

Marine benthic algae from Wake Atoll

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Abstract—The 40 species of marine benthic algae represent specimens collected on eight occasions between December 1841 and June 1998 from isolated Wake Atoll located 546 km north of the nearest land mass, i.e., Taongi Atoll in the Marshall Islands. Thirty five of the 40 species are reported for the first time from Wake Atoll. The annotated listing includes 5 species of blue-green algae (cyanobacteria), 11 species of green algae, 11 species of brown algae and 13 species of red algae. The marine algae from Wake Atoll are, for the most part, species common to both the Hawaiian Islands and Micronesia, but show a slightly closer affinity with algae from Hawaiian waters. Only the green algae *Caulerpa urvilleana* and *Halimeda renschii*, and the brown alga *Padina minor* have not been reported from the Hawaiian Islands.

Introduction

Wake Atoll (19° 17' N latitude and 166° 36' E longitude) is a small atoll in the central Pacific, approximately 3 km wide and 6.5 km long. It comprises three islets, i.e., Wake I., Wilkes I. and Peale I., with a land area of approximately 6.5 km² (Figure 1). The marine flora and fauna of Wake Atoll are of special biogeographical interest because of its isolation from other islands in the central Pacific. The closest land mass is Taongi Atoll, the northernmost atoll within the Marshall

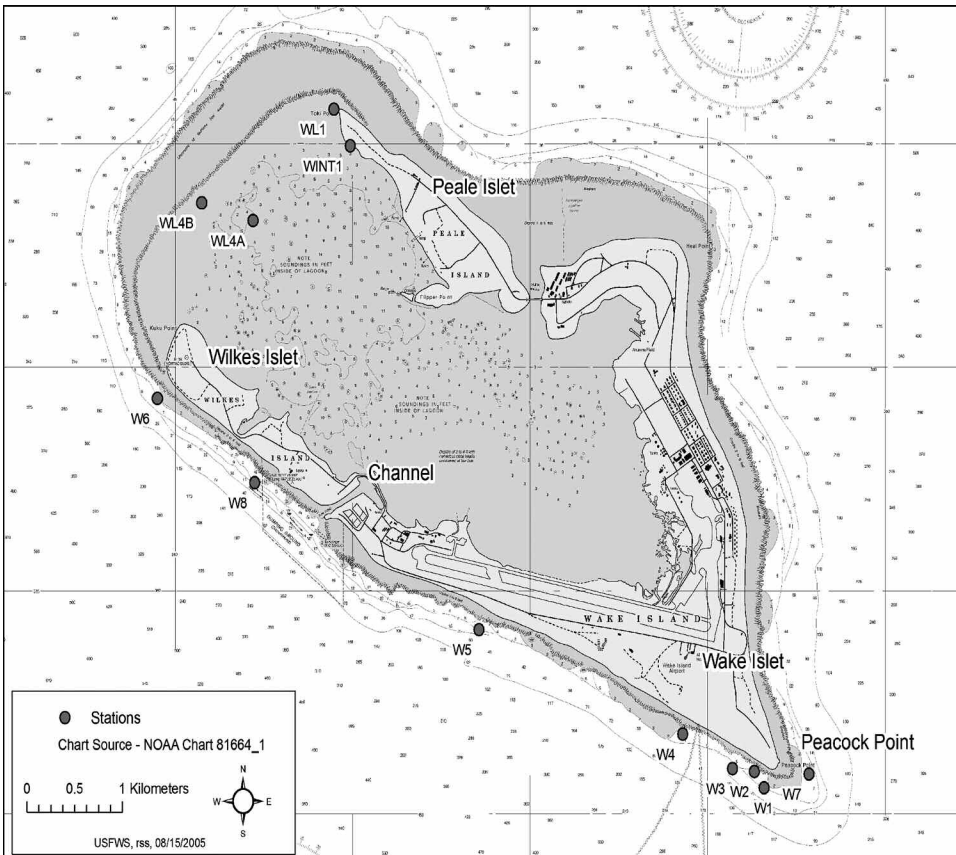


Figure 1. Map of Wake Atoll showing June 1998 algal collection sites.

Islands, located 546 km to the south. Wake Atoll is under the jurisdiction of the U.S. Air Force and is presently a military base administered by the U.S. Army Space and Strategic Defense Command.

The first and only published record of marine benthic algae from Wake Atoll comprised five species, i.e., two Chlorophyta (green algae) and three Phaeophyta (brown algae), collected on 20 December 1841 during the U.S. Exploring Expedition (Bailey & Harvey 1874). An unpublished marine biological survey of the Peacock Point sewage outfall and other point-source discharges at Wake Atoll was prepared by the U.S. Department of the Interior Fish and Wildlife Service and U.S. Department of Commerce National Marine Fisheries Service in March 1999. One of us (K.B. Foster) listed and quantified 19 species of marine benthic algae from the southern reefs of Wake Islet and Wilkes Islet, i.e., 2 species of Cyanophyta (blue-green algae or cyanobacteria), 7 species of Chlorophyta (green algae), 7 species of Phaeophyta (brown algae) and 3 species of Rhodophyta (red

algae). Five of the 19 species were designated by only generic names. A species of the green alga *Enteromorpha* was also observed in the drainage plume of the power plant discharge of cooling water.

Bryan (1959) reviews the natural history of Wake Atoll. The most recently published marine biological study of Wake Atoll was conducted by Lobel & Lobel (2004) on the marine fishes based on collections and observations made during two expeditions to the atoll on 10 to 23 July 1997 and 15 to 29 May 1999, as well as historical collections and observations. The authors concluded that the fish population was more common to the northern Mariana Islands (87%) and Marshall Islands (82%) than to the Hawaiian Islands (40%). Although no algae were collected on their trips to Wake Atoll (P. S. Lobel, Personal Communication, March 2005), they state in the publication that “We did not find sea grass, algal flats, or mangroves.”

Materials and Methods

The annotated listing of marine benthic algae is primarily based on the 54 specimens collected by one of us (K.B. Foster) in June 1998 in association with a study of the Peacock Point sewage outfall located at the southeast corner of Wake Islet and at other sites on Wake Atoll. The five species reported by Bailey & Harvey (1874) are included in the listing.

A database search of algal specimens from Wake Atoll within the Bishop Museum Herbarium Pacificum revealed 43 specimens, i.e., 25 crustose corallines and 18 non-crustose corallines. The 25 crustose corallines are not included in this study; however, the 18 non-crustose corallines plus two additional epiphytes found in the collections are included here.

Five specimens were collected during the Tanager Expedition by Horace Mann in July 1923 (4 specimens) and by J.B. Pollock on 4 August 1923 (1 specimen). The remaining 15 specimens were collected by John E. Randall on 6, 10 and 12 June 1953 (7 specimens), by F. Raymond Fosberg (FRF) on 9 March 1963 (2 specimens) and by “W” Jan Newhouse (WJN) on 15 November 1967 (3 specimens) and on 17 April 1968 (3 specimens). In three cases, specimens were previously identified by either Joan C. Hare or by Maxwell S. Doty (MSD), and credit is provided accordingly.

The 54 specimens collected by K.B. Foster were designated with his prefix (KN) and collection numbers. In the majority of cases, the prefix and specimen numbers of Isabella A. Abbott (IA) were also assigned to the same specimens. All specimens were provided with specimen numbers of the Bishop Museum (BISH) and cited with the other collection or specimen numbers in this paper. All specimens were included in the algal species database and were deposited in the Bishop Museum Herbarium Pacificum.

Collection Sites

The descriptions of the stations where collections were made during June 1998 were summarized from the U.S. Department of the Interior Fish and Wildlife Service and U.S. Department of Commerce National Marine Fisheries Service 1999 report, and from notes made by one of us (K.B. Foster). The sewage outfall pipe extended 21 meters in a southerly direction from shore and discharged at a depth of 10 to 11 meters. SCUBA was used extensively during the fieldwork by K.B. Foster and his colleagues at Wake Atoll.

W1 (19° 16.120' N, 166° 39.318' E). High energy site near the eastern tip of the atoll located approximately 150 m SE (upcurrent) of outfall pipe and within the discharge Zone of Mixing (ZOM), 18.3 m deep, Wake I., leg. KBF, 19 June 1998. [KN 180, 182–185].

W2 (19° 16.190' N, 166° 39.262' E). Low to moderate energy site located at the end of the outfall pipe and at the center of Zone of Initial Dilution (ZID), 13.7 m deep, Wake I., leg. KBF, 19 June 1998. [KN 186–190].

W3 (19° 16.213' N, 166° 39.139' E). Low to moderate energy site located within the ZOM and approximately 150 m NW (downcurrent) of the outfall pipe, 13.7 m deep, Wake I., leg. KBF, 20 June 1998. [KN 191–195].

W4 (19° 16.359' N, 166° 38.858' E). Low to moderate energy site located near the downcurrent limit of the ZOM and approximately 500 m NW from the end of the pipe, 13.7 m deep, Wake I., leg. KBF, 20 June 1998. [KN 146, 147, 149, 151].

WINT1 (19° 19.088' N, 166° 36.941' E). Intertidal zone, Peale I., leg. KBF, 21 June 1998 [KN 196].

WL1 (19° 9.08' N, 166° 36.94' E). Lagoon, wave-swept reef, Peale Point (west end of Peale I.), <1 m deep, leg. KBF, 21 June 1998 [KN 197–201, 203].

W5 (19° 16.819' N, 166° 37.710' E). Low to moderate energy site located approximately 2.41 km northwest of outfall pipe, 15.2 m deep, Wake I., leg. KBF, 22 June 1998. [KN 172–175, 178, 179].

W6 (19° 17.853' N, 166° 35.902' E). Approximately 7.24 km NW of outfall pipe, 16.8 m deep, Wilkes I., leg. KBF, 22 June 1998. [KN 205–208].

W7 (19° 6.176' N, 166° 39.585' E). Metal Dump Reef, Peacock Point, 26 m deep, Wake I., leg. KBF, 23 June 1998. [KN 213].

WL4A (19° 8.620' N, 166° 36.383' E). Western Lagoon, 2.4 m deep, leg. KBF, 24 June 1998 [KN 209–210].

W8 (19° 17.336' N, 166° 36.651' E). D-buoy, 100 m due west of entrance of south harbor channel, 27.4 m deep, Wilkes I., leg. KBF, 27 June 1998. [KN 212].

WL4B (19° 18.722' N, 166° 36.252' E). Lagoon slope of west barrier reef, strong currents, 1.5 m deep, leg. KBF, 28 June 1998. [KN 213].

Results

CYANOPHYTA

ORDER OSCILLATORIALES

FAMILY OSCILLATORIACEAE

Lyngbya aestuarii (Mertens) Liebman

BISH 716681 (WL4B:KN 213b, IA 23516b), epiphytic on *Asteronema breviarticulatum*.

The greenish-black trichomes are 6 to 24 μm in diameter and possess slightly tapering apices.

Lyngbya majuscula (Dillwyn) Harvey

USDI-FSW & USDOC-NMFS (1999); BISH 716638 (MSD 18579), center of lagoon, 1.2 to 1.4 m deep, leg. J.E. Randall, 12 June 1953; BISH 716644 (W1:KN 184, IA 23486); BISH 716648 (W2:KN 188b, IA 23490b); BISH 716653 (W3:KN 193a, IA 23495a), intertangled with *Calothrix pilosa*; BISH 716677 (W6:KN 208, IA 23510).

The colors of the trichomes vary from reddish brown, greenish red to green. Except for specimen BISH 716638 which possesses trichomes 70 to 125 μm in diameter, all of the other specimens are much smaller in diameter ranging from 16 to 32 μm in diameter. All specimens have the characteristic narrow granular cells and blunt rounded apices.

FAMILY PHORMIDIACEAE

Symploca hydroides (Harvey) Kützing

BISH 716676 (W6:KN 207b, IA 23509b).

Specimens appear brush-like, and individual trichomes are 4 to 6 μm in diameter.

FAMILY RIVULARIACEAE

Calothrix pilosa Harvey

BISH 716646 (W2:KN 186b, IA 23488b), epiphytic on *Padina minor*; BISH 716654 (W3:KN 193b, IA 23495b), intertangled with *Lyngbya majuscula*.

Trichomes are 8 to 10 μm in diameter with distinct intercalary heterocysts.

Calothrix scopulorum (Weber & Mohr) C. Agardh ex Bornet & Flahault

BISH 716682 (WL4B:KN 213c, IA 23516c), epiphytic on *Asteronema breviarticulatum*.

Trichomes are distinctly tapered and each possesses a basal heterocyst; the base of the trichomes is approximately 8 μm in diameter.

CHLOROPHYTA

ORDER ULVALES

FAMILY ULVACEAE

Enteromorpha clathrata (Roth) Greville

BISH 570330 (WJN 53–93), intertidal on seaward shore on windward side, 6 June 1953, leg. J.E. Randall.

The immature specimens are 2–3 mm high on a piece of dead coral and possess uniseriate and multiseriate branches throughout. The cells are arranged in longitudinal rows and each cell contains several pyrenoids.

ORDER CLADOPHORALES
FAMILY SIPHONOCLADACEAE

Dictyosphaeria cavernosa (Forsskål) Børgesen

Bailey & Harvey (1874) as *Dictyosphaeria favulosa* Decaisne; BISH 512284 (H. Mann 282), July 1923, leg. H. Mann; BISH 545373 (MSD 18581), center of lagoon, 1.2–1.5 m deep, 12 June 1953, leg. J.E. Randall and det. M.S. Doty; BISH 716678 (WL4A:KN 209, IA 23511).

The dried specimens are hollow and do not possess trabeculae.

ORDER BRYOPSIDALES
FAMILY CAULERPACEAE

Caulerpa cupressoides (Vahl) C. Agardh

Bailey & Harvey (1874) as *Caulerpa mamillosa* Montagne.

Caulerpa racemosa (Forsskål) J. Agardh

USDI-FSW & USDOC-NMFS (1999) as *Caulerpa peltata* Lamouroux; BISH 716663 (WL1:KN 198, IA 23500).

The erect axes possess spherical ramuli.

Caulerpa serrulata (Forsskål) J. Agardh

USDI-FSW & USDOC-NMFS (1999); BISH 512277 (H. Mann 28.1), Wake I., July 1923, leg. H. Mann; BISH 716642 (W1:KN 182, IA 23484); BISH 716647 (W2: KN 187, IA 23489); BISH 716657 (W4:KN 146); BISH 716671 (W5:KN 178a, IA 23480a); BISH 716673 (W6:KN 205a, IA 23507a).

The erect axis and primary branches are flat with serrated margins.

Caulerpa urvilleana Montagne

USDI-FSW & USDOC-NMFS (1999) as *Caulerpa cupressoides* (Vahl) C. Agardh; BISH 512276 (H. Mann 28), Wake I., July 1923, leg. H. Mann; BISH 716661 (WINT1:KN 196, IA 23498); BISH 716666 (WL1:KN 201a, IA 23503a).

Caulerpa urvilleana appears similar to *Caulerpa serrulata*; however, the erect branches of *C. urvilleana* are angular and possess dentate projections.

FAMILY DERBESACEAE

Derbesia tenuissima (Moris & Notaris) P. Crouan & H. Crouan

BISH 716652 (W3:KN 192a, IA 23494a), fertile; BISH 716658 (W4:KN 147).

Siphons are 16 to 24 µm in diameter with pyriform sporangia, 104 µm long and 28 to 52 µm in diameter. The base of the sporangium possesses double septa. The siphons are thinner than the 50 to 70 µm diameter reported in Hawaiian specimens by Abbott & Huisman (2004).

FAMILY HALIMEDACEAE

Halimeda renschii Hauck

BISH 706088 (Pollock 167a), reef flat, 4 August 1923, leg. J.B. Pollock and det. J.C. Hare in November 1993.

The rhizoidal filaments are not bulbous but appear broad and adhere to the basal segments. Segments are up to 4 mm long and 5 mm wide.

Halimeda velasquezii W.R. Taylor

USDI-FSW and USDOC-NMFS (1999) as *Halimeda opuntia* (Linnaeus) Lamouroux; BISH 716641 (W1:KN 180, IA 23482); BISH 716650 (W2:KN 190, IA 23492); BISH 716656 (W3:KN 195, IA 23497); BISH 716659 (W4:KN 149); BISH 716664 (WL1:KN 199, IA 23501); BISH 716669 (W5:KN 173, IA 23475).

All specimens are less than 6.5 cm high with branching primarily in one plane, i.e., flat in appearance. The medullary filaments fuse in pairs for short distance, never completely separating. Surface utricles are up to 32 μm long and 16 to 24 μm in diameter, irregularly round in surface view. Unlike the type description (Taylor 1962), the outer utricles do separate but not readily under pressure. The short fusion of medullary filaments and the rounded surface view of the surface utricles distinguish *H. velasquezii* from *H. fragilis* Taylor and *H. gracilis* Harvey ex J. Agardh, respectively.

FAMILY UDOTEACEAE

Avrainvillea amadelpa (Montagne) A. Gepp & E. Gepp.

USDI-FSW & USDOC-NMFS (1999) as *Rhipilia orientalis* A. Gepp & E. Gepp; BISH 716679 (WL4A:KN 210, IA 23512).

The single specimen, 6 cm high, possesses torulose and tapering siphons, 16–24 μm in diameter, with rounded apices and intertangled into a pseudocortex. Macroscopically, the Wake Atoll specimen appears similar to *Avrainvillea lacerata* Harvey ex J. Agardh which has thinner blades, i.e., lacks a pseudocortex.

ORDER DASYCLADALES

FAMILY DASYCLADACEAE

Neomeris annulata Dickie

USDI-FSW & USDOC-NMFS (1999); BISH 716645 (W1:KN 185, IA 23487); BISH 716651 (W3:KN191, IA 23493).

Specimens possess the characteristic external annular calcifications and internal oblong gametangia.

PHAEOPHYTA

ORDER ECTOCARPALES

FAMILY ECTOCARPACEAE

Asteronema breviarticulatum (J. Agardh) Ouriques & Bouzon

USDI-FSW & USDOC-NMFS (1999) as *Hincksia breviarticulata* (J. Agardh) P. Silva; BISH 557174 (WJN 2154), outer reef, Peale I., 17 April 1968,

leg. "W" J. Newhouse and det. J.C. Hare on 19 November 1991; BISH 716680 (W7:KN 213a, IA 23515a).

Filaments possess hamate branch tips and subspherical plurilocular reproductive bodies.

ORDER SPHACELARIALES
FAMILY SPHACELARIACEAE

Sphacelaria tribuloides Meneghini

BISH 716639 (FRF 43539), dense felt on reef flat, north shore, terminal area, Wake I., 9 March 1963, leg. F.R. Fosberg; BISH 570361 (WJN 2152), lagoon shore, Wilkes I., 15 November 1967, leg. "W" J. Newhouse.

The multiseriate dark brown filaments possess the characteristic-shaped propagules with pointed triangular arms.

ORDER DICTYOTALES
FAMILY DICTYOTACEAE

Dictyopteris plagiogramma (Montagne) Vickers

Bailey & Harvey (1874) as *Haliseris plagiogramma* Montagne.

Dictyota bartayresiana Lamouroux

USDI-FSW & USDOC-NMFS (1999) as *Dictyota* sp.; BISH 555784 (WJN 2153), lagoon shore, Wilkes I., 15 November 1967, leg. "W" J. Newhouse; BISH 716667 (WL1: KN 201b, IA 23503b).

The immature specimens of BISH 716667 are less than 1.5 cm long with rounded apices, and resemble prostrate *Dictyota friabilis* Setchell.

Dictyota ceylanica Kützing

USDI-FSW & USDOC-NMFS (1999) as *Dictyota divaricata* Lamouroux; BISH 555783 (WJN 2155), Wake I., 17 April 1968, leg. "W" J. Newhouse; BISH 716643 (W1:KN 183, IA 23485); BISH 716649 (W2:KN 189, IA 23491); BISH 716655 (W3:KN 194, IA 23496); BISH 716660 (W4:KN 151); BISH 716662 (WL1:KN 197, IA 23499); BISH 716668 (W5:KN 172, IA 23474); BISH 716670 (W5:KN 175, IA 23477); BISH 716674 (W6:KN 206, IA 23508).

Dictyota ciliolata Sonder ex Kützing

USDI-FSW & USDOC-NMFS (1999) as *Dictyota* sp.; BISH 716672 (W5:KN 179, IA 23481).

Specimens appear erect, up to 5 cm high, with branches 3 to 4 mm wide. The margins are smooth, non-dentate, with occasional spatulate bladelets on the margins of few branches. The presence of the spatulate bladelets resemble *D. sandvicensis* Sonder; however, the overall morphology, thick texture and brown color differ.

Dictyota sandvicensis Sonder

BISH 556678 (MSD 18580), center of lagoon, <1.5 m deep, 12 April 1953, leg. J.E. Randall.

Specimens, up to 4 cm high, have few bladelets; the spatulate bladelets are not as clearly evident as seen in Hawaiian specimens.

Padina boryana Thivy

Bailey & Harvey (1874) as *Padina pavonia* Adamson.

Padina minor Yamada

USDI-FSW & USDOC-NMFS (1999) as *Padina* sp.; BISH 716646 (W2:KN 186a, IA 23488a).

The moderately calcified specimens, up to 3 cm high and 3 cm wide, appear macroscopically similar to the common *Padina santae-crucis* Børgesen in Hawaiian waters. The blades are two cells thick with woolly rhizoids, and possess hairs on both sides of the blades. The specimens, however, are non-indusiate and the hairlines are equal in width, with sori occurring adjacent and above consecutive hairlines.

ORDER SCYTOSIPHONALES

FAMILY SCYTOSIPHONACEAE

Rosenvingeia intricata (J. Agardh) Børgesen

BISH 554754 (WJN 2156), drift on outer reef, Peale I., 17 April 1968, leg. "W" J. Newhouse.

ORDER FUCALES

FAMILY SARGASSACEAE

Turbinaria ornata (Turner) J. Agardh

Bailey & Harvey (1874).

RHODOPHYTA

ORDER NEMALIALES

FAMILY ACROCHAETIACEAE

Acrochaetium liagorae Børgesen

BISH 716685 (WL1:KN 203a, IA 23505a, slide), endophytic in *Ganonema farinosum*.

FAMILY LIAGORACEAE

Ganonema farinosum (Lamouroux) Fan & Wang

USDI-FSW & USDOC-NMFS (1999) as *Liagora* sp.; BISH 716685 (WL1:KN 203, IA 23505, slide).

ORDER CORALLINALES

FAMILY CORALLINACEAE

Jania pumila Lamouroux

BISH 716684 (W3:KN 192c, IA 23494c, slide); BISH 716675 (W6:KN 207a, IA 23509a).

Specimens are 20-24 μm in diameter and have three or more unbranched intergenicula between dichotomies. The length of the intergenicula is more than

four times the diameter. Specimens appear macroscopically very similar to *Jania capillacea* Harvey common in Micronesian waters.

ORDER GIGARTINALES

FAMILY HYPNEACEAE

Hypnea spinella (C. Agardh) Kützing

BISH 512658 (H. Mann 28.3), Wake I., July 1923, leg. H. Mann.

Specimens are about 1 cm high, clumped and branches possess secondary attachments.

ORDER CERAMIALES

FAMILY CERAMIALES

Aglaothamnion boergesenii (Aponte & Ballantine) L'Hardy-Halos & Rueness

USDI-FSW & USDOC-NMFS (1999); BISH 716686 (W5:KN 174, IA 23476, slide); BISH 716688 (W6:KN 205c, IA 23507c, slide, tetrasporic).

Specimens were epiphytic on a *Dictyota* fragment.

Centroceras clavulatum (C. Agardh) Montagne

BISH 527909 (WJN 53-87), mixed with *Polysiphonia tepida*, seaward reef flat on windward side, 0.3-0.6 m deep, 6 June 1953, leg. J. E. Randall; BISH 538292 (FRF 43539a), mixed with *Sphacelaria tribuloides*, north shore at terminal area, Wake I., 9 March 1963, leg. F.R. Fosberg.

Specimens contain 14 periaxial cells with conspicuous spines at nodes.

Ceramium flaccidum (Harvey ex Kützing) Ardisone

BISH 716683 (W3:KN 192b, IA 23494b, slide, tetrasporic); BISH 716689 (W6:KN 205e, IA 23507e, slide, tetrasporic); BISH 716690 (W8:KN 212, IA 23514, slide, tetrasporic).

This species is characterized by its unequal terminal branches (Abbott, 1999). Cortical bands are up to 32 to 48 μm in diameter and consist of approximately three rows of cells with the bottom row separated by a space below the upper two rows.

Ceramium punctiforme Setchell

BISH 716688 (W6:KN 205d, IA 23507d, slide, female).

Specimens, which were epiphytic on a *Dictyota* fragment, possess stout prostrate axis with numerous rhizoids, and club-like erect axis.

Ceramium tenuissimum (Roth) Areschong

BISH 716665 (WL1:KN 200, IA 23502), epiphytic on *Dictyota ceylanica* Kützing.

Branching pattern is repeatedly subdichotomous with cortical bands 44 to 52 μm in diameter.

Heterosiphonia crispella (C. Agardh) Wynne

BISH 716688 (W6:KN 205b, IA 23507b, slide, sterile).

Specimens were epiphytic on a *Dictyota* fragment.

FAMILY RHODOMELACEAE

Polysiphonia setacea Hollenberg

BISH 587387 (slide), 10 June 1953, leg. J.E. Randall.

Erect bristle-like axes, 40 to 44 μm in diameter with four pericentral cells, arise from slender prostrate axis.

Polysiphonia tepida Hollenberg

BISH 538305 (WJN 53-86), seaward reef flat on windward side, 0.3-0.6 m deep, 6 June 1953, leg. J.E. Randall.

The brown turf, 5 mm high, is mixed with fine sand particles. The erect axes are 80-120 μm in diameter and possess 7 pericentral cells, each approximately twice as long as wide.

Tolypocladia glomerulata (C. Agardh) Schmitz

BISH 716640 (WJN 2153), epiphytic on *Dictyota ceylanica*, lagoon shore of Wilkes I., XI-15-67, leg. "W" J. Newhouse; BISH 716687 (W5:KN 178b, IA 23480b, slide).

Specimens are purple with characteristic acute branchlets arranged spirally on the erect polysiphonous axis.

Discussion

Besides the 5 species reported by Bailey & Harvey (1874), 35 additional species of marine benthic algae are documented for the first time from Wake Atoll, i.e., 5 species of Cyanophyta, 9 species of Chlorophyta, 8 species of Phaeophyta and 13 species of Rhodophyta, based on voucher specimens examined. Five additional species, i.e., *Spirocoleus crosbyanus* (Tilden) P. Silva (= *Phormidium crosbyanum* Tilden), *Cladophora* sp., *Dictyopteris repens* (Okamura) Børgesen, *Lobophora variegata* (Lamouroux) Womersley ex Oliveira and *Jania micrarthrodia* Lamouroux were reported by U.S. Department of the Interior Fish and Wildlife Service & U.S. Department of Commerce National Marine Fisheries Service (1999); however, no voucher specimens were present in the collections.

Some insight on the dominant algae on the southern coast of Wake Atoll was obtained by one of us (KBF) during SCUBA dives. *Lyngbya majuscula*, *Halimeda velasquezii* and *Dictyota ceylanica* were the most dominant algal species at Stations W3, W4 and W5 located downcurrent of the sewage outfall and south of Wake Islet. *Lyngbya majuscula* and *Dictyota ceylanica* were dominant at Station W1 located upcurrent of the outfall at the southeast tip of Wake Islet, and *L. majuscula* was dominant at Station W2 at the outfall site. The green alga, *Caulerpa racemosa*, was dominant at Station 6 off the southern seaward shore of Wilkes Islet.

Although the number of marine benthic algal species reported here is small, the majority of the marine flora of Wake Atoll are species common to both the Hawaiian Islands and Micronesia. The flora, however, shows a slightly closer affinity to the Hawaiian algal flora (Abbott 1999; Abbott & Huisman 2004) than

to that of the closer Marshall Islands (Tsuda 2002) or the western Mariana Islands (Tsuda 2003, Lobban & Tsuda 2003).

The five species of blue-green algae (cyanobacteria) are found throughout the tropical and subtropical Pacific Ocean, and serve as poor indicators in terms of algal biogeography. All 13 species of red algae are present in the Hawaiian Islands; however, less than half of the red algal species are reported from the Marshall Islands (4 species or 31%) and the Mariana Islands (6 species or 46%). The low number of red algal species in the Micronesian Islands is attributed to the paucity of floristic information on the filamentous-like red algae in Micronesia as compared to the Hawaiian Islands. The green and brown algae serve as the better basis of comparison between Wake Atoll and the surrounding island groups. The green algae *Caulerpa urvilleana* and *Halimeda renschii*, and the brown alga *Padina minor* are the only algal species reported from Wake Atoll that have not been reported from the Hawaiian Islands. The three species, however, are present in Micronesia.

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References

- Abbott, I.A. 1999. Marine red algae of the Hawaiian Islands. Bishop Museum Press, Honolulu. xv + 477 pp.
- Abbott, I.A. & J.M. Huisman. 2004. Marine green and brown algae of the Hawaiian Islands. Bishop Museum Press, Honolulu. xi + 259 pp.

- Bailey, J.W. & W.H. Harvey. 1874. Algae. In U.S. Exploring Expedition, Vol. 17, Botany Cryptogamia. Sherman & Co., Philadelphia. pp. 153–192.
- Bryan, E.H. Jr. 1959. Notes on the geography and natural history of Wake Island. Atoll Research Bulletin (66): 1–22.
- Lobban, C.S. & R.T. Tsuda. 2003. Revised checklist of benthic marine macroalgae and seagrasses of Guam and Micronesia. *Micronesica* 35/36: 54–99.
- Lobel, P.S. & L.K. Lobel. 2004. Annotated checklist of the fishes of Wake Atoll. *Pacific Science* 58: 65–90.
- Taylor, W. R. 1962. Two undescribed species of *Halimeda*. *Bulletin of the Torrey Botanical Club* 89: 172–177.
- Tsuda, R.T. 2002. Checklist and bibliography of the marine benthic algae from the Marshall Islands. University of Guam Marine Laboratory, Technical Report No. 106, 33 pp.
- Tsuda, R.T. 2003. Checklist and bibliography of the marine benthic algae from the Mariana Islands (Guam and CNMI). University of Guam Marine Laboratory, Technical Report No. 107, 49 pp.
- U.S. Department of the Interior Fish and Wildlife Service & U.S. Department of Commerce National Marine Fisheries Service (USDI-FWS & USDOC-NMFS). 1999. Baseline marine biological survey, Peacock Point Outfall and other point-source discharges, Wake Atoll, Pacific Ocean. Prepared for U.S. Army Space and Missile Defense Command, Department of the Army. ii + 23 pp.

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