NATURAL RESOURCE INVENTORY REPORT OF THE FIJI ISLANDS 2010

VOLUME 2: MARINE RESOURCES INVENTORY OF THE FIJI ISLANDS

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- 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.

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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.

2.1CORAL 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).

2.1.1HARD 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.
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- 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

Marine Plants	
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 Chlorophycecae, 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.

Marine Invertebrates	
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 complied 7000 species including around 760 species of Fijian gatropods 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.
Marine Vertebrates	
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 hawkbill turtle Eretmochelys imbricata (Bustard, 1970 as cited in Morris and Pratt, 1997:10). Loggerheads (Caetta caretta) are present but uncommon. Flatbacks (Chelonia depressa), Ridleys (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 bopbies (Sula leucogaster), red-footed boobies (Sula sula), lesser frigate birds (Fregata ariel) and White tailed tropic birds (Phaethon lepterus) (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 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, 1885, 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 anecodotal 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	*Balaenoptera musculus*	Blue whale
	Balaenoptera physalus	Fin whale
	Balaenoptera spp.	Minke whales[1]
	Balaenoptera sp. 2	'Bryde's-like' whales[2]
	Megaptera novaeangliae	Humpback whale
Suborder Odontoceti (toothed whales)		
Physeteridae	*Physeter macrocephalus*	Sperm whale
Kogiidae	*Kogia breviceps*	Pygmy sperm whale
Delphinidae	*Steno bredanensis*	Rough-toothed dolphin
	Tursiops sp.	Bottlenose dolphin – (could have been *T. tursiops* or *T. aduncus*)
	Stenella attenuata	Pantropical spotted dolphin
	Stenella longirostris	Spinner dolphin
	Delphinus sp.	Common dolphin – (could have been a long – beaked or short – beaked common dolphin)
	Lagenodelphis hosei	Fraser's dolphin
	Pseudorca crassidens	False killer whale
	Orcinus orca	Killer whale
	Globicephala macrorhynchus	Short-finned pilot whale
Ziphiidae	*Mesoplodon densirostris*	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

[1] Due to difficulties in at sea species subspecies identification and historical differences in taxonomic classification – all Minke whale species and subspecies are listed together.

[2] 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 *bulosa* 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 (*Thalasia, 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 posses 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	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

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 *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 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	*Lingula*	*anatina*	Lamarck, 1801	Include Lingula sp. reported by Bitner 2008
		Craniida	Craniidae	*Novocrania*	*sp.*		May prove to be a new species (cf. Bitner 2008)
	Rhynchonellata	Rhynchonellida	Cryptoporidae	*Cryptopora*	*maldivensis*	Muir-Wood, 1959	Bitner (2008)

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

		Thecideida	Thecidellinidae	*Thecidellina*	*maxilla*	(Hedley, 1899)	May include species Thecidellina 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	Architechtonicidae	1	1
	Pyramidelloida	Pyramidellidae	1	1
	Cephalaspidea	Acteonidae	2	4
		Haminoeidae	2	4
		Hydatinidae	2	3
		Bullidae	1	2
	Archaepulmonata	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	*Parachiton*	*acuminatus*
		Parachiton	*puppis*
		Nierstraszella	*lineata*
		Callochiton	*neocaledonicus*
		Chiton	*tuberculatus*
		Chiton	*affinis*
		Chiton (Rhyssoplax)	*ectypus*
		Chiton (Rhyssoplax)	*pulcherrimus*
		Chiton (Rhyssoplax)	*subassimilis*
		Chiton (Tegulapax)	*hululensis*
		Acanthopleura	*gemmata*
		Lucilina	*lamellosa*
		Lucilina	*nigropunctata*
		Lucilina	*novemrugata*
		Onithochiton	*societatis*
		Cryptoplax	*elioti*
		Cryptoplax	*larvaeformis*
		Cryptoplax	*striata*
		Cryptoplax	*menkrawitensis*
		Choneplax	*littlerorum*

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 teh 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 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 (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 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. of confirmed living and fossilized Species	No. sp. Possibly Found or mistakenly identified in Fiji	TOTAL
Gastropoda	Cypraeidae	*Cypraea*	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 polyphekadion* (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. , *Heliofungia* spp. , *Lobophyllia* spp., *Nemenzophyllia* 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, magroves, 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.

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APPENDIX

CONTACT LIST OF THE VARIOUS STAKEHOLDERS

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NLTB	Unaisi Cebaivalu Solomoni Nata
SPC	Ian Peebles
WCS	Sunil Cara Miller
Lands	Laisa Raratabu Selina Talamaisinai
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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 *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), 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	*Lingula*	*anatina*	Lamarck, 1801	Include *Lingula* sp. reported by Bitner 2008
		Craniida	Craniidae	*Novocrania*	sp.		May prove to be a new species (cf. Bitner 2008)
	Rhynchonellata	Rhynchonellida	Cryptoporidae	*Cryptopora*	*maldivensis*	Muir-Wood, 1959	Bitner (2008)
			Basiliolidae	*Basiliola*	*lucida*	(Gould, 1862)	Bitner (2008)
				Basiliola	*roddai*	Cooper, 1978	
				Basiliola	*beecheri*	(Dall, 1895)	Bitner (2008)
			Dyscoliidae	*Abyssothyris*	*wyvillei*	(Davidson, 1878)	Bitner (2008)
				Abyssothyris	*briggsi*	Cooper, 1978	
				Xenobrochus	*rotundus*	Bitner, 2008	Type locality: Lau Ridge
			Terebratulidae	*Dallithyris*	*pacifica*	Bitner, 2006	Type locality: Bligh Water
			Cancellothyrididae	*Terebratulina*	*japonica*	(GB Sowerby, 1846)	Bitner (2008)

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

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Cetacean Biodiversity of the Fiji Islands

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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 anecodotal 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	*Balaenoptera musculus* *	Blue whale
	Balaenoptera physalus	Fin whale
	Balaenoptera spp.	Minke whales[3]
	Balaenoptera sp. 2	'Bryde's-like' whales[4]
	Megaptera novaeangliae	Humpback whale
SUBORDER ODONTOCETI (toothed whales or odontocetes)		
Family Physeteridae	*Physeter macrocephalus*	Sperm whale
Family Kogiidae	*Kogia breviceps* *	Pygmy sperm whale
Family Delphinidae	*Steno bredanensis* *	Rough-toothed dolphin
	Tursiops sp.	Bottlenose dolphin – (could have been *T.tursiops* or *T.aduncus*)
	Stenella attenuata	Pantropical spotted dolphin
	Stenella longirostris	Spinner dolphin
	Delphinus sp. *	Common dolphin – (could have been a long – beaked or short – beaked common dolphin)

[3] Due to difficulties in at sea species subspecies identification and historical differences in taxonomic classification – all Minke whale species and subspecies are listed together.

[4] 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.

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

**unconfirmed record*

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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

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 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 posses a shell consisting of two rounded plates called *valves* joined at one edge by a flexible ligament called the *hinge*.	
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 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

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 Lophorata, 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 posses 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 there biogeographic distribution in the region showed a total of 145 species belonging in 18 families (Morris, 2006). However 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

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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	*Lingula*	*anatina*	Lamarck, 1801	Include *Lingula* sp. reported by Bitner 2008
		Craniida	Craniidae	*Novocrania*	sp.		May prove to be a new species (cf. Bitner 2008)

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

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

		Thecideida	Thecidellinidae	*Thecidellina*	*Maxilla*	(Hedley, 1899)	May include species *Thecidellina* 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	*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	Architechtonicidae	1	1
	Pyramidelloida	Pyramidellidae	1	1
	Cephalaspidea	Acteonidae	2	4
		Haminoeidae	2	4
		Hydatinidae	2	3
		Bullidae	1	2
	Archaepulmonata	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.[1] 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	*Conus*	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. of confirmed living and fossilized Species	No. sp. Possibly Found or mistakenly identified in Fiji	TOTAL
Gastropoda	Cypraeidae	*Cypraea*	75	18	93

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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 buiding 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

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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 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 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 leafs 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 *bulosa* 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 (*Thalasia, 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).

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The Fiji Islands – a biodiversity hotspot for marine algae

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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 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, 1885, 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.

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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.

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