Marine Benthic Algae from Seamounts along the Mariana Islands, Western Pacific

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Abstract—The marine benthic algae from six seamounts, i.e., isolated submerged reefs, banks and shoals, along the Mariana Islands were identified and recorded based on SCUBA collections obtained during the August-September 2003 and the September 2005 cruises by the U.S. National Oceanic and Atmospheric Administration (NOAA). The algae represented the first collections obtained from Supply Reef, Zealandia Bank and Tatsumi Reef within the Mariana Arc and from Stingray Shoal, Pathfinder Reef, and Arakane Reef within the West Mariana Ridge. A total of 67 species were documented, i.e., 8 species of blue-green algae, 30 species of red algae, 5 species of brown algae, and 24 species of green algae. Thirty-one algal species were collected only from seamounts within the West Mariana Ridge, and 5 algal species were collected only from seamounts (including Santa Rosa Reef reported previously) within the Mariana Arc. The remaining 31 algal species were recorded from seamounts along both the West Mariana Ridge and Mariana Arc. Aside from 5 taxa identified only to genus, 4 species of red algae (Antithamnion decipiens, Ceramium isogonum, Chondria bullata and Gayliella transversalis) were new records for Micronesia (including Mariana Islands). Ten additional species of red algae (Caulacanthus ustulatus, Ceramium affine, Ceramium codii, Chondria simpliciuscula, Dasya cf. corymbifera, Jania pumila, Jania rubens, Lomentaria hakodatensis, Polysiphonia dotyi and Polysiphonia sertularioides) were new records for the Mariana Islands.

Introduction

Approximately 20 isolated submerged banks, reefs, and shoals are located along the Mariana Arc and the West Mariana Ridge within the Mariana Islands in the Western Pacific. Most of these features could be identified as “seamounts” and would fall under the one inclusive umbrella definition proposed by Staudigel et al. (2010), i.e., “any geographically isolated topographic feature
on the seafloor taller than 100 m, including ones whose summit regions may temporarily emerge above sea level, but not including features that are located on continental shelves or that are part of other major landmasses. These submerged features can be biologically diverse due to its isolation and the steep slopes which allow nutrient-rich waters to be carried upwards from the depths and, in turn, contribute to the presence of a unique biota (Littler et al. 1986) and, at times, a high percent of endemism (Shank 2010). These seamounts also can serve as stepping stones which allow marine organisms (Hubbs 1959, Parker & Tunnicliffe 1994) to naturally disperse to new geographic locations.

Santa Rosa Reef, the southernmost isolated submerged reef in the Mariana Arc, was the site of the first algal study (Tsuda et al. 2012) of a seamount in the Mariana Islands. The specimens were collected during the same August-September 2003 and September-October 2005 cruises to the Mariana Islands by the U.S. National Oceanic and Atmospheric Administration (NOAA) Pacific Islands Fisheries Science Center (PIFSC) Coral Reef Ecosystem Division (CRED) discussed here. Thirty-two algal species were recorded from Santa Rosa Reef, including the predominantly Caribbean species Dasycladus vermicularis (Scopoli) Krasser (i.e., new Polynesian and Micronesian record) and Cutleria irregularis I.A. Abbott & Huisman (i.e., new Micronesian record). Six other species (Dasya iyengarii Borgesen, Polysiphonia delicatula Hollenberg, Polysiphonia homotia Setchell & N.L. Gardner, Neomeris mucosa M. Howe, Rhipilia micronesica Yamada, and Udotea palmetta Decaisne) represented new records for the Mariana Islands.

During the same 2003 and 2005 cruises to the Mariana Islands, algae were collected for the first time from six other isolated reefs, banks and shoals, i.e., Supply Reef, Zealandia Bank and Tatsumi Reef within the Marianas Arc, and Stingray Shoal, Pathfinder Reef and Arakane Reef within the West Mariana Ridge. Most of the algae were sorted, preliminarily identified, and held at the Bishop Museum in Hawaii. The uniqueness of this collection became evident when NOAA discontinued making algal collections from these and other isolated submerged features in the Mariana Islands and also due to the interesting algal findings obtained from Santa Rosa Reef.

The Mariana Islands are located between 12° and 21° N latitude, and 142° and 147° E longitude, and extend in a north-south orientation midway between Honshu (Japan) and Papua New Guinea in the western Pacific. The islands (PIFSC 2010) include nine mostly uninhabited, small volcanic islands to the north, i.e., Uracas (Farallon de Pajaros), Maug, Asuncion, Agrihan, Pagan, Alamagan, Guguan, Sarigan, and Anatahan, and six volcanic-carbonate islands to the south. Except for Aguijan and Farallon de Medinilla, four of the six southern islands (Saipan, Tinian, Rota and Guam) are inhabited. The three northernmost Mariana Islands (Uracas, Maug and Asuncion) represent the island component, and Stingray Shoal and Zealandia Bank are part of the submerged volcanic component of the Mariana Trench Marine National Monument (Mariana Trench MNM) established by U.S. Presidential Proclamation on 6 January 2009. The island of Guam, the largest and most populated southernmost island of the Mariana Islands, is a separate U.S. Territory and not politically part of the U.S. Commonwealth of the Northern Mariana Islands (CNMI).

Except for the 90 species (Tsuda & Tobias 1977a, 1977b) reported from the small volcanic islands to the north, previously published algal studies were restricted to the larger and more accessible southern islands of the Mariana Islands. Marine algal studies were initially conducted by Japanese phycologists (Okamura 1904, 1916, Yamada 1931, 1940, 1941, Tokida 1939). Taxonomic and floristic studies on Mariana benthic algae (excluding diatoms) included studies on Laurencia (Yamada 1931), Caulerpa (Yamada 1940, Taylor 1977), Halimeda (Yamada 1941, Moul 1964), crustose corallines (Johnson 1957, 1964, Gordon et al. 1976), Turbinaria (Taylor 1964), Chlorodesmis (Ducker 1967), Herposiphonia (Hollenberg 1968c), Phaeophyta from Guam (Tsuda 1972a), Sargassum (Tsuda 1972b, 1988, Soe-Htun & Yoshida 1986), Rhipilia (Gilbert 1978, Verbruggen & Schils 2012), Bostrychia (Kumano 1979), Galaxaura (Itono 1980), Chamaedoris and Stenopeltis (Itono & Tsuda 1980a), Titanophora (Itono & Tsuda 1980b), Ulva

The objective of this study was to document baseline algal species diversity from the six other seamounts within the Mariana Islands. The last known algal collection made on any submerged features in the Mariana Islands was on 24 September 2005.

**Materials and Methods**

The algal specimens were haphazardly collected via SCUBA by two divers, i.e., PSV in August and September 2003 and KNP in September 2005 while aboard the NOAA research vessel *Oscar Elton Sette*. The algae were collected between the surface (one pinnacle of Zealandia Bank) and a depth of 36.6 m. Algae collected from five of six seamounts (except Zealandia Bank, ZEA-02-05) were in water shallower than the mesophotic depth (32 to 78 m deep) depicted by Wagner et al. (2014) at Johnston Atoll where nine species of macroalgae (non-turf or epiphytes) were recorded.

Algae were placed in plastic bags, labelled, and frozen immediately after each dive. Prior to examination, the frozen algae in plastic bags from each station were thawed in tap water. The thawed seawater was poured carefully out of the bags and replaced with 4% formalin in seawater to prevent the decomposition of delicate epiphytes. The collections were examined under the dissecting microscope, and epiphytes and turf were separated. The majority of the small specimens were mounted on glass slides, i.e., the specimens were decalcified with 10% hydrochloric acid, stained with either aniline blue or iodine, and mounted with 30% corn syrup (Karo) with phenol. Larger specimens were mounted on herbarium paper; two specimens were preserved in vials with 4% formalin in seawater. All specimens were databased and archived in *Herbarium Pacificum* (BISH) at the Bishop Museum, Honolulu.

**Collecting Stations**

The six seamounts in the Mariana Islands (Figure 1) are listed from north to south within the Mariana Arc and the West Mariana Ridge. NOAA stations are designated by a code which includes the first three letters of the seamount’s place name (STI) for Stingray Shoals, followed by the station number (01), and terminating in the year collection was made (03) for year 2003, e.g., STI-01-03. Descriptions of the seamounts below were extracted from Brainard et al. (2012). Features of Zealandia Bank, Pathfinder Reef, and Arakane Reef are shown in Figures 2–5.

**MARIANA ARC**

Supply Reef, located 25 km north of Maug, is a steep-sided, conical stratovolcano (summit 300 m in diameter) and possesses ridges on all flanks, with a minimum depth of approximately 9 m. SUP-01-03, 20° 08.404' N, 145° 05.897' E, small shallow reef, strong current (> 2 knots), 12.2–19.8 m deep, coll. P. S. Vroom, 01 September 2003.

Zealandia Bank, located 25 km northeast of Sarigan, is an elongated stratovolcano formed by two adjacent volcanic pinnacles 1 km apart (Figure 2). During low tides, one of the two pinnacles is 1 m above sea level. ZEA-01-03, 16° 53.855' N, 145° 51.176' E, vertical walls of 46 m high pinnacles, 14.6 m deep, coll. P. S. Vroom, 25 August 2003. ZEA-02-03, 16° 53.692' N, 145° 50.964' E, vertical walls of 46 m high pinnacles, 15.8 m deep, coll. P. S. Vroom, 25 August 2003. ZEA-02-05, 16° 53.692' N, 145° 50.964' E, vertical wall of second pinnacle, 0-36.6 m deep, coll. K. N. Page, 17 September 2005.
Figure 1. Map of the islands, reefs, banks and shoals within the Mariana Islands. Map provided by NOAA PIFSC CRED (2015).

Tatsumi Reef, located 2 km south of Tinian, possesses a flat top (5.5 x 2 km) with a minimum depth of 6 m. It was presumably formed by uplifted limestone overlying an older volcanic core. TAT-01-03, 14° 54.111' N, 146° 39.466' E, 30.9 m deep, reef located midway between Tinian and Aguijan, coll. fish towed-diver survey team J. Laughlin and B. Zgliczynski, 17 September 2003.

West Mariana Ridge

Stingray Shoal, located on the northern end of the West Mariana Ridge, is a conical remnant volcanic seamount with an estimated minimum depth of 13 m. STI-01-03, 20° 29.662' N, 142° 26.341' E, shallow bank with well-developed coral reef and sand patches, 18.3–24.4 m deep, coll. P. S. Vroom, 29 August 2003. STI-02-03, 20° 29.669' N, 142° 26.300' E, shallow bank with well-developed coral reef and sand patches, 18.3–24.4 m deep, coll. P. S. Vroom, 29 August 2003.

Pathfinder Reef, located 150 km west of Saipan, is a remnant volcanic submerged ridge with spur and groove reef structure and a minimum depth of 10 m (Figure 3). PAT-01-03, 16° 30.228' N, 143° 08.928' E, carbonate pavement on reef slope separated by deeper sand channels, 18.0 m deep, coll. P. S. Vroom, 14 September 2003. PAT-02-03, 16° 30.144' N, 143° 08.721' E, carbonate pavement on reef slope separated by deeper sand channels, 20.7 m deep, coll. P. S. Vroom, 14 September 2003. PAT-01-05, 16° 30.228' N, 143° 8.956' E, northeast side of bank, flat with little relief and high surge, 13.7–16.2 m deep, coll. K. N. Page, 24 September 2005. PAT-02-05, 16°

Arakane Reef, located 110 km southwest of Tinian, is a small (i.e., 1.8 x 1 km) shallow bank with a minimum depth of approximately 10 m (Figures 4 and 5). ARA-01-03, 15° 38.045' N, 142° 45.558' E, broad patches of reef with small sand channels, 13.7–21.3 m deep, coll. P. S. Vroom, 15 September 2003. ARA-02-03, 15° 38.194' N, 142° 45.595' E, broad patches of reef with small sand channels, 13.7–21.3 m deep, coll. P. S. Vroom, 15 September 2003. ARA-01-05, 15° 38.624' N, 142° 45.529' E, strong current and surge, 15.2–16.5 m deep, coll. K. N. Page, 25 September 2005. ARA-02-05, 15° 38.167' N, 142° 45.567' E, strong current and surge, 19.2–19.8 m deep, coll. K. N. Page, 25 September 2005.

Floristic Account

Sixty-seven species of marine benthic algae were recorded from the six seamounts in the Marianas Islands. Four species of red algae represented new records for Micronesia and are preceded by two asterisks (**). Ten additional species of red algae represented new records for the Marianas Islands (part of Micronesia) and are preceded by one asterisk (*).

PHYLUM CYANOBACTERIA

Class Cyanophyceae

ORDER OSCILLATORIALES

FAMILY OSCILLATORIACEAE

**Lyngbya confervoides** C. Agardh ex Gomont; Desikachary 1959: 315, pl. 49 (fig. 8), pl. 52 (fig. 1).

Trichomes are 14–18 µm diam and 4–6 µm long with rounded apices.

Specimens examined. ZEALANDIA BANK: ZEA-01-03 (BISH 722338), ZEA-02-03 (BISH 720938). PATHFINDER REEF: PAT-01-03 (BISH 722359), PAT-02-03 (BISH 722386), PAT-01-05 (BISH 743254). ARAKANE REEF: ARA-01-05 (BISH 763250, 763258), ARA-02-05 (BISH 763276).

**Lyngbya sordida** Gomont; Tilden 1910: 118, pl. 5 (fig. 37); Engene et al. 2010: 593, figs. 1A, 1D. [= *Lyngbya polychroa* (Meneghini) Rabenhorst]

Specimens examined. ZEALANDIA BANK: ZEA-01-03 (BISH 722345). PATHFINDER REEF: PAT-02-03 (BISH 722379), PAT-02-05 (BISH 743264).

**Moorea bouillonii** (L. R. Hoffman & Demoulin) Engene, Rottacker, Kastovsky, Byrum, Hy. Choi, Ellisman, Komárek & Gerwick; Lobban & Tsuda 2003: 57, fig. 2 as *Lyngbya bouillonii*.

Specimens examined. SUPPLY REEF: SUP-01-03 (BISH 720889). ARAKANE REEF: ARA-01-03 (BISH 763296).

FAMILY PHORMIDIACEAE

**Phormidium** sp.

Specimens appear as maroon-green clumps. Cells are 5–8 µm diam, 4–20 µm long and slightly separated from each other within the thin colorless sheath.

Specimens examined. ARAKANE REEF: ARA-01-05 (BISH 763244, 763247, 763252, 763262), ARA-02-05 (BISH 763270, 763279, 763286).

FAMILY SCHIZOTRICHACEAE

**Schizothrix calcicola** (C. Agardh) Gomont ex Gomont; Littler & Littler 2000: 464.

Specimens examined. STINGRAY SHOALS: STI-02-03 (BISH 720879). SUPPLY REEF: SUP-01-03 (BISH 720890).
**ORDER NOSTOCALES**  
**FAMILY RIVULARIACEAE**

*Calothrix confervicola* C. Agardh ex Bornet & Flahault; Fan 1956: 169, fig. 6.  
Trichomes are 10 µm diam at base.  
Specimens examined. PATHFINDER REEF: PAT-01-05 (BISH 743246 on *Dictyota ceylanica* and *Chlorodesmis caespitosa*). ARAKANE REEF: ARA-01-05, epiphytic on *Microdictyon okamurae*, BISH 763242.

*Rivularia polyotis* (J. Agardh) Hauck; Tilden 1910: 286, fig. 20 (figs. 5 and 6).  
Trichomes are 8‒12 µm diam and constricted.  
Specimens examined. PATHFINDER REEF: PAT-01-03 (BISH 722365), PAT-02-03 (BISH 722384), PAT-02-05 (BISH 743260). ARAKANE REEF: ARA-02-03 (BISH 722415). TATSUMI REEF: TAT-01-03 (BISH 722641 on *Halimeda taenicola*).

*Scytonematopsis pilosa* (Harvey ex Bornet & Flahault) I. Umezaki & M. Watanabe; Humm & Wicks 1980: 152.  
[= *Calothrix pilosa* Harvey]  
Trichomes are 12‒16 µm diam with intercalary heterocysts.  
Specimens examined. PATHFINDER REEF: PAT-01-05 (BISH 743249).

**PHYLUM RHODOPHYTA**  
**Class Florideophyceae**  
**ORDER NEMALIALES**  
**FAMILY LIAGORACEAE**

*Ganonema farinosum* (J.V. Lamouroux) K. C. Fan & Yung C. Wang; Abbott 1999: 77, figs. 11A–G.  
Specimens examined. TATSUMI REEF: TAT-01-03 (BISH 722642).

**ORDER BONNEMAISONIALES**  
**FAMILY BONNEMAISONIACEAE**

*Asparagopsis taxiformis* (Delile) Trevisan de Saint-Léon; Abbott 1999: 174, figs. 43C‒D.  
Specimens on slide are a mixture of *Polysiphonia* spp. and the sporophyte phase of *Asparagopsis taxiformis* characterized by three pericentral cells.  
Specimens examined. STINGRAY SHOALS: STI-02-03 (BISH 720885).

**ORDER CORALLINALES**  
**FAMILY CORALLINACEAE**

*Jania pumila* J. V. Lamouroux; N’Yeurt & Payri 2010: 56, fig. 98.  
Decalcified specimens are 52‒88 µm diam.  
Specimens examined. PATHFINDER REEF: PAT-01-03 (BISH 722371), PAT-02-05 (BISH 743263). ARAKANE REEF: ARA-01-05 (BISH 763246), ARA-02-05 (BISH 763289). TATSUMI REEF: TAT-01-03 (BISH 722643).

*Jania rubens* J. V. Lamouroux; Taylor 1950: 133.  
The specimen is 3 mm long and up to 60 µm diam with terminal tips distinctly acute.  
Specimens examined. PATHFINDER REEF: PAT-01-05 (BISH 743241).

**ORDER PEYSSONNELIALES**  
**FAMILY PEYSSONNELIACEAE**

*Peyssonnelia* sp.  
The collection consists of two small blades (1 cm diam). The dorsal surface shows lines of round cells (ca. 8 µm diam) in parallel rows from the apical margin. Branched unicellular rhizoids arise from the ventral basal sector of the thin crust.  
Specimens examined. PATHFINDER REEF: PAT-02-03 (BISH 722385).
ORDER GIGARTINALES
FAMILY CAULACANTHACEAE
*Caulacanthus ustulatus* (Turner) Kützing; Abbott 1999: 104, figs. 20D–F.
Morphology of specimen is similar to *Hypnea spinella*; however, this specimen possesses polygonal cortical cells, 6–12 µm diam.
Specimens examined. ARAKANE REEF. ARA-02-05 (BISH 763283).

FAMILY CYSTOCIONIACEAE
*Hypnea spinella* (C. Agardh) Kützing; Abbott 1999: 117, figs. 25B–E.
Specimens are 240–320 µm diam and possess slightly elongated cortical cells.
Specimens examined. ZEALANDIA BANK: ZEA-01-03 (BISH 722343 on a *Halimeda* segment). PATHFINDER REEF: PAT-01-03 (BISH 722370), PAT-02-03 (BISH 722383), PAT-02-05 (BISH 743268). ARAKANE REEF: ARA-01-03 (BISH 722390), ARA-02-03 (BISH 722418).

ORDER RHODYMENIALES
FAMILY CHAMPIACEAE
*Champia parvula* (C. Agardh) Harvey; Skelton & South 2007: 68, figs. 126–133.
Specimens examined. PATHFINDER REEF: PAT-02-03 (BISH 722387).

FAMILY LOMENTARIACEAE
*Lomentaria hakodatensis* Yendo; Abbott 1999: 224, figs. 62A–D.
Specimens examined. ZEALANDIA BANK: ZEA-02-03 (BISH 743238). PATHFINDER REEF: PAT-01-03 (BISH 722373), PAT-02-03 (BISH 722381). ARAKANE REEF: ARA-01-03 (BISH 722393), ARA-02-03 (BISH 722406).

ORDER CERAMIALES
FAMILY CERAMIACEAE
**Antithamnion decipiens** (J. Agardh) Athanasiadis; Abbott 1999: 250, figs. 69C–D.
Specimens examined. ARAKANE REEF: ARA-01-03 (BISH 722397).

Specimens examined. ZEALANDIA BANK: ZEA-02-03 (BISH 722352). PATHFINDER REEF: PAT-01-03 (BISH 722360).

*Antithamnionella graeffei* (Grunow) Athanasiadis; Skelton & South 2007: 87, figs. 186–188.
Specimens examined. STINGRAY SHOALS: STI-02-03 (BISH 720884 on *Chondria* sp. fragment).

*Ceramium affine* Setchell & N. L. Gardner; South & Skelton 2000: 54, figs. 1–10.
Specimens examined. PATHFINDER REEF: PAT-02-03 (BISH 722380). ARAKANE REEF: ARA-02-03 (BISH 722412).

Specimens examined. TATSUMI REEF: TAT-01-03 (BISH 722644 on *Ganonema farinosum*).

**Ceramium isogonum** Harvey; Skelton & South 2007: 98, figs. 240–245.
Filaments are up to 120 µm diam, with slightly elongated vertical cells formed acropetally and basipetally at node, and with forciate apices. Tetrasporangia lack involucres and divide tetrahedrally.
Specimens examined. ARAKANE REEF: ARA-01-03 (BISH 722398).

*Ceramium macilentum* J. Agardh; South & Skelton 2000: 71, figs. 52–62; Skelton & South 2007: 103, figs. 246–250.
Specimens possess 6 periaxial cells which produce cells acropetally at node. The specimens are 60–74 µm diam which is less than half the diameter reported by Skelton & South (2007). Apices are distinctly forcipate or circinate.

**Corallophila klewiegii** Weber-van Bosse; N’Yeurt & Payri 2010: 114, fig. 227.

[= *Corallophila apiculata* (Yamada) R. Norris]

Specimens examined. STINGRAY SHOALS: STI-02-03 (BISH 720886 on *Chondria* sp. fragment). ZEALANDIA BANK: ZEA-02-05 (BISH 743236, fragment). ARAKANE REEF: ARA-02-05 (BISH 763275).

**Gayliella transversalis** (Collins & Hervey) T. O. Cho & Fredericq; Cho & Fredericq 2006: 727, figs. 5a–n; N’Yeurt & Payri 2010: 117, figs. 228 and 229.


Specimens examined. ZEALANDIA BANK: ZEA-01-03 (BISH 722339).

**Dasya** cf. *corymbifera* J. Agardh; Abbott 1999: 320, figs. 90A–C.

Specimens are 5–13 mm long and appear to fall within the circumscription of *D. corymbifera*.

**Dasya iyengarii** Børgesen; N’Yeurt & Payri 2010: 127, figs. 258–261.

Non-corticated specimens possess prominent round basal cell in side branches and terminal incurved tips.

**Chondria polyrhiza** Collins & Hervey; Abbott 1999: 360, figs. 103G–H.

Specimens examined. ZEALANDIA BANK: ZEA-01-03 (BISH 722542). PATHFINDER REEF: PAT-02-05 (BISH 743265).

**Chondria bullata** N’Yeurt & Payri, N’Yeurt & Payri 2010: 140, figs. 292–294.

**Chondria simpliciuscula** Weber-van Bosse; N’Yeurt & Payri 2010: 143, fig. 304.

**Leveillea jungermannioides** (Hering & Martens) Harvey; Abbott 1999: 396, figs. 116A–D.

**Polysiphonia dotyi** Hollenberg; Hollenberg 1968b: 198, figs. 1A, 1B, 4 and 5.

**Polysiphonia homoia** Setchell & N. L. Gardner; Hollenberg 1968b: 201, fig. 2B.
Specimens examined. STINGRAY SHOALS: STI-02-03 (BISH 719820).

*Polysiphonia sertularioides* (Grateloup) J. Agardh; Abbott 1999: 414, figs. 121A–D as *Polysiphonia flaccidissima* Hollenberg.

[= *Neosiphonia flaccidissima* (Hollenberg) M. S. Kim & I. K. Lee]

Specimens examined. ZEALANDIA BANK: ZEA-01-03 (BISH 722344). ARAKANE REEF: ARA-01-03 (BISH 722394), ARA-02-03 (BISH 722409).

*Polysiphonia upolensis* (Grunow) Hollenberg; Hollenberg 1968a: 94, figs. 6D, 6E, 29, 35, 42.

Specimens are 15 mm long with erect branches 100 µm diam at mid-height. Thallus possesses four pericentral cells and unicellular rhizoids are cut from pericentral cells.

Specimens examined. ZEALANDIA BANK: ZEA-01-03 (BISH 722346). PATHFINDER REEF: PAT-01-03 (BISH 722372), PAT-02-03 (BISH 722382).

**Family Wrangeliacae**

*Anotrichium tenue* (C. Agardh) Nägeli; Abbott 1999: 247, fig. 68D.

Specimens are 100–120 (160) µm diam.

Specimens examined. PATHFINDER REEF: PAT-01-03 (BISH 722372), PAT-02-03 (BISH 722382).

**Phylum Ocrophyta**

**Class Phaeophyceae**

**Order Dictyotales**

**Family Dictyotaceae**

*Dictyopteris repens* (Okamura) Børgesen; Tsuda 1972a: 94, pl. 3 (fig. 1).

Specimens examined. STINGRAY SHOALS: STI-02-03 (BISH 720881 on *Chondria* sp. fragment). ZEALANDIA BANK: ZEA-01-03 (BISH 722340). PATHFINDER REEF: PAT-01-03 (BISH 722363), PAT-02-03 (BISH 722376), PAT-02-05 (BISH 743262). ARAKANE REEF: ARA-01-03 (BISH 722403), ARA-02-03 (BISH 722407).

*Dictyota bartayresiana* J. V. Lamouroux; Tsuda 1972a: 95, pl. 3 (figs. 2–3).

All specimens were fragments less than 1 cm long.

Specimens examined. SUPPLY REEF: SUP-01-03 (BISH 720894). PATHFINDER REEF: PAT-01-05 (BISH 743244).

*Dictyota ceylanica* Kützing; Tsuda 1972a: 96, pl. 4 (fig. 2) as *Dictyota divaricata* J. V. Lamouroux.

The largest specimen is 1.5 cm long. All specimens possess narrow flattened acute apices.

Specimens examined. PATHFINDER REEF: PAT-01-05 (BISH 743243), PAT-02-05 (BISH 743261). ARAKANE REEF: ARA-02-03 (BISH 722414), ARA-01-05 (BISH 763251, 763254, 763256), ARA-02-05 (BISH 763277, 763280, 763290).

*Dictyota friabilis* Setchell; Tsuda 1972a: 96, pl. 4 (fig. 3).
The single specimen is 4 mm long and possesses a single dichotomous broad terminal branch.

Specimens examined: ARAKANE REEF: ARA-01-03 (BISH 722401).

**Lobophora sp.**

The present specimens were exposed to formalin and would best be left under their generic name until further specimens are obtained for molecular analyses based on the recent study by Vieira et al. (2014) on *Lobophora* in New Caledonia.


**PHYLM CHLOROPHYTA**

**Class Ulvophyceae**

**ORDER BYOPSIDALES**

**FAMILY Bryopsidaceae**

*Bryopsis hypnoides* J. V. Lamouroux; Abbott & Huisman 2004: 96, fig. 33A.

Specimens examined. PATHFINDER REEF: PAT-01-05 (BISH 743255).

**FAMILY Caulerpaceae**

*Caulerpa ambigua* Okamura; Eubank 1946: 410, pl. 22, figs. 2a and 2b; Draisma et al. 2014: 1031.

Specimens examined. STINGRAY SHOALS: STI-01-03 (BISH 720880 on *Chondria* sp. fragment), STI-02-03 (BISH 720888 on *Chondria* sp. fragment).

*Caulerpa chemnitzia* (Esper) J. V. Lamouroux; Kraft 2007: 171, figs. 64A–C as *Caulerpa peltata*. (=*Caulerpa peltata* J.V. Lamouroux, see Belton et al. 2014)

Specimens examined. PATHFINDER REEF: PAT-01-03 (BISH 722358), PAT-01-05 (BISH 743253).

*Caulerpa racemosa* (Forsskål) J. Agardh; Eubank 1946: 419.

Specimen is a peltate form of *C. racemosa*.

Specimens examined. PATHFINDER REEF: PAT-01-05 (BISH 743251).

*Caulerpa webbiana* Montagne; Eubank 1946: 415, figs. 1a–f, 2c.

Specimen consists of 4 mm high whorled uprights from a prostrate rhizome. Draisma et al. (2014) showed that *Caulerpa elongata* Weber-van Bosse and *C. webbiana* are clearly not conspecific.

Specimens examined. PATHFINDER REEF: PAT-01-05 (BISH 743252). ARAKANE REEF: ARA-01-05 (BISH 763261).

**FAMILY Dichotomosiphonaceae**

*Avrainvillea lacerata* J. Agardh; Olsen-Stojkovich 1985: 33, fig. 18, pl. 6b.

Specimens examined. ZEALANDIA BANK: ZEA-01-03 (BISH 722347).

**FAMILY Halimedaceae**

*Halimeda fragilis* W. R. Taylor; Taylor 1950: 88, pl. 48 (fig. 2).

Specimens appear chalky with nodal medullary filaments unfused.

Specimens examined. PATHFINDER REEF: PAT-02-05 (BISH 743267).

*Halimeda gracilis* Harvey ex J. Agardh; Taylor 1950: 144, fig. 44.

Specimens examined. ARAKANE REEF: ARA-01-03 (BISH 722405), ARA-02-03 (BISH 722422).


Specimens examined. ZEALANDIA BANK: ZEA-01-03 (BISH 722337), ZEA-02-03 (BISH 722348). ZEA-02-05 (BISH 743234, 743235). ARAKANE REEF. ARA-01-05 (BISH 763243, 763263), ARA-02-05 (BISH 763264).

*Halimeda taenicola* W. R. Taylor; Taylor 1950: 86, pl. 46 (fig. 1).
Specimens examined. ZEALANDIA BANK: ZEA-01-03 (BISH 722336), ZEA-02-03 (BISH 722349). PATHFINDER REEF: PAT-01-03 (BISH 722355), PAT-02-03 (BISH 722374, 722388), PAT-01-05 (BISH 743239), PAT-02-05 (BISH 743258). ARAKANE REEF: ARA-01-03 (BISH 722404), ARA-02-03 (BISH 722420), ARA-02-05 (BISH 763282).

**Halimeda cf. tuna** (J. Ellis & Solander) J. V. Lamouroux; Hillis-Colinvaux 1980: 122, figs. 17, 20, 34.

Although the distribution of *Halimeda tuna* seems to be restricted to the Mediterranean Sea and the Atlantic Ocean (Verbruggen et al. 2005), this single specimen has been tentatively placed under *H. tuna* since morphological and anatomical characters are similar to characters noted by Taylor (1950) and Hillis-Colinvaux (1980). The morphology of BISH 763271 differs from *H. cuneata* Hering where Kojima et al. (2015) relegated previously identified specimens of *H. tuna* in Japanese waters. Molecular analysis of more Pacific “*H. tuna*” should be undertaken to resolve this situation; Pacific “*H. tuna*” may be a cryptic new species.

Specimens examined. ARAKANE REEF. ARA-02-05 (BISH 763271).

**FAMILY RHIPILIACEAE**

*Rhipilia orientalis* A. Gepp & E. Gepp; Taylor 1950: 72, pl. 36 (fig. 1).

Specimens examined. ARAKANE REEF: ARA-02-03 (BISH 722419).

**FAMILY UDOTEACEAE**

*Chlorodesmis caespitosa* J. Agardh; Ducker 1967: 157,pls. 3, 12, 13, 14 and 19.

Specimens examined. PATHFINDER REEF: PAT-01-03 (BISH 722362), PAT-02-03 (BISH 722378), PAT-02-05 (BISH 743248, 743269).

*Rhipidosiphon javensis* Montagne; Abbott & Huisman 2004: 140, figs. 52C–D.

Morphologically, the specimens resemble the flabellate form of *Tydemania expeditionis* Weber-van Bosse. The siphons which comprise the blades of *R. javensis* are, however, unequally constricted above each dichotomy.

Specimens examined. PATHFINDER REEF: PAT-01-05 (BISH 743247), PAT-02-05 (BISH 743259). ARAKANE REEF: ARA-02-05 (BISH 763284, 763287, 764138).

**ORDER CLADOPHORALES**

**FAMILY ANADYMENACEAE**

*Microdictyon okamurae* Setchell; N’Yeurt & Payri 2007: 11, figs. 10–12.

Specimen consists of cells 460–540 µm diam and 400–1100 µm long with crenulate apical attachment sites. BISH 763242 was covered with *Calothrix confervicola*.

Specimens examined. ARAKANE REEF: ARA-01-03 (BISH 722400), ARA-02-03 (BISH 722413), ARA-01-05 (BISH 763242), ARA-02-05 (BISH 763281).

*Microdictyon* sp.

Stellate branching patterns are present in few areas. Cells are mostly oblong, 880 µm long and 320–400 µm diam. Branch attachment is by annular wall thickening. The specimens may represent a new species of *Microdictyon*.

Specimens examined. ARAKANE REEF: ARA-01-05 (BISH 763248, 763259), ARA-02-05 (BISH 763269, 763273).

**FAMILY BOODLEACEAE**

*Boodlea composita* (Harvey) F. Brand; N’Yeurt & Payri 2007: 23, figs. 31–34.

Specimen is 3 mm long with main branch up to 200 µm diam and branches up to 96 µm diam.

Specimens examined. ARAKANE REEF: ARA-01-05 (BISH 763257).

*Boodlea vanbossea*e Reinbold; Dawson 1956: 29, fig. 6.
BISH 720891 is a young filament which is 1 cm long and 96–120 µm diam with conspicuous rhizoids, up to 240 µm long with fimbriate terminal apices.

Specimens examined. SUPPLY REEF: SUP-01-03 (BISH 720891 on Lobophora sp.).

*Phyllodictyon anastomosans* (Harvey) Kraft & M. J. Wynne; Abbott & Huisman 2004: 63, figs. 16A–B.

Specimen is immature but possesses opposite branching pattern.

Specimens examined. ARAKANE REEF: ARA-02-05 (BISH 763291).

**FAMILY CLADOPHORACEAE**

*Cladophora cf. flexuosa* (O. F. Müller) Kützing; Abbott & Huisman 2004: 72, fig. 20C.

Specimen is 2 mm long and resembles the basal filament of *C. flexuosa*.

Specimens examined. ARAKANE REEF: ARA-02-05 (BISH 763278).

*Cladophora cf. vagabunda* (Linnaeus) C. Hoek; Abbott & Huisman 2004: 79, figs. 24A–D.

Filaments are up to 10 mm tall and represent immature specimens.

Specimens examined. ARAKANE REEF: ARA-01-03 (BISH 722402), ARA-02-03 (BISH 722411).

**FAMILY PITHOPHORACEAE**

*Dictyosphaeria cavernosa* (Forsskål) Børgesen; Egerod 1952: 350, figs. 1b–f, 2f, 2g.

Specimens examined. SUPPLY REEF: SUP-01-03 (BISH 720892). PATHFINDER REEF: PAT-01-05 (BISH 743257). ARAKANE REEF: ARA-02-03 (BISH 722421), ARA-01-05 (BISH 763249), ARA-02-05 (BISH 763265, 764136).

*Dictyosphaeria versluysii* Weber-van Bosse; Egerod 1952, 351, figs. 1a, 2h–k.

Specimens examined. ZEALANDIA BANK: ZEA-01-03 (BISH 722335), ZEA-02-03 (BISH 722351). PATHFINDER REEF: PAT-01-03 (BISH 722356).

**FAMILY VALONIACEAE**

*Valonia ventricosa* J. Agardh; Kraft 2007: 121, figs. 51A–D.

[*= Ventricaria ventricosa* (J. Agardh) Olsen & J. A. West]

Specimens examined. SUPPLY REEF: SUP-01-03 (BISH 720893). ZEALANDIA BANK: ZEA-01-03 (BISH 722334), ZEA-02-03 (BISH 722350). PATHFINDER REEF: PAT-01-03 (BISH 722357), PAT-02-03 (BISH 722389), PAT-02-05 (BISH 743270). ARAKANE REEF: ARA-02-03 (BISH 722416).

**Discussion**

The 67 algal species included 8 blue-green algae, 30 red algae, 5 brown algae and 24 green algae. Four species of red algae (*Antithamnion decipiens*, *Ceramium isogonum*, *Chondria bullata* and *Gayliella transversalis*) represented new records for Micronesia (includes Mariana Islands). An additional 10 species of red algae represented new records for the Mariana Islands which included *Caulacanthus ustulatus*, *Ceramium affine*, *Ceramium codii*, *Chondria simpliciscula*, *Dasya cf. corymbifera*, *Jania pumila*, *Jania rubens*, *Lomentaria hakodatensis*, *Polysiphonia dotyi* and *Polysiphonia sertularioides*. The fact that all of the new records were species of red algae is not surprising since the red algae were the least studied within the Mariana Islands.

Five algal species were identified only to the generic level. The red-colored Cyanobacteria *Phormidium* sp. was abundant and characterized Arakane Reef in September 2005 at both sites, especially at ARA-01-05. This blue-green alga, however, was not collected from Arakane Reef during the same month in 2003. The brown alga which one would normally identify as *Lobophora variegata* (J. V. Lamouroux) Womersley ex E. C. Oliveira was listed as *Lobophora* sp. based on the findings of Vieira et al. (2014) of 14 species of *Lobophora* in New Caledonia. Our specimens which were collected in 2003 and 2005 were previously preserved in formalin and could not be
subjected to molecular analysis. The morphology of the Mariana seamount specimens of *Peyssonnelia* sp. did not typify widely distributed species around Pacific islands. The specimens of *Polysiphonia* sp. were unique in that they possessed 4–7 pericentral cells in the prostrate branches and 4–5 pericentral cells in the erect branches. The variable numbers of pericentral cells in the erect and prostrate branches differ from *Polysiphonia tsudana* Hollenberg which possesses 4 and 6–9 pericentral cells in the prostrate and erect branches, respectively. The fifth unidentified species, *Microdictyon* sp., possessed oblong cells with fine mesh with branch attachments by annular thickening. The specimens were only collected in September 2005 from Arakane Reef from both sites, ARA-01-05 and ARA-02-05, and differed morphologically from other species of *Microdictyon* reported around Pacific islands.

Fourteen (44%) of the 32 species of algae recorded by Tsuda et al. (2012) from Santa Rosa Reef (Mariana Arc) were also present among the 67 species recorded here. The species included 3 blue-green algae (*Calothrix confervicola*, *Lyngbya sordida*, *Scytonematopsis pilosa*), 3 red algae (*Dasya iyengarii*, *Hypnea spinella*, *Polysiphonia homoia*), 1 brown alga (*Dictyota ceylanica*) and 7 green algae (*Dictyosphaeria cavernosa*, *Dictyosphaeria verslusysii*, *Halimeda fragilis*, *Halimeda opuntia*, *Halimeda taenicola*, *Halimeda cf. tuna*, and *Microdictyon okamurae*).

Of the 67 algal species recorded in 2003 and 2005, 31 species were collected only from seamounts within the submerged West Mariana Ridge, and 5 species were collected only from seamounts (including Santa Rosa Reef reported previously by Tsuda et al. 2012) within the Mariana Arc. One would have expected the greater number of species to be associated with the Mariana Arc which includes 14 islands lying in a north-south orientation adjacent to the seamounts. The remaining 31 algal species were present on seamounts along both the West Mariana Ridge and the Mariana Arc.

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Figures 2–5.
Figure 2. Vertical wall at one of two pinnacles at Zealandia Bank. Figure 3. In-situ image of *Halimeda taenicola* at Pathfinder Reef. Figure 4. In-situ image of *Caulerpa webbiana* at Arakane Reef. Figure 5. Arakane Reef, strong surge and currents, characterized by a high abundance of soft coral *Lobophytum* sp. and the red pigmented Cyanobacteria *Phormidium* sp. All photos by KNP.