

New Species Records of Marine Benthic Algae in the Papahānaumokuākea Marine National Monument (Northwestern Hawaiian Islands)¹

ROY T. TSUDA²

*Botany-Herbarium Pacificum, Natural Sciences, Bernice P. Bishop Museum,
1525 Bernice Street, Honolulu, Hawai‘i 96817-2704 USA;
email: roy.tsuda@bishopmuseum.org*

HEATHER L. SPALDING & ALISON R. SHERWOOD²

*Department of Botany, 3190 Maile Way, University of Hawai‘i-Mānoa,
Honolulu, Hawai‘i 96822 USA;
emails: hspaldin@hawaii.edu; asherwoo@hawaii.edu*

The species listing below comprises an additional 29 species of marine benthic algae within the Papahānaumokuākea Marine National Monument (PMNM), a World Heritage site, which encompasses an area of 360,000 km² of the Northwestern Hawaiian Islands. The 10 islands, atolls and shoals within the PMNM, aligned from northwest to southeast, include Kure Atoll, Midway Atoll, Pearl & Hermes Atoll, Lisianski Island, Laysan Island, Maro Reef, Gardner Pinnacles, French Frigate Shoals, Necker Island and Nihoa Island.

The 29 new records for the PMNM consist of 1 species of Cyanobacteria, 23 species of Rhodophyta, 1 species of Phaeophyceae and 4 species of Chlorophyta, which were primarily reported by Abbott (1999) and Abbott & Huisman (2004) from at least one of the Main Hawaiian Islands (MHI) to the southeast. Other references which report species from the MHI are cited with the islands where the species were previously reported.

These 29 species increase the number of marine benthic algal species found in the PMNM from 335 (Tsuda 2014) to 364 species or by 8.6%. Voucher specimens with BISH numbers are deposited in *Herbarium Pacificum (BISH)* of the Bishop Museum. Voucher specimens with NWHI numbers are presently deposited in the Alison R. Sherwood Laboratory at the University of Hawai‘i-Mānoa. AlgaeBase (Guiry & Guiry 2015) was consulted for current names and synonyms.

Two specimens were initially identified morphologically as the invasive species *Gracilaria salicornia* (C. Agardh) E.Y. Dawson and *Hypnea musciformis* (Wulfen) J.V. Lamouroux present in the MHI; however, molecular analyses (using the UPA region) ruled out the initial identification and document the specimens here as *Gracilaria* sp. and *Hypnea* sp.

1. Contribution No. 2015-007 the Hawaii Biological Survey.

2. Research Associate, Hawaii Biological Survey, Bishop Museum, 1525 Bernice Street, Honolulu, Hawai‘i 96817-2704, USA

Phylum CYANOBACTERIA***Schizothrix mexicana*** Gomont**New PMNM record**

The specimens consist of firm irregular gelatinous layers adhering to sand, up to 8.5 cm across and 2–7 mm thick (dried), and mostly blackish-green in color. Cells of trichomes are 4–6 µm in diameter and 1–2x diameter long. The specimens were initially identified as *Leptolyngbya crosbyana* (Tilden) Anagnostidis & Komárek; however, *L. crosbyana* usually forms brown or tan hemispherical buttons on solid substrata.

MHI distribution. O‘ahu (Khan 1967).

PMNM materials examined. **MARO:** 28–36 m deep, *RV Townsend Cromwell*, 4 Jul 1997, *BISH* 694028 (*IA* 23260); lobster traps, 23.8–25.6 m deep, *R. Moffitt*, 27 Jun 2006, *BISH* 723424 (*IA* 31654).

Phylum RHODOPHYTA***Actinotrichia fragilis*** (Forsskål) Børgesen**New PMNM record**

MHI distribution. Kaua‘i, O‘ahu, Lāna‘i, Moloka‘i, Kaho‘olawe, Maui, and Hawai‘i (Abbott 1999).

PMNM material examined. **NIHOA:** Subtidal, *C. Agegian et al.*, Summer 1981, *BISH* 642557 (*IA* 21215a).

Akalaphycus liagoroides (Yamada) Huisman,

I.A. Abbott & A.R. Sherwood

New PMNM record[= *Stenopeltis liagoroides* (Yamada) Itono & Yoshizaki]

MHI distribution. Kaua‘i, O‘ahu, Moloka‘i, and Maui (Huisman *et al.* 2004).

PMNM material examined. **GARDNER:** *K. McDermid & B. Stuercke*, 14 Sep 2002, det. I.A. Abbott (31 Oct 2005), *BISH* 694351.

Champia vieillardii Kützing**New PMNM record**

MHI distribution. Maui (Abbott 1999).

PMNM material examined. **NECKER:** NOWRAMP 2002, *K. Kukea-Shultz & K. Peyton*, 10 Sep 2002, *BISH* 694269.

Chondrophyucus succisus (A.B. Cribb)

K.W. Nam

New PMNM record

MHI distribution. Kaua‘i, O‘ahu, Moloka‘i, Lāna‘i, Maui, Kaho‘olawe, and Hawai‘i (Abbott 1999).

PMNM material examined. **FRENCH FRIGATE:** *C. Agegian et al.*, Summer 1987, *BISH* 691504 (*IA* 19190).

Chrysiomenia kaernbachii Grunow**New PMNM record**

MHI distribution. O‘ahu and Maui (Abbott 1999).

PMNM materials examined. **LISIANSKI:** *K. Geisler*, 22 Sep 2000, det. I.A. Abbott (4 Jun 2003), *BISH* 698667. **MARO:** NOWRAMP 2002, outside, *K. Kukea-Shultz & K. Peyton*, 16 Sep 2002, *BISH* 694152; MAR-27, *K. Geisler*, 19 Sep 2000, det. I.A. Abbott, *BISH* 698074.

Cubiculosporum koronicarpis Kraft**New PMNM record**

MHI distribution. O‘ahu (Abbott 1999).

PMNM material examined. **NECKER:** NOWRAMP 2002, intertidal, *J. Polloi*, 10 Sep 2002, det. I.A. Abbott (12 Jan 2006), *BISH* 694628.

Dasya murrayana I.A. Abbott &

A.J.K. Millar

New PMNM record*MHI distribution.* Kaua'i, O'ahu, and Hawai'i (Abbott 1999).*PMNM material examined.* LISIANSKI: NOWRAMP 2, LIS-35, K. Geisler, 22 Sep 2000, det. I.A. Abbott (4 Jun 2003), *BISH* 698663.***Dichotomaria obtusata*** (J. Ellis & Solander)

Lamarck

New PMNM record[=*Galaxaura obtusata* (J. Ellis & Solander) J.V. Lamouroux]*MHI distribution.* O'ahu and Hawai'i (Abbott 1999).*PMNM material examined.* NECKER: C. Agegian et al., Summer 1981, *BISH* 692289 (IA 21228e).***Erythrocolon podagricum*** J. Agardh**New PMNM record***MHI distribution.* O'ahu and Maui (Abbott 1999).*PMNM material examined.* MARO: NOWRAMP 2002, K. Kukea-Shultz & K. Peyton, 15 Sep 2002, det. I.A. Abbott (2004), *BISH* 692159.***Galaxaura divaricata*** (Linnaeus)

Huisman & R.A. Townsend

New PMNM record[= *Galaxaura fasciculata* Kjellman]*MHI distribution.* O'ahu, Moloka'i, and Kaho'olawe (Abbott 1999).*PMNM materials examined.* KURE: NOWRAMP 2002, M. Hughes, 25 Sep 2002, *BISH* 694991. LAYSAN: NOWRAMP 2002, K. Kukea-Shultz & K. Peyton, 17 Sep 2002, *BISH* 694706; NOWRAMP 2002, K. Kukea-Shultz & K. Peyton, 17 Sep 2002, *BISH* 694721. NECKER: NOWRAMP 2002, K. Kukea-Shultz & K. Peyton, 10 Sep 2002, *BISH* 693658; NOWRAMP 2002, K. Kukea-Shultz & K. Peyton, 10 Sep 2002, *BISH* 694279; NOWRAMP 2002, K. McDermid & B. Stuercke, 10 Sep 2002, *BISH* 294294.***Galaxaura filamentosa*** R.C.Y. Chou**New PMNM record***MHI distribution:* Penguin Bank located SW Moloka'i (Agegian & Abbott 1985) and Maui (Abbott 1999).*PMNM material examined.* NIHOA: NOWRAMP 2002, J. Polloi, 9 Sep 2002, *BISH* 694608.***Gelidiella machrisiana*** E.Y. Dawson**New PMNM records***MHI distribution.* O'ahu and Hawai'i (Abbott 1999).*PMNM materials examined.* MARO: K. Geisler, 15 Oct 2000, det. I.A. Abbott (22 Oct 2003), *BISH* 698634 (IA 30373). NECKER: NOWRAMP 2002, NEC-R-3, K. Kukea-Shultz & K. Peyton, 10 Sep 2002, det. I.A. Abbott (11 May 2004), *BISH* 694307.***Gracilaria* sp.****New PMNM record**

The herbarium sheet consists of two specimens, 4 and 5 cm long with branches extremely thin, 1 mm in diameter. The specimens were initially identified based on morphological characteristics as the invasive species *Gracilaria salicornia*. Although high quality DNA was not extracted from the Necker specimens, molecular analyses (UPA region; e.g., Sherwood et al. 2010) conducted on other *Gracilaria* collected in similar mesophotic

habitats in the Main Hawaiian Islands did not reveal *G. salicornia*.

PMNM material examined. **NECKER:** 28–70 m deep, *RV Townsend Cromwell*, 16 Jun 1997, *BISH 691797 (IA 23243)*.

***Halymenia actinophysa* M. Howe**

New PMNM record

MHI distribution. Maui (Abbott 1999).

PMNM material examined. **LAYSAN:** NOWRAMP 2002, LAY-03, *K. Kukea-Shultz & K. Peyton*, 17 Sep 2002, det. I.A. Abbott, *BISH 736158*.

***Halymenia stipitata* I.A. Abbott**

New PMNM record

MHI distribution. O‘ahu and Maui (Abbott 1999).

PMNM material examined. **LISIANSKI:** NOWRAMP 2002, *K. Kukea-Schultz & K. Peyton*, 2 Nov 2002, *BISH 695858*.

***Hypnea* sp.**

New PMNM record

About a third of the herbarium specimens from the deeper waters of the PMNM cited below possesses few tendril-like terminal branches which show some similarity to the invasive *Hypnea musciformis*. Molecular analyses using the UPA region, however, indicate that most specimens below are in a separate and unidentified clade from several different confirmed *H. musciformis* samples (Sherwood et al. 2010).

PMNM material examined. **PEARL & HERMES.** *K. Geisler*, 11 Oct 2000, *BISH 698755 (IA 30463)*. **MARO:** lobster traps, 25.6–45.7 m deep, *R. Moffitt*, 20 Jun 2006, *BISH 723408 (IA 31675)*. **NECKER:** Townsend-Cromwell Cruise 00-07, lobster trap, 26–37 m deep, *R. Moffitt*, 12 Jun 2000, *BISH 772522 (IA 25307)*; 26–31 m deep, *R. Moffitt*, 11 Jul 2004, *BISH 7133327 (IA 29405)*; 29–31 m deep, *R. Moffitt*, 10 Jun 2005, *BISH 715611 (IA 31421)*; O.E. Sette 05-08, lobster traps, 27.4–29.3 m deep, *R. Moffitt*, 16 Jun 2005, *BISH 715612 (IA 31416)*; lobster traps, 25.6–45.7 m deep, *R. Moffitt*, 12 Jun 2006, *BISH 723421 (IA 31637)*; lobster traps, 42.1–56.7 m deep, *R. Moffitt*, 11 Jun 2006, *BISH 723436 (IA 31598)*.

***Macrocarpus perennis* (I.A. Abbott)**

S.M. Lin, S.-Y. Yang & Huisman

New PMNM record

[= *Liagora perennis* I.A. Abbott]

MHI distribution. O‘ahu, Type (Abbott 1999).

PMNM material examined. **GARDNER:** *K. McDermid & B. Stuercke*, 14 Sep 2002, det. I.A. Abbott (31 Oct 2005) as *Liagora perennis*, *BISH 694364*.

***Neoizziella divaricata* (C.K. Tseng)**

S.M. Lin, S.-Y. Yang & Huisman

New PMNM record

[= *Liagora divaricata* C.K. Tseng]

MHI distribution. O‘ahu (Abbott 1999).

PMNM material examined. **MARO:** TC-22, *K. Peyton*, 23 Jul 2002, det. I.A. Abbott, *BISH 521692 (IA 31545)*.

***Pterocladia caerulea* (Kützing)**

Santelices & Hommersand

New PMNM record

[= *Pterocladia caerulea* (Kützing) Santelices]

MHI distribution. Kaua‘i, O‘ahu, Maui, and Hawai‘i (Abbott 1999).

PMNM material examined. **NIHOA:** NOWRAMP 2002, *J. Polloi*, 9 Sep 2002, det. I.A. Abbott

(22 Sep 2004), *BISH* 694609.

Rhodolachne decussata M.J. Wynne **New PMNM record**

MHI distribution. O'ahu, Moloka'i, and Maui (Abbott 1999).

PMNM material examined. **LISIANSKI:** NOWRAMP 2000, #2, *K. Geisler*, 22 Sep 2000, det. I.A. Abbott (6 Aug 2003), *BISH* 705611 (*IA* 30214).

Titanophora pikeana (Dickie) J. Feldmann **New PMNM record**

MHI distribution. Kaua'i and O'ahu (Abbott 1999).

PMNM material examined. **MIDWAY:** Sand Island, lagoon, *N. Hoffman*, Aug 2000, det. I.A. Abbott, *BISH* 669210 (*IA* 25468).

Trichogloeopsis mucosissima (Yamada) I.A.

Abbott & Doty

New PMNM record

MHI distribution. Kaho'olawe and Hawai'i (Abbott 1999).

PMNM material examined. **MIDWAY:** Reef crest near swim platform, intertidal, *K. McDermid*, 6 Jun 1999, det. I.A. Abbott, *BISH* 720928 (*KM* 4679).

Yamadaella caenomyce (Decaisne) I.A. Abbott **New PMNM record**

MHI distribution. O'ahu, Moloka'i, Maui, and Hawai'i (Abbott 1999).

PMNM materials examined. **MIDWAY:** Reef face, *K. McDermid*, Jun 1999, det. I.A. Abbott, *BISH* 710917 (*IA* 31144, *KM* 4751). **LAYSAN:** Tide pools on semi-exposed bench, *F. Ball*, 14 Jul 1977, *BISH* 701534 (*IA* 17261).

Phylum OCHROPHYTA

Class PHAEOPHYCEAE

Rosenvingea intricata (J. Agardh) Børgesen **New PMNM record**

MHI distribution. O'ahu, Maui, and Hawai'i (Abbott & Huisman 2004).

PMNM examined. **LISIANSKI:** NOWRAMP 2002, LIS-09-38, *K. Kukea-Shultz & K. Peyton*, 1 Oct 2002, det. J. Fisher, *BISH* 736015.

Phylum CHLOROPHYTA

Cladophora catenata (Linnaeus) Kützing **New PMNM record**

[= *Cladophoropsis luxurians* W.J. Gilbert, *Cladophora luxurians* (W.J. Gilbert) I.A. Abbott & Huisman]

MHI distribution. Kaua'i, O'ahu, Moloka'i, and Hawai'i (Abbott & Huisman 2004).

PNMN material examined. **MARO:** NOWRAMP 2002, *K. McDermid & B. Stuercke*, 16 Sep 2002, *BISH* 694197 (*KM* 7048).

Cladophoropsis fasciculata (Kjellman) Wille **New PMNM record**

[=*Cladophoropsis sundanensis* Reinbold]

The specimens were identified by Isabella A. Abbott as *Cladophoropsis sundanensis* and fell within the circumscription of that species in the taxonomic revision of the genus by Leliaert & Coppejans (2006). The apical cells ranged from 56–160 µm in diameter.

MHI distribution. O'ahu, Moloka'i, Kaho'olawe and Hawai'i (Abbott & Huisman 2004).

PMNM materials examined. **KURE:** SE side, intertidal, *J. Polloi*, 25 Sep 2002, det. I.A. Abbott, *BISH* 694985. **PEARL & HERMES:** NOWRAMP 2002, *K. Kukea-Shultz & K. Peyton*, 19 Sep 2002, det. I.A. Abbott, *BISH* 694386; NOWRAMP 2002, *K. Kukea-Shultz & K. Peyton*, 19 Sep 2002, det. I.A. Abbott, *BISH* 694412. **NECKER:** Intertidal, *H. Fortner*, 27 Jun 1984, det. I.A. Abbott, *BISH*

701413 (IA 17328).

Cladophoropsis membranacea (Hofman Bang

ex C. Agardh) Børgesen

New PMNM record

The diameter of the apical cells was greater than in *Cladophoropsis fasciculata* and ranged between 180–320 µm.

MHI distribution. Kauaʻi, Oʻahu, Molokaʻi, Kahoʻolawe, and Hawaiʻi (Abbott & Huisman 2004).

PMNM materials examined. **PEARL & HERMES:** K. Geisler, 8 Oct 2000, BISH 698812 (IA 30434). **NECKER:** lobster traps, 29.2–80.5 m deep, R. Moffitt, 13 Jun 2005, det. I.A. Abbott, BISH 717624 (IA 31413).

Pseudochlorodesmis parva W.J. Gilbert

New PMNM record

[= *Siphonogramen parvum* (W.J. Gilbert) I.A. Abbott & Huisman]

Clumps (about 6 mm across) of siphons were growing on sandy substrata. The siphons possess few branches, <1 cm long and 24–72 µm in diameter. The siphons of BISH 694216 were slender, 24–32 µm in diameter, and were initially identified as *Derbesia tenuissima* (Moris & Notaris) P. Crouan & H. Crouan. Verbruggen *et al.* (2009) showed that the *Pseudochlorodesmis-Siphonogramen* complex displayed cryptic diversity exceeding the family level and proposed to maintain *Pseudochlorodesmis* as a form genus with *Siphonogramen* incorporated under this genus.

MHI distribution. Kauaʻi and Oahu (Abbott & Huisman 2004).

PMNM materials examined. **LAYSAN:** NOWRAMP 2002, J. Polloi, 17 Sep 2002, BISH 694216; 58 m deep, J. Leonard, 23 May 2013, NWHI-197; 58 m deep, J. Leonard, 23 May 2013, NWHI-199; 61 m deep, D. Wagner, 24 May 2013, NWHI-207.

Acknowledgments

Our sincere appreciation to all individuals who collected the above listed algal specimens between 1984 and May 2013 from the PMNM — Catherine Agegian, Fred Ball, Heather Fortner, Karen Geisler, Nancy Hoffman, Marc Hughes, J. Kanakoa Kukea-Shultz, Jason Leonard, Karla McDermid, Robert Moffitt, Ryan Okano, Kimberly Peyton, Jeremy Polloi, Brooke Stuercke and Daniel Wagner. The late Isabella A. Abbott is acknowledged for initially identifying many of the herbarium specimens, especially the red algae.

Literature Cited

- Abbott, I.A.** 1999. *Marine red algae of the Hawaiian Islands*. Bishop Museum Press, Honolulu. 477 pp.
- Abbott, I.A. & Huisman, J.M.** 2004. *Marine green and brown algae of the Hawaiian Islands*. Bishop Museum Press, Honolulu. 259 pp.
- Agegian, C.R. & Abbott, I.A.** 1985. Deep water macroalgal communities: A comparison between Penguin Bank (Hawaii) and Johnston Atoll. *Proceedings of the Fifth International Coral Reef Congress, Tahiti* 5: 47–50.
- Guiry, M.D. & Guiry, G.M.** 2015. *AlgaeBase*. World-wide electronic publication, National University of Ireland, Galway. Available from: <http://www.algaebase.org>; Last accessed: 10 February 2015.
- Huisman, J. M., Abbott, I.A. & Sherwood, A.R.** 2004. Large subunit rDNA gene sequences and reproductive morphology reveal *Stenopeltis* to be a member of the Liagoraceae (Nemaliales, Rhodophyta), with a description of *Akalaphycus* gen. nov.

- European Journal of Phycology* **39**: 257–272.
- Khan, K.R.** 1967. Developmental morphology of some blue-green algae of Oahu shores in relation to certain ecological factors. Unpublished M.S. Thesis, University of Hawaii at Mānoa, Honolulu. 182 pp.
- Leliaert, F & Coppejans, E.** 2006. A revision of *Cladophoropsis* Børgesen (Siphonocladales, Chlorophyta). *Phycologia* **45**: 657–679.
- Sherwood, A.R., Kurihara, A., Conklin, K.Y., Sauvage, T. & Presting, G.G.** 2010. The Hawaiian Rhodophyta Biodiversity Survey (2006–2010): A summary of principal findings. *BMC Plant Biology* **10**: 258.
- Tsuda, R.T.** 2014. Bibliographic catalogue of the marine benthic algae in the Papahānaumokuākea Marine National Monument (Northwestern Hawaiian Islands). *Phytotaxa* **167**: 35–60. <http://dx.doi.org/10.11646/phytotaxa.167.1.2>
- Verbruggen, H., Vlaeminck, C., Sauvage, T., Sherwood, A.R., Leliaert, F. & De Clerck, O.** 2009. Phylogenetic analysis of *Pseudochlorodesmis* strains reveals cryptic diversity above the family level in the siphonous green algae (Bryopsidales, Chlorophyta). *Journal of Phycology* **45**: 726–731.