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Supplementary material

Macroalgal calcification and the effects of ocean acidification and global warming

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Table S1. Described species in genus *Halimeda* since 1980

Species	Classification	References
H. borneensis Taylor, *H. cylindracea* Decaisne, *H. favulosa* Howe, *H. macroloba* Decaisne, *H. incrassata* (Ellis) Lamouroux, *H. monile* (Ellis & Solander) Lamouroux, *H. stuposa* Taylor, *H. melanesica* Valet, *H. fragilis* Taylor, *H. micronesica* Yamada, *H. cryptica* Colinvaux & Graham, *H. cuneata* Hering, *H. discoidea* Decaisne, *H. gigas* Taylor, *H. lacunalis* Taylor, H. macrophysa Askenasy, *H. magnidisca* Noble, *H. scabra* Howe, *H. taenicola* Taylor, *H. tuna* (Ellis & Solander) Lamouroux, *H. xishaensis* Dong & Tseng, *H. hummii* Ballantine, *H. bikinensis* Taylor, *H. gracilis* Harvey ex J. Agardh, *H. lacrimosa* Howe, *H. simulans* Howe, *H. copiosa* Goreau & Grahamc, *H. distorta* (Yamada) Colinvaux, *H. goreauii* Taylor, *H. minima* (Taylor) Colinvaux, *H. opuntia* (L.) Lamouroux, *H. renschii* Hauck, *H. velasquezii* Taylor, *H. misiki* n. sp. *H. hederacea*, *H. pygmaea*, *H. pumila*, *H. ryukyuensis*,	*Halimeda*, Halimedaceae, Bryopsidales, Ulvophyceae	Hillis-Colinvaux 1980; Ballantine 1982; Noble 1986; Dong and Tseng 1980; Kooistra *et al*. 2002; Verbruggen and Kooistra 2004; Verbruggen *et al*. 2007; Kojima *et al*. 2015; Cremen *et al*. 2016

Table S2. Responses of calcified marine macroalgae to ocean warming

Green, negative responses; yellow, polynomial or mixed responses; red, positive responses; and white, no response to increasing temperature. Some factors or parameters were not measured or reported (Nr)

Species	Calcification response	Photosynthesis and growth response	Temperature (°C)	Treatment time	Author and year
Clathromorphum circumscriptum	Nr	Negative effects on reproduction and photosynthetic rate	2–12	21 weeks	Adey (1973)
Corallina officinalis	Nr	Negative effects on growth; No growth at 25°C	6–25	8 weeks	Colthart and Johansen (1973)
Porolithon onkodes	No effects on calcification rates	Increased bleaching and decreased photosynthetic rates	25–29	8 weeks	Anthony *et al*. (2008)
Hydrolithon reinboldii	No effects on calcification rates	No effects on bleaching	27.2–29.8	20 days	Comeau *et al*. (2014)
Lithophyllum kotschyanum	No effects on calcification rates in spring	Nr	24–31.5	4 weeks	Comeau *et al*. (2016)
Lithophyllum kotschyanum	Negative impacts on calcification rates in summer	Nr	24–31.5	4 weeks	Comeau *et al*. (2016)
Hydrolithon onkodes	Increased rates of skeletal dissolution	Negative effects on survival rate	26–29	8 weeks	Diaz-Pulido *et al*. (2012)
Hydrolithon onkodes	Negative effects on calcification rates	Negative effects on herbivory susceptibility	26–29 (420–830 µatm CO_2)	3 weeks	Johnson and Carpenter (2012)
Ellisolandia elongata	Negative effects on calcification rates	Increased bleaching and decreased photosynthetic rates	15–35	4 weeks	Guy-Haim *et al*. (2016)
Lithophyllum yessoense	Polynomial responses	Polynomial responses	5–25	40 days	Ichiki *et al*. (2000)
Lithothamnion glaciale Kjellm	Negative effects on calcite density	No effects on growth band width	8–15	Over the last 50 years	Kamenos and Law (2010)
Phymatolithon calcareum	Polynomial responses; Optimum calcification at temperatures higher than 10°C	Nr	0–20	6 weeks	King and Schramm (1982)
Corallina vancouveriensis	No effects on calcification rates	No effects on growth	15.3–17.4	9 months	Kram *et al*. (2016)
Lithophyllum cabiochae	No effects on calcification	Increased bleaching, ocean acidification exacerbates the impacts of ocean warming	Seasonal 13.3–22.0 and 16.3–25.0	1 year	Martin and Gattuso (2009)
Lithophyllum cabiochae	Increasing temperature is beneficial for calcification during winter. Otherwise, temperature has little effect	Increased respiration and photosynthetic rates during winter, Otherwise, temperature has little effect	Seasonal 13.3–22.0 and 16.3–25.0	1 year	Martin *et al*. (2013)
Ellisolandia elongata	No effects on calcification rates	It was able to acclimate to higher temperatures over 6 months	Seasonal 20–25 and 20–28	6 months	Nannini *et al*. (2015)
Lithotamnion coralloides	No effects on calcification rates	No effects on photosynthetic and respiration	10–19 (380–1000 µatm CO_2)	3 months	Noisette *et al*. (2013)
Lithophyllum stictaeforme.	Nr	24–26°C decreased survival and reproductive maturation	10–26	1 year	Rodríguez-Prieto (2016)
Lithophyllum margaritae	Increased calcification	Increased photosynthesis and respiration	10–30	60 h	Steller *et al*. (2007)

Species	Calcification response	Photosynthesis and growth response	Temperature (°C)	Treatment time	Author and year
Porolithon onkodes	Calcification unaffected at 30°C, reduced at 32°C	Negative effects on photosynthesis	27–32	16 days	Tanaka *et al*. (2017)
Neogoniolithon fosliei	Nr	Negative effects on F_v/F_m and mortality	27–32	7 days	Webster *et al*. (2011)
Phymatolithon calcareum	Nr	No significant effects on F_v/F_m at +8°C from summer maximum	9–25	5 weeks	Wilson *et al*. (2004)
Amphiroa tribulus, Lithothamnion sp.	Negative effects on calcification rates	Negative effects on respiration and photosynthetic	30–32	10 days	Vásquez-Elizondo and Enríquez (2016)
Halimeda heteromorpha	Negative impacts on calcification rates in summer; Positive effects on calcification rates in winter	Polynomial responses	20–32	8 weeks	Brown *et al*. (2019)
Halimeda macroloba, H. cylindracea	Negative effects on calcification rates	Negative effects on photosynthesis	28–32 (400 and 1200 μatm CO_2)	5 weeks	Sinutok *et al*. (2012)
Halimeda	Negative effects on calcification rates	Positive effects on photosynthesis	28–31 (pH 7.6 and 8.0)	4 weeks	Campbell *et al*. (2016)
Halimeda macroloba, H. cylindracea	Negative effects on calcification rates	Negative effects on F_v/F_m; 32°C is the upper limits for survival	28–34 (39–203 Pa CO_2)	5 weeks	Sinutok *et al*. (2011)
Lithophyllum okamurae	Nr	Polynomial responses; Optimum temperature for sporelings growth was 20°C	5–35	2 weeks	Yoshioka *et al*. (2020)
Corallina officinalis	Negative effects on calcification rates	Negative effects on physiological rates	20–23	7 weeks	Rendina *et al*. (2019)
Jania rubens	calcium carbonate content was reduced	No effects on algal metabolism and phenolic content	24–28	21 days	Rich *et al*. (2018)
Amphiroa gracilis	Nr	Algae became bleached but photosynthesis was not impacted	19–23 (pH 7.8–8.2)	21 days	Huggett *et al*. (2018)
Corallina officinalis Amphiroa anceps	Nr	Negative effects on growth	23–28 (pH 7.6–8.1)	2 weeks	Graba-Landry *et al*. (2018)
Corallina officinalis	Negative effects on calcification rates	No effects on growth	13–28	7 days	Kim *et al*. (2018)
Lithophyllum cabiochae	Decreased the content of $MgCO_3$	Nr	13.3–25 (400–700 μatm CO_2)	1 year	Nash *et al*. (2016)
Neogoniolithon sp.	Negative effects on calcification rates	Nr	10–25	47 days	Ries *et al*. (2016)
Padina pavonica, Halimeda tuna	Nr	Polynomial responses	12–34	21 days	Savva *et al*. (2018)
Corallina officinalis	Nr	30 and 35°C resulted in bleaching	20–35	7 days	Latham (2008)
Sporolithon cf. durum	Nr	Negative effects on germling growth	27–29	2 weeks	Page and Diaz-Pulido (2020)
Porolithon onkodes	Nr	Negative effects on growth and photosynthesis	29–31	60 days	Lei *et al*. (2020)
Chamberlainium sp.	Positive effects on Ca^{2+} content of algal skeletons	No effects on growth and photosynthesis	20–25 (450–900 matm CO_2)	47 days	Kim *et al*. (2020)
Porolithon onkodes	Dolomite concentration increased at 1,225 μatm and 30°C; Aragonite increased at 296 μatm and 28°C	Nr	28–30 (296–1225 matm CO_2)	2 months	Diaz-Pulido *et al*. (2014)

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