COMPARING LONG-TERM STANDING STOCK AND TISSUE C:N:P RATIOS BETWEEN *HALIMEDA* AND *PENICILLUS* (CHLOROPHYTA, BRYOPSIDALES) ACROSS A TROPHIC GRADIENT WITHIN FLORIDA BAY, USA.

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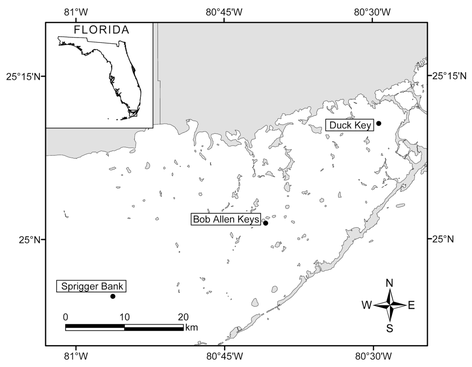
Introduction

Florida Bay (FB) is a coastal subtropical lagoon with large seagrass beds characterized by calcareous biogenic sediments that are recognized to be phosphorus (P) limited (Zieman 1989, Fourqurean et al. 1992). *Halimeda* and *Penicillus* are the two most abundant genera of calcareous green algae (CGA) in FB. The standing stock and nutrient tissue content of these CGA communities have been surveyed as part of the Florida Coastal Everglades Long-term Ecological Research program for nine years (2008-2017); from the southwest (Sprigger Bank, SB) to the central area (Bob Allen, BA) and to the northeast region (Duck Key, DK). Within FB, there is a gradient of higher nitrogen (N) and lower phosphorus (P) from the northeast region of the bay to the southwest regions of the bay as previously reported in seagrass studies (Fourqurean et al. 1992, Frankovich and Fourqurean 1997).

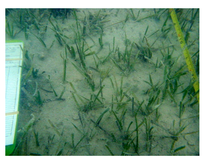
The hypotheses being explored are:

- The standing stock will be genera dependent with expected larger contribution by *Halimeda* spp. than in *Penicillus* spp.
- The standing stock will be site dependent with a larger contribution expected towards to southwest region of the bay (SB) than the sites closer to the northeast region of the bay (BA, DK).
- There will be no variability expected in nutrient tissue content between *Halimeda* and *Penicillus* because they are both coenocytic and calcifying green macroalgae.
- *Penicillus* will show a spatial variability of N and P limitation with higher nitrogen and lower phosphorus towards the northeast region of the bay.

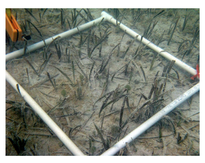


Methods

- Three sites: Sprigger Bank, Bob Allen Keys and Duck Key were surveyed four to six times a year, from 2008-2017.
- The standing crop of *Halimeda* spp. and *Penicillus* spp. was collected by hand using three randomly placed 0.25m^2 quadrats at each site.



Duck Key *(TS/Ph 9)*



Bob Allen *(TS/Ph 10)*

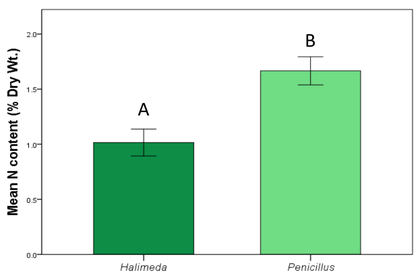
Sprigger Bank *(TS/Ph 11)*

- Specimens in each quadrat were separated at the genus level and cleaned.
- The samples were dried for 48 hours at 60^{o}C and the total mass was recorded by weighing the sample.
- For each site, three thalli of each genus present were selected and ground for nutrient analysis.
- The samples were analyzed for carbon and nitrogen tissue content using a CHN analyzer (Fisons NA1500; Fisons Instruments, Milan, Italy). Elemental P tissue content was measured by the dry-oxidation-acid hydrolysis extraction followed by a colorimetric analysis of phosphate concentration method (Fourqurean et al. 1992).
- Statistical analyses were carried out using IBM SPSS software. Parametric tests (one-way ANOVA) were used for normally distributed sampling. Non-parametric tests (Mann-Whitney and Kruskal-Wallis) were used for samples not normally distributed.

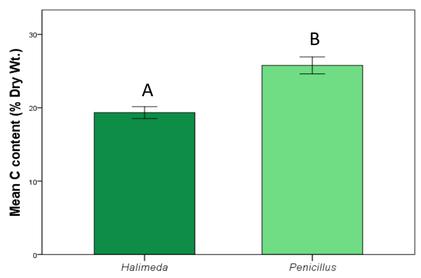
Halimeda spp.

Penicillus spp.

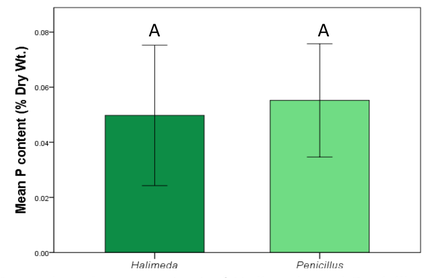
Results



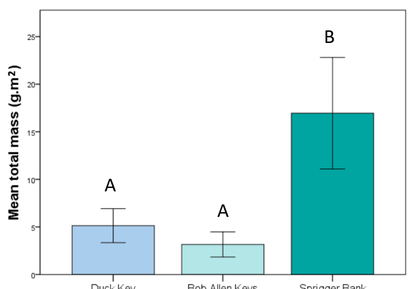
Mean nitrogen content of *Halimeda* and *Penicillus* at Sprigger Bank from 2008-2017. Vertical bars are ± 2 standard error. Values with the same letter are not statistically significant (P > 0.05).



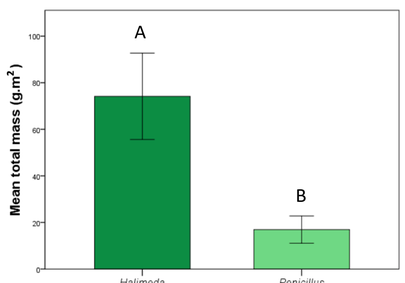
Mean carbon content of *Halimeda* and *Penicillus* at Sprigger Bank from 2008-2017. Vertical bars are ± 2 standard error. Values with the same letter are not statistically significant (P > 0.05).



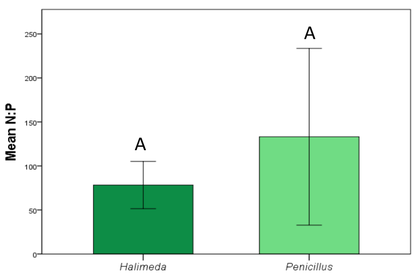
Mean phosphorus content of *Halimeda* and *Penicillus* at Sprigger Bank from 2008-2017. Vertical bars are ± 2 standard error. Values with the same letter are not statistically significant (P > 0.05).



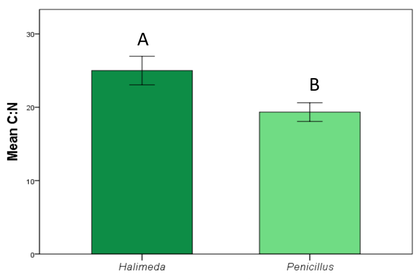
Mean standing stock of *Halimeda* and *Penicillus* at Sprigger Bank from 2008-2017. Vertical bars are ± 2 standard error. Values with the same letter are not statistically significant (P > 0.05).



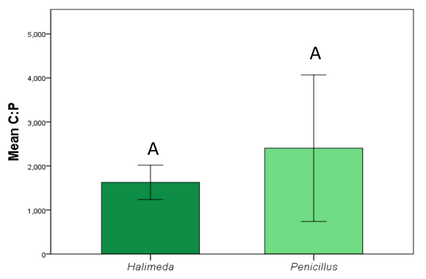
Mean standing stock of *Penicillus* at all three sites from 2008-2017. Vertical bars are ± 2 standard error. Values with the same letter are not statistically significant (P > 0.05).



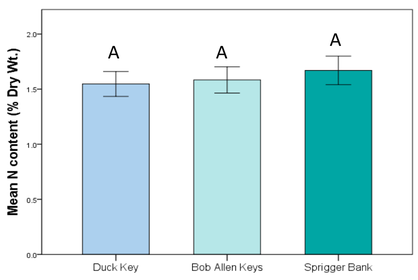
Mean nitrogen to phosphorus ratio of *Halimeda* and *Penicillus* at Sprigger Bank from 2008-2017. Vertical bars are ± 2 standard error. Values with the same letter are not statistically significant (P > 0.05).



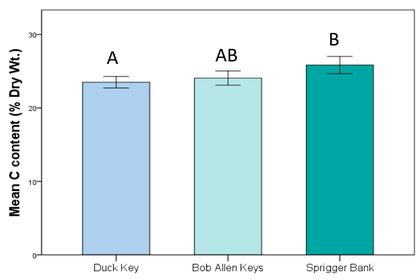
Mean carbon to nitrogen ratio of *Halimeda* and *Penicillus* at Sprigger Bank from 2008-2017. Vertical bars are ± 2 standard error. Values with the same letter are not statistically significant (P > 0.05).



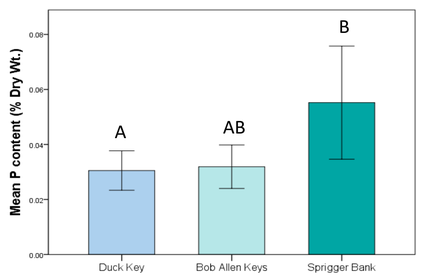
Mean carbon to phosphorus ratio of *Halimeda* and *Penicillus* at Sprigger Bank from 2008-2017. Vertical bars are ± 2 standard error. Values with the same letter are not statistically significant (P > 0.05).



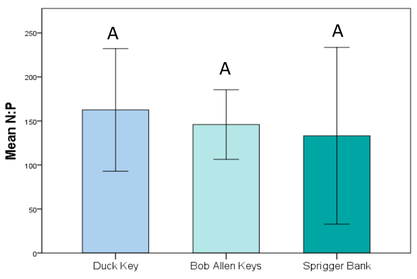
Mean nitrogen content of *Penicillus* at all three sites from 2008-2017. Vertical bars are ± 2 standard error. Values with the same letter are not statistically significant (P > 0.05).



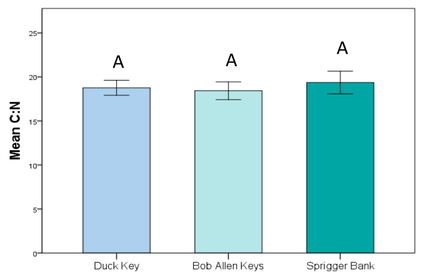
Mean carbon content of *Penicillus* at all three sites from 2008-2017. Vertical bars are ± 2 standard error. Values with the same letter are not statistically significant (P > 0.05).



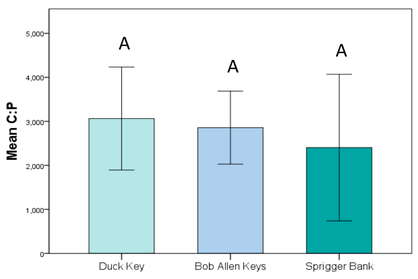
Mean phosphorus content of *Penicillus* at all three sites from 2008-2017. Vertical bars are ± 2 standard error. Values with the same letter are not statistically significant (P > 0.05).



Mean nitrogen to phosphorus ratio of *Penicillus* at all three sites from 2008-2017. Vertical bars are ± 2 standard error. Values with the same letter are not statistically significant (P > 0.05).



Mean carbon to nitrogen ratio of *Penicillus* at all three sites from 2008-2017. Vertical bars are ± 2 standard error. Values with the same letter are not statistically significant (P > 0.05).



Mean carbon to phosphorus ratio of *Penicillus* at all three sites from 2008-2017. Vertical bars are ± 2 standard error. Values with the same letter are not statistically significant (P > 0.05).

Genera	Locality	C%	N%	P%	N:P	C:P	C:N	C:N:P Ratio	Reference
Halimeda	Sprigger Bank, Florida Bay, USA	19.34	1.02	0.05	78.31	1628.08	25	1628:78:1	
	N. Queensland, Australia	48	3.79	0.25	33	488	14.8	488:33:1	Atkinson & Smith 1983
	Corsica, France	34	5.30	0.18	67	501	7.5	501:67:1	Atkinson & Smith 1983
	Hawaii, USA	33	3.63	0.17	47	499	10.6	499:47:01	Atkinson & Smith 1983
	Enewetak, Pacific Ocean	30	4.74	0.09	42	872	7.38	872:42:1	Atkinson & Smith 1983
	Belize, Caribbean	14.9	0.44	0.02	48.9	1910	38	1910:49:1	Lapointe et al. 1992
	Jamaica, Caribbean	6.8	0.54	0.03	44.4	642	14.6	642:44:1	Lapointe et al. 1992
	Jamaica, Caribbean	6.8	0.54	0.03	39.8	584	14.7	584:40:1	Lapointe et al. 1997
	Curaçao, Caribbean	16.5	0.39	0.01	28.14		45.01		Teichberg et al. 2012
	Akumal Bay, Mexico	17	1				26		Mutchler et al. 2007
	Tobago, Caribbean	15.7	0.7	0.05	33	840	25	840:33:1	Lapointe et al. 2010
	Tobago, Caribbean	15	0.7	0.03	52	1379	26	1379:52:1	Lapointe et al. 2010
	Tobago, Caribbean	12.6	0.4	0.03	34	1188	34	1188:34:1	Lapointe et al. 2010
	Tobago, Caribbean	13.4	0.4	0.01	67	2526	37	2526:67:1	Lapointe et al. 2010
	Tobago, Caribbean	13.8	0.5	0.03	35	1109	31	1109:35:1	Lapointe et al. 2010
	Florida Keys, USA						11		Lamb et al. 2012
	Florida Keys, USA						10.8		Lamb et al. 2012
	Florida Keys, USA						9.7		Lamb et al. 2012
	Florida Keys, USA						10.6		Lamb et al. 2012
	Florida Keys, USA						14.3		Lamb et al. 2012
	Florida Keys, USA						9.5		Lamb et al. 2012
Penicillus	Duck Key, Florida Bay, USA	23.49	1.55	0.03	162.56	3064.97	18.77	3065:162:1	
	Bob Allen, Florida Bay, USA	24.06	1.58	0.03	145.91	2857.78	18.43	2858:146:1	
	Sprigger Bank, Florida Bay, USA	25.84	1.67	0.06	133.15	2404.18	19.37	2404:133:1	
	Akumal Bay, Mexico	31	2				15		Mutchler et al. 2006
	Bermuda, Caribbean		1.20	0.03					McGlathery et al. 1992

Table 1 showing observed C:N:P ratios of *Halimeda* and *Penicillus* at Florida Bay, USA and ratios obtained in other regions of the world. Rows highlighted in blue represent data obtained from our study in Florida Bay.

Summary:

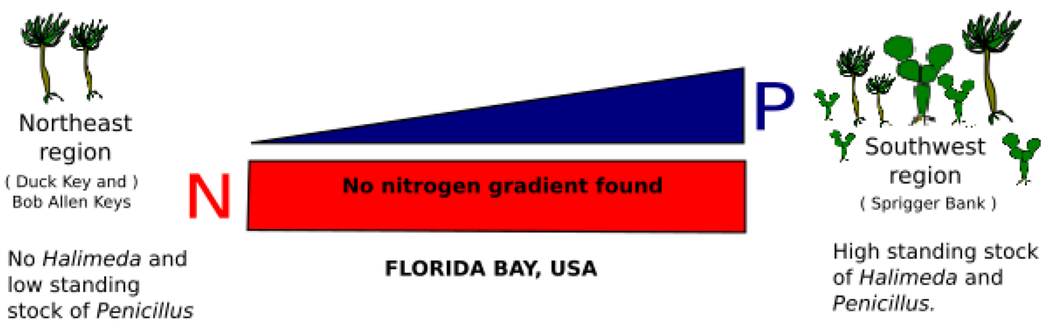
Between genera in Florida Bay:

- *Halimeda* was more abundant with lower C and N tissue content values than *Penicillus*, however, P tissue content was similar for both genera.
- N:P and C:P ratios were higher for *Penicillus* than *Halimeda*. C:N ratio was higher in *Halimeda* than in *Penicillus.*
- The mean C, N and P tissue content for both genera in FB were within the range reported by the literature for other regions in the world (Table 1).

Across sites in Florida Bay:

- *Penicillus was* more abundant with significantly higher C and P content in the southwest than northeast region of the bay.
- The expected N gradient was not found in Florida Bay as N content was similar across all sites.
- C:N:P ratios for *Penicillus* were similar across all sites.

Discussion



- No nitrogen gradient present, however, N tissue content values were above regional values but below the critical concentration (1.8%N) reported by Duarte (1990) showing nitrogen limitation in FB.
- P tissue content lower in northeast region where there is lower standing stock. P values were higher in FB than other values reported throughout the Caribbean but much lower than the critical concentration (0.2%) reported by Duarte (1990). This shows phosphorus limitation in both genera and across FB which was reflected in previous seagrass studies in FB (Fourqurean et al. 1992).
- Other factors such as turbidity, pH and salinity could be contributing to low standing stock in the northeast region and a complete absence of *Halimeda*.
- While our study shows that standing stock of CGA is observed as both genera- and site-dependent with phosphorus limitation in the bay, further studies are needed to explain factors limiting the distribution of *Halimeda* to Sprigger Bank, and the low production at all three sites, nutrient tissue content differences between these genera.

Acknowledgments

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