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1 ***Pyropia orbicularis* sp. nov. (Rhodophyta, Bangiaceae) based on a**
2 **population previously known as *Porphyra columbina* from the central**
3 **coast of Chile**

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Mis en forme : Espagnol (Chili)

Code de champ modifié

Mis en forme : Espagnol (Chili)

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23 **Abstract**

24 A new species of bladed Bangiales, *Pyropia orbicularis* sp. nov. M.E. Ramírez, L.
25 Contreras-Porcía & M.L. Guillemin, has been described for the first time from the central
26 coast of Chile based on morphology and molecular analyses. The new species was
27 incorrectly known as *Porphyra columbina* (now *Pyropia columbina* (Montagne) W.A.
28 Nelson), and it can be distinguished from other species of *Pyropia* through a range of
29 morphological characteristics, including the shape, texture and colour of the thallus, and the
30 arrangement of the reproductive structures on the foliose thalli. Molecular phylogenies
31 based on both the mitochondrial COI and plastid *rbcL* gene regions enable this species to
32 be distinguished from other species within *Pyropia*. *Pyropia orbicularis* sp. nov. belongs to
33 a well supported clade of *Pyropia* from the southern oceans that include specimens from
34 the South Pacific (North, South, Chatham, Stewart, Auckland, and Campbell Island, New
35 Zealand; New South Wales, and Macquarie Island, Australia) including *P. columbina* and
36 *P. plicata*. Within this clade, the highest sequence identity was observed between *Pyropia*
37 *orbicularis* sp. nov. and *Pyropia* sp. FIC from the Falkland Islands.

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39

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41 **Key words:** Bangiales, COI, Morphology, *Porphyra*, *Pyropia*, *rbcL*, South Pacific

42

43

44 **Introduction**

45 In a recent worldwide study of Bangiales (Rhodophyta) based on molecular analysis using
46 nuclear (SSU rRNA) and chloroplast *rbcL* regions, Sutherland *et al.* (2011) recognized the
47 existence of fifteen genera of which seven are filamentous and eight foliose. Of the foliose
48 genera, *Porphyra* sensu lato, which has representatives in all seas, has undergone many
49 changes in its classification in the last decade (e.g. Anilkumar & Rao 2005, Yoshida *et al.*
50 2005, Kikuchi *et al.* 2010, Nelson & Broom 2010, Kucera & Saunders 2012, Mateo-Cid *et*
51 *al.* 2012, Nelson 2013).

52 The economic and cultural importance of *Porphyra* sensu lato is widely known and
53 appreciated in Asian countries, notably Japan and China, North and South America,
54 Australia and New Zealand (Aguilar-Rosas *et al.* 1998, Jian & Chen 2001, He & Yarish
55 2006, Blouin *et al.* 2011) and has been one of the red algal genera with the largest
56 production and marketing worldwide. In Chile, species of the genus *Pyropia* and *Porphyra*,
57 specifically the taxon known as *Porphyra columbina* Montagne (now *Pyropia columbina*
58 (Montagne) W.A Nelson), are commonly called "luche or lucht" and have been harvested
59 and consumed since the late Pleistocene by coastal populations in the country (Seguel &
60 Santelices 1988, Buschmann *et al.* 2001, González & Santelices 2003, Dillehay *et al.*
61 2008). It is reported that the species, under the name *P. columbina*, is highly seasonal and
62 grows abundantly between September-March along the upper intertidal zone of the Chilean
63 coast from Arica (18°S) to Tierra del Fuego (55°S) (Ramírez & Santelices 1991, Hoffman
64 & Santelices 1997). It is also known that this species may lose up to 90% of fresh weight
65 during low tide (Contreras-Porcía *et al.* 2011) and several mechanisms of tolerance are
66 activated during this adverse cellular condition in comparison with many other species

67 (Contreras-Porcía *et al.* 2011, 2012, 2013; Flores-Molina *et al.* 2013). Nevertheless, the
68 identity of the taxon “*Porphyra columbina*” in Chile has been questioned principally
69 because (1) the majority of Chilean specimens to which this name has been applied belong
70 to warm temperate localities (see discussion in Nelson & Broom 2010) and (2) because the
71 external morphology of specimens assigned to *P. columbina* in the Chilean coast is not
72 consistent with the original description by Montagne (1842) or specimens recently re-
73 evaluated by Nelson & Broom (2010). Thus, given their importance in ecophysiological
74 studies, aquaculture management plans and biotechnological applications, it is crucial to
75 classify this species and to be able to distinguish it from the many other foliose Bangiales,
76 the majority of which are undescribed (J. Brodrie, L. Contreras, E. Macaya and M-L.
77 Guillemin unpublished data) along the Chilean coast.

78

79 Molecular studies have revealed cryptic speciation within the genus *Porphyra* sensu
80 lato (e.g. Broom *et al.* 1999, 2004, 2010, Brodie *et al.* 2007, Lindstrom 2008). Brodie *et al.*
81 (in preparation), who sequenced samples of a foliose species assigned to “*Porphyra*
82 *columbina*” collected from the length of the Chile coast, concluded, as had Sutherland *et al.*
83 (2011), that there was no evidence of this species in the Chilean flora. They also concluded
84 that of the foliose genera documented by Sutherland *et al.* (2011), three are present in
85 Chile: *Porphyra*, *Pyropia* and *Wildemanina*. Gross morphology within and between species
86 is extremely diverse, varying from linear through ovate, to orbicular or funnel shaped, with
87 entire or dentate, planar, undulate margins, and variable colour (yellow, olive green, brown
88 and red-brown). In this context, and taking into account new molecular data gathered from
89 197 samples distributed from Arica (18°S) to Tierra del Fuego (55°S) (J. Brodrie, L.
90 Contreras, E. Macaya and M-L. Guillemin unpublished data), the morphological and

91 molecular data suggest the absence of *P. columbina* along the Chilean coast. The aim of the
92 present study was to documents and clarifies the taxonomic status of one of these
93 populations present on the Central coast of Chile (Maitencillo beach, Valparaíso) based on
94 morphological and molecular analysis of COI and *rbcL* genes.

95

96 **Materials and methods**

97 *Collection of samples.* A total of one hundred of *Porphyra* specimens previously identified
98 as "*Porphyra columbina*" were collected from the upper and mid intertidal zone with low
99 wave exposure along 300–500 m of coastline from Maitencillo beach, Valparaiso, Chile
100 (32°39'S 71°26'W) from March 2012 to January 2013. Samples were stored immediately
101 in plastic bags containing seawater and transported to the laboratory in a cooler at 5–7 °C.
102 In the laboratory, algae were rinsed with 0.22 µm-filtered seawater and immediately
103 pressed as herbarium vouchers. Subsamples were dried in desiccant silica gel (Vetec
104 Analytical Reagents, Brazil) for subsequent DNA analysis, and other subsamples kept in
105 filtered fresh seawater at 14 ± 2 °C, under a $30\text{--}50 \mu\text{mol m}^{-1} \text{s}^{-1}$ of photon flux density
106 (Growth Chamber W-19, Amilab, Chile) prior to morphological analysis. The holotype
107 specimen (MAI0007) was housed in the herbarium of the National Museum of Natural
108 History, Chile under the number SGO162483. One isotype (MAI0006) was housed in the
109 Colección de Flora y Fauna Prof. Patricio Sánchez Reyes (SSUC), Departamento de
110 Ecología, Pontificia Universidad Católica de Chile (SSUC-7758).

111 *Morphological observations.* Thallus shape, colour, texture and rhizoid disposition
112 was described from fifty plants. Also, microscopic observations of hand-cut transverse
113 sections were used to determine the tissue thickness, number of cell layers and

114 identification of reproductive structures. Dimensions of vegetative, rhizoidal cells and
115 reproductive tissue (i.e. zygotosporangium and spermatangium) were measured and the
116 number and size of zygospores per zygotosporangium, and spermatia per spermatangium
117 were recorded. Images were made using a Nikon Microscopy Unit (Nikon Corp. Tokyo,
118 Japan) coupled to a digital recording system (CoolSNAP-Procf, Media Cybernetics, Silver
119 Spring, MD, USA) and analyzed using the Image Pro Plus Version 4.5 software (Media
120 Cybernetics, Silver Spring, MD, USA).

121 *DNA extraction and amplification.* Dried algal tissue was finely grounded in liquid
122 nitrogen. DNA was extracted following the protocol described by Saunders (1993), slightly
123 modified by Faugeron et al. (2001). COI-5P was amplified using the primer pair GazF1 (5'-
124 TCA ACA AAT CAT AAA GAT ATT GG -3') and GazR1 (5'-ACT TCT GGA TGT CCA
125 AAA AAY CA -3'), following the amplification protocols of Saunders (2005). The
126 chloroplastic gene *rbcL*, encoding the large subunit of the ribulose-1,5-bisphosphate
127 carboxylase/oxygenase enzyme, was amplified using the primers F-*rbcL* (5'- TTG CAT
128 AYG ATA TTG ATY TAT TTG AA-3') and R-*rbcS* (5'- RAG CTG TTT KTA AAG
129 GWC CAC AA-3') and protocols published previously (Hommersand *et al.* 1994,
130 Fredericq & López-Bautista 2002). For both markers, PCR amplifications were performed
131 in a Perkin Elmer Gene Amp PCR System 9700 (Applied Biosystems, Foster City, USA).
132 All PCR products were purified using UltraClean™ DNA Purification kits (MO BIO
133 Laboratories, Carlsbad, USA) and sequenced using the forward and the reverse
134 amplification primers by Macrogen Inc. (Seoul, South Korea). Sequences were edited using
135 Chromas v. 2.33 (McCarthy 1997) and alignments were obtained using the CLUSTAL
136 function of Mega v 5 (Tamura *et al.* 2011).

137 Sequences were obtained from 14 specimens (604 bp for the COI and 876 bp for the
138 *rbcL*) and deposited in GENBANK. Specimen collection information and GENBANK
139 accession numbers are detailed in Table 1. In addition to the new sequences of *Pyropia*
140 *orbicularis sp. nov.* obtained in this study, 57 COI and 317 *rbcL* sequences were retrieved
141 from GENBANK for further analyses. A complete list of specimens used in the molecular
142 analyses is detailed in Table S1.

143 *Molecular analysis.* Two data sets were created for the COI and the *rbcL*,
144 respectively. Three species belonging to the genus *Porphyra* were used as outgroups (i.e. *P.*
145 *mumfordii*, *P. purpurea* and *P. umbilicalis*, Table S1). Each sequence data set was
146 partitioned according to codon position. The best-fit models were estimated independently
147 for each partition by the Akaike Information Criteria (AIC) implemented in TREEFINDER
148 (Jobb *et al.* 2004) and the parameters of the different substitution models were estimated
149 independently for each partition. AIC identified J2 + G model for the first codon position of
150 the *rbcL*, J3 + G for the second codon position of the *rbcL*, J1 + G for the first codon
151 position of the COI, GTR +G for the second codon position of the COI, and HKY for the
152 third codon position of both genes. Phylogenetic relationships were inferred with a mixed
153 model in a maximum likelihood framework by using TREEFINDER, version January 2008
154 (Jobb *et al.* 2004) and support for the nodes was assessed with 1,000 bootstrap
155 pseudoreplicates.

156 Bayesian inference was performed using the general type of the best fit model
157 parameters defined for each dataset using MrBayes v 3.1.2 (Huelsenbeck & Ronquist
158 2001). Four independent analyses were run with four chains each, for five million
159 generations. Trees and parameters were sampled every 1,000 generations and the default
160 parameters were used to fit temperature and swapping. The first 25% of sampled trees were

161 discarded as “burn-in” to ensure stabilization. The remaining trees were used to compute a
162 consensus topology and posterior probability values.

163 Inter- and intraspecific uncorrected p-distances, were calculated in Mega v 5
164 (Tamura *et al.* 2011). Interspecific measures correspond to the pairwise distances between
165 the *Pyropia* specimens used in the tree reconstruction; here the sequence of MAI0007 (i.e.
166 holotype specimen, SGO162483) was used for *Pyropia orbicularis* *sp. nov.* Intraspecific
167 sequence divergence was estimated in 12 species of *Porphyra* (2 for the COI and 12 for the
168 *rbcL*, respectively) and 29 species of *Pyropia* (4 for the COI and 26 for the *rbcL*,
169 respectively) for which multiple sequences were available in GENBANK (Table S1).

170

171

172 **Results**

173 *Pyropia orbicularis* [M.E. Ramírez, L. Contreras-Porcia & M.L. Guillemin], *sp. nov.*

174 (Figs 1–10, Fig. S1, Table 1-3)

175 **Type:** —CHILE. Maitencillo beach, Valparaíso, 32°39'S 71°26'W, coll. Contreras-Porcia,
176 Núñez, Guajardo and Fierro, 12-10-2012, holotype: SGO162483 (Fig. 2), isotype: SSUC-
177 7758

178

179 Gametophyte blades orbicular, 2.8–14 cm high and 4–16 cm wide, with an irregular
180 undulate margin; monostromatic, 36–139 µm thick in transverse section, attached to rocky
181 substratum by abundant rhizoidal cells at the base of the thallus. Colour green-grey to
182 brown on outer edges. Vegetative cells with a single stellate chloroplast. Monoecious;
183 reproductive structures marginal; spermatangial sori pale golden patches interspersed with

184 deep red zygotosporangia and sterile cells; zygotosporangia in packets of a2/b2/c2 and
185 spermatangia in packets of a4/b4/c4.

186

187 **Habitat:** —Upper and mid intertidal rock.

188 **Etymology:** —orbicularis for the typical shape of the blades, rounded or orbicular outline

189

190 **Molecular analysis:** — For the chloroplast marker *rbcL* (876 bp), only one haplotype was

191 observed for the 13 sequenced individuals of *Pyropia orbicularis sp. nov.* Three haplotypes

192 were detected for the mitochondrial marker COI, with 3 polymorphic sites along the 604

193 base pairs fragment sequenced (13 sequenced individuals, Table 1). Figures 9 and 10 show

194 the maximum likelihood phylograms constructed with the *rbcL* sequences of 89 *Pyropia*

195 specimens, and the COI sequences of 34 *Pyropia* specimens, respectively. For both genes,

196 tree topologies based on Bayesian and maximum likelihood analyses were largely

197 congruent and shared comparable support values for major nodes (Figs 9 and 10).

198 For the COI, all specimens from Maitencillo beach form a strongly supported monophyletic

199 lineage (support values >99%, Fig. 10). For the *rbcL*, the gene where the more complete

200 data set is available, *Pyropia orbicularis sp. nov.* form a strongly supported monophyletic

201 clade with *Pyropia sp.* FIC collected in Port Stanley in the East Falkland Island (Broom *et*

202 *al.* 2010) (support values >99%, Fig. 9). The uncorrected p-distance between *P. orbicularis*

203 *sp. nov.* and *P. sp.* FIC is of 0.57 % for the *rbcL* (i.e. 5 substitutions). *Pyropia orbicularis*

204 *sp. nov.* is part of a well-supported clade encompassing 16 *Pyropia* species from the

205 southern hemisphere that includes specimens from the Southern Ocean (King George

206 Island), the South Atlantic (South Africa and Falkland Islands) and the South Pacific

207 (North, South, Chatham, Stewart, Auckland, and Campbell Islands, New Zealand, New

208 South Wales, and Macquarie Island, Australia) (Fig. 9). This southern hemisphere clade
209 includes *P. columbina* (Nelson & Broom 2010, Broom *et al.* 2010), where the uncorrected
210 p-distance between *P. orbicularis sp. nov.* and *P. columbina* is of $3.11 \pm 0.54\%$ for the *rbcL*
211 (i.e. 27.28 ± 5.00 substitutions). The COI data set did not allow to confirm the position of
212 *P. sp. FIC* as the sister species of *P. orbicularis sp. nov.* within a southern hemisphere
213 *Pyropia* clade owing to the low number of *Pyropia* COI sequences available in GENBANK
214 (three times fewer than for the *rbcL*). Indeed, no COI sequences are available for the 15
215 other southern hemisphere species.

216 Interspecific divergences in the genus *Pyropia* (mean 12.81% for COI and 5.64%
217 for the *rbcL*) are much deeper than the intraspecific divergences in both the genus *Pyropia*
218 and *Porphyra* (mean 0.05% and 0.41% for COI and 0.09% and 0.17% for *rbcL*, for *Pyropia*
219 and *Porphyra*, respectively) (Table 3). Between specimens of *P. orbicularis sp. nov.*,
220 intraspecific divergences for the COI range from 0.00% up to 0.66% while for the *rbcL*,
221 where only one haplotype was detected, intraspecific divergences were of 0.00% (Table 3).

222

223 Discussion

224 The description of a new species of *Pyropia*, *P. orbicularis sp. nov.*, resolves the identity of
225 the species misidentified as *Porphyra columbina*, now *Pyropia columbina* (Montagne)
226 W.A. Nelson, from the population Maitencillo beach; central coast of Chile. *Pyropia*
227 *orbicularis sp. nov.* and *P. columbina* exhibit morphological differences in both the shape
228 and length of the thallus. The gametophyte thallus of *P. orbicularis* reaches a size of 14 cm,
229 while that of *P. columbina* reaches up to 5 cm (Montagne 1842, Nelson & Broom 2010).
230 Both species are distinguishable by the colour and thickness of the blade. *P. columbina* has

231 a pink-gray colour (Nelson & Broom 2010), and a thin thallus (75-90 μm), whereas *P.*
232 *orbicularis* is green-grey to brown in colour and has a thick thallus (36-139 μm).

233 These morphological differences are congruent with the molecular data, as measured using
234 the COI and *rbcL* markers. Despite both species being positioned within a clade conformed
235 of several *Pyropia* species from the Southern Pacific, the divergence between *P. orbicularis*
236 and *P. columbina* is up to 3%. Geographically, *P. columbina* has, until now, been confined
237 to the temperate, cold waters of New Zealand's sub-Antarctic Auckland and Campbell
238 Islands, the Antipodes Islands, and the Falkland Islands. The apparent limitation of the
239 distribution of *P. columbina* up to 51°S raises questions about the reports of this species on
240 the central coast of Chile. Another species which is close to *P. orbicularis* in our
241 phylogenetic analysis is the recently described *Pyropia plicata* W.A. Nelson from the New
242 Zealand region, distributed in the North, South and Chatham Islands (Nelson 2013).
243 However, this species is different from *P. orbicularis* primarily in the configuration of the
244 reproductive regions (Table 2).

245 With molecular phylogenetic analysis, sequences of *P. orbicularis* from Chile were
246 shown to be similar to the species coded as *Pyropia* sp. FIC from the Falkland Islands
247 (Broom *et al.* 2010). The values of uncorrected p-distance for the *rbcL* between *P.*
248 *orbicularis* and *Py. FIC* (0.57%) are low and fall within the limit of the *Pyropia*
249 intraspecific genetic distance for this gene (0.00%-0.82%, Table 3). Broom *et al.* (2010)
250 described some morphological characteristics of the thallus from *Pyropia sp FIC* that
251 coincide with the descriptions of *P. orbicularis* from Maintencillo beach (e.g. male and
252 female regions of the blade intermixed; had a brownish-red thallus), which could validate
253 the inclusion of *Py. FIC* within *P. orbicularis*. However, as only one locality has been

254 sampled and only one *rbcL* haplotype is available for both species it is premature to
255 consider that *Pyropia* sp. FIC of the Falkland Islands is conspecific with *Pyropia*
256 *orbicularis* sp. nov. Considering the large latitudinal gradient along the Pacific coast of
257 Chile, where *P. columbina* was previously reported, a more detailed study of *P. orbicularis*
258 sp. nov. is needed in order to better determine the amount of genetic diversity present
259 within this species and to delimit its latitudinal range. In addition, a more detailed
260 molecular and morphological analysis of the Bangiales flora from Chile will be necessary
261 to unravel the possible presence of cryptic diversity along the South Eastern, Pacific coast.

262

263

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270

271

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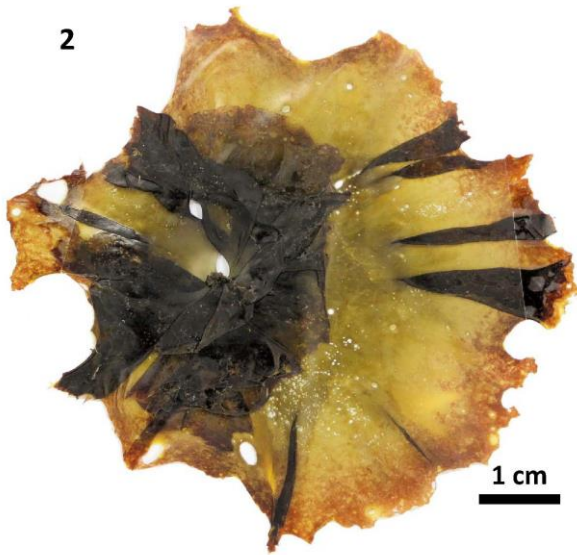
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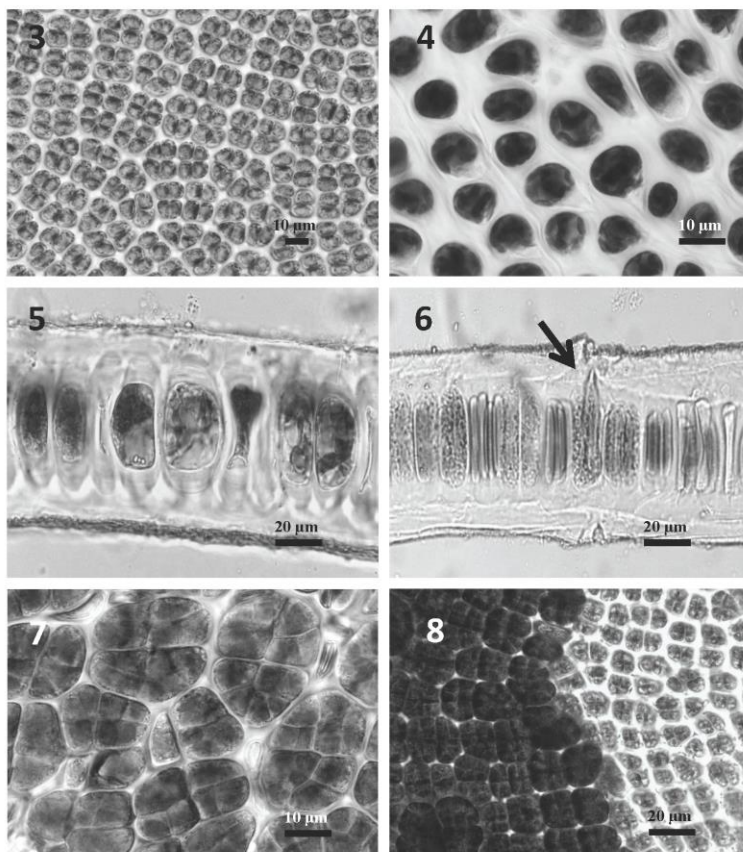
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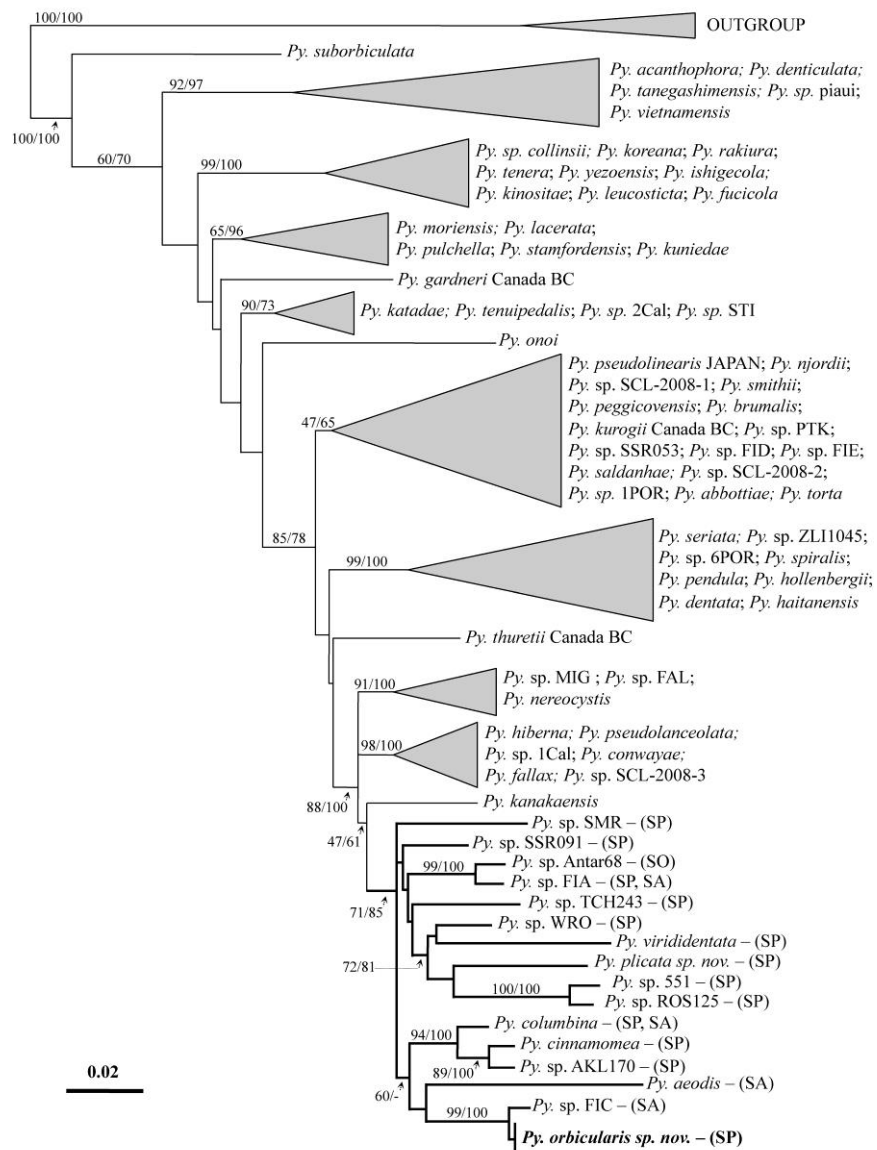
390 **FIGURES 1-2.** *Pyropia orbicularis* sp. nov. **Fig.1.** Habit of the foliose gametophyte from
391 the upper intertidal zone from Maitencillo beach, Valparaiso, Chile. **Fig. 2.** Holotype
392 specimen of *Pyropia orbicularis* sp. nov. SGO162483, collected from the upper intertidal
393 zone of Maitencillo beach, Valparaíso, Chile.



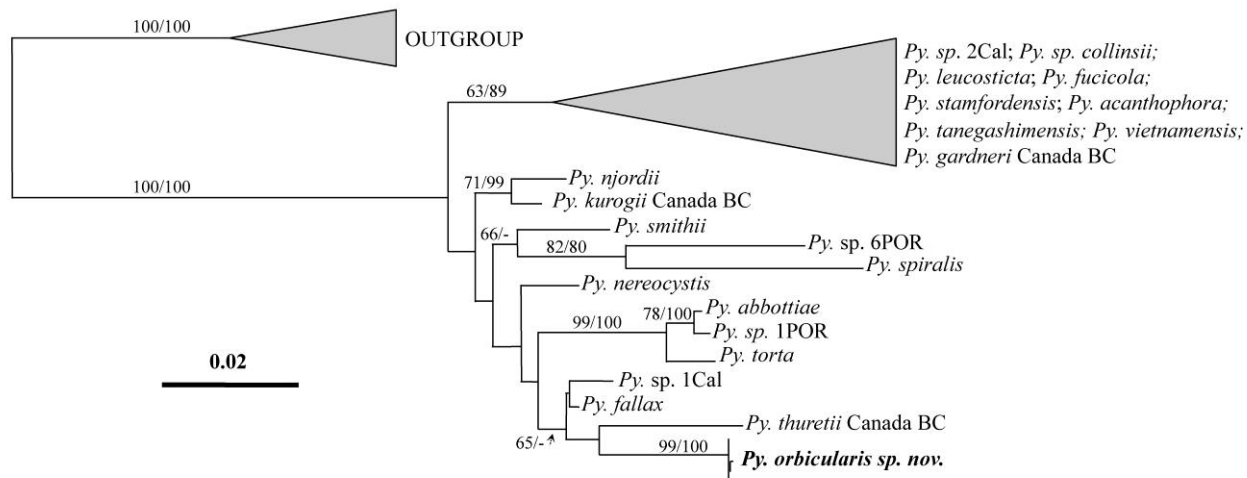
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396 **FIGURES 3-8.** Vegetative and reproductive characteristics of *Pyropia orbicularis* sp. nov.

397 **Fig. 3.** Surface view of vegetative region of the thallus. **Fig. 4.** Surface view of basal,
 398 rhizoidal cells. **Fig. 5.** Cross-section of vegetative region of thallus. **Fig. 6.** Trichogyne
 399 (arrow). **Fig. 7.** Surface view of zygotosporangia. **Fig. 8.** Fertile region of the blade with
 400 packets of developing zygotosporangia (larger) and packets of spermatangia (smaller).



402 **FIGURE 9.** Maximum likelihood rooted tree for *rbcL* sequences (876 bp) of *Pyropia*.
403 *Porphyra mumfordii*, *P. purpurea* and *P. umbilicalis*, were used as outgroups. For each
404 node, Maximum Likelihood bootstrap values and Bayesian Posterior Probabilities are
405 indicated (ML/BPP). Only high support values (>60) are shown; - = clade not observed in
406 the Bayesian Inference. Next to collapsed branches are abbreviated species or sequences
407 names, GENBANK accession numbers have been omitted for brevity but are listed in Table
408 S1 (Supporting Information, sequences highlighted in grey). Region where specimens were
409 collected are indicated within parenthesis: SA = South Atlantic, SP = South Pacific, SO =
410 Southern Ocean. Thick lines highlight the southern hemisphere clade that include *Pyropia*
411 *orbicularis sp. nov.*



412

413 **FIGURE 10.** Maximum likelihood rooted tree for COI sequences (604 bp) of *Pyropia*. *Porphyra mumfordii*, *P. purpurea* and *P.*
 414 *umbilicalis*, were used as outgroups. For each node, Maximum Likelihood bootstrap values and Bayesian Posterior Probabilities are
 415 indicated (ML/BPP). Only high support values (>60) are shown; - = clade not observed in the Bayesian Inference. Next to collapsed
 416 branches are abbreviated species or sequences names, GENBANK accession numbers have been omitted for brevity but are listed in
 417 Table S1 (Supporting Information, sequences highlighted in grey).

418 **TABLE 1:** Specimen collection information, voucher number and GenBank accession numbers of individuals from Maitencillo beach,
 419 Valparaíso, Chile, sequenced during this work. See morphological features in Supporting Information (Fig. S1).

Taxon	Collection data	Sample coding/ voucher number	GenBank accession numbers	
			COI	<i>rbcL</i>
<i>Pyropia orbicularis</i> sp. nov.	02/01/2012. Collector: MR. Flores-Molina; A. Nuñez.	MAI0101	KF479515	KF479481
	02/01/2012. Collector: MR. Flores-Molina; A. Nuñez.	MAI0102	-	KF479482
	02/01/2012. Collector: MR. Flores-Molina; A. Nuñez.	MAI0103	KF479516	-
	10/12/2012. Collector: E. Guajardo, L. Contreras-Porcía, C. Fierro & A. Nuñez	MAI0001	KF479502	KF479484
	10/12/2012. Collector: E. Guajardo, L. Contreras-Porcía, C. Fierro & A. Nuñez	MAI0002	KF479503	KF479485
	10/12/2012. Collector: E. Guajardo, L. Contreras-Porcía, C. Fierro & A. Nuñez	MAI0003	KF479504	KF479486
	10/12/2012. Collector: E. Guajardo, L. Contreras-Porcía, C. Fierro & A. Nuñez	MAI0005	KF479505	KF479488
	10/12/2012. Collector: E. Guajardo, L. Contreras-Porcía, C. Fierro & A. Nuñez	MAI0006/ SSUC-7758	KF479506	KF479489
	10/12/2012. Collector: E. Guajardo, L. Contreras-Porcía, C. Fierro & A. Nuñez	MAI0007/ SGO162483	KF479507	KF479490
	10/12/2012. Collector: E. Guajardo, L. Contreras-Porcía, C. Fierro & A. Nuñez	MAI0008	KF479508	KF479491

10/12/2012. Collector: E. Guajardo, L. Contreras-Porcía, C. Fierro & A. Nuñez	MAI0009	KF479509	KF479492
10/12/2012. Collector: E. Guajardo, L. Contreras-Porcía, C. Fierro & A. Núñez	MAI0014	KF479512	KF479497
10/12/2012. Collector: E. Guajardo, L. Contreras-Porcía, C. Fierro & A. Núñez	MAI0015	KF479513	KF479498
10/12/2012. Collector: E. Guajardo, L. Contreras-Porcía, C. Fierro & A. Núñez	MAI0016	KF479514	KF479499

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422 **TABLE 2:** Morphological features of *Pyropia orbicularis sp. nov.* from Maitencillo beach,
 423 Valparaiso, Chile, *Pyropia columbina* and *Pyropia plicata*.

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Feature	<i>Pyropia orbicularis sp. nov.</i>	<i>Pyropia columbina</i> ^{1,2}	<i>Pyropia plicata</i> ³
Size blade (cm, diameter)	4–16	< 5	4–12
Shape	Orbicular	Rosette to ovate	Circular to oval
Color	Green-brown	Purple to grey	Purple to grey
Habitat	Upper-mid intertidal zone	Intertidal zone	Upper-mid intertidal zone
Seasonality	Year-round	Year-round	Year-round
Sexuality	Monoecious	Monoecious	Monoecious
Vegetative thickness (µm)	36–139	75–90	50–55
Reproductive thickness (µm)	31–188	-	60–110
Vegetative cells (µm, length × width)	18–42 x 10–36	-	-
Rhizoidal cells (µm, length × width)	26–54 x 17–38	-	-
Spermatangium	a4/b4/c4	a/4, b/4, c/8–16	a/2, b/2, c/8
Zygosporangium	a2/b2/c2	a/4–8, b/4–8	a/8, b/8, c/8

425 ¹ Referred to (Nelson and Broom 2010) and ²(Montagne 1842).

426 ³ Referred to (Nelson 2013).

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431 **TABLE 3:** Intra- and inter-specific uncorrected p-distance - in percent - in *Porphyra* and *Pyropia*.

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	COI (604 bp.)		<i>rbcL</i> (876 bp.)	
	Nb. of pairwise comparisons	p-distance (%) Mean \pm SD (Min-Max)	Nb. of pairwise comparisons	p-distance (%) Mean \pm SD (Min-Max)
Intraspecific diversity - <i>Porphyra</i>	72	0.41 \pm 0.23 (0.00-1.15)	584	0.17 \pm 0.20 (0.00-0.71)
Intraspecific diversity - <i>Pyropia</i>	67	0.05 \pm 0.09 (0.00-0.39)	938	0.09 \pm 0.16 (0.00-0.82)
Intraspecific diversity - <i>Pyropia orbicularis sp. nov.</i>	78	0.17 \pm 0.18 (0.00-0.66)	78	0.00 \pm 0.00 (0.00-0.00)
Interspecific diversity - <i>Pyropia</i>	231	12.81 \pm 2.59 (2.48-17.97)	2926	5.64 \pm 1.59 (0.00-10.16)

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440 **TABLE S1.** Specimen collection information, sequence length and GenBank accession numbers of sequences of COI and *rbcL* used in
 441 the analyses. Specimens are in alphabetical order. Sequences used in ML and IB tree reconstruction are highlighted in grey.

Taxon	Collection location	Sequence length		GenBank Accession No	
		COI	<i>rbcL</i>	COI	<i>rbcL</i>
<i>Porphyra</i>					
<i>Porphyra cuneiformis</i>	Juneau, AK, USA		1411		AF452428
<i>Porphyra cuneiformis</i>	Salt lake outlet, Russian Harbor, Kodiak Island, Alaska, USA		1198		EU223049
<i>Porphyra cuneiformis</i>	Humpback Bay, Unalaska Island, Alaska, USA		1161		EU223051
<i>Porphyra cuneiformis</i>	Iniskin Bay, Cook Inlet, Alaska, USA		1161		EU223053
<i>Porphyra cuneiformis</i>	Kake Ferry Terminal, Alaska, USA		1324		EU223055
<i>Porphyra dioica</i>	Lanyon Bay, Glamorgan, Wales, UK	537		DQ442888	
<i>Porphyra dioica</i>	Sandon, Orkney, Scotland, UK	537		DQ442889	
<i>Porphyra dioica</i>	Talmine, Sutherland, Scotland, UK	539		DQ191339	
<i>Porphyra dioica</i>	Sidmouth, Devon, England, UK	539		DQ191340	
<i>Porphyra dioica</i>	Sidmouth, UK		1387		HQ687546
<i>Porphyra dioica</i>	North of Aberystwyth, Wales, UK		1424		AF081291

<i>Porphyra dioica</i>	UK		1007		AF095859
<i>Porphyra dioica</i>	North of Aberstwyth, Wales, UK		1068		AY028524
<i>Porphyra linearis</i>	Aberystwyth, UK		1387		HQ687547
<i>Porphyra linearis</i>	Maine, Cape Neddick, southern ME, USA		1358		JN028945
<i>Porphyra linearis</i>	Seapoint, Kittery, ME, USA		1069		AF078745
<i>Porphyra mumfordii</i>	British Columbia, Bamfield, Bradys Beach, Canada	664	1363	JN028502	JN028946
<i>Porphyra mumfordii</i>	Yachats, OR, USA		1411		AF452434
<i>Porphyra mumfordii</i>	Rosario Beach, Skagit County, Washington, USA		1370		EU223111
<i>Porphyra mumfordii</i>	Rosario Beach, Skagit County, Washington, USA		1352		EU223112
<i>Porphyra mumfordii</i>	Devil's Punchbowl, Lincoln County, Oregon, USA		1367		EU223113
<i>Porphyra mumfordii</i>	Orlebar Point, Gabriola Island, British Columbia, Canada		1293		EU223114
<i>Porphyra occidentalis</i>	Point No Point, BC, Canada		1411		AF452436
<i>Porphyra occidentalis</i>	Cape Palmerston, Vancouver Island, British Columbia, USA		1262		EU223118
<i>Porphyra occidentalis</i>	Olympic Peninsula, between Makah Bay and Sekiu, Clallam County, Washington, USA		1296		EU223119
<i>Porphyra papenfussii</i>	So. George I., AK, USA		1402		AF452437
<i>Porphyra papenfussii</i>	Seldovia Point, Cook Inlet, Alaska, USA		1386		EU223120
<i>Porphyra papenfussii</i>	Telegraph Cove, Vancouver Island, British Columbia, Canada		1362		EU223121
<i>Porphyra papenfussii</i>	Ridley Island, British Columbia, Canada		1312		EU223122

<i>Porphyra papenfussii</i>	Perevalnie Passage, Shuyak Island, Alaska, USA	1288		EU223123
<i>Porphyra purpurea</i>	New Brunswick, Richebucto Cape Breakwater, Canada	664	1363	JN028518 JN028949
<i>Porphyra purpurea</i>	Litstock, Somerset, UK		1387	HQ687516
<i>Porphyra purpurea</i>	Avonport, Nova Scotia, Canada		1049	AY028533
<i>Porphyra purpurea</i>	Herring Cove, Nova Scotia, Canada		1049	AY028532
<i>Porphyra purpurea</i>	Light House Cove, Dipper Harbor, New Brunswick, Canada		1067	AY028535
<i>Porphyra purpurea</i>	Leighton Cove, Whiting, ME, USA		1071	AF078746
<i>Porphyra purpurea</i>	Leighton Cove, Whiting, ME, USA		1013	AY028534
<i>Porphyra purpurea</i>	Camp Ellis, Saco, ME, USA		1043	AY028536
<i>Porphyra purpurea</i>	Camp Ellis, Saco, ME, USA		1043	AY028537
<i>Porphyra sp. olivii</i>	Taverna Chara, Thessaloniki Gulf, Greece		1467	DQ837007
<i>Porphyra sp. olivii</i>	N. Krini, Thessaloniki Gulf, Greece		1467	DQ837008
<i>Porphyra sp. olivii</i>	Dover Point, NH, USA		1455	DQ813625
<i>Porphyra sp. olivii</i>	Yacht Club, Hull, MA, USA		1386	DQ813617
<i>Porphyra sp. olivii</i>	Hammonasset State Park, CT, USA		1439	DQ813611
<i>Porphyra sp. SCL-2008-4</i>	Akutan Harbor, Akutan Island, Alaska, USA		1364	EU223240
<i>Porphyra sp. SCL-2008-4</i>	Akutan Harbor, Akutan Island, Alaska, USA		1286	EU223242
<i>Porphyra sp. SCL-2008-5</i>	Creyke Point, Strait of Juan de Fuca, British Columbia, Canada		1312	EU223184
<i>Porphyra sp. SCL-2008-5</i>	Nudibranch Point, Barkley Sound, British Columbia, Canada		1352	EU223185

<i>Porphyra sp. SCL-2008-5</i>	Baker's Beach, Humboldt County, California, USA	1306	EU223187
<i>Porphyra sp. SCL-2008-5</i>	Morning Cove, Kenai Peninsula, Alaska, USA	1351	EU223188
<i>Porphyra sp. SCL-2008-5</i>	East headland, McArthur Pass, Kenai Peninsula, Alaska, USA	1353	EU223189
<i>Porphyra sp. SCL-2008-5</i>	Fishboat Bay, Strait of Juan de Fuca, Canada	1380	EU223190
<i>Porphyra sp. SCL-2008-5</i>	Sombrio Beach, Strait of Juan de Fuca, British Columbia, Canada	1349	EU223191
<i>Porphyra sp. SCL-2008-5</i>	Botany Bay, Strait of Juan de Fuca, British Columbia, Canada	1344	EU223192
<i>Porphyra sp. SCL-2008-5</i>	Halibut Point, Sitka Sound, Alaska, USA	1349	EU223193
<i>Porphyra sp. SCL-2008-5</i>	Akutan Point, Akutan Island, Alaska, USA	1351	EU223194
<i>Porphyra sp. SCL-2008-5</i>	Akutan Point, Akutan Island, Alaska, USA	1307	EU223195
<i>Porphyra sp. SCL-2008-5</i>	Clover Point, Victoria, British Columbia, Canada	1282	EU223196
<i>Porphyra sp. SCL-2008-5</i>	Yugnat Rocks, Katmai National Park, USA	1307	EU223197
<i>Porphyra sp. SCL-2008-5</i>	Akutan Point, Akutan Island, Alaska, USA	1307	EU223198
<i>Porphyra sp. SCL-2008-5</i>	Seppings Island, Barkley Sound, British Columbia, Canada	1370	EU223199
<i>Porphyra sp. SCL-2008-5</i>	Amalik Bay, Katmai National Park, Alaska, USA	1193	EU223200
<i>Porphyra sp. SCL-2008-5</i>	Cape Palmerston, Vancouver Island, British Columbia, USA	1203	EU223201
<i>Porphyra sp. SCL-2008-5</i>	Port Dick, Kenai Peninsula, Alaska, USA	1304	EU223202
<i>Porphyra sp. SCL-2008-5</i>	Pumicestone Bay, Unalaska Island, Alaska, USA	1307	EU223203
<i>Porphyra sp. SCL-2008-5</i>	Humpback Bay, Unalaska Island, Alaska, USA	1304	EU223204

<i>Porphyra sp. SCL-2008-5</i>	Shark Point, Kodiak Island, Alaska, USA	1364		EU223205
<i>Porphyra sp. SCL-2008-5</i>	Outside Big Bay, Shuyak Island, Alaska, USA	1304		EU223206
<i>Porphyra sp. SCL-2008-5</i>	Egg Island, Alitak Bay, Kodiak Island, USA	1366		EU223207
<i>Porphyra sp. SCL-2008-5</i>	Harling Point, Victoria, British Columbia, Canada	1367		EU223208
<i>Porphyra sp. SCL-2008-5</i>	John Brown's Beach, Japonski Island, Alaska, USA	1349		EU223210
<i>Porphyra sp. SCL-2008-5</i>	Japonski Island, Sitka Sound, Alaska, USA	1306		EU223211
<i>Porphyra sp. SCL-2008-5</i>	Sayward, Vancouver Island, British Columbia, USA	1151		EU223213
<i>Porphyra sp. SCL-2008-5</i>	Nudibranch Point, Barkley Sound, British Columbia, Canada	1274		EU223215
<i>Porphyra sp. SCL-2008-5</i>	Spray Cape, Unalaska Island, Alaska	1379		EU223216
<i>Porphyra sp. SCL-2008-5</i>	Chatham Sound, British Columbia, Canada	1272		EU223217
<i>Porphyra umbilicalis</i>	Newfoundland and Labrador, St. Brides, Canada	664	1363	JN028569 JN028956
<i>Porphyra umbilicalis</i>	Faroe Islands	532		AM94340 1
<i>Porphyra umbilicalis</i>	Faroe Islands	532		AM94340 2
<i>Porphyra umbilicalis</i>	Faroe Islands	532		AM94340 3
<i>Porphyra umbilicalis</i>	Faroe Islands	532		AM94340 4
<i>Porphyra umbilicalis</i>	Birchington on Sea, Kent, England, UK	536		DQ442892

<i>Porphyra umbilicalis</i>	Easdale, Kintyre, Scotland, UK	537		DQ442891
<i>Porphyra umbilicalis</i>	Crawfordsburn, Belfast Lough, Co. Down, Northern Ireland, UK	539		DQ191334
<i>Porphyra umbilicalis</i>	Sidmouth, Devon, England, UK	539		DQ191336
<i>Porphyra umbilicalis</i>	Combe Martin, Devon, England, UK	539		DQ191331
<i>Porphyra umbilicalis</i>	Near Margate, Kent, England, UK	539		DQ191333
<i>Porphyra umbilicalis</i>	Combe Martin, Devon, England, UK	539		DQ191332
<i>Porphyra umbilicalis</i>	Sidmouth, UK		1387	HQ687559
<i>Porphyra umbilicalis</i>	Annapolis Co., NS, Canada		1411	AF452446
<i>Porphyra umbilicalis</i>	Sand Beach, Bar Harbor, Mount Desert Island, ME, USA		1072	AY028540
<i>Porphyra umbilicalis</i>	Red Point, Swans Island, ME, USA		1070	AY028541
<i>Porphyra umbilicalis</i>	Reids State Park, Georgetown, ME, USA		1069	AY028539
<i>Porphyra umbilicalis</i>	Fort Williams, Portland Head, ME, USA		1073	AF078747
<i>Porphyra umbilicalis</i>	Two Lights State Park, Cape Elizabeth, ME, USA		1063	AY028538
<i>Porphyra umbilicalis</i>	New Hampshire, Dover, Dover Point, USA		1422	AF271077
<i>Porphyra umbilicalis</i>	New Hampshire, New Castle, Jaffrey Point, USA		1422	AF271076
<i>Porphyra umbilicalis</i>	Nahant Mass, USA		1961	AB118584

Pyropia

<i>Pyropia abbottiae</i>	British Columbia, Ridley Island, Canada	745	1363	JN028597	JN028962
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<i>Pyropia abbotiae</i>	Sitka, AK, USA	1411	AF452423
<i>Pyropia abbotiae</i>	Baker's Beach, Humboldt County, California, USA	1349	EU223021
<i>Pyropia abbotiae</i>	Peehan, Admiralty Island, Alaska, USA	1387	EU223022
<i>Pyropia abbotiae</i>	Harling Point, Victoria, British Columbia, Canada	1366	EU223024
<i>Pyropia abbotiae</i>	Clover Point, Victoria, British Columbia, Canada	1366	EU223025
<i>Pyropia abbotiae</i>	Harling Point, Victoria, British Columbia, Canada	1326	EU223027
<i>Pyropia acanthophora</i>	Ponta da Fortaleza, Ubatuba, Sao Paulo, Brazil	660	JN222746
<i>Pyropia acanthophora</i>	Ponta da Fortaleza, Ubatuba, Sao Paulo, Brazil	660	JN222747
<i>Pyropia acanthophora</i>	Praia Vermelha do Sul, Ubatuba, Sao Paulo, Brazil	660	JN222749
<i>Pyropia acanthophora</i>	Praia Dura, Ubatuba, Sao Paulo, Brazil	660	JN222745
<i>Pyropia acanthophora</i>	Praia Dura, Ubatuba, Sao Paulo, Brazil	660	JN222743
<i>Pyropia acanthophora</i>	Praia Dura, Ubatuba, Sao Paulo, Brazil	660	JN222744
<i>Pyropia acanthophora</i>	Ilha Vitória, Ubatuba, Sao Paulo, Brazil	660	JN222748
<i>Pyropia acanthophora</i>	Praia da Lagoinha, Ubatuba, Sao Paulo, Brazil	660	JN222750
<i>Pyropia acanthophora</i>	Ubatuba, Sao Paulo, Brazil	1507	HQ605695
<i>Pyropia aeodis</i>	Paternoster, South Africa	1445	GU165843
<i>Pyropia brumalis</i>	Vancouver, BC, Canada	1366	AF452426
<i>Pyropia brumalis</i>	Third Beach, Stanley Park, Vancouver, British Columbia, Canada	1270	EU223038

<i>Pyropia cinnamomea</i>	Bruce's Rock, Otago, South I, NZ	1453	EU521637
<i>Pyropia columbina</i>	Chatham Island, Waitangi Wharf Headland, NZ	1475	GU046439
<i>Pyropia columbina</i>	Chatham Island, Ohira, NZ	1468	GU046434
<i>Pyropia columbina</i>	Chatham Island, Solomon's Monument, NZ	1460	GU046433
<i>Pyropia columbina</i>	South Island, Kings Rock, South Otago, NZ	1405	GU046432
<i>Pyropia columbina</i>	Antipodes Island, NZ	1487	GU046442
<i>Pyropia columbina</i>	Auckland Islands, Enderby Island, Sandy Bay, NZ	1472	GU046437
<i>Pyropia columbina</i>	Auckland Islands, Enderby Island, Sandy Bay, NZ	1349	GU046438
<i>Pyropia columbina</i>	Auckland Islands, Enderby Island, Sandy Bay, south-eastern corner, NZ	1385	GU046445
<i>Pyropia columbina</i>	Auckland Islands, Enderby Island, Sandy Bay, south-eastern corner, NZ	1496	GU046447
<i>Pyropia columbina</i>	Auckland Islands, Enderby Island, Sandy Bay, NZ	1484	GU046436
<i>Pyropia columbina</i>	Campbell Island, north-eastern corner of Penguin Bay, NZ	1400	GU046444
<i>Pyropia columbina</i>	Falkland Islands, East Falkland, Top Island, Port Stanley, UK	1391	GU046423
<i>Pyropia columbina</i>	Falkland Islands, Cape Pembroke, Christina Bay, UK	1430	GU046443
<i>Pyropia columbina</i>	Campbell Island, NZ	1482	GU046412
<i>Pyropia columbina</i>	Chatham Island, Waitangi Wharf Headland, NZ	1475	GU046439
<i>Pyropia conwayae</i>	Lincoln City, Oregon, USA	1413	AF452427

<i>Pyropia conwayae</i>	Baker's Beach, Humboldt County, California, USA		1353		EU223040
<i>Pyropia conwayae</i>	Chesterman Beach, British Columbia, Canada		1216		EU223043
<i>Pyropia dentata</i>	Shirahama, Chiba, Japan		1387		HQ687520
<i>Pyropia denticulata</i>	Mooloolaba, Queensland, Australia		1352		HQ687521
<i>Pyropia fallax</i>	British Columbia, Murchison Island Lagoon, Gwaii Haanas, Canada	664	1363	HQ969862	JN028967
<i>Pyropia fallax</i>	Vancouver, BC, Canada		1381		AF452429
<i>Pyropia fallax</i>	Clover Point, Victoria, British Columbia, Canada		1366		EU223056
<i>Pyropia fallax</i>	Harling Point, Victoria, British Columbia, Canada		1366		EU223057
<i>Pyropia fallax</i>	Surf Bay, Akun Island, Alaska, USA		1369		EU223058
<i>Pyropia fallax</i>	Surf Bay, Akun Island, Alaska, USA		1371		EU223059
<i>Pyropia fallax</i>	Surf Bay, Akun Island, Alaska, USA		1366		EU223060
<i>Pyropia fallax</i>	Surf Bay, Akun Island, Alaska, USA		1366		EU223061
<i>Pyropia fallax</i>	Katmai Bay, Katmai National Park, Alaska, USA		1383		EU223063
<i>Pyropia fallax</i>	Akutan Bay, Akutan Island, Alaska, USA		1386		EU223064
<i>Pyropia fallax</i>	Outside Beach, Cook Inlet, Alaska, USA		1364		EU223065
<i>Pyropia fallax</i>	Lucy Island, Chatham Sound, British Columbia, Canada		1316		EU223067
<i>Pyropia fallax</i>	Pasagshak Bay, Kodiak Island, Alaska, USA		1296		EU223079
<i>Pyropia fallax</i>	Pumicestone Bay, Unalaska Island, Alaska, USA		1364		EU223083

<i>Pyropia fallax</i>	Shakun Islets, Katmai National Park, Alaska, USA		1320		EU223084
<i>Pyropia fallax</i>	Avatanak Island, AK, USA		1399		GU319865
<i>Pyropia fucicola</i>	British Columbia, Tahsis, Island #40 on Esperenza Inlet Chart, Canada	664	1363	JN028614	JN028969
<i>Pyropia fucicola</i>	Kiukpalik Island, Katmai National Park, Alaska, USA		1349		EU223086
<i>Pyropia fucicola</i>	Surf Bay, Akun Island, Alaska, USA		1368		EU223087
<i>Pyropia fucicola</i>	Japonski Island, Sitka Sound, Alaska, USA		1359		EU223088
<i>Pyropia fucicola</i>	Outside Foul Bay, Afognak Island, Alaska, USA		1152		EU223090
<i>Pyropia fucicola</i>	Juneau, Alaska, USA		1411		AF452430
<i>Pyropia gardneri</i>	British Columbia, Chaatl Island across from Newton Point, Haida Gwaii, Canada	661	1363	HM91530 0	JN028973
<i>Pyropia haitanensis</i>	Yuge, Ehime, Japan		1961		AB118585
<i>Pyropia hiberna</i>	Foot of 15th Street, Pacific Grove, Monterey County, CA, USA		1342		GU319866
<i>Pyropia hollenbergii</i>	Agua Verde, Baja California Sur, Mexico		1350		HQ687523
<i>Pyropia hollenbergii</i>	Bahia Agua Verde, Baja California Sur, Mexico		1362		AY794401
<i>Pyropia ishigecola</i>	Yoshio, Katsuura, Chiba, Japan		1356		HQ687524
<i>Pyropia kanakaensis</i>	British Columbia, Bamfield, Seppings, Canada		1363		JN028978
<i>Pyropia kanakaensis</i>	Kanaka Bay, WA, USA		1367		AF452431
<i>Pyropia kanakaensis</i>	Baker's Beach, Humboldt County, California, USA		1328		EU223097

<i>Pyropia kanakaensis</i>	Baker's Beach, Humboldt County, California, USA		1359		EU223098
<i>Pyropia kanakaensis</i>	Olympic Peninsula, between Makah Bay and Sekiu, Clallam County, Washington, USA		1352		EU223099
<i>Pyropia katadae</i>	Ise, Mie, Japan		1387		HQ687525
<i>Pyropia katadae</i>	Kawatana, Yamaguchi Prefecture, Japan		1961		AB118583
<i>Pyropia katadae</i>	Pohang, Gyeongsangbukdo, Korea		1441		HQ728199
<i>Pyropia katadae</i>	Taiping Corner, Qingdao, China		1447		DQ630039
<i>Pyropia kinositae</i>	Arito, Suttu, Hokkaido, Japan		1496		EU521641
<i>Pyropia kinositae</i>	Miyagi, Naruse, Japan		1402		AB366145
<i>Pyropia kinositae</i>	Hokkaido, Otaru, Shukutsu, Japan		1402		AB366139
<i>Pyropia koreana</i>	Ohuri, Gangwondo, Korea		1441		HQ728198
<i>Pyropia kuniedae</i>	Sachon, Namhae, Gyeongsangnamdo, Korea		1441		HQ728200
<i>Pyropia kurogii</i>	British Columbia, Ridley Island, Prince Rupert, Canada	815	1363	JN028655	JN028980
<i>Pyropia kurogii</i>	Katmai Bay, Katmai National Park, Alaska, USA		1359		EU223101
<i>Pyropia kurogii</i>	Udamak Cove, Unalaska Island, Alaska, USA		1355		EU223102
<i>Pyropia kurogii</i>	Gaada'x, Admiralty Island, Alaska, USA		1320		EU223103
<i>Pyropia kurogii</i>	Outside Beach, Cook Inlet, Alaska, USA		1345		EU223104
<i>Pyropia kurogii</i>	Sandy Beach, Sitka Sound, Alaska, USA		1345		EU223105
<i>Pyropia kurogii</i>	Udamak Cove, Unalaska Island, Alaska, USA		1275		EU223107

<i>Pyropia kurogii</i>	Portage Bay, Unalaska Island, Alaska, USA		1224		EU223108
<i>Pyropia kurogii</i>	Juneau, Alaska, USA		1411		AF452432
<i>Pyropia lacerata</i>	Shirahama, Chiba, Japan		1382		HQ687527
<i>Pyropia leucosticta</i>	New Brunswick, Lepreau exposed biodiversity site, Bay of Fundy, Canada	664	1363	JN028662	JN028981
<i>Pyropia leucosticta</i>	Smoo, Cave, Durness, Scotland, UK	524		DQ442910	
<i>Pyropia leucosticta</i>	Faroe Islands	532		AM94339	
<i>Pyropia leucosticta</i>	Berwick-upon-Tweed, Northumberland, England, UK	539		DQ191338	
<i>Pyropia leucosticta</i>	Hannafore Point, Looe, Cornwall, England, UK	539		DQ191337	
<i>Pyropia leucosticta</i>	Sidmouth, UK		1387		HQ687528
<i>Pyropia leucosticta</i>	New Hampshire, New Castle, Jaffrey Point, USA		1422		AF271078
<i>Pyropia leucosticta</i>	Gove Point, Cobscook Bay, Lubec, ME, USA		1030		AF078744
<i>Pyropia leucosticta</i>	Two Lights State Park, Cape Elizabeth, ME, USA		1030		AY028525
<i>Pyropia moriensis</i>	Otaru, Hokkaido, Japan		1431		EU521645
<i>Pyropia nereocystis</i>	British Columbia, Cape Beale, exposed front, Bamfield, Canada	664		JN028685	
<i>Pyropia nereocystis</i>	Sitka, AK, USA		1368		AF452435
<i>Pyropia nereocystis</i>	Cape Udak, Umnak Island, Alaska, USA		1368		EU223115
<i>Pyropia nereocystis</i>	Passage Island, Cook Inlet, Alaska, USA		1244		EU223116

<i>Pyropia nereocystis</i>	Ushagat Island, Barren Islands, Alaska, USA		1105		EU223117
<i>Pyropia njordii</i>	Nova Scotia, Lighthouse at Peggys Cove, Canada	815	1363	JN028693	JN028986
<i>Pyropia onoi</i>	Mori, Hokkaido, Japan		1359		HQ687529
<i>Pyropia peggicovensis</i>	Nova Scotia, Peggys Cove, Halifax Co., Canada		1363		JN028991
<i>Pyropia pendula</i>	Calerita, Baja California Sur, Mexico		1360		HQ687530
<i>Pyropia perforata</i>	British Columbia, Qualicum Beach, Canada		1363		JN028996
<i>Pyropia perforata</i>	Punta Popotla, Baja California, Mexico		1448		GU046416
<i>Pyropia perforata</i>	Sitka, Alaska, USA		1411		AF452438
<i>Pyropia perforata</i>	Baker's Beach, Humboldt County, California, USA		1349		EU223125
<i>Pyropia perforata</i>	Birch Bay, Whatcom County, Washington, USA		1353		EU223126
<i>Pyropia perforata</i>	Crescent City Light, Del Norte County, California, USA		1367		EU223127
<i>Pyropia perforata</i>	Clover Point, Victoria, British Columbia, Canada		1366		EU223128
<i>Pyropia perforata</i>	Three Saints Bay, Kodiak Island, Alaska, USA		1348		EU223129
<i>Pyropia perforata</i>	Campbell River, Vancouver Island, British Columbia, Canada		1362		EU223130
<i>Pyropia perforata</i>	Brady's Beach, Barkley Sound, British Columbia, Canada		1359		EU223131
<i>Pyropia perforata</i>	Northwest Afognak Island, Alaska, USA		1366		EU223132
<i>Pyropia perforata</i>	North jetty, Humboldt Bay, Humboldt County, California, USA		1359		EU223133
<i>Pyropia perforata</i>	South cove, Cape Arago, Coos County, Oregon, USA		1316		EU223134

<i>Pyropia plicata sp. nov.</i>	Ocean View, Kaikoura, South I, NZ	1483	GU046410
<i>Pyropia pseudolanceolata</i>	Harling Point, Victoria, BC, Canada	1366	EU223145
<i>Pyropia pseudolanceolata</i>	Amalik Bay, Katmai National Park, Alaska, USA	1370	EU223141
<i>Pyropia pseudolanceolata</i>	Akutan Point, Akutan Island, Alaska	1385	EU223142
<i>Pyropia pseudolanceolata</i>	Rosario Beach, Skagit County, Washington, USA	1378	EU223143
<i>Pyropia pseudolanceolata</i>	Rosario Beach, Skagit County, Washington, USA	1378	EU223144
<i>Pyropia pseudolanceolata</i>	Izhut Bay, Afognak Island, Alaska, USA	1366	EU223146
<i>Pyropia pseudolanceolata</i>	Outside Big Bay, Shuyak Island, Alaska, Canada	1366	EU223147
<i>Pyropia pseudolanceolata</i>	Sedanka Point, Unalaska Island, Alaska, USA	1365	EU223148
<i>Pyropia pseudolanceolata</i>	Humpback Bay, Unalaska Island, Alaska, USA	1351	EU223149
<i>Pyropia pseudolanceolata</i>	Cape Sitkinak, Sitkinak Island, Alaska, USA	1385	EU223150
<i>Pyropia pseudolanceolata</i>	Skan Bay, Unalaska Island, Alaska, USA	1365	EU223151
<i>Pyropia pseudolanceolata</i>	Deadman Bay, San Juan Island, San Juan County, Washington, USA	1331	EU223152
<i>Pyropia pseudolanceolata</i>	French Beach, Vancouver Island, British Columbia, Canada	1385	EU223153
<i>Pyropia pseudolanceolata</i>	Botany Bay, Strait of Juan de Fuca, British Columbia, Canada	1387	EU223154
<i>Pyropia pseudolanceolata</i>	Fishboat Bay, Strait of Juan de Fuca, Canada	1365	EU223155
<i>Pyropia pseudolanceolata</i>	Marine Gardens, Devil's Punchbowl, Lincoln County, Oregon, USA	1359	EU223156

<i>Pyropia pseudolanceolata</i>	Perevalnie Passage, Shuyak Island, Alaska, USA		1359		EU223157
<i>Pyropia pseudolanceolata</i>	Harling Point, Victoria, British Columbia, Canada		1291		EU223159
<i>Pyropia pseudolanceolata</i>	Northwest Dundas Island, British Columbia, Canada		1158		EU223162
<i>Pyropia pseudolanceolata</i>	Outside Big Bay, Shuyak Island, Alaska, Canada		1179		EU223166
<i>Pyropia pseudolinearis</i>	Choshi, Chiba, Japan		1387		HQ687531
<i>Pyropia pulchella</i>	Waihau Bay East, North Island, NZ		1353		HQ687532
<i>Pyropia rakiura</i>	Ocean View, Kaikoura, South I, NZ		1496		EU521646
<i>Pyropia rosengurtii</i>	Faroe Islands	532			AM943399
<i>Pyropia rosengurtii</i>	England	539			DQ191335
<i>Pyropia saldanhae</i>	Kommetjie, South Africa		1466		GU165838
<i>Pyropia seriata</i>	Hondo, Kumamoto, Japan		1387		HQ687533
<i>Pyropia smithii</i>	British Columbia, Ramsey Island (point adjacent Kloo Rock), Gwaii Haanas, Canada	661		JN028778	
<i>Pyropia smithii</i>	British Columbia, Alder Island, Gwaii Haanas, Canada		1363		JN028997
<i>Pyropia smithii</i>	Nudibranch Point, Barkley Sound, British Columbia, Canada		1337		EU223224
<i>Pyropia sp. 1Cal</i>	California, Jade Cove, USA	664	1358	JN028786	JN028999
<i>Pyropia sp. 1POR</i>	British Columbia, Whiffen Spit, SookeHarbour, Vancouver Island, Canada	664	1363	JN028790	JN029001
<i>Pyropia sp. 2Cal</i>	California, McAbee Beach, Monterey, USA	664	1358	JN028791	JN029002

<i>Pyropia</i> sp. 551	Gerringong boat harbor, NSW, Australia		1412		GU319870
<i>Pyropia</i> sp. 6POR	Texas, South Jetty, Port Arkansas, USA	664	1363	JN028792	JN029003
<i>Pyropia</i> sp. AKL170	Southeast Sandy Bay, Enderby I, Auckland Is, NZ		1400		GU046403
<i>Pyropia</i> sp. Antar68	Admiralty Bay, King George Island, South Shetlands Archipelago, Antarctica		1563		HQ605698
<i>Pyropia</i> sp. collinsii	Rhode Island, Fort Wetherill, USA	664	1363	JN028795	JN029004
<i>Pyropia</i> sp. FAL	Saldamando, Baja California, Mexico		1369		HQ687535
<i>Pyropia</i> sp. FIA	Top Island, Port Stanley, East Falkland, Falkland Is.		1470		GU165842
<i>Porphyra</i> sp. FIA	Macquarie Island, Australia		1465		GU046428
<i>Pyropia</i> sp. FIC	Top Island, Port Stanley, East Falkland, Falkland Is.		1449		GU046422
<i>Pyropia</i> sp. FID	East Loafers, Sea Lion I, Falkland Is.		1476		GU046406
<i>Pyropia</i> sp. FID	Top Island, Port Stanley, East Falkland, Falkland Is.		1353		GU165886
<i>Pyropia</i> sp. FIE	Top Island, Port Stanley, East Falkland, Falkland Is.		1479		GU046408
<i>Pyropia</i> sp. MIG	Faru de San Miguel, Baja California, Mexico		1387		HQ687536
<i>Pyropia</i> sp. Piaui	Parnaiba, Piaui, Brazil		1562		HQ605697
<i>Pyropia</i> sp. PTK	Northwest Bay, Manawa Tawhi, Three Kings Islands, NZ		1387		HQ687537
<i>Pyropia</i> sp. ROS125	Henderson Point, North I, NZ		1368		HQ687538
<i>Porphyra</i> sp. SCL-2008-1	Harling Point, Victoria, British Columbia, Canada		1317		EU223013
<i>Porphyra</i> sp. SCL-2008-1	Peacock Pt, Unalaska Island, Alaska, USA		1353		EU223018

<i>Porphyra sp. SCL-2008-1</i>	Helianthus Cove, Akun Island, Alaska, USA		1353		EU223019
<i>Porphyra sp. SCL-2008-1</i>	Sedanka Point, Unalaska Island, Alaska, USA		1359		EU223020
<i>Porphyra sp. SCL-2008-2</i>	South Head, Cook Inlet, Alaska, USA		1328		EU223168
<i>Porphyra sp. SCL-2008-2</i>	Katmai Bay, Katmai National Park, Alaska, USA		1360		EU223169
<i>Porphyra sp. SCL-2008-2</i>	Carlisle Island, Alaska, USA		1367		EU223170
<i>Porphyra sp. SCL-2008-2</i>	Sarannaya Bay, Kamchatka, Russia		1367		EU223171
<i>Porphyra sp. SCL-2008-2</i>	Captains Bay, Amaknak Island, Alaska, USA		1125		EU223173
<i>Porphyra sp. SCL-2008-2</i>	Alimuda Bay, Unalaska Island, Alaska, USA		1234		EU223176
<i>Porphyra sp. SCL-2008-2</i>	Volcano Bay, Unalaska Island, Alaska, USA		1191		EU223178
<i>Porphyra sp. SCL-2008-2</i>	Driftwood Bay, Unalaska Island, Alaska, USA		1290		EU223180
<i>Porphyra sp. SCL-2008-3</i>	Whiffin Spit, Strait of Juan de Fuca, British Columbia, Canada		1352		EU223138
<i>Porphyra sp. SCL-2008-3</i>	Whiffin Spit, Strait of Juan de Fuca, British Columbia, Canada		1377		EU223139
<i>Porphyra sp. SCL-2008-3</i>	John Brown's Beach, Japonski Island, Alaska, USA		1386		EU223140
<i>Pyropia sp. SMR</i>	Curio Bay, Southland, South I, NZ		1369		HQ687539
<i>Pyropia sp. SSR053</i>	Ocean View, Kaikoura, South I, NZ		1581		GU046411
<i>Pyropia sp. SSR091</i>	Brighton, Otago, South I, NZ		1465		GU046421
<i>Pyropia sp. stamfordensis</i>	Rhode Island, Governor Sprague Bridge 17, Narragansett, USA	664	1363	JN028798	JN029005

<i>Pyropia sp. STI</i>	Campbell Point, Otago, South I, NZ	1376	HQ687540
<i>Pyropia sp. TCH243</i>	Torias Corner, Stewart I, NZ	1437	GU046418
<i>Pyropia sp. WRO</i>	Punakaiki, Westland, South I, NZ	1365	HQ687541
<i>Pyropia sp. ZLI1045</i>	Paternoster, South Africa	1465	GU165839
<i>Pyropia spiralis</i>	Vila Velha, Espírito Santo, Brazil	660	JN222754
<i>Pyropia spiralis</i>	Vila Velha, Espírito Santo, Brazil	1564	HQ605696
<i>Pyropia spiralis</i>	Cibratel, Itanhaém, Sao Paulo, Brazil	660	JN222755
<i>Pyropia spiralis</i>	Ponta da Armacao, Florianópolis, Santa Catarina, Brazil	660	JN222757
<i>Pyropia spiralis</i>	Baleia, Sao Sebastiao, Sao Paulo, Brazil	660	JN222758
<i>Pyropia spiralis</i>	Tijucopava, Guarujá, Sao Paulo, Brazil	660	JN222759
<i>Pyropia spiralis</i>	Itaipu, Santos, Sao Paulo, Brazil	660	JN222760
<i>Pyropia spiralis</i>	Lage de Santos, Santos, Sao Paulo	660	JN222756
<i>Pyropia spiralis</i>	Praia da Lagoinha, Ubatuba, Sao Paulo, Brazil	660	JN222753
<i>Pyropia suborbiculata</i>	Wonsando, Chungchungnamdo, Korea	1441	HQ728201
<i>Pyropia suborbiculata</i>	Kanagawa, Yokosuka, Sajim, Japan	1961	AB287948
<i>Pyropia suborbiculata</i>	Mansonboro Island, NC, USA	1066	AY028523
<i>Pyropia suborbiculata</i>	Kawatana, Yamaguchi Prefecture, Japan	1961	AB118580
<i>Pyropia suborbiculata</i>	Waterford, CT, USA	1066	AF078743
<i>Pyropia suborbiculata</i>	Fort Fisher, New Hanover Co., NC, USA	1326	U04041

<i>Pyropia tanegashimensis</i>	Praia Dura, Ubatuba, Sao Paulo, Brazil	660		JN222752	
<i>Pyropia tanegashimensis</i>	Iseki, Tanegashima, Kagoshima, Japan		1387		HQ687542
<i>Pyropia tenera</i>	Kawaura, Kumamoto, Japan		1387		HQ687543
<i>Pyropia tenera</i>	Kumamoto, Kawaura, Japan		1411		AB243206
<i>Pyropia tenera</i>	Kanagawa, Kawasaki, Tonomachi, Japan		1402		AB366148
<i>Pyropia tenera</i>	Kumamoto, Kuratake, Japan		1429		AB455544
<i>Pyropia tenera</i>	Kumamoto, Shinwa, Japan		1429		AB455545
<i>Pyropia tenera</i>	Mie, Ise, Miyakawa, Japan		1429		AB455546
<i>Pyropia tenera</i>	Aichi, Toyohashi, Toyokawa, Japan		1429		AB455547
<i>Pyropia tenera</i>	Kawaura, Kumamoto Prefecture, Japan		1961		AB118576
<i>Pyropia tenera</i>	Shinwa, Kumamoto Prefecture, Japan		1961		AB118577
<i>Pyropia tenera</i>	Soma, Fukushima Prefecture, Japan		1961		AB118578
<i>Pyropia tenuipedalis</i>	Urayasu, Chiba, Honshu, Japan		1400		EU521649
<i>Pyropia tenuipedalis</i>	Yamaguchi, Yamaguchi, Futajima, Japan		1961		AB287951
<i>Pyropia thuretii</i>	British Columbia, Tahsis, Island south of Clotchman I., Spanish Pilot Group, Tahsis, Canada	815	1363	JN028801	JN029007
<i>Pyropia torta</i>	British Columbia, Alder Island, Gwaii Haanas, Canada	664	1358	JN028802	JN029008
<i>Pyropia torta</i>	Sitka, AK, USA		1383		AF452445
<i>Pyropia torta</i>	Whiffin Spit, Strait of Juan de Fuca, British Columbia,		1385		EU223229

	Canada		
<i>Pyropia torta</i>	Harling Point, Victoria, British Columbia, Canada	1367	EU223230
<i>Pyropia torta</i>	Botany Bay, Strait of Juan de Fuca, British Columbia, Canada	1355	EU223231
<i>Pyropia torta</i>	Skan Bay, Unalaska Island, Alaska, USA	1359	EU223232
<i>Pyropia torta</i>	Pumicestone Bay, Unalaska Island, Alaska, USA	1359	EU223233
<i>Pyropia torta</i>	Pirate Cove, Baranof Island, Alaska, USA	1359	EU223234
<i>Pyropia torta</i>	Vista Mar, San Juan Island, San Juan County, Washington, USA	1320	EU223236
<i>Pyropia vietnamensis</i>	Pedra do Sal, Parnaíba, Piauí, Brazil	660	JN222751
<i>Pyropia vietnamensis</i>	Thangaseri, Kerala, India	1358	HQ687544
<i>Pyropia virididentata</i>	Lyll Bay, Wellington, North I, NZ	1472	EU521650
<i>Pyropia yezoensis</i>	Galmok, Tongyoung, Gyeongsangnamdo, Korea	1441	HQ728197
<i>Pyropia yezoensis</i>	Hakodate, Hokkaido, Japan	1961	AB118574
<i>Pyropia yezoensis</i>	Ogatsu, Miyagi Prefecture, Japan	1961	AB118575
<i>Pyropia yezoensis</i>	Ogatsu, Miyagi Prefecture, Japan	1411	AB243204
<i>Pyropia yezoensis</i>	Hokkaido, Date, Usu Bay, Japan	1402	AB366137
<i>Pyropia yezoensis</i>	Hokkaido, Date, Cape Arutori, Japan	1402	AB366140
<i>Pyropia yezoensis</i>	Muroran, Bokoi-minami, Japan	1402	AB366141
<i>Pyropia yezoensis</i>	Hokkaido, Mori, Japan	1402	AB366142

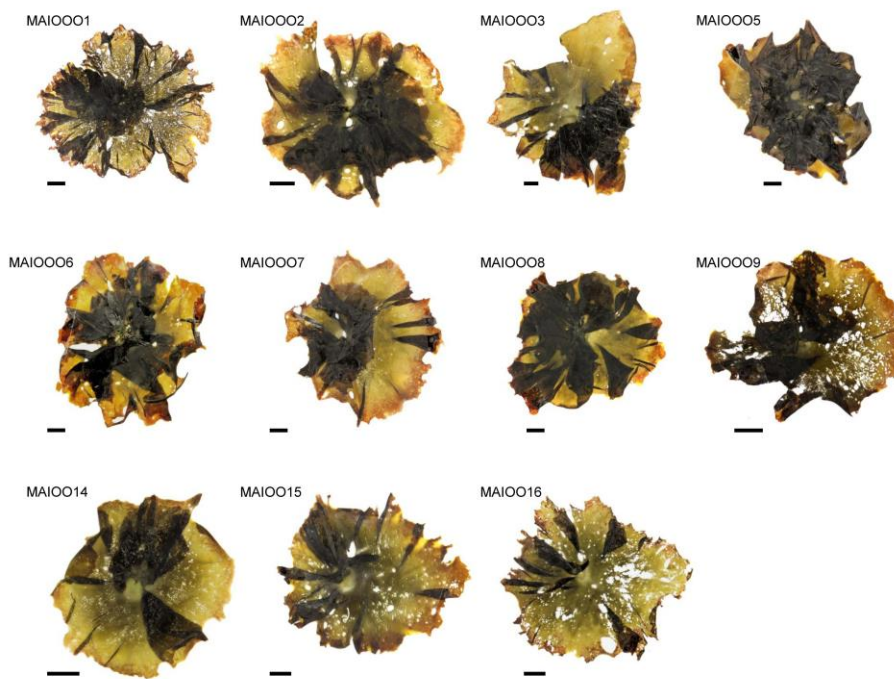
<i>Pyropia yezoensis</i>	Miyagi, Naruse, Japan	1402	AB366144
<i>Pyropia yezoensis</i>	Miyagi, Shichigahama, Japan	1402	AB366147
<i>Pyropia yezoensis</i>	Chiba, Urayasu, Chidori, Japan	1430	AB455542
<i>Pyropia yezoensis</i>	Hokkaido, Otaru, Shukutsu, Japan	1430	AB455543
<i>Pyropia yezoensis</i>	Eastport, Maine, USA	1421	AF021032
<i>Pyropia yezoensis</i>	Cultivated strain	1961	AB118590
<i>Pyropia yezoensis</i>	Cultivated strain	1467	DQ227860
<i>Pyropia yezoensis</i>	Cultivated strain	1467	DQ227861
<i>Pyropia yezoensis</i>	Cultivated strain	1467	DQ227862
<i>Pyropia yezoensis</i>	Cultivated strain	1467	DQ227863
<i>Pyropia yezoensis</i>	Cultivated strain	1467	DQ227864
<i>Pyropia yezoensis</i>	Cultivated strain	1467	DQ227865
<i>Pyropia yezoensis</i>	Cultivated strain	1467	DQ227866

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444 **FIGURE S1.** Habitat of foliose gametophytes of *Pyropia orbicularis* sp. nov. collected
445 from Matencillo beach, Valparaiso, Chile. Scale bar = 2 cm.

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