf5_02_ImplementationReportsCollaboratingOrgs_WDCS.pdf)

Whitley, G. P. (1927). A Checklist of Fishes Recorded from Fijian Waters. *Pan-Pacific Research Institute Journal*, 2(1), 3– 8.

Wikipedia Foundation Incorporation. (2010a). *Buffer Zones*. USA: New York.

Wikipedia Foundation Incorporation. (2010b). *Introduced Species*. USA: New York.

Wikipedia Incorporation. (2010c). *List of Birds of Fiji*. New York: USA. Retrieved June 13 , 2010, from [http://en.wikipedia.org/wiki/List\\_of\\_birds\\_of\\_Fiji](http://en.wikipedia.org/wiki/List_of_birds_of_Fiji)

Winterbotton, R., and Emery, A. R. (1983). Beneath the Blue Lagoon: An Ichthyological Expedition to Fiji. *Rotunda*, 16 (3), 18 - 27.

Wood, C.A. and Wetmore, A. (1925). *A Collection of Birds from the Fiji Islands*. Fiji: Suva.

Woodward, S.P. (1855). Description of a New Species of Recent Rhynchonella. *Annals and Magazine of Natural History*, 2(16), 444.

Wu, J.C. (2006). *The Mineral Industry of Fiji*. United States of America: Reston. Retrieved February 7, 2010, from <http://minerals.usgs.gov/minerals/pubs/country/2006/myb3-2006-fj.pdf>

Yeatman, H.C. (1983). Copepods from Microhabitats in Fiji, Western Samoa and Tonga. Micronesia. *Pacific Science*, 19:57-90.

Zann, L.P and Lovell, E. (1992). *The Corals of the Mamanuca Group*. Report to National Environment Management Programme. Fiji: Suva.

Zann, L.P. (1992). The State of Fiji's Marine Environment, National Environmental Management Project report. TA No 1206. Department of Town and Country Planning. Government of Fiji. Fiji: Suva.

Zann, L.P., and Boulton, L. (1985). The Distribution, Abundance and Ecology of the Blue Coral *Heliopora coerulea* (Pallas) in the Pacific. *Coral Reefs*, 4, 125-134.

Zug, G. R., Springer, V. G., Williams, J. T., and Johnson, G. D. (1989). The Vertebrates of Rotuma and Surrounding Waters. *Atoll. Res. Bull.*, 316, 1- 25.

# APPENDIX

## CONTACT LIST OF THE VARIOUS STAKEHOLDERS

<b>Stakeholders</b>	<b>Contact Person</b>
<b>Hydrology Section PWD</b>	Asenaca Siteri Oneil Kumar
<b>FEA</b>	Subash Karunesh Rao
<b>Meteorological Office</b>	Ravin
<b>USP</b>	Professor William Aalbersberg Posa Skelton Siteri Tikoca Marika Tuiwawa Edward Lovell G. Robin South Johnson Seeto
<b>Mareqeti Viti</b>	Dick Watling
<b>Fisheries</b>	Aisake Batibasage Yashika Nand
<b>FLMMA</b>	Professor William Aalbersberg Siteri Tikoca Posa Skelton Marika Tuiwawa
<b>SPC</b>	En Beeles Posa Skelton
<b>NLTB</b>	Unaisi Cebaivalu Solomoni Nata
<b>SPC</b>	Ian Peebles
<b>WCS</b>	Sunil Cara Miller
<b>Lands</b>	Laisa Raratabu Selina Talamaisinai
<b>Mareqeti Viti</b>	Dick Watling

<b>SOPAC</b>	Paul
<b>Forestry</b>	Samuela Lagitaki Akosita Noor
<b>Agriculture</b>	Kelera Osea Bolawatabu Maria Elder
<b>Department of Energy</b>	Susana Pulini
<b>Mineral Resources Department</b>	Raijieli Baleiwai Urmila

Source: Created by Author (2010).

# Brachiopods of the Fiji Islands

**Maria A. Bitner & Posa A. Skelton**

## Introduction

Brachiopods are one of the oldest groups of marine invertebrates dating back to the Cambrian period (550 million years ago). About 350 living species have been described, in contrast to over 26,000 fossil species known. They are exclusively marine species that resemble bivalves in having two shells.

The earliest brachiopod records from Fiji were those of Woodward (1855), Davidson (1880) and Thomson (1927), who reported *Lingula anatina* Lamarck, 1801 and *Rhynchonella grayi* [= *Basiliolella grayi*] (Woodward, 1855). Other notable reports of Fiji brachiopods were of Cooper (1978), Ladd (1934), Eliot (1961) and more recently the work of French researchers on Musorstom 10 and Bordau 1 from 1998 to 1999. Brachiopods from the French research were identified and published by Bitner (2006, 2008).

A total of 27 Brachiopod species are attributed to the Fiji fauna (Table 1), of which nine have type localities in Fiji. Whether these nine species are exclusive to the Fiji fauna remains to be validated pending further research of neighbouring countries. The remaining species have a South-west Pacific biogeographic distribution.

Table 1. Brachiopods of Fiji

Phylum	Class	Order	Family	Genus	Species	Authority	Comments
Brachiopoda	Lingulata	Lingulida	Lingulidae	<i>Lingula</i>	<i>anatina</i>	Lamarck, 1801	Include <i>Lingula</i> sp. reported by Bitner 2008
		Craniida	Craniidae	<i>Novocrania</i>	sp.		May prove to be a new species (cf. Bitner 2008)
	Rhynchonellata	Rhynchonellida	Cryptoporidae	<i>Cryptopora</i>	<i>maldivensis</i>	Muir-Wood, 1959	Bitner (2008)
			Basiliolidae	<i>Basiliola</i>	<i>lucida</i>	(Gould, 1862)	Bitner (2008)
				<i>Basiliola</i>	<i>roddai</i>	Cooper, 1978	
				<i>Basiliola</i>	<i>beecheri</i>	(Dall, 1895)	Bitner (2008)
			Dyscoliidae	<i>Abyssothyris</i>	<i>wyvillei</i>	(Davidson, 1878)	Bitner (2008)
				<i>Abyssothyris</i>	<i>briggsi</i>	Cooper, 1978	
				<i>Xenobrochus</i>	<i>rotundus</i>	Bitner, 2008	Type locality: Lau Ridge
			Terebratulidae	<i>Dallithyris</i>	<i>pacifica</i>	Bitner, 2006	Type locality: Bligh Water
			Cancellothyrididae	<i>Terebratulina</i>	<i>japonica</i>	(GB Sowerby, 1846)	Bitner (2008)



			<i>Terebratulina</i>	<i>waimanensis</i>	Ladd, 1934	
			<i>Terebratulina</i>	<i>australis</i>	Bitner, 2006	Type locality: Lau Ridge
			<i>Terebratulina</i>	<i>reevei</i>	Dall, 1920	Bitner (2008)
		Chlidonophoridae	<i>Eucalathis</i>	<i>rugosa</i>	Cooper, 1973	Bitner (2008)
		Aulacothyroptidae	<i>Fallax</i>	<i>neocaledonensis</i>	Laurin, 1997	Bitner (2008)
			<i>Septicollarina</i>	sp.		According to Bitner (2008) - need more material
		Frenulinidae	<i>Frenulina</i>	<i>sanguinolenta</i>	(Gemlin, 1791)	Bitner (2008)
		Megathyrididae	<i>Argyrotheca</i>	sp.		Bitner (2008)
		Platidiidae	<i>Amphithyris</i>	<i>buckmani</i>	Thomson, 1918	Bitner (2008)
			<i>Leptothyrella</i>	<i>fijiensis</i>	Bitner, 2008	Type locality: Bligh Water
		Daliinidae	<i>Dallina</i>	<i>triangularis</i>	Yabe & Hatai, 1934	Bitner (2008)
			<i>Dallina</i>	<i>vitilevensis</i>	Ladd, 1934	
			<i>Nipponithyris</i>	<i>lauensis</i>	Bitner, 2008	Type locality: Lau Ridge
			<i>Nipponithyris</i>	<i>fijiensis</i>	(Elliott, 1961)	Homonym: <i>Abyssothyris</i> <i>fijiensis</i>
			<i>Campages</i>	<i>ovalis</i>	Bitner, 2008	Type locality: Lau Ridge
	Thecideida	Thecidellinidae	<i>Thecidellina</i>	<i>maxilla</i>	(Hedley, 1899)	May include species <i>Thecidellina</i> sp. reported by Cooper (1978) from Fiji

## References

Bitner, M.A. 2006. Recent Brachiopoda from the Fiji and Wallis and Futuna Islands, South-West Pacific. *In* Richer De Forges B. & Justine, J.-L (eds). *Tropical Deep-Sea Benthos*, vol. 24. *Memoires du Museum national d'Histoire naturelle* 193: 15-32. Paris ISBN: 2-85653-585-2.

Bitner, MA. 2008. New data on the recent brachiopods from the Fiji and Wallis and Futuna Islands, South-West Pacific. *Zoosystema* 30(2): 419-461.

Cooper, G.A. 1978. Tertiary and Quaternary brachiopods from the Southwest Pacific. *Smithsonian Contributions to Paleobiology* 38: 1-23.

Davidson, T. 1880. Report on the Brachiopoda dredged by H.M.S. Challenger during the years 1873-1876. *Report of the Scientific Results of the voyage of HMS Challenger (Zoology)* 1: 1-67.

Elliott, G.F. 1961. Appendix. A fossil species referred to *Abyssothyris*, in Muir-Wood, H. (ed.). Homeomorphy in recent Brachiopoda: *Abyssothyris* and *Neorhynchia*. *Annals and Magazine of Natural History*. Series. 13, 3: 526.

Ladd, H.S. 1934. Geology of Vitilevu, Fiji. *Bernice P. Bishop Museum Bulletin*. 119: 1-263.

Woodward, S.P. 1855. Description of a new species of recent *Rhynchonella*. *Annals and Magazine of Natural History*. Series 2, 16: 444

## Cetacean Biodiversity of the Fiji Islands

Cara Miller\* & Siteri Tikoca\*\*

\*Pacific Islands Programme, Whale & Dolphin Conservation Society International

\*\*South Pacific Regional Herbarium, Institute of Applied Sciences, USP

Cetaceans are aquatic mammals (phylum Mammalia) characterized by having a fusiform (streamlined) body shape, paddle-shaped front limbs and vestigial hind limbs. Their tails have evolved and have been flattened into a fluke to aid propulsion or movement through the water. The name 'cetacean' comes from the Latin word 'cetus' meaning large sea animal combined with the ancient Greek word 'kotos' meaning 'sea monster' (Carwardine, 2002).

The order Cetacea includes whales, dolphins, and porpoises. It has just over eighty living species, grouped into the suborders Odontoceti (the toothed whales, including dolphins and porpoises) and Mysticeti (the baleen whales). There are numerous extinct species discovered and identified through fossil records.

A recent review confirmed twelve cetacean species records in Fijian waters as well as six additional unconfirmed species records (Miller, 2009). A majority of these records came from anecdotal and opportunistic sightings (Ohsumi 1979; Kasamatsu *et al.* 1995; Jefferson *et al.* 1993; Paton & Gibbs 2002) and therefore this listing represents a relatively limited and conservative understanding of cetacean diversity, ecology and population status in Fijian waters. Nevertheless, these records do suggest that suitable habitat and prey conditions are available in the Fijian EEZ for a wide variety of cetacean species.

Some of the interesting whales found in Fiji waters include:

- Sperm whales (*Physeter macrocephalus*) have been well documented in Fijian waters. Townsend (1931, 1935) indicated that individuals were seen year-round although more so during the winter and spring months (June-November). Unpublished surveys of Dawbin (reported in Paton and Gibbs 2002) in the mid-fifties also reported sperm whales. Sperm whales are still seen in Fijian waters today, and have been known to strand on several occasions in shallow waters (Fiji Times, 2009).
- Dawbin (1959) observed and tagged seven Sei whales in Fijian waters between 1956 and 1958. These researchers differentiated these animals from a very similar species, the Bryde's whale (*Balaenoptera brydei*), whose presence in Fiji has since been confirmed genetically (Kanda *et al.* 2007) as well as by recent footage from a dive operator near Savusavu (C. Miller, pers. comm.).
- Ohsumi (1979) further noted the presence of minke whales (*Balaenoptera spp.*), as did more recent Japanese sighting surveys (Kasamatsu *et al.* 1995). Dwarf minke whales have also been confirmed within Fijian waters after two individuals were observed at close range during a prolonged stay in a coastal lagoon near Koro Island (C. Miller, pers. comm.).
- Blue whales (*Balaenoptera musculus*) may also be occasional visitors to Fiji as a survey by Ohsumi (1979) indicated that a pair of blue whales was sighted west of Tonga. This species is the largest living cetacean and can reach 35m in length.
- The Oceania subpopulation of humpback whales (*Megaptera novaeangliae*) has recently been classified as Endangered on the IUCN red list. This classification was largely based

on the small number of individuals visible on tropical breeding grounds in comparison to pre-whaling abundance estimates, including comparisons between historical and recent land-based counts conducted in Levuka, Ovalau (Paton et al. 2009). During the past year, land-based surveys have also been initiated from Makogai Island during the peak migration period to further assess the status of this species in Fijian waters.

- Paton and Gibbs (2002) stated that anecdotal reports indicated that fin whales (*Balaenoptera physalus*) had been sighted in waters just south of Fiji, which was supported by Japanese whaling ship records (Ohsumi 1979).
- Species confirmation of a stranded female Blainville’s beaked whale near Viti Levu was confirmed by genetic analysis (Leslie *et al.* 2005).
- Critical resting habitat of spinner dolphins (*Stenella longirostris*) has been documented in a small coral reef system off the north-east coast of Viti Levu. In addition, it appears that the pod using this day-time resting area is resident (C. Miller, pers. comm.).
- Additional species sighted in Fijian waters include short-finned pilot whales, false killer whales, pantropical spotted dolphins, orca, rough-toothed dolphin, and bottlenose dolphins (Gibbs and Paton 2003 in Bourke and Powell 2004, Reeves *et al.* 1999, Miller, 2009). Less reliable records have also been collated for Fraser’s dolphin, common dolphin, and the pygmy sperm whale (Reeves et al. 1999, UNEP-WCMC 2003).

Table 1: Summary of cetacean species reported in Fijian waters.

Family	Scientific name	Common name
SUBORDER MYSTICETI (baleen whales or mysticetes)		
Family Balaenopteridae	<i>Balaenoptera musculus</i> *	Blue whale
	<i>Balaenoptera physalus</i>	Fin whale
	<i>Balaenoptera</i> spp.	Minke whales <sup>3</sup>
	<i>Balaenoptera</i> sp. 2	‘Bryde’s-like’ whales <sup>4</sup>
	<i>Megaptera novaeangliae</i>	Humpback whale
SUBORDER ODONTOCETI (toothed whales or odontocetes)		
Family Physeteridae	<i>Physeter macrocephalus</i>	Sperm whale
Family Kogiidae	<i>Kogia breviceps</i> *	Pygmy sperm whale
Family Delphinidae	<i>Steno bredanensis</i> *	Rough-toothed dolphin
	<i>Tursiops</i> sp.	Bottlenose dolphin – (could have been <i>T.tursiops</i> or <i>T.aduncus</i> )
	<i>Stenella attenuata</i>	Pantropical spotted dolphin
	<i>Stenella longirostris</i>	Spinner dolphin
	<i>Delphinus</i> sp. *	Common dolphin – ( could have been a long – beaked or short – beaked common dolphin)

<sup>3</sup> Due to difficulties in at sea species subspecies identification and historical differences in taxonomic classification – all Minke whale species and subspecies are listed together.

<sup>4</sup> Due to difficulties in at sea species and subspecies identification and recent changes to taxonomic classifications – all Bryde’s whales, Eden’s whales, and Sei whales are listed together.

	<i>Lagenodelphis hosei</i> *	Fraser's dolphin
	<i>Pseudorca crassidens</i>	False killer whale
	<i>Orcinus orca</i> *	Killer whale
	<i>Globicephala macrorhynchus</i>	Short-finned pilot whale
Family Ziphiidae	<i>Mesoplodon densirostris</i>	Blainville's beaked whale

\*unconfirmed record

#### References:

- Bourke, D. and S. Powell. 2004. Australia. Progress Report on Cetacean Research, January 2003 to December 2003, with statistical data for the calendar year 2003.
- Carwardine, M. 2002. Whales, dolphins and porpoises. Dorling Kindersley Publishing, Inc. New York, NY.
- Dawbin, W. H. 1956. Whale marking in South Pacific waters. *Norsk Hvalfangsttidende* 9: 485-508.
- Dawbin, W. H. 1959. New Zealand and South Pacific whale marking and recoveries to the end of 1958. *Norsk Hvalfangsttidende* 48(5): 213-238.
- Gibbs, N. and D. Paton. 2003. Preliminary report on the survey of whales and dolphins in the Lomaiviti Island group of Fiji August-September 2003. Report to Australian Department of Environment and Heritage and Fijian Department of Environment.
- Kasamatsu, F., S. Nishiwaki, and H. Ishikawah. 1995. Breeding areas and southbound migrations of southern minke whales *Balaenoptera acutorostrata*. *Marine Ecology Progress Series* 119(1-3): 1-10.
- Kanda, N., M. Goto, H. Kato, M.V. McPhee and L.A. Pastene. 2007. Population genetic structure of Bryde's whales (*Balaenoptera brydei*) at the inter-oceanic and trans-equatorial levels. *Conservation Genetics* 8: 853-864.
- Kawamura, A. 1980. Food habits of the Bryde's whales taken in the South Pacific and Indian Oceans. *Scientific Reports of the Whales Research Institute* 32: 1-23.
- Leslie, M S., A. Batibasaga, D. S. Weber, D. Olson, and H. C. Rosenbaum. 2005. First record of Blainville's beaked whale *Mesoplodon densirostris* in Fiji. *Pacific Conservation Biology* 11(4): 302-304.
- Miller, C. 2009. Current State of Knowledge of Cetacean Threats, Diversity and Status in the Pacific Islands Region (Revised 2009) - UNEP/CMS/PIC2/Inf.6-01. Second Meeting of the Signatories for the Convention of Migratory Species Memorandum of Understanding for the Conservation of Cetaceans and their habitats in the Pacific Islands Region. July 28-29<sup>th</sup> 2009, Auckland, New Zealand.
- Ohsumi, S. 1978. Provisional report on the Brydes whales caught under special permit in the Southern Hemisphere. Report of the International Whaling Commission 28:281-287.
- Ohsumi, S. 1979a. Bryde's whales in the North Pacific in 1977. *Report of the International Whaling Commission* 29: 265-266.
- Ohsumi, S. 1979b. Provisional report of the Bryde's whales caught under special permit in the southern hemisphere in 1977/78 and a research programme for 1978/79. *Report of the International Whaling Commission* 29: 267-273.
- Paton, D., A. Batibasaga, S. Sharma, W. O'Connor and N. Nand. 2009. Report of the Whale and Dolphin Survey undertaken in the Lomaiviti Island Group, Fiji 2008. Unpublished report, 31 p.

- Paton, D. and N. J. Gibbs. 2002. Documented and anecdotal cetacean sightings, 1761-2001, in the Samoa, Fiji, Vanuatu and Solomon Island regions.
- Paterson, R.A., P. Paterson and D. H. Cato. 2001. Status of humpback whales, *Megaptera novaeangliae*, in east Australia at the end of the 20th century. *Memoirs of the Queensland Museum* 47: 579–586.
- Ralogaivau, T, 2009. Giant Whale dies, villagers share 34 tabua. Fiji Times, retrieved on 15<sup>th</sup> September 2009 from [www.fijitimes.com/story.aspx?id=127899](http://www.fijitimes.com/story.aspx?id=127899)
- Reeves, R. R., S. Leatherwood, G. S. Stone and L. G. Eldredge. 1999. Marine Mammals in the Area served by the South Pacific Regional Environment Programme (SPREP). South Pacific Regional Environment Programme (SPREP), Apia, Samoa.
- SPWRC (South Pacific Whale Research Consortium). 2009. Report of the Annual Meeting of the South Pacific Whale Research Consortium, Auckland, New Zealand: 9-12 February 2009. IWC Scientific Document SC/61/SH15.
- Townsend, C. H. 1931. Where the nineteenth century whaler made his catch. *New York Zoological Society* 34(6): 173-179.
- Townsend, C. H. 1935. The distribution of certain whales as shown by logbook records of American whalships. *Zoologica* 19: 1-50.
- UNEP-WCMC (United Nations Environment Programme – World Conservation Monitoring Centre). 2003. Checklist of mammals listed in the CITES appendices and in EC regulation 338/97. 6<sup>th</sup> Edition. JNCC Report No. 342.

## Biodiversity of Molluscs in Fiji

### Siteri Tikoca

The phylum Mollusca represents a large group of organisms inhabiting areas ranging from freshwater, marine and terrestrial environments. Molluscs are a highly diverse in size, anatomical structures and behavior; it is difficult to class them under similar characteristics that would define all of its members. Gilchrist, over the past 40 years, had collected and compiled over 7,000 specimens including 760 species of Fijian bivalves and gastropods which are held at the Smithsonian Institute (Morris, 1998) and the most recent information on bivalves from the Great Astrolabe Reef was compiled by Joan Koven. As molluscs classification are relatively well known they are briefly summarized below.

Molluscum contains ten classes of which two are extinct (Heliconellouda and Rostroconchia) (see Table 1). The gastropods (class Gastropoda) are by far the most numerous group accounting for 80% of the phylum. The cephalopods (Cephalopoda) including squids, cuttlefish and octopus are among the most advanced in terms of there anatomical structure (Wikipedia projects, 2009).

Table 1 lists the ten molluscan classes and their key characteristic and distribution

<b>Class</b>	<b>Major organisms</b>	<b>Distribution</b>
Caudofoveata	They are small, worm-like, lacking shells or distinct muscular foot, have scales and calcareous spines called sclerites, for movement.	seabed : 200–3,000 meters (660–9,800 ft)
Aplacophora	solenogasters, small, shell-less worm-like marine organisms	seabed 200–3,000 meters (660–9,800 ft)
Polyplacophora	Chitons. Has a shell which is composed of eight separate shell plates or valves.	rocky tidal zone and seabed
Monoplacophora	They have cap-like shells i.e. single, flat, rounded bilateral shell that is often thin and fragile. (a limpet-like organisms)	seabed 1,800–7,000 meters (5,900–23,000 ft); one species 200 meters (660 ft)
Gastropoda	Are the most diversified class accounting for 80% of the whole phylum. Includes abalone, limpets, conch, nudibranchs, sea hares, sea butterfly, snails, slugs	marine, freshwater, land
Cephalopoda	Characterized by a bilateral body symmetry, a prominent head, and a modification of the muscular foot into arms or tentacles. Includes squid, octopus, cuttlefish, nautilus	Marine
Bivalvia	Marine and freshwater mollusc species, including	marine, freshwater

	scallops, clams, oysters and mussels. They possess a shell consisting of two rounded plates called <i>valves</i> joined at one edge by a flexible ligament called the <i>hinge</i> .	
Scaphopoda	Marine molluscs. Molecular data suggests that the scaphopods are a sister group to the cephalopods. Includes Tusk shells	marine 6–7,000 meters (20–22,970 ft)
Rostroconchia	Extinct molluscs dating from the early Cambrian to the late Permian. Fossils suggest that they are probable ancestors of bivalves	Marine
Helcionelloida	Extinct group of ancient molluscs which are the oldest known conchiferan mollusc fossils; snail-like organisms such as <i>Latouchella</i>	Marine

The term *mollusc* is derived from the French *mollusque*, which originated from the Latin *molluscus*, from *mollis*, soft. *Molluscus* was itself an adaptation of Aristotle's τὰ μαλάκια, ‘the soft things’, which he applied to cuttlefish (Wikipedia Projects, 2009).

Gubanov *et al* (2003) stated that molluscs are generally regarded as members of Lophotrochozoa (including Brachiopods), a group defined by having trochophore larvae and, in the case of living Lophotrochozoa, a feeding structure called a lophophore. The other members of the Lophotrochozoa are the annelid worms and seven marine phyla.



## Bivalves

### Joan Koven and Siteri Tikoca

Bivalves are marine and freshwater molluscs that include scallops, clams, oysters and mussels. They possess a shell consisting of two rounded plates called valves joined at one edge by a flexible ligament called the hinge (Wikipedia projects, 2009).

A list compiled by Parkinson in 1982 listed 102 species of Bivalves from 25 families from Viti Levu and its adjacent Islands. An investigation regarding their biogeographic distribution in the region showed a total of 145 species belonging in 18 families (Morris, 2006). However, the latest study done by Koven in 1992 in the Great and North Astrolabe Reef indicated a total of 28 families, 68 genera and 181 species.

Table 1.1 illustrates the different taxonomic classifications and the total number of individuals (species) of molluscs that fall under the class Bivalvia.

Class	Order	Family	Genus	Species
Bivalvia	Arcoida	Acteonidae	3	14
		Glycymerididae	2	3
	Limoida	Limidae	2	6
	Mytiloida	Mytilidae	4	8
	Ostreoida	Gryphaeidae	2	2
		Ostreidae	3	4
		Plicatulidae	1	3
		Placunidae	1	1
		Pectinidae	8	13
		Spondylidae	1	15
	Pterioda	Pinnidae	3	4
		Isognomonidae	1	2
		Malleidae	1	1
		Pteriidae	3	10
	Veneroida	Trapeziidae	1	5
		Cardiidae	5	11

		Carditidae	1	1
		Chamidae	1	7
		Fimbriidae	1	1
		Lucinidae	4	7
		Mactridae	1	1
		Mesodesmatidae	1	1
		Donacidae	1	2
		Psammobiidae	2	7
		Semelidae	2	2
		Tellinidae	2	21
		Tridacnidae	2	4
		Veneridae	9	26
Total			68	182

# Brachiopods of the Fiji Islands

Maria A. Bitner & Posa A. Skelton

## Introduction

Brachiopods are one of the oldest groups of marine invertebrates dating back to the Cambrian period (550 million years ago). About 350 living species have been described, in contrast to over 26,000 fossil species known. They are exclusively marine species that resemble bivalves in having two shells.

The earliest brachiopod records from Fiji were those of Woodward (1855), Davidson (1880) and Thomson (1927), who reported *Lingula anatina* Lamarck, 1801 and *Rhychonella grayi* [= *Basiliolella grayi*] (Woodward, 1855). Other notable reports of Fiji brachiopods were of Cooper (1978), Ladd (1934), Eliot (1961) and more recently the work of French researchers on Musorstom 10 and Bordau 1 from 1998 to 1999. Brachiopods from the French research were identified and published by Bitner (2006, 2008).

A total of 27 Brachiopod species are attributed to the Fiji fauna (Table 1.2), of which nine have type localities in Fiji. Whether these nine species are exclusive to the Fiji fauna remains to be validated pending further research of neighboring countries. The remaining species have a South-west Pacific biogeographic distribution.

Table 1.2 Brachiopods of Fiji

Phylum	Class	Order	Family	Genus	Species	Authority	Comments
Brachiopoda	Lingulata	Lingulida	Lingulidae	<i>Lingula</i>	<i>anatina</i>	Lamarck, 1801	Include <i>Lingula</i> sp. reported by Bitner 2008
		Craniida	Craniidae	<i>Novocrania</i>	sp.		May prove to be a new species (cf. Bitner 2008)

	Rhynchonellata	Rhynchonellida	Cryptoporidae	<i>Cryptopora</i>	<i>maldivensis</i>	Muir-Wood, 1959	Bitner (2008)
			Basiliolidae	<i>Basiliola</i>	<i>lucida</i>	(Gould, 1862)	Bitner (2008)
				<i>Basiliola</i>	<i>roddai</i>	Cooper, 1978	
				<i>Basiliola</i>	<i>beecheri</i>	(Dall, 1895)	Bitner (2008)
			Dyscoliidae	<i>Abyssothyris</i>	<i>wyvillei</i>	(Davidson, 1878)	Bitner (2008)
				<i>Abyssothyris</i>	<i>briggsi</i>	Cooper, 1978	
				<i>Xenobrochus</i>	<i>rotundus</i>	Bitner, 2008	Type locality: Lau Ridge
			Terebratulidae	<i>Dallithyris</i>	<i>pacifica</i>	Bitner, 2006	Type locality: Bligh Water
			Cancellothyrididae	<i>Terebratulina</i>	<i>japonica</i>	(GB Sowerby, 1846)	Bitner (2008)
				<i>Terebratulina</i>	<i>waimanensis</i>	Ladd, 1934	
				<i>Terebratulina</i>	<i>australis</i>	Bitner, 2006	Type locality: Lau Ridge
				<i>Terebratulina</i>	<i>reevei</i>	Dall, 1920	Bitner (2008)
			Chlidonophoridae	<i>Eucalathis</i>	<i>rugosa</i>	Cooper, 1973	Bitner (2008)
			Aulacothyropsidae	<i>Falla</i>	<i>neocaledonensis</i>	Laurin, 1997	Bitner (2008)

			<i>Septicollarina</i>	sp.		According to Bitner (2008) - need more material	
			Frenulinidae	<i>Frenulina</i>	<i>sanguinolenta</i>	(Gemlin, 1791)	Bitner (2008)
			Megathyrididae	<i>Argyrotheca</i>	sp.		Bitner (2008)
			Platidiidae	<i>Amphithyris</i>	<i>buckmani</i>	Thomson, 1918	Bitner (2008)
				<i>Leptothyrella</i>	<i>fijiensis</i>	Bitner, 2008	Type locality: Bligh Water
			Daliinidae	<i>Dallina</i>	<i>triangularis</i>	Yabe & Hatai, 1934	Bitner (2008)
				<i>Dallina</i>	<i>vitilevensis</i>	Ladd, 1934	
				<i>Nipponithyris</i>	<i>Lauensis</i>	Bitner, 2008	Type locality: Lau Ridge
				<i>Nipponithyris</i>	<i>Fijiensis</i>	(Elliott, 1961)	Homonym: <i>Abyssothyris fijiensis</i>
				<i>Campages</i>	<i>Ovalis</i>	Bitner, 2008	Type locality: Lau Ridge

		Thecideid a	Thecidellini dae	<i>Thecidell ina</i>	<i>Maxilla</i>	(Hedle y, 1899)	May include species <i>Thecidel lina</i> sp. reported by Cooper (1978) from Fiji
--	--	----------------	---------------------	--------------------------	----------------	-----------------------	---

## Gastropods

### Joan Koven and Siteri Tikoca

Gastropods are the most diversified class accounting for 80% of the whole phylum. The class includes abalone, limpets, conch, nudibranchs, sea hares, sea butterfly, snails, slugs. They acquire habitats in freshwater, estuarine and marine habitats.

Studies carried out in 1990 by Brodie and Brodie listed a total of 253 species of opisthobranchs (shell – less molluscs) mainly collected from southern Viti Levu. Out of which the major orders were: Nudibranchia with 162 species, Cephalaspidae with 43 species, sacoglossa with 27 species, Notospida with 7 species, and orders Entomotaeniata and Anaspida with 6 species respectively (Morris, 2006).

Recent studies carried out in the Great Astrolabe Reef by Koven from 1986 – 2006 has the records of the following gastropods on the reef which totaled up to 536 of marine gastropod species from 141 genera as shown in Table 1.3 below. The data represented in the table does not include Terrestrial gastropods.

Table 1.3: Marine Gastropods of Fiji

Class	Order	Family	<i>Genus</i>	<i>Species</i>
Gastropoda	Patellogastropoda	Patellidae	2	2
	Docoglossa	Haliotidae	1	5
	Vetigastropoda	Fissurellidae	4	5
		Neritidae	1	5
		Neritopsidae	1	1
		Stomatellidae	3	5
		Trochidae	9	18
		Turbinidae	6	14
	Sorbeoconcha	Strombidae	4	22
	Neotaenioglossa	Cerithiidae	1	1
		Modulidae	1	2
		Planaxidae	1	2
		Siliquariidae	2	4

		Vermetidae	2	4
		Littorinidae	1	3
		Vanikoridae	2	2
		Rissoidae	1	2
		Triphoridae	1	1
		Eulimidae	1	1
		Thycidae	1	1
		Epitoniidae	3	20
	Neogastropoda	Buccinidae	1	19
		Nassariidae	3	12
		Columbellidae	6	26
		Fasciolaridae	1	76
		Conidae	2	6
		Drillidae	2	19
		Terebridae	8	19
		Turridae	1	2
		Cancellariidae	1	38
		Costellariidae	5	44
		Mitridae	1	8
		Olividae	23	6
		Muricidae	1	2
		Harpidae	1	3
		Turbinellidae	2	14
	Neomesogastropoda	Naticidae	1	50
		Cypraeidae	2	2
		Ovulidae	2	10
		Bursidae	1	2
		Cassidae	3	15



		Ranellidae	2	2
		Tonnidae	1	1
		Capulidae	3	5
		Hipponicidae	2	2
		Ficidae	1	1
		Lamellaridae	3	5
		Trividae	1	1
	Heterostropha	Architechtonicidae	1	1
	Pyramidelloida	Pyramidellidae	1	1
	Cephalaspidea	Acteonidae	2	4
		Haminoeidae	2	4
		Hydatinidae	2	3
		Bullidae	1	2
	Archaeapulmonata	Ellobiidae	1	2
	Besommatophora	Siphonariidae	1	2
	Nautilida	Nautilidae	1	2
	Sepioida	Spirulidae	1	5
Total			141	536

**Cone Shells – Conidae**  
**Johnson Seeto and Siteri Tikoca.**

Conidae is the scientific name given to cone shells or snails which are sophisticated predatory sea snails, marine gastropod molluscs.<sup>[1]</sup> Coneshells are dominated by one genus, *Conus*, which has about 500 living species world wide with a record of 99 living species in Fiji. The shells of cone snails are shaped roughly like an ice-cream cone. The narrow end of the cone shell is the anterior end, and the wide end shows the usually very low spire of the gastropod shell.

Many studies have been previously carried out of *Conus* but the recent being that carried out by Seeto (1998). Previous studies include that done by Cernohosky in years 1964 and 1978 whereby he listed 80 species of *Conus* in 1964 from his collections and also from literature. Lewis in 1973 confirmed 85 living species, whereas Koven (1991, 1997) also confirmed *Conus* species from the Great Astrolabe Reef. Seeto in 1998 confirmed a total of 99 living *Conus* species, 29 fossilized conus species. Fossilized conus species had been previously noted by a couple of people some of which include Ladd (1934), Salva et al. (1976), Cernohorsky (1978b), Gilchrist (1984, 1987). In addition, from studying literature Seeto (1998) proposed that there 17 other living conus species which have been proposed to most likely be in Fiji, out of which he is certain that seven are present in Fiji. The summary of the number of total living and fossilized conus species recorded by Seeto in 1998 is summarized in Table 1.7 below.

Table 1.7 illustrates the different taxonomic classifications and the total number of individuals (species) of molluscs that fall under the genera *Conus*.

Division/Class	Genera	No. Confirmed Living Species	No. sp. possibly Found in Fiji	No. fossilised sp.	TOTAL
Gastropoda	<i>Conus</i>	99	17	29	145

## **Biodiversity of Cowries (Cypraeidae) in Fiji**

### **Johnson Seeto and Siteri Tikoca**

Cowries or cowry shells are the common name given to Cypraeidae which is a taxonomic family of small to large sea snails. These are marine gastropod molluscs in the superfamily Cypraeoidea (Wikipedia projects, 2009).

Cypraeidae have adult shells which are very rounded, almost like an egg; they do not look like a typical gastropod shell. In virtually all of the species in the family Cypraeidae, the shells are extremely smooth and shiny. This is because in the living animal, the shell is nearly always fully covered with the mantle.

For nearly 200 years, every species in the family Cypraeidae was placed in one genus, *Cypraea*, but recently the cowries have been divided into many different genera (Wikipedia projects, 2009). However according to Seeto (peers Comm, 2009) the various cowries have been divided into different sub genus according to their shapes however they all still come under just one genus.

Many studies have been carried out of molluscs (including cowries) in the Pacific and also including Fiji. The most recent study of cowries would be the annotated checklist living and fossilized cowries in Fiji by Johnson Seeto in 2001 mostly from his own shell collections and from literature. Seeto (2001) described 75 species of cowries which he believes is or was found in Fiji at a certain time( confirmed species), and he also mentions 18 other cowries that could possibly be in Fiji or the ones that he believes were probably mistakenly identified (unconfirmed species). However, prior to the mentioned study, there were many other previous studies conducted of cowries in Fiji and the Pacific. Such studies include that done by Schilder and Schilder in the year 1939 (describing 49 species in the Samoa – Fiji region), whereas Steadman and Cotton in 1943 described 61 species and re – described many of the cowries found in Fiji putting them in different subspecies names. Cernohosky in years 1964, 1967 and 1978 described 57 species (he had an extensive collection of marine molluscs including cowries from the group) and Iredale (1935).

The summary of the number of total living and fossilized cowries recorded by Seeto in 2001 is summarized in Table 1.8 below.

Table 1.8 illustrates the different taxonomic classifications and the total number of individuals (species) of molluscs that fall under the genera *Cypraea*.

Division/Class	Family	Genera	No.sp. confirmed of living fossilized Species	and	No. sp. Possibly Found or mistakenly identified in Fiji	TOTAL
Gastropoda	Cypraeidae	<i>Cypraea</i>	75		18	93

## References

Bitner, M.A. 2006. Recent Brachiopoda from the Fiji and Wallis and Futuna Islands, South-West Pacific. In Richer De Forges B. & Justine, J.-L (eds). Tropical Deep-Sea Benthos, vol. 24. Memoires du Museum national d'Histoire naturelle 193: 15-32. Paris ISBN: 2-85653-585-2.

Bitner, MA. 2008. New data on the recent brachiopods from the Fiji and Wallis and Futuna Islands, South-West Pacific. *Zoosystema* 30(2): 419-461

Brusca, R.C., and Brusca, G.J. (2003). Invertebrates (2 Ed.). *Sinauer Associates*. pp. 702. ISBN 0878930973.

Cooper, G.A. 1978. Tertiary and Quaternary brachiopods from the Southwest Pacific. *Smithsonian Contributions to Paleobiology* 38: 1-23.

Cowie, Robert H. (1998) Catalog of the Nonmarine Snails and Slugs of the Samoan Islands. Bishop Museum Bulletin in Zoology 3 Bishop Museum Press, Honolulu 1 - 122.

Davidson, T. 1880. Report on the Brachiopoda dredged by H.M.S. Challenger during the years 1873-1876. *Report of the Scientific Results of the voyage of HMS Challenger (Zoology)* 1: 1-67.

Elliott, G.F. 1961. Appendix. A fossil species referred to *Abyssothyris*, in Muir-Wood, H. (ed.). Homeomorphy in recent Brachiopoda: *Abyssothyris* and *Neorhynchia*. *Annals and Magazine of Natural History*. Series. 13, 3: 526.

Garratt, A. (1887) On the terrestrial molluscs of the Viti Islands. Proceedings of the Zoological Society, London part 1, 164 - 184, part 2, 284 - 316.

Germain, L. (1932) La faune malacologique des^iles Fiji.

Annales de L'institut Oceanographique. 12(2), 39 – 63

Giribet, G., Okusu, A., Lindgren, A.R., Huff, S.W., Schrödl, M., and Nishiguchi, M.K. (May 2006). "Evidence for a clade composed of molluscs with serially repeated structures: Monoplacophorans are related to chitons". Proceedings of the National Academy of Sciences of the United States of America 103 (20): 7723–7728. doi: [10.1073/pnas.0602578103](https://doi.org/10.1073/pnas.0602578103). <http://www.pnas.org/content/103/20/7723.full>. Retrieved 2008-09-30.

Gubanov, A.P., and Peel, J.S. (2003). "The early Cambrian helcionelloid mollusc *Anabarella Vostokova*". *Palaeontology* 46 (5): 1073–1087. doi:[10.1111/1475-4983.00334](https://doi.org/10.1111/1475-4983.00334).

Haynes. A. (1998) Fiji Biodiversity Strategy and Action Plan, Technical Group 2 – Terrestrial Vertebrates and Invertebrates (Unpublished).

- Koven, J. F. (2006). Molluscan Biodiversity of Fiji's Great and North Astrolabe Reefs from 1986 – 2006. School of Marine Studies Collection, University of the South Pacific, Suva, Fiji.
- Little, L., Fowler, H.W., Coulson, J., and Onions, C.T., Ed (1964). "Mollusca". Shorter Oxford English Dictionary. *Oxford University Press*.
- Little, L., Fowler, H.W., Coulson, J., and Onions, C.T., Ed (1964). "Malacology". Shorter Oxford English Dictionary. *Oxford University press*.
- Morris.C.W. (1998). *Marine Biodiversity Technical Report*. Fiji Biodiversity Strategy and Action Plan. (Unpublished Report)
- Ladd, H.S. 1934. Geology of Vitilevu, Fiji. *Bernice P. Bishop Museum Bulletin*. 119: 1-263.
- Ruppert, E.E., Fox, R.S., and Barnes, R.D. (2004). Invertebrate Zoology (7 Ed.). *Brooks / Cole*. pp. 284–291. ISBN 0030259827.
- Schwabe, E., Sirenko, B. I. & Seeto, J. (2008). *A checklist of Polyplacophora (Mollusca) from the Fiji islands*. *Zootaxa 1777: 1–52*.
- Solem, A. (1959) Systematics and zoogeography of the land and freshwater Mollusca of the New Hebrides. *Fieldiana : Zoology* Vol. 43,1, Chicago Natural History Museum 1 - 359.
- Solem, A. (1978) Land snails from Mothe, Lakemba and Karoni Islands, Lau Archipelago, Fiji. *Pacific Science*, vol 32, 1, 39-45.
- Seeto, J (1998), An update on the Living and Fossil cone shells (Gastropoda: Conidae) of Fiji. University of the South Pacific, Fiji.
- Seeto, J (1998), An annotated checklist of the Living and Fossil cowries (Gastropoda: Cypraeidae) of Fiji, University of the South Pacific, Fiji.
- THE PAPUSTYLA - Manua Land Snail Society
- Parkinson, B. 1988. Collecting in Fiji 8, P. 13
- Parkinson, B. 1990. Notes on the Fiji land snail fauna 9, p. 2-3.
- Potter, D. 1989. Fijian Land snails. A check list for Mana Island 7, p. 9-10.
- Tregenza, K. Variations in Fijian Placostylus. 11, p10
- Wikipedia Projects, retrieved on 29<sup>th</sup> October 2009, from <http://en.wikipedia.org/wiki/Snail>
- Wikipedia Projects, retrieved on 6<sup>th</sup> September 2009, from <http://en.wikipedia.org/wiki/Mollusca>
- Woodward, S.P. 1855. Description of a new species of recent *Rhynchonella*. *Annals and Magazine of Natural History*. Series 2, 16: 444

## Hard Corals of Fiji

### Edward Lovell & Siteri Tikoca

Corals are grouped under the Phylum Coelenterata in the Class Anthozoa, which are divided into two subclasses, depending on the number of tentacles. Those with eight tentacles are called the octocorallia, or Alcyonaria, which include soft corals, blue coral, sea fans and sea pens. Those with six or a multiple of six tentacles are called the Hexacorallia or Zoantharia. This group comprises the reef-building corals, sea anemones, and zoanthids. This account deals with the hard or stony corals which represent the reef building corals of Fiji. They mostly belong to the Order Scleractinia but also several other taxonomic entities within the Coelenterates which secrete hard skeletons. Hard corals usually dominate the reef community providing habitat both in terms of morphologic relief and material for reef construction. (Morris and Pratt, 1998).

In addition to the hard corals, crustose coralline algae play a fundamental role in reef formation through cementing the corals together. Coral reefs are among the most biologically diverse of communities on earth. They play an important role in coastal protection, as a source of food security for local communities, as an important resource for tourism, and as a potential source of biologically active compounds for the production of pharmaceuticals.

A reference collection of Fijian stony corals is housed at the University of the South Pacific. It was commenced by Carlson, Beveridge and Gawel in 1974. A total of 212 species are represented by voucher specimens in the USP collections. The identifications of these corals were later revised in 1980 by Pichon to conform to the taxonomy in the Australian Institute of Marine Science (AIMS) monograph series, *Scleractinia* of Eastern Australia (Veron and Pichon 1976, 1979, 1982; Veron Pichon & Wijsman – Best 1977; Veron & Wallace 1984). Identifications of the genera *Acropora*, *Montipora*, *Anacropora* and *Astreopora* are incomplete and the *Acroporidae* has yet to be revised. However Veron 1990 a,b described 50 genera and 144 species (Morris and Pratt, 1998).

From the reference collection and field survey, Lovell and McLardy (2008) recorded 342 species within 72 genera of Scleractinian hard corals in Fiji. Of these, ahermatypic (non reef building corals) Scleractinia comprise six species within four genera; the remainders are hermatypic (reef building corals). A further 12 non-Scleractinian species within five genera also occur. Fiji is the type locality for 47 species which is largely the result of collections made by Dana (1846) during the United States Exploring Expedition 1838-1842, the specimens of which are currently been held at the Smithsonian Museum in Washington DC, USA (Lovell and McLardy, 2008).

The following list was abstracted from the CITES administered corals of Fiji and summarizes information drawn from publications, reports and coral export records (Lovell, 2002a; Obura and Mangubhai 2003; Lovell, 2005; Fenner, 2006; Bonito (in prep), Fiji Fisheries records (unpublished); Veron, 1993; 2000; Wallace, 1999) and museum voucher specimens from the University of the South Pacific marine collection and the Museum of Tropical Queensland (Wallace 1999; Pichon 1980; Lovell 2005), with additions from the Smithsonian National Museum of Natural History (NMNH). Unregistered specimens represent identified material from the Cakaulevu/North Vanua Levu expedition (Jenkins *et al.*, 2004), which will be incorporated into the collections of the University of the South Pacific. Zann and Boulton (1985) described the distribution of the blue coral, *Heliopora coerulea*, which is common in the isolated northern Fijian island of Rotuma (approx. 300nm north of the main island group) and which was recently found in the main archipelago (Lovell and McLardy, 2008).

The Fiji hard coral list (see table below) also includes a compilation of data derived from species surveys from around Viti Levu and includes locations to the west and north of Vanua Levu (Lovell and McLardy, 2008). Important areas such as Rotuma (Gardiner, 1898) and the extensive Lau Group (Hoffmeister, 1945; Phipps and Preobrazhensky 1977; Salvat *et al.*, 1997) have received limited study with regard to species occurrence. Viti Levu is the centre of the aquarium trade collection where most of the surveys were undertaken, so Table 1 is considered to include all those species that could be potentially traded within the quota framework.

The presence of a voluntary export quota, submitted to the CITES Secretariat by an exporting Party, can be an important component of a non-detriment finding for both the exporting country and for an importing Party (should one be required by their stricter measures). Additionally, two resource surveys assessing the number of corals within CITES categories were undertaken.

Scleractinian coral species number found in Fiji were observed to approach that predicted by Veron (2000) totaling 354 species.

There have been numerous predictions with relevant field records to support them. However there remain some predictions which are unsupported by field records, and some records of species presence which were not predicted by Veron (Lovell and McLardy, 2008). Of those predictions of species occurrences in Fiji (without field records), 27 are also not found in adjacent countries in the central southwest Pacific and so are unlikely to occur in Fiji (see Table below).

Summary of Records from Fiji of CITES-listed hard corals :

Class	No. Orders	No. Families	No. Genera	No. Species
Anthozoa	3	19	74	344
Hydrozoa	2	3	3	10
TOTALS	5	22	79	354

## References

BONITO, V. (in prep) Coral species listing. Enhancement of Marine Biodiversity Conservation Efforts in Votua Village, Fiji Islands. Regional Natural Heritage Programme, Dept. of Environment and Water Resources.

DANA, J.D. 1846. *Zoophytes, United States Exploring Expedition 1938-1942. Vol. VII.* Smithsonian Museum. Available from: <http://www.sil.si.edu/DigitalCollections/usexex> [Accessed 30 June, 2007]

FENNER, D. 2006. Coral diversity survey: Mamanuca Islands and Coral Coast, Fiji, 2005 For Coral Cay Conservation and the University of the South Pacific. *Institute of Applied Science* No. 2005/10

- GARDINER, J.S. 1898. The coral reefs of Funafuti, Rotuma and Fiji, together with some notes on the structure and formation of coral reefs in general. *Proc. Cambridge Phil. Soc.* 9: 417-503.
- HOFFMEISTER, J.E. 1945. Corals. In: Hoffmeister, J.E. and Ladd, H.S. Geology of Lau, Fiji: *Bulletin Bernice P. Bishop Museum* 81; 171: 8(2): 70-159; 298-311.
- JENKINS, A., SYKES, H., SKELTON, P., FIU, M., & LOVELL, E. (2004). *Fiji's Great Sea Reef: The first marine biodiversity survey of Cakaulevu and associated coastal habitats*. WWF Fiji Country Programme, Suva.
- LOVELL, E.R. 2002a. The Coral Reefs of Yadua Island, Bua, Fiji. Report submitted to the National Trust of Fiji as part of the Greenforce Program U. K. Unpublished report.
- LOVELL, E.R. & McLardy, C, 2008. Annotated checklist of the CITES-listed corals of Fiji with reference to Vanuatu, Tonga, Samoa and American Samoa, JNCC Report No. 415.
- MORRIS C. W, & PRATT C, 1998. Fiji Biodiversity Strategy and Action Plan. Marine Biodiversity Technical Group Report. 1998. Unpublished Report.
- OBURA, D. & MANGUBHAI, S. 2003. Marine Biological Survey Report of the Great Astrolabe Reef, Ono Kadavu. Fiji Barrier Reef Ecoregion, Fiji Islands. WWF South Pacific Programme. 64 pp.
- PICHON, M. (unpubl). University of the South Pacific Coral Collection, May 1980: Specimen Catalogue. Institute of Marine Resources. Unpublished report
- PHIPPS, C.V.G. & Preobrazhensky, B.V. 1977. Morphology, development and general coral distribution of some reefs of the Lau Islands, Fiji. *Memoirs du Bureau de Recherches Géologiques et Minières*,. 89, 440-445.
- SALVAT, B., RICHARD, G, TOFFART, J.L , RICARD, M & GALZIN, R. 1977. Reef Lagoon Complex of Lakemba Island (Lau Group, Fiji) Geomorphology, Biotic Associations and Socio-Ecology. *Proceedings of the Third International Coral Reef Symposium*. 2L, 297-303.
- VERON, J.E.N. 1993. A Biogeographic Database of Hermatypic Corals. Species of the Central Indo-Pacific Genera of the World. *Australian Institute of Marine Science Monographic Series* Vol. 10.
- VERON, J.E.N. 2000. *Corals of the World*. . Sci. editor Mary Stafford-Smith, Australian Institute of Marine Science and CRR Qld. Pty. Ltd. 3 Volumes, ISBN 0 642 32236 8, 0 642 32237 6, 0 642 32238 4.
- VERON, J.E.N. & PICHON, M. 1976. Scleractinia of eastern Australia, Part 1: Families Thamnasteriidae, Astrocoenidae, Pocilloporidae. *Australian Institute Marine Science Monograph Series*. 1, 86pp.
- VERON, J.E.N., PICHON, M. & WIJSMAN-BEST, M. 1977. Scleractinia of eastern Australia, Part 2: Families Faviidae, Trachyphyllidae. *Aust. Ins. Mar. Sci., Monogr. Ser.* 3, 232pp.



VERON, J.E.N. & PICHON, M. 1979. Scleractinia of eastern Australia, Part 3 Families Agariciidae, Siderastreidae, Fungiidae, Oculinidae, Merulinidae, Mussidae, Pectinidae, Caryophyllidae, Dendrophylliidae. *Aust. Inst. Mar. Sci., Monogr. Ser. 4*, 422pp.

VERON, J.E.N. & PICHON, M. 1982. Scleractinia of eastern Australia, Part 4: Family Poritidae, *Aust. Ins. Mar. Sci., Monogr. Ser. 5*, 159pp.

VERON J.E.N. & WALLACE C.C. 1984.

WALLACE, C.C. 1999. *Staghorn Corals of the World. A revision of the coral genus Acropora worldwide with emphasis on morphology, phylogeny and biography*. Publ., Collingwood, Australia: CSIRO Publishing. ISBN 0 643 06391 9, 422pp.

ZANN, L.P. & BOULTON L. 1985. The distribution, abundance and ecology of the blue coral *Heliopora coerulea* (Pallas) in the Pacific. *Coral Reefs* 4:125-134.

Appendix 1: General coral reef references pertaining to the central southwest Pacific

BIRKELAND, C., RANDALL, R. & AMESBURY, S. 1994. Coral and reef-fish assessment of the Fagatele Bay National Marine Sanctuary. Report to the National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce. Washington DC.

BOSCHMA, H. 1950. Notes on the coral reefs near Suva in the Fiji Islands. *Proceedings Koninklijke Nederlandse Akademie van Wetenschappen (C)* 53(3),1-6.

CAIRNS, S.D., HOEKSEMA B.W., & VAN DER LAND, J. 1999. List of extant corals. *Atoll Research Bulletin*, 459, 13-45

CUMMING, R., LOVELL, E.R., CARLSON B.A., DULVY, N.K., HUGHES, A., KOVEN, J.F., QUINN, N.J., SYKES, H.R., TAYLOR, O.J.S., TOSCANO, M.A., & VAUGHAN, D. 2001. Geographic extent and severity of mass coral bleaching in Fiji 2000, in relation to seawater temperature. *Proceedings of the 9th International Coral Reef Symposium*, Bali 2002.

DONE, T.J. & NAVIN, K.F. 1990. Vanuatu Marine Resources: Report of a biological survey. Australian International Development Assistance Bureau, *Australian Institute of Marine Science* Publication No. 501

FENNER, D. 2007. Coral diversity survey: Volivoli Beach, Viti Levu and Dravuni and Great Astrolabe Reef, Fiji, 2006. *Institute of Applied Sciences* Technical Report No. 2007/03, The University of the South Pacific.

FISK, D.A. & BIRKELAND, C. 2002. *Status of Coral Communities on the Volcanic Islands of American Samoa : A Re-Survey of Permanent Monitoring Sites*. Report to Dept. Marine & Wildlife Resources, Pago Pago, American Samoa.

FISK, D. & LOVELL, E.R. 2002. Report On The Cites Coral Identification Workshops in Tonga Department of Environment, Nuku'alofa, Tonga, Sponsored by Canada -South Pacific Ocean Development (C-SPOD) and the South Pacific Regional Environment Programme (SPREP).

FISK, D. & LOVELL, E.R. 2003. Management Systems for Corals-in-Trade Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) - Permitting and Coral Specimen Identification Workshop 1. Port Vila, Vanuatu 2. Honiara, Solomon Islands. Unpublished Consultants Report.

FISK, D., LOVELL, E.R & POWER, M. 2003. Management Systems for Corals-in-Trade, CITES - Permitting and Coral Specimen Identification National Training Workshops (Fiji, Tonga, Solomon Islands, Vanuatu). Summary Report. Canada -South Pacific Ocean Development (C-SPOD) and the South Pacific Regional Environment Programme (SPREP).

IT IS. 2007. Integrated Taxonomic Information System. <http://www.itis.gov/> [Accessed 25 January 2008].

KOVEN, J. & PAULAY, G. 1997. Checklist of Coral Species, Great Astrolabe Reefs, Fiji. University of the South Pacific, Marine Studies, Technical Report, *Series Number 97/6*. ISSN 1018-2896, University of the South Pacific.

LITTLER, M.M., LITTLER, D.S., BROOKS, B.L. & KOVEN, J. F. 1997. A unique coral reef formation discovered on the Great Astrolabe Reef, Fiji. *Coral Reefs*, 16(1), 51-54.

LOVELL, E.R. 2001a. Status Report: Collection of coral and other benthic reef organisms for the marine aquarium and curio trade in Fiji. WorldWide Fund for Nature South Pacific Program. WWF 2001.

LOVELL, E.R. 2001b. Status of the Trade in Stony Corals: Republic of Fiji. Workshop on the Trade in Stony Corals Jakarta, Indonesia, April 2001. National Oceanic and Atmospheric Agency.

LOVELL, E.R. 2001c. Coral Bleaching in Fiji: A Reef Check appraisal. Report to the Reef Check Foundation for the University of Rhode Island.

LOVELL, E.R. 2001d. Assessment and monitoring of coral reefs for determining sustainability of collection for the aquarium trade. In Sustainable Management of the Marine Aquarium trade. Pacific Regional Workshop Proceedings. South Pacific Regional Environmental Programme (SPREP).

LOVELL, E.R. 2002b. Submission to the Specialist Group of the CITES Standing Committee - Sustainability and Management (in Fiji's Aquarium Trade). Status report submitted to the CITES Secretariat through the Fiji's European Union Ambassador at the 46th Conference of the Parties (Santiago, Chile) on the state of management in Fiji's Aquarium Trade.

LOVELL, E.R. 2002c. Creation of an Aquarium Fisheries Management Plan (AFMP) for live rock, corals and other benthos in the Walt Smith International collection areas. Unpublished report

LOVELL, E.R. 2003a. Development of an Aquarium Fisheries Management Plan (AFMP) for live corals in the Aquarium Fish, Fiji collection areas. Unpublished report

LOVELL, E.R. 2003c. Baseline and general stock monitoring survey of Motunikeasulua Reefs, Cakauvakababa-i-Yata Reef, Nakubu Reef - East lagoons and reef flat Yakauke Reef. off-shore from Lautoka : August 12 - 14 2003. Report submitted to Walt Smith International. Unpublished report

LOVELL, E.R. 2004a. Monitoring of Coral Collecting Areas for Walt Smith International (Fiji) Ltd. July 2004. Report submitted to Walt Smith International. Unpublished report

LOVELL, E.R. 2004b. Baseline Biological Survey of To'atuga Reef (5 Mile Reef). Report for Pacific Environment Consultants Ltd, Apia, Samoa for the Department of Environment and Conservation, Ministry of Natural Resources and Environment (MNRE). Unpublished report

LOVELL, E.R. 2005. Poster title: Coral Recruitment and Growth in Fiji after the Coral Bleaching in 2000 and 2002. Tropical Biodiversity Okinawa 2005 conference: Asia-Pacific studies on coral reefs and islands. Univ. of Ryukus, Okinawa.

LOVELL, E.R. 2006. Records of Scleractinia from Fiji. *In*: WWF 2006. Marine Biodiversity Survey of Cakaulevu (Great Sea Reef) and Associated Coastal Habitats. Vanua Levu, Fiji, 5-16 December 2004. WWF Fiji, WWF-South Pacific Programme. 207pp.

LOVELL, E.R. & TOLOA, F. 1994 Palolo Deep National Marine Reserve: A Survey, Inventory and Information Report. *South Pacific Regional Environmental Programme: Reports and Studies Series no. 84.*

LOVELL, E.R. & TOLOA, F. 2002. Baseline Biological Survey of Fagaloa Bay with the assessment of changes to the marine environment of the bay in the last twenty years. Afulilo Hydro Electric Power Plant project, commissioned by the Electric Power Corporation (EPC) Apia, Samoa. June 2002. Unpublished report

PARRY-JONES, R. 2004. Fiji's Non-Detriment Finding Methodology for Extraction of and Trade in Marine Aquarium Species. Report by theTraffic Oceania South Pacific Programme to the Govt. of Fiji.

PARRY-JONES, R. 2004. Fiji's Non-Detriment Finding Methodology for Extraction of and Trade in Marine Aquarium Species. Report by theTraffic Oceania South Pacific Programme to the Govt. of Fiji.

- SOUTH, G.R., SKELTON, P.A., DEVANTIER, L., TURAK, E. & LOVELL, E.R. 2003. Marine protected areas and marine biodiversity conservation: case studies from Indonesia and Samoa. Abstract *Pacem in Maribus XXX*, Kiev, Ukraine. October 2003.
- SPALDING, M.D., RAVILIOUS, C., & GREEN, E.P 2001. *World Atlas of Coral Reefs*. Prepared at the UNEP World Conservation Monitoring Centre. University of California Press, Berkeley, USA.
- TAYLOR, O.J.S, HUGHES, A., & LOVELL, E. R. 2002. Greenforce Management Proposal: The Coral Reefs of Yadua and Yadua-Taba. Report for the National Trust for Fiji. Unpublished report
- VERON, J.E.N. 1986. *Coral of Australia and the Indo-Pacific*. Ryde, NSW, Australia: Angus and Robertson.
- VERON, J.E.N. 1990a. Checklist for the hermatypic corals of Vanuatu. *Pacific Science* 44 (1): 51-70.
- VERON, J.E.N. & TURAK, E. 2006. Coral Diversity. In: Green, A., Lokand, P., Atu W., Rhamohia, P., Thomas P. and J. Albany (eds). A Solomon Islands Marine Assessment: Technical report of survey conducted May 13 to June 17, 2004. *TNC Pacific Island countries Report No. 1/06*.
- WALLACE, C. C. 1997. The Indo-Pacific centre of coral diversity re-examined at species level. *Proceedings of the 8th International Coral Reef Symposium* 1: 365-370.
- WALLACE, C.C. & PANDOLFI, J. 1991. Indo-Pacific coral biogeography: a case study from the *Acropora selago* group. *Australian Systematic Botany*. 4:199-210.
- WALLACE, C.C., CHEN, C.A., FUKAMI, H. & MUIR, P.R. 2007. Recognition of separate genera within *Acropora* based on new morphological, reproductive and genetic evidence from *Acropora togianensis*, and elevation of the subgenus *Isopora* Studer, 1878 to genus (Scleractinia: Astocoeniidae; Acroporidae). *Coral Reefs* 26(2), 231-239.
- ZANN, L. & LOVELL, E.R . 1992. The Coral Reefs of the Mamanuca Group, Fiji. Preliminary descriptions and Recommendations for Management. National Environmental Management Project. Report on the Marine Environment. Annex 3, Unpublished report.
- ZANN, L.P., BRODIE, J. & VUKI, V. 1990a. History and dynamics of the crown-of-thorns starfish *Acanthaster planci* (L.) in the Suva area, Fiji. *Coral Reefs* 9: 135-144.

## Seagrasses of the Fiji Islands

**Posa A. Skelton**

### Introduction

#### *What are seagrasses?*

Seagrasses are flowering plants (angiosperms) that grow exclusively in the marine environment. Although some seagrasses resemble terrestrial grasses, they are not related. Seagrasses are polyphyletic and may have derived from land directly, or via rivers and other freshwater bodies. For a plant to be able to survive in a saline environment it needs to be able to grow fully submerged in water, adapt to varying salinity levels, have an anchoring and pollination systems, and compete with other species.

#### *Why are they important?*

Seagrass species often form dense meadows that are nursery and foraging grounds for many commercially important species. The meadows are often inter-linked with other ecological systems such as coral reefs, mangroves and salt-marshes, enabling an incredible flow of energy through the systems. Some seagrass species are preferred food for many culturally important species such as dugongs, marine turtles and waterfowls. Seagrass leaves provide habitats for countless animals and plants, and assist in filtering the water column. Dead seagrass contributes to nutrient cycles.

#### *History of seagrass research in Fiji*

The most comprehensive taxonomic account of the seagrasses of Fiji was provided by den Hartog (1970) as part of his global review of seagrasses. He listed five taxa (*H. ovalis* ssp *ovalis*, *H. ovalis* ssp *bullosa*, *Halodule pinifolia*, *H. uninervis* and *Syringodium isoetifolium*). A.C. Smith (1979) recognised den Hartog's subspecies at the species level; merging *H. ovalis* ssp *bullosa* with *H. minor*. He also recorded *H. pinifolia*, *H. uninervis* and *S. isoetifolium* as well as the brackish-water *Ruppia maritima* var. *pacifica*. McMillan & Bridges (1982) noted the distinctiveness of *Halophila ovalis* ssp *bullosa* suggesting that it may warrant a species ranking. Recently, Skelton & South (2006) updated the nomenclature of seagrasses of Fiji recognising three *Halophila* taxa [*H. ovalis*, *H. ovalis* ssp. *bullosa*, *H. decipiens*], two *Halodule* species [*H. pinifolia*, *H. uninervis*] and *Syringodium isoetifolium*.

#### *Seagrass diversity*

The polyphyletic nature of seagrasses can be seen by their diverse range in shapes and sizes, including strap-like blades found in *Halodule*, the cylindrical strands of *Syringodium* and the paddle-shaped leaves (*Halophila*).

There are 60 seagrass species recognized globally, of which only six are found from Fiji. While most Fijian seagrass species have been known since the early 1960s, the presence of *Halophila decipiens* was only confirmed in 2004. Some seagrass species reported by Spalding *et al.* (2003) and Littler & Littler (2002) from Fiji (*Thalassia*, *Cymodocea*, *Halophila minor* and *H. ovata*) remains doubtful. *Halophila ovalis* subspecies *bullosa* is the only endemic seagrass found only in Fiji, Tonga and Samoa.

#### *Seagrass distribution*

The seagrass flora of the Fiji islands has an Indo-West Pacific affiliation. Fiji and Tonga are the eastern-most limits for *Halodule* species. *Syringodium isoetifolium* and *Halophila decipiens* have a Pacific wide distribution (as far east as French Polynesia and Hawaii), although the latter remains to be recorded for Tonga and Samoa.

The geographic distribution of seagrass in Fiji remains to be adequately documented. A summary of Fiji's seagrass distribution is found in McKenzie & Yoshida (2007). Only a few sites have been studied, mostly by researchers associated with the University of the South Pacific, including students, and visiting scientists. Seagrass are also noted in environmental impact assessment reports undertaken by consultants, research by non-governmental organizations and also during coral reef monitoring work (Fiu, 2004, 2005; Skelton & South 2006; Solandt *et al.* 2002; Solomona *et al.*, 2002; Sykes 2003; Vuki 1994).

Seagrass species zonation is highly variable in that shallow water species can be found in deep waters, and vice versa. *Halophila decipiens* recently discovered in 2004 is perhaps the only truly deep water species in Fiji, and it grows in 10-25 m water. So far it has only been collected from the Cakaulevu Reef. *Halophila ovalis* ssp *bullosa* is often found in the intertidal zones (exposed during low-tides, but submerged at high tides). This species either grows in patches, or intermixed with *Halodule* species in the upper subtidal areas. *Halodule pinifolia* is found mostly in the intertidal, often exposed during low tides, but also grows in subtidal areas. *Halodule uninervis* grows from upper-subtidal to deep waters (30 m). *Syringodium isoetifolium* is mostly subtidal usually in calm places.

#### *Seagrass knowledge gaps*

There are many areas of Fiji that are yet to be surveyed to determine species diversity and population. These areas will need to be mapped and this information utilised for decision making, especially with regards to use and conservation. Despite their important role in the marine ecosystem, very little is known in terms of their condition. With threats from climate change, natural disasters (tsunami and earthquakes) and anthropogenic activities it is important that monitoring of seagrass beds be undertaken, as they can provide early-warning to managers and communities on the state of the coast. Molecular research is needed to support morphological research in confirming species delimitation. Two genera are particularly important – *Halodule* and *Halophila* that require further research. Waycott *et al.* (2004) suggested that *Halodule uninervis* and *H. pinifolia* are con-specific. While their observation was based on Australian material, the Fijian populations of the two species appear quite distinct so that it makes sense to keep them separate. *Halophila ovalis* ssp *bullosa* is quite distinct by the blister-like character on the leaves. Another character is the fewer paired veins (to 7) compared to *H. ovalis sensu stricto* (> 7).

#### References:

- Fiu, M. 2004. Kabara marine baseline biological survey report. September 2004. WWF-Climate change project. WWF-Fiji. 14pp.
- Fiu, M. 2005. Tikina Sawaieke-Gau: marine baseline biological survey report, 7-12 February, 2005. WWF-Fiji, 17pp.

McKenzie, L.J., & Yoshida, R.L. 2007. Seagrass-Watch: Guidelines for Monitoring Seagrass Habitats in the Fiji Islands. *Proceedings of a training workshop*. Corpus Christi Teachers College, Laucala Bay, Suva. Fiji 16<sup>th</sup> June 2007. 42 pp.

McMillan, C., & Bridges, K.W. 1982. Systematic implications of bullate leaves and isozymes for *Halophila* from Fiji and Western Samoa. 12: 73-188.

Skelton, P.A. & South, G.R. 2006. Seagrass biodiversity of the Fiji and Samoa Islands, South Pacific. *New Zealand Journal of Marine and Freshwater Research*. 40: 345-356

Smith, A.C. 1979. Flora Vitiensis Nova. A new flora of Fiji (Spermatophytes only). Vol. 1. Lawai, Kauai, Hawaii. 495 p.

Solandt, J., Harding, S., Walker, D., Slater, J., & Raines, P. 2002. Fiji – Castaway Island progress report: baseline survey data March-May 2002. Coral Cay Conservation Ltd., London. 41pp.

Solomona, P., Wilson, L., Afzal, D., Areki, D., Cerelala, A., Fiu, M., Mitchell, J., Nakibo, T., Rupeni, E., Salusalu, B., Susau, A., & Thaman, B. 2002. A preliminary baseline assessment of the Malomalo i qoliqoli. October 2002. WWF-SPP. 40 pp.

Sykes, H.R., 2003. Report on surveys carried out at Robinson Crusoe resort on Likuri Island, Viti Levu. 30 Nov. 2003. Resort Support, Suva. 4pp.

Vuki, V.C. 1994. Long-term changes of Suva reef flat communities from conventional *in situ* survey and remote sensing methods. PhD Thesis. University of Southampton.

Waycott, M., McMahon, K., Mellors, J., Calladine, A., & Keline, D. 2004. A guide to tropical seagrasses in the Indo-West Pacific. James Cook University, Townsville. 72 pp.

The Fiji Islands – a biodiversity hotspot for marine algae

G. Robin South

Institute of Marine Resources, The University of the South Pacific, Suva, Fiji

For purposes of this report, the benthic marine macro algae comprise members of the phyla Chlorophyta, Ochrophyta (Class Phaeophyceae) and Rhodophyta. There are many other phyla of algae represented in the Fijian marine algal flora, but these are so poorly known that it would be presumptuous and meaningless to attempt to list them at this time. This includes the Cyanobacteria, which are strongly represented in the flora, but which provide many challenges regarding their taxonomy and nomenclature.

South and Kasahara (1992) provided a detailed account of earlier work on the benthic marine macro algae of the Fiji Islands, and this was updated by N'Yeurt et al. (1996) and South and Skelton (2003b). Payri et al. (2007) substantially increased the known number of species from

their deep-water surveys conducted on the Great Sea Reef, Gau, the remote Ringgold Islands, and Kadavu.

The earliest reports of Fijian algae were those of Grunow (1874), Dickie (1876) and Askenasy (1888), and it was almost a century later before the next additions to the flora were reported by Chapman (1971, 1977) and Kapraun and Bowden (1978). Japanese contributions added greatly to our knowledge of the flora starting in the mid-nineteen eighties (Enemoto and Ajisaka, 1983; Itono and Ajisaka, 1984; Ajisaka and Enomoto, 1985; Itono 1985a, b; Kasahara 1985, 1988), and these were followed by the list of species reported by Garbary et al. (1991) from various sites around Viti Levu and Taveuni.

Since the phycological research laboratory was established at the University of the South Pacific in 1990, extensive studies of the marine algae have taken place. The Phycological Herbarium (SUVA-A) was established and is now a regional depository of algae from the Pacific islands, housing approximately 8,000 specimens. Publications since that time include those by South (1991, 1992, 1993, 1995) and collaborators (N'Yeurt, 1993a, b, 1996, 2001, 2002; South and N'Yeurt 1993; South et al., 1993; N'Yeurt and South 1997). Keats (1995, 1997) and Keats and Chamberlain (1994) contributed to our understanding of Fiji's non-geniculate coralline algae. Several new taxa have been described (South & Skelton, 2000; 2003; N'Yeurt and Payri, 2009; and N'Yeurt et al. 2006, 2008) and many more are awaiting description e.g. Great Sea Reef (Skelton, unpubl.; Payri et al., 2007).

Within the regional context, there is a great need for monographic studies, such as those by South and Skelton (2000) for *Ceramium*, Skelton and South (2003a) for *Caulerpa* and Mattio (2007) for *Sargassum*. Only through such comparative studies can we learn more about Fiji's benthic macro algae and their relationships with those in the SW Pacific Region and beyond. For some highly complex and widespread genera such as *Hypnea* (South, 2003) the naming of species from Fiji is at best superficial, since we will not understand the genus until a major regional review, supported by molecular evidence, has been completed.

Large areas of Fiji remain scarcely explored or unexplored for algae, including most of the Yasawa Islands, the Lau Group, Taveuni Island, remote parts of northern Vanua Levu and elsewhere, with only about 15% of the islands collected. As predicted in South and Skelton (2003) the richest discoveries remain to be made from deep sampling and from reef fronts; this was clearly demonstrated by Payri et al. (2007) who reported 58 new records from their deep water surveys of the Great Sea Reef and Kadavu, with an additional 22 taxa awaiting description. There are many other areas to be explored, including those where seasonal upwelling is known to occur, such as the Yasawas. It might not be necessary to travel far and wide, as there is one site as yet poorly collected, at Namada on the coral Coast, some 2 hours drive from Suva, where deep collections on what is essentially a reef front close to the main highway, are likely to reveal many new records. Similarly, the Suva Barrier Reef yielded many new records, thanks to the dive surveys made by Derek Keats during the early 1990s, and more could be expected from similar work.

Table 1 summarises the currently-known species biodiversity for Fiji's benthic macro algae.



Table 1.

Summary of species biodiversity of marine benthic macro algae of the Fiji Islands (including Rotuma).

Sources: N'Yeurt (1996), South & Skelton (2003b); Payri *et al.* (2007), as well as subsequent new records as cited in the text, and species *inedit.* Held at the Phycological Herbarium, University of the South Pacific (SUVA-A) and the Herbarium, IRD, Nouméa.

Division/Class	No. Species	No. Genera	No. Undescribed taxa
Chlorophyta	217	40	7
Ochrophyta (Phaeophyceae)	49	22	1
Rhodophyta	310	115	20
TOTALS	576	177	28

This latest count on the species biodiversity of benthic macro-algae in Fiji yields a total of 576 taxa, from 177 genera, and with at least an additional 28 more to be described. This total is higher than that for Micronesia (564: Skelton & South, 2007). With the likelihood of many more new distribution records and new taxa to be described from Fiji in the future, it is evident that Fiji has the highest species biodiversity of macro algae in the Pacific islands, and should be classified as a biodiversity centre of high importance, a biodiversity hotspot.

References:

- Ajisaka S, Enomoto S (1985) *Dictyota* Lamouroux (Dictyotales, Phaeophyceae) of the Fiji and Solomon Islands. Kagoshima University Research Centre for the South Pacific. Occasional Papers No. 5, 35-41.
- Askenasy E (1888) Algen. In: *Forschungsreise S.M.S. Gazelle. IV. Theil, Botanik* [Fasc. 2]. Berlin. 58 pp., XII pls.
- Chapman VJ (1971) The marine algae of Fiji. *Revue Algologique* 2, 164-171.
- Chapman VJ (1977) Marine algae of Norfolk Island and the Cook Islands. *Botanica Marina* 20, 161-165.
- Dickie G (1876) Notes on algae collected by H.N. Moseley, M.A. of H.M.S. "Challenger", chiefly obtained in Torres Straits, coasts of Japan and Juan Fernandez. *Journal of the Linnean Society [London], Botany*. 15, 446-455.
- Enomoto S, Ajisaka T (1983) Marine algae of Viti Levu, the Fiji Islands: Chlorophyceae (Preliminary report). Report 4, Oceanography and Biological Sciences, Prompt Report of 2<sup>nd</sup> Scientific Survey of South Pacific. Kagoshima University: South Pacific Regional Herbarium: 14-17.
- Garbary DJ, Oliveira JC, Scagel RF, Villeneuve S (1991) Notes and distribution records for the marine algae of Fiji. *Micronesica* 24, 249-260.
- Grunow A (1874) Algen der Fidschi-, Tonga- und Samoa-Inseln, gesammelt von Dr. E. Graeffe. Erst Folge: Phaeosporeae, Fucoideae und Florideae. *Journal Museum Godeffrey* VI(1), 23-50.
- Itono H (1985a) Some noteworthy species of *Galaxaura* (Chaetangiaceae, Rhodophyta) from Fiji. Kagoshima University Research Center for the South Pacific. Occasional Papers No. 5, 43-51.

- Itono H (1985b) *Rhodolachne radicata*, a new species of red alga (Rhodophyceae, Ceramiales) from Fiji and southern parts of Japan. Kagoshima University Research Center for the South Pacific. Occasional Papers No. 5, 53-64.
- Itono H, Ajisaka T (1984) Taxonomic study of the marine algae from Fiji. *Prompt Rep. 1<sup>st</sup> Scientific survey of the South Pacific. Report 4, Marine Science & Fisheries*. Research Center for the Pacific, Kagoshima University: Institute of Marine Resources, University of the South Pacific. 84-85.
- Kapraun DF, Bowden WA (1978) Additions to the benthic marine algal flora of Fiji. *Micronesica* 14, 199-207.
- Kasahara H (1985) Marine green and red algae collected at Viti Levu and Ndravuni Islands of Fiji. M.Sc. Thesis: Kagoshima University. 83 p.
- Kasahara H (1988) (in Japanese: 'description and illustrations of marine Chlorophyceae collected at Viti Levu, Suva, Makaluva and Ovalau, Fiji'.) mimeographed.
- Keats DW (1995) *Lithophyllum cuneatum* sp. nov. (Corallinaceae, Rhodophyta), a new species of non-geniculate coralline alga semi-endophytic in *Hydrolithon onkodes* (Heydrich) Penrose et Woelkerling and *Neogoniolithon* sp. from Fiji, South Pacific. *Phycological Research* 1, 151-160.
- Keats DW (1997) *Lithophyllum insipidum* Adey, Townsend et Boykins and *L. flavescens* sp nov.: two flat lithophylloid coralline algae (Corallinales, Rhodophyta) abundant in shallow reef environments in Fiji. *Phycologia* 36, 351-365.
- Keats DW, Chamberlain YM (1994) Three species of *Hydrolithon* (Rhodophyta, Corallinaceae): *Hydrolithon onkodes* (Heydrich) Penrose and Woelkerling, *Hydrolithon superficiale* sp. nov., and *H. samoëense* (Foslie) comb. nov. from South Africa. *South African Journal of Botany* 60, 8-21.
- Mattio, L. (2007) Revision of the brown algal genus *Sargassum* (Phaeophyta, Fucales) in Fiji, South Pacific. IRD, Noumea. 35 pp.
- N'Yeurt ADR (1993a) *A Floristic Survey of the Intertidal and Shallow Benthic Marine Algae of Rotuma*. MSc Thesis, the University of the South Pacific. 270 pp.
- N'Yeurt ADR (1993b) A preliminary checklist of the marine benthic algae of Rotuma. *The University of the South Pacific Marine Studies Programme Technical Reports* 93(2), 1-14.
- N'Yeurt ADR (1995) *Meristotheca procumbens* P. Gabrielson et Kraft (Gigartinales, Solieriaceae): an edible seaweed from Rotuma Island. *South Pacific Journal of Natural Science* 14, 242-250.
- N'Yeurt ADR (1996) A preliminary floristic survey of the intertidal and shallow-subtidal benthic marine algae of Rotuma Island. *Australian Systematic Botany* 9, 361-490.
- N'Yeurt ADR (2001) Marine algae from the Suva Lagoon and Reef, Fiji. *Australian Systematic Botany* 14(5), 689-869.
- N'Yeurt ADR (2002) A revision of *Amansia glomerata* C. Agardh, *Amansia rhodantha* (Harvey) J. Agardh and *Melanamansia glomerata* (C. Agardh) R.E. Norris (Rhodophyta: Rhodomelaceae). *Botanica Marina* 45, 231-242.
- N'Yeurt ADR, Payri C (2008) *Sebdenia cerebriformis* sp. nov. (Sebdeniaceae, Sebdeniales) from the south western Pacific ocean. *Phycological Research* 56, 113-120.
- N'Yeurt ADR, Payri C (2009) Four new species of Rhodophyceae from Fiji, Polynesia and Vanuatu, South Pacific. *Phycological Research* 57, 12-24.

- N'Yeurt ADR, Payri C, Gabrielson, PW, Fredericq S (2006) *Pennatiphycs menouana* gen. Et sp. nov. (Rhodophyta, Dicranemataceae) from New Caledonia and Fiji (South Pacific): vegetative and reproductive morphology and molecular phylogeny. *Phycologia* 45, 422-431.
- N'Yeurt ADR, South GR (1997) Biodiversity and biogeography of marine benthic algae in the Southwest Pacific, with specific reference to Rotuma and Fiji. *Pacific Science* 51, 18-28.
- N'Yeurt ADR, South GR, Keats DW (1996) A revised checklist of the benthic marine algae of the Fiji Islands, South Pacific (including the Island of Rotuma). *Micronesica* 29(1), 49-98.
- Payri C, Petek S, Menou J-L, Lasne G, Butscher J (2007) Biodiversity and marine substances from the Fiji Islands. Algae/Sponges/Ascidians/Echinoderms. IRD-Noumea. 75 pp.
- Skelton PA, South GR (2007) The benthic marine algae of the Samoan Archipelago, South Pacific, with emphasis on the Apia district. *Nova Hedwigia* Beiheft 132, 1-350.
- South GR (1991) Benthic marine algae from Dravuni Island, Astrolabe Islands, Kadavu, Fiji. *University of the South Pacific Marine Studies Programme Technical Report* 1991(5), 1-13.
- South GR (1992) Contributions to a catalogue of the marine algae of Fiji. I. *Halimeda* (Chlorophyceae). University of the South Pacific Marine Studies Programme Technical Report 1992(2), 1-19.
- South GR (1993) Edible seaweeds of Fiji: an ethnobotanical study. *Botanica Marina* 36, 335-349. South GR (1995) *Gracilaria maramae* sp. nov. (Gracilariaceae, Gracilariales, Rhodophyta), an economically important species from the Fiji Islands, South Pacific. In: I.A. Abbott (ed.) *Taxonomy of Economic Seaweeds with Reference to Some Pacific Species*. Vol. 3, pp. 177-184. California Sea Grant College System, La Jolla.
- South GR, Kasahara H (1992) A preliminary checklist of the benthic marine algae of the Fiji Islands, South Pacific. *Micronesica* 25(1), 41-70.
- South GR, N'Yeurt ADR (1993) Contributions to a catalogue of benthic marine algae of the Fiji Islands. II. *Caulerpa* and *Caulerpella* (Chlorophyta – Caulerpales). *Micronesica* 26, 107-136.
- South GR, N'Yeurt ADR, Raj-Prasad RA (1993) Additions and amendments to the benthic marine algal flora of Fiji, including the island of Rotuma. *Micronesica* 26, 175-196.
- South GR, Skelton PA (2000) A review of *Ceramium* (Ceramiales, Rhodophyceae) from Fiji and Samoa, South Pacific. *Micronesica* 33(1/2), 45-99.
- South GR, Skelton PA (2003a) Revisions and additions to *Caulerpa* (Chlorophyta, Caulerpales) from the Fiji Islands, South Pacific, including *Caulerpa reniformis* sp. nov. *Australian Systematic Botany* 16, 539-548.
- South GR, Skelton P (2003b) Catalogue of the marine benthic macroalgae of the Fiji Islands, South Pacific. *Australian Systematic Botany* 16, 699-758.

# **The Marine and Estuarine Fishes of Fiji**

## **Johnson Seeto & G. Robin South**

### Introduction

Marine and freshwater fishes include all those fishes that inhabit Fiji's coastal and lagoonal habitats, deepsea fishes, and those species that are principally marine but may spend at least some of their life cycle in estuarine environments where they are subjected to fluctuations in salinity. As stated by Jenkins *et al.* (2010) "deciding what is a 'freshwater' fish, and how it differs from an 'estuarine' fish is problematic, yet we acknowledge the accepted ecological classification of fishes in fresh water is summarised by Tim Berra (2001): there are three divisions of fresh water fishes (primary, secondary and peripheral), based on their tolerance of salt water".

This summary is based on Seeto's (2010) checklist of Fiji's fishes, where he lists 2031 species, plus an additional 275 doubtful records, from a total of 200 families. Seeto's list includes freshwater and estuarine species. Jenkins *et al.* (2010) list 203 freshwater and estuarine species: no attempt has been made here to analyse overlaps between these two lists, but is worth noting that Jenkins *et al.* (2010) state that only 5% of the species in their report can be considered exclusively freshwater. Thus, it would seem that more than 2000 species fall into the marine and estuarine categories in the Fiji Islands.

### Historical:

For a full description of the historical aspects of fish collections in Fiji refer to Seeto (2010). Previous scientific expeditions have collected fish in Fiji and they included the Challenger Expedition (Günther, 1889) which conducted a deep sea survey in Fiji; the Fiji-New Zealand Expedition (Nutting, 1924); the Templeton-Crocker Expedition to western Polynesia and Melanesia (Seale, 1935); the fish collected by the yacht "Alva" (Borodin, 1932); the Wilkes Expedition (Fowler, 1940a); the Crane Expedition (Herre, 1935); and the scientific expedition to the tropical Pacific on the steamer "Albatross" (Kendall and Goldsborough, 1911). Günther (1857-1910) also listed many Fijian fishes. Other fish collections were reported by Boulenger (1897) on a collection of fish at Rotuma by J. Stanley Gardener; Jordan and Dickerson (1908) on a collection of fish from Fiji; Whitley (1927) reported on a checklist of the fishes of Fiji; Fowler (1932) listed fish obtained at Fiji; and Fowler (1955a) wrote about fish collected by Dr. and Mrs. Marshall Laird in Fiji.

The first book that described the Fijian fish fauna was written by Henry W. Fowler in 1959 and it covered only about 560 species. Carlson (1975) wrote a checklist of 575 Fijian fish species (107 families) based mainly on collections he made with Mike Gawel while setting up the University of the South Pacific marine reference collection.

#### Collections:

Present day fish collections have included those of R. Winterbottom and A. Emery (1983) from the Royal Ontario Museum, Canada and V. G. Springer's team (1982) from the Smithsonian Institute, Washington. Their collection data were incorporated in Seeto's list. Zug *et al.*, (1989) listed the vertebrates of Rotuma (including fish) after a visit in 1988; and Blaber *et al.*, (1993b) listed 355 species of fishes from their baitfish research in Fiji from 1991 to 1993. David Greenfield and his team from the University of Hawaii collected fish in Fiji in May, 1999. IRD collected deepsea fauna from Fiji 5 years ago. The marine reference collection housed in the Division of Marine Studies at USP is an important reference source for Fiji's marine fishes.

#### Endemism:

Thirty-three of the 2031 marine fishes recorded from Fiji are considered marine endemics (Seeto, 2010). This is a low level of endemism compared with, for example, terrestrial fauna and flora in Fiji.

#### Gaps:

As noted by Seeto (2010) it is likely that new records will continue to turn up in the marine fish fauna. The deepsea samples collected by IRD revealed new records, and it is likely that many more will be discovered as further investigations are made in the future. For many families, there is a need for detailed taxonomic investigations, especially those with large numbers of species.

#### Threats:

Overfishing is the major threat to some species (e.g. *Cheilinus undulates*), whereas habitat destruction or loss is also a contributing factor to loss of biodiversity in areas where mangroves have been destroyed, in urban or heavily polluted areas, or those areas subject to significant infrastructure development such as tourism sites, road construction, etc. For the future, it will be important for Fiji to maintain close vigilance on the potential introduction of invasive species, such as through the aquarium trade, or through aquaculture.

#### References:

- Blaber, S. J. M., Milton, D. A., Rawlinson, N. J. F. and Sesawa, A. 1993b. A Checklist of fishes recorded by the Baitfish Research Project in Fiji from 1991 to 1993. pp. 102- 110. *In* : Blaber, Milton and Rawlinson (eds.) 1993. *ACIAR Proceedings* No. 52.
- Borodin, N. A. 1932. Scientific results of the yacht "Alva" world cruise, July, 1931 to March, 1932, in command of William K. Vanderbilt. *Bull. Vanderbilt Mar. Mus.*, 1(3): 65-101.
- Boulenger, G. A. 1897. A list of the fishes obtained by Mr. J. Stanley Gardener at Rotuma, South Pacific Ocean. *Ann. Mag. Nat. Hist.*, 6 (20): 371 -374.
- Carlson, B. A. 1975. A preliminary check-list of the fishes of Fiji (based on specimens in the Marine Reference Collection of the University of the South Pacific, Suva, Fiji). Univ. S. Pac., Suva, Fiji (mimeogr.): 94 pp.

- Fowler, H. W. 1932. Fishes obtained at Fiji in 1929. *Occ. Paps. B. P. Bishop Mus.*, 9 (920): 13 pp.
- Fowler, H. W. 1955. A collection of coral-reef fishes made by Dr. and Mrs. Laird at Fiji. *Trans. Roy. Soc. New Zealand*. 83 (2): 373 - 381.
- Fowler, H. W. 1959. Fishes of Fiji. Government of Fiji, Suva, Fiji: 670 pp.
- Günther, A. 1873 - 1910. Andrew Garrett's Fische der Südsee. *Jour. Mus. Godeffroy*, 1 - 9: 515 pp.
- Günther, A. 1889. Report on the pelagic fishes collected by H. M. S. Challenger during the years 1873-76. In: Report on the scientific results of the voyage of H. M. S. Challenger during the years 1873-76, 31(78): 1 - 47.
- Herre, A. W. C. T. 1935. New fishes obtained by the Crane Pacific Expedition. *Field Mus. Nat. Hist.*, Publ. 335, *Zool. Ser.*, 18 (12): 383 - 438.
- Jenkins, A.P., Kailola, P.J., Boseto, D. & Kinikoto, M. (2010). Freshwater Fishes of the Fiji Islands (*this publication: 5 pp.*)
- Jordan, D. S. and Dickerson, M. C. 1908. On a collection of fishes from Fiji, with notes on certain Hawaiian fishes. *Proc. U. S. Nat. Mus.*, 34(1625): 603 - 617.
- Kendall, W. C. and Goldsborough, E. L. 1911. The shore fishes. In: Reports on the scientific results of the expedition to the tropical Pacific, in charge of Alexander Agassiz, by the U. S. Fish Commission steamer "Albatross" from August, 1899, to March, 1900. *Mem. Mus. Comp. Zool., Harvard Coll.*, 26(7): 241-337.
- Nutting, C. C. 1924. The fishes in the Fiji- New Zealand Expedition. *Univ. Iowa Studies Nat. Hist.*, 10(5), fishes: 57 - 67.
- Seale, A. 1935. The Templeton Crocker Expedition to western Polynesia and Melanesian islands, 1933. Fishes. *Proc. Calif. Acad. Sci.*, 4th Ser., 21 (27): 337 -378.
- Seeto, J. (2010) A Checklist of the Fishes of Fiji and a Bibliography of Fijian Fish. *The University of the South Pacific Marine Studies Technical Report* 2010 (1): 220 pp.
- Springer, V. G. 1982. Pacific plate biogeography, with special reference to shorefishes. *Smith. Contr. Zool.*, 367: 182 pp.
- Winterbotton, R. and Emery, A. R. 1983. Beneath the Blue Lagoon: An ichthyological expedition to Fiji. *Rotunda*, 16 (3): 18 - 27.
- Zug, G. R., Springer, V. G., Williams, J. T. and Johnson, G. D. 1989. The vertebrates of Rotuma and surrounding waters. *Atoll. Res. Bull.*, no. 316: 1- 25.



