Int. J. Biosci. 2024

INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 24, No. 2, p. 120-132, 2024

RESEARCH PAPER OPEN ACCESS

Seagrass community structure in Maribojoc Bay, Bohol, Philippines

Honey Jane C. Mascariñas[*]

College of Technology and Allied Sciences, Bohol Island State University, Calape, Bohol, Philippines

Key words: Seagrass, Diversity, Percent cover, Marine protected area, Maribojoc Bay

http://dx.doi.org/10.12692/ijb/24.2.120-132 Article published on February 07, 2024

Abstract

Seagrasses are an integral part of coastal and marine biodiversity. However, their existence and ecological functions are likely unfamiliar to many. The study area has no previous seagrass assessment. Eight sampling sites were surveyed in the coastal areas of Maribojoc Bay to investigate the status of seagrass among stations as well as between MPAs and non-MPAs. The study used a standardized field sampling design with three parallel, fixed transects of 50 meters. Seven species of seagrass were found, with *Thalassia hemprichii* being the most prevalent (52.79%) and *Halodule pinifolia* being the species that appears least frequently. The highest seagrass cover was observed in Brgy. Dipatlong, Maribojoc (non-MPA), while the lowest percentage cover was observed in Brgy. Ubujan, Tagbilaran (non-MPA). Only the two sites in Dauis showed a significant difference (>0.05) between an MPA and a non-MPA. There was no significant difference ($p > 0.05$) in the percentage cover of seagrass species among sampling stations. Seagrass percentage cover ranged from 17.45% (poor) to 60% (good). Overall, the seagrass community structure in Maribojoc Bay revealed sparse distribution, "fair" seagrass condition (38.65%), high dominance (2.98), low evenness (0.72), and low diversity (H' = 1.40). The findings of this study can be used as a basis for improving the existing coastal management and promote the preservation of seagrass ecosystems.

[*] **Corresponding Author:** Honey Jane C. Mascariñas ✉ hjmascarinas@yahoo.com

Introduction

Seagrasses contribute to the total biodiversity of the coastal and marine environment. They create small patches that grow into huge, continuous meadows that may consist of one or more species, with up to 12 species present in one site (McKenzie, 2008). Seagrass meadows are among Earth's most productive ecosystems (Duarte and Chiscano, 1999). They are primary producers that drive local nutrient cycles (Hemming and Duarte, 2000) and support local food web (Gullström *et al.*, 2008). They play a substantial part in sustaining valuable ecosystem services comparable to those given by ecosystems like coral reefs and mangrove forests (Phillips and Milchakova, 2003; Nordlund *et al.*, 2016). Seagrasses are found mainly in shallow, clear inshore areas between mean sea level and the depth range that is likely restricted at its deepest edge by the availability of light for photosynthesis (McKenzie, 2008). The abundance of seagrass often follows a parabolic pattern as depth increases, reaching a maximum abundance at intermediate depths and then decreasing exponentially. They also thrive in the intertidal zone, where the largest meadows grow on softer soils like sand and mud. The survival of the seagrass species near the shallow edge depends on low-tide exposure, wave action, and the corresponding low salinity and turbidity from fresh water inflow (Duarte, 1991).

Factors such as light, salinity, temperature, wave action, and nutrient availability have a substantial impact on the spatial distribution of seagrass (Orth *et al.*, 2006; Hemming and Duarte, 2000). Being plants, they need light for photosynthesis (Dennison *et al.*, 1993), which is the primary factor regulating seagrass growth and distribution (Hall *et al.*, 1999; Bach *et al.*, 1998). Likewise, seagrass growth and distribution are also influenced by temperature and salinity (Masini and Manning, 1997; Koch and Dawes, 1991; Bulthuis, 1987), and sheltered environments are crucial for its establishment (Van Katwijk and Hermus, 2000; Dan *et al.*, 1998; Lee Long *et al.*, 1993). However, a number of environmental stresses, frequently linked to human activity, have led to a decline in seagrass, including eutrophication of water, changes in coastal salinity, turbidity, and introduced species (Waycott *et al.*, 2009; Orth *et al.*, 2006). Land-based activities, such as wastewater pollution, mining, agriculture, and run-off from deforestation, also put pressure on the seagrass ecosystem (Short *et al.*, 2011; Hemming and Duarte, 2000). In addition, climate change has an impact on seagrass ecosystems, so resource productivity may be affected in the future (Mackenzie *et al.*, 2007).

About 72 species of seagrass found worldwide, and Western Australia has more than 30 species identified (Saenger *et al.*, 2013). On the otherhand, Fortes (2017) claims the Philippines have the second-highest number, with 18 species of seagrass widely distributed throughout the country. In Bohol, about 14 seagrass species are encountered in different towns (Green *et al.*, 2022). Although unknown to many, seagrasses are beneficial in the province, because the majority of Boholanos rely on coastal resources for food and livelihoods. Unfortunately, seagrass beds are seriously threatened by development and reclamation activity in some areas of Bohol. In Maribojoc Bay, human pressure on its coastal area increases as the coastline is fringed by a fast-growing city and urbanized municipalities. In order to make way for coastal development, the shallow coastal habitats colonized by most seagrasses are often dug up or covered. Seagrasses may experience stress if these issues are not resolved, which would undermine and deteriorate their natural production and ecosystem values. Besides, seagrass loss and deterioration will not only cause scarcity in resource availability, but will also have an impact on the ecological integrity of Maribojoc Bay. This study assessed the status of seagrass community structure between marine protected areas (MPAs) and non-MPAs of Maribojoc Bay. Hence, the results of this study would help support the seagrass management and conservation systems in the country. Moreover, the information provided in this study is useful in planning and implementing a long-term seagrass habitat monitoring program with a focus on seagrass ecological integrity.

Materials and methods

Maribojoc Bay is situated in the southwestern part of the island province of Bohol, and it encompasses the coastal communities of Maribojoc, Cortes, Dauis, Panglao, and Tagbilaran City (Fig. 1). Dauis and Panglao are both located in Panglao Island. It spans a surface area of 145 square kilometers and has a total of 73.4 kilometers of coastline. Twenty-seven (27) coastal barangays are situated along the periphery of the bay area. Four stations were established and eight sites were surveyed to assess the seagrass status and compare the condition of seagrass between marine protected areas (MPA) and none marine protected areas (non-MPAs). Adjacent non-MPA sites were selected for similarities in geographical location, land use and environmental conditions.

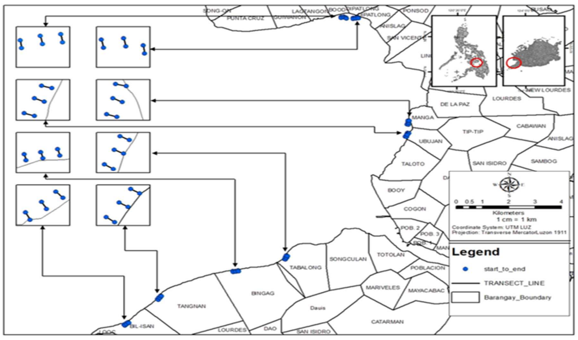


Fig. 1. Map showing the location of transect lines in the eight study sites of Maribojoc Bay, Bohol

Sampling and data collection

This study used a standardized field sampling design with three parallel, fixed transects of 50 meters. Three transect lines, each 100 meters apart from the other, were set perpendicular to the shoreline at each sampling site. For each transect line, a quadrat measuring 50 cm × 50 cm was laid at five-meter intervals along each transect (Short *et al.*, 2006). A total of 11 quadrats were sampled, and biotic factors like species composition, abundance, percent cover, diversity, and distribution were assessed within each quadrat. Seagrass species were identified using the classification scheme by Fortes (2013) and the identification keys developed by McKenzie *et al.*, (2003). Several physico-chemical properties, such as depth (meter tape), salinity (refractometer), temperature (mercurial thermometer), underwater horizontal visibility (secchi disk), DO (DO meter), and pH (pH meter) were measured along each transect line. The texture of the substrate was identified, along with the dominant grain sizes (e.g. sand, fine sand, mud, rocks, etc). Sampling was done during intertidal and subtidal using snorkeling or scuba equipment. The coordinates of starting and ending points of transects were recorded by GPS. Positions, areas of seagrass, and extent for each study site were also recorded by GPS. The date, time, tidal information, and other relevant observations found were also entered in the data sheet.

Calculation of seagrass coverage and condition

An ocular estimate of percent cover was based on the seagrass percentage cover photo guide by McKenzie *et al.* (2007). The cover (C) of each species in each 50 cm × 50 cm quadrat was calculated using the formula:

$$C = \frac{\Sigma(M_i \times f_i)}{\Sigma f}$$

The seagrass cover for each transect was determined by dividing the sum of the average cover for each quadrat by the number of quadrats utilized. The corresponding percent cover per sampling site was determined by getting the total percent cover of transects divided by the number of transects used for each sampling site. The seagrass percent cover was then classified using Jackson and Nemeth's (2007) classifications, where poor = 0-25%, fair = 26-50%, good = 51-75%, and excellent = 76-100%.

Calculation of seagrass diversity index

Relative abundance was calculated determine the abundance and distribution of each species. Abundance of seagrass species was determined by calculating the total number of individual species (n), dividing the total number of species populations (N), and multiplying by one hundred (100). The relative abundance may be given in percentages (%).

Relative Abundance (%) = (n/N)*100

Where n = individual species count

N=total species count

Shannon Diversity Index and Simpson Index Dominance were computed to assess the diversity index, dominance, and evenness of seagrass species among sampling stations and between sites (Magurran, 2004).

$H' = -\Sigma pi \ln pi$ $E = H'/H\max$

$$D = \sum_{i=1}^{S}(pi)^2 = \sum_{i=1}^{S}(ni/N)^2$$

Whittaker plot or rank-abundance curve was created using Tinn-R version 6.01 and R for windows version 4.0.1

Data analysis

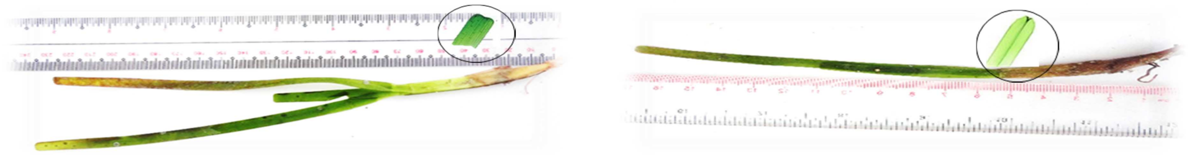
A one-way analysis of variance (ANOVA) was used to test for significant differences among sampling stations and between sites at an alpha (α=0.05) level of confidence. Potential differences between MPAs and non-MPAs were also determined. A post-hoc test was used to define the subsets of variance that contribute to differences among sampling stations and between sites. The data was analyzed using SPSS.

Results and discussion

Seven species of seagrass were identified in Maribojoc Bay, Bohol (Table 1, Fig. 2). There were three species of the family Hydrocharitaceae: *Enhalus acoroides, Halophila ovalis,* and *Thalassia hemprichii,* and four species of the family Cymodoceaceae: *Cymodocea rotundata, Halodule pinifolia, Halodule uninervis, and Syringodium isoetifolium.* The seagrass encountered is about 39% of the total species found in the country (Fortes 2017). The occurrence of seagrass species ranged from *Thalassia-Enhalus* beds to a maximum of seven species in mixed communities. In the Philippines, seagrass beds are often a mix of *E. acoroides, C. rotundata, T. hemprichii, H. pinifolia, H. uninervis,* and *H. ovalis* (Meñez *et al.*, 1983). Of the seven seagrass species, *T. hemprichii* was observed to be the most ubiquitous. Among the four stations, only Dauis had all seven seagrass species, and these species were encountered at both MPA and non-MPA sites. The greater number of seagrass species in Dauis can be attributed to its landscape, which is a cliff-rocky shore. Seagrasses are sheltered from direct impacts from sediment burial and human disturbances like the construction of tourism facilities, pollution, and human settlements. Besides, there are only two resorts located in Dauis. Other sites recorded six or five of the species, and the lowest was in Brgy. Ubujan, Tagbilaran (non-MPA), with only two species found. The difference in the number of seagrass species found among four stations and between MPAs and non-MPAs is an indication of the deteriorating seagrass ecosystem in Maribojoc Bay.The decline of seagrass species can be attributed both directly and indirectly to anthropogenic activities. In particular, Tagbilaran is a high-use bayside area that serves as a fishing ground, docking port, tourism destination, and human settlement.

In terms of relative abundance, *Thalassia hemprichii* had the highest percentage across sampling stations (Fig. 3). More than half of the overall relative abundance was obtained by *T. hemprichii* (52.79%) when all stations were combined. The remaining percentages were *Enhalus acoroides* (18.85%*), Cymodocea rotundata* (9.55%), *Halodule uninervis* (7.48%*), Halophila ovalis* (7.20%*), Syringodium isoetifolium* (3.96%), and *Halodule pinifolia* (0.18%), respectively. ANOVA analysis (Table 2) showed a significant difference ($p > 0.05$) in seagrass species relative abundance of (F (6, 21) = 19.77, p = 0.00). A Tukey post hoc test revealed a significant difference between *Hp vs Cr* (p = 0.01), *Hp vs Ho* (p = 0.01), *Hp vs Ea* (p = 0.00), *Hp vs Th* (p = 0.00), *Si vs Th* (p = 0.00), *Hu vs Th* (p = 0.00), *Cr vs Th* (p = 0.00), *Ho vs Th* (p = 0.00), and *Ea vs Th* (p = 0.04). There was no significant difference between any other subsets of seagrass relative abundance.

Highest relative abundance of *T. hemprichii* was recorded in the municipality of Dauis (59.36%), followed by Maribojoc (56.73%), Panglao (53.85%), and Tagbilaran City (41.22%), respectively. One-way ANOVA analysis (Table 3) showed no significant difference ($p > 0.05$) in *T. hemprichii* relative abundance among sampling stations (F (3, 20) = 1.56, p = 0.23). The relative abundance of *E. acoroides* was highest in Tagbilaran City (41.47%). It was slightly higher than *T. hemprichii*, followed by Maribojoc (21.40%), Dauis (12.29%), and Panglao (0.26%), respectively.



A. *Cymodocea rotundata*
Common Name: Smooth ribbon seagrass
Family: Cymodoceaceae
General Description: Leaves are long, flat, strap-like and 2-4mm wide. Leaf tip smooth and rounded.

D. *Halodule pinifolia*
Common Name: Needle seagrass
Family: Cymodoceaceae
General Description: Leaves are thin, flat and needle-like and up to 20 cm long. Leaf central vein splits into two at the rounded leaf tip.

B. *Enhalus acoroides*
Common Name: Tape seagrass
Family: Hydrocharitaceae
General Description: Leaves are thicker, ribbon-like and 30-150 cm long. The longest among seagrass species in the Philippines.

E. *Halodule uninervis*
Common Name: Needle seagrass
Family: Cymodoceaceae
General Description: Leaves range from short to very long and leaf tip form a trident shape.

C. *Halophila ovalis*
Common Name: Spoon seagrass, aka paddleweed/ fan seagrass
Family: Hydrocharitaceae
General Description: No hairs on leaf surface, oval shaped leaf with more than eight cross veins.

F. *Syringodium isoetifolium*
Common Name: Noodle seagrass
Family: Cymodoceaceae
General Description: Leaves cylindrical and 7-30 cm long. Leaf tip smooth and tapers to a point.

G. *Thalassia hemprichii*
Common Name: Sickle seagrass
Family: Hydrocharitaceae
General Description: Leaves are curved shape and 10-40 cm long. Leaf tips usually round and smooth.

Fig. 2. Photographs and brief background of seagrass species identified in Maribojoc Bay, Bohol

One-way ANOVA analysis showed a significant difference ($p<0.05$) in *E. acoroides* relative abundance among sampling stations (F (3, 20) = 3.89, p = 0.02). A Tukey post-hoc test revealed a significant difference between Tagbilaran and Panglao (p = 0.02). Dauis had the highest relative abundance of *C. rotundata* (12.82%), followed by Panglao (11.26%), Tagbilaran (9.54%), and Maribojoc (4.58%), respectively. One-way ANOVA analysis showed no significant difference ($p>0.05$) in *C. rotundata* relative abundance among sampling stations (F (3, 20) = 0.62, p= 0.61).

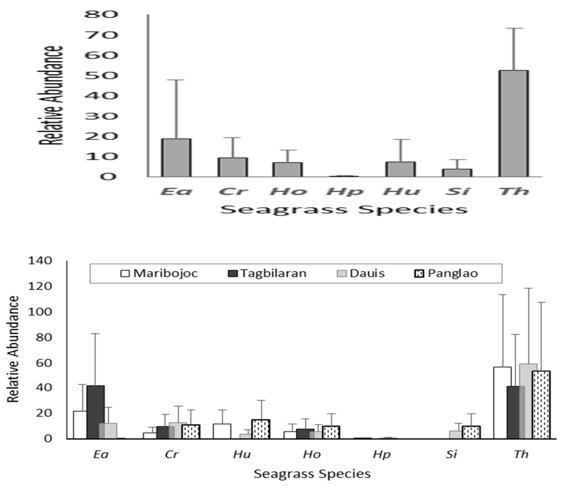


Fig. 3. Relative abundance of seagrass species in Maribojoc Bay and four sampling stations (error bars are standard deviation)

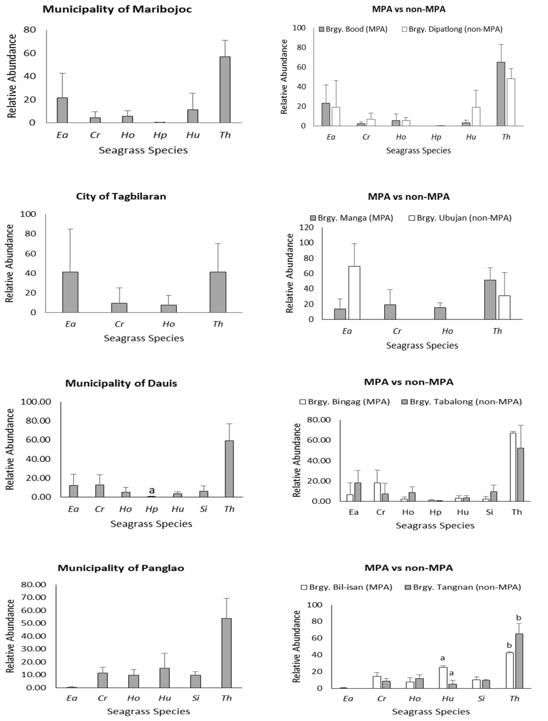


Fig. 4. Relative abundance of seagrass species in each sampling station and between MPAs and non-MPAs (error bars are standard deviation). One-way ANOVA test present similarity between groups and values with the same superscript showed significant difference (p<0.05)

Panglao had the highest relative abundance of *H. uninervis* (15.03%), followed by Maribojoc (11.40%) and Dauis (3.48%), respectively. One-way ANOVA analysis showed a significant difference ($p > 0.05$) in *H. uninervis* relative abundance among sampling stations ($F(3, 20) = 3.17$, $p = 0.05$). A Tukey post hoc test revealed a significant difference between Tagbilaran and Panglao ($p = 0.05$). Panglao had the highest relative abundance of *H. ovalis* (9.78%), followed by Tagbilaran (7.78%), Maribojoc (5.76%), and Dauis (5.47%), respectively. One-way ANOVA analysis showed no significant difference ($p > 0.05$) in *H. ovalis* relative abundance among sampling stations ($F(3, 20) = 0.48$, $p = 0.70$). Meanwhile, *S. isoetifolium* was encountered only on Panglao Island: Panglao (9.84%) and Dauis (6.01%). One-way ANOVA analysis showed a significant difference ($p > 0.05$) in *S. isoetifolium* relative abundance among sampling stations ($F(3, 20) = 12.81$, $p = 0.00$). A Tukey post hoc test revealed a significant difference between Dauis and Maribojoc ($p = 0.02$); Dauis and Tagbilaran ($p = 0.02$); Panglao and Maribojoc ($p = 0.00$); and Panglao and Tagbilaran ($p = 0.00$). Lastly, *H. pinifolia* with the lowest relative abundance was only found in Dauis (0.58%) and Maribojoc (0.13%). One-way ANOVA analysis showed no significant difference ($p > 0.05$) in *H. pinifolia* relative abundance among sampling stations ($F(3, 20) = 2.75$, $p = 0.07$).

In the municipality of Maribojoc, the most abundant species of seagrass was *T. hemprichii (56.73%),* followed by *E. acoroides (21.40%), H. uninervis (11.40%), H. ovalis (5.76%), C. rotundata (4.58%),* and *H. pinifolia (0.13%),* respectively (Fig. 4 and Table 4). In Brgy Bood (MPA), the most abundant was *T. hemprichii (65.07%),* followed by *E. acoroides (23.41%), H. ovalis (5.76%), H. uninervis (3.41%),* and *C. rotundata (2.34%),* respectively. Whereas, in Brgy Dipatlong (non-MPA), the most abundant species, was *T. hemprichii (48.38%),* followed by *H. uninervis (19.39%)* and *E. acoroides (19.39%), C. rotundata (6.82%), H. ovalis (5.76%)* and *H. pinifolia (0.25%),* respectively. A one-way ANOVA test showed no significant difference ($p > 0.05$) in seagrass relative abundance between Brgy Bood (MPA) and Brgy Dipatlong (non-MPA). In Tagbilaran City, the most abundant was *E. acoroides (41.47%),* slightly higher than *T. hemprichii (41.22%),* followed by *C. rotundata (9.54%) and H. ovalis (7.77%),* respectively.

Table 1. Species composition and distribution of seagrass among sampling stations and between sites

Species	Maribojoc		Tagbilaran		Dauis		Panglao	
	Bood MPA	Dipatlong	Manga MPA	Ubujan	Bingag MPA	Tabalong	Bil-isan MPA	Tangnan
C. rotundata	+	+	+	-	+	+	+	+
E. acoroides	+	+	+	+	+	+	+	-
H. pinifolia	-	+	-	-	+	+	-	-
H. uninervis	+	+	-	-	+	+	+	+
H. ovalis	+	+	+	-	+	+	+	+
S. isoetifolium	-	-	-	-	+	+	+	+
T. hemprichii	+	+	+	+	+	+	+	+
Total species	5	6	4	2	7	7	6	5

+presence, - absence

Table 2. Analysis of variance (ANOVA) to test seagrass relative abundance between species (p<0.05)

		Sum of Squares	Df	Mean Square	F	P-value
Relative Abundance	Between Groups	7712.362	6	1285.394	19.76762	0.00
	Within Groups	1365.529	21	65.02521		
	Total	9077.891	27			

Table 3. One-way ANOVA analysis showing difference on seagrass relative abundance among four sampling stations and Tukey post hoc test showing significant difference between sampling stations (p < 0.05)

Seagrass sp.	N	One-way ANOVA Test			Tukey's Multiple Comparisons					
		Sum of squares	F	P-value	1-2	1-3	1-4	2-3	2-4	3-4
E. acoroides	24	19550.01	3.89	0.02*	0.40	0.90	0.34	0.14	0.02*	0.73
C. rotundata	24	2256.49	0.62	0.61	0.87	0.60	0.70	0.96	0.99	1.00
H. ovalis	24	867.13	0.48	0.70	0.99	0.99	0.84	0.92	0.95	0.66
H. pinifolia	24	4.27	2.75	0.07	0.95	0.25	0.95	0.10	1.00	0.10
H. uninervis	24	2509.38	3.17	0.05*	0.21	0.49	0.90	0.93	0.05*	0.18
S. isoetifolium	24	587.90	12.81	0.00*	1.00	0.02*	0.00*	0.02*	0.00*	0.27
T. hemprichii	24	9912.87	1.56	0.23	0.45	0.97	1.00	0.24	0.34	1.00

Sites: 1-Maribojoc, 2-Tagbilaran, 3-Dauis, 4-Panglao * The mean difference is significant at the 0.05 level.

Table 4. One-way ANOVA tests showing difference on seagrass relative abundance in each sampling station and between MPAs and n-MPAs (p<0.05)

Station		Maribojoc		Tagbilaran		Dauis		Panglao	
Barangays		Bood (MPA) vs Dipatlong (n-MPA)		Manga (MPA) vs Ubujan (n-MPA)		Bingag (MPA) vs Tabalong (n-MPA)		Bil-isan (MPA) vs Tangnan (n-MPA)	
Seagrass sp.	N	F	P-value	F	P-value	F	P-value	F	P-value
E. acoroides	6	0.26	0.64	13.59	0.02*	1.06	0.36	2.13	0.22
C. rotundata	6	1.96	0.23	2.17	0.21	0.31	0.61	2.26	0.21
H. ovalis	6	0.39	0.57	19.57	0.01*	2.54	0.19	0.16	0.71
H. pinifolia	6	1.00	0.37	na	na	0.38	0.57	Na	Na
H. uninervis	6	2.62	0.18	na	na	0.86	0.41	49.85	0.00*
S. isoetifolium	6	na	na	na	na	3.19	0.15	0.01	0.93
T. hemprichii	6	0.65	0.47	3.39	0.14	2.07	0.22	12.16	0.03*

* The mean difference is significant at the 0.05 level.

In Brgy Manga (MPA), the most abundant, was *T. hemprichii (51.43%),* followed by *C. rotundata (19.08%), H. ovalis (15.55%),* and *E. acoroides (13.93%),* respectively. While in Brgy Ubujan (non-MPA), only two species were found, and the most abundant was *E. acoroides (69%),* followed by *T. hemprichii (31%),* respectively. A one-way ANOVA test showed a significant difference ($p > 0.05$) in *E. acoroides* (F (1, 4) = 13.59, p = 0.02) and *H. ovalis* (F (1, 4) = 19.57, p = 0.01) relative abundance between

Brgy Manga (MPA) and Brgy Ubujan (non-MPA). In the municipality of Dauis, where seven (7) seagrass species were found, the most abundant was *T. hemprichii (59.36%),* followed by *C. rotundata (12.82%), E. acoroides (12.29%), S. isoetifolium (6.01%), H. ovalis (5.47%), H. uninervis (3.48%),* and *H. pinifolia (0.58%),* respectively. Moreover, *T. hemprichii (66.67%)* was more abundant in Brgy Bingag (MPA), followed by *C. rotundata (18.22%), E. acoroides (6.46%), H. ovalis (2.33%), H. uninervis (3.23%), S. isoetifolium (2.20%)* and *H. pinifolia (0.90%),* respectively. Whereas, in Brgy Tabalong (non-MPA), the most abundant species, was *T. hemprichii (52.05%),* followed by *E. acoroides (18.12%), S. isoetifolium (9.82%), H. ovalis (8.61%), C. rotundata (7.41%), H. uninervis (3.73%)* and *H. pinifolia (0.26%),* respectively. A one-way ANOVA test showed no significant difference ($p > 0.05$) in seagrass relative abundance between Brgy Bingag (MPA) and Brgy Tabalong (non-MPA). In the municipality of Panglao, the most abundant species of seagrass was *T. hemprichii (53.85%),* followed by *H. uninervis (15.03%), C. rotundata (11.26%), S. isoetifolium (9.84%), H. ovalis (9.78%),* and *E. acoroides (0.26%),* respectively. In Brgy Bil-isan (MPA), the most abundant, was *T. hemprichii (42.47%),* followed by *H. uninervis (25.20%), C. rotundata (14.04%), S. isoetifolium (10.14%), H. ovalis (7.64%),* and *E. acoroides (0.51%),* respectively. Meanwhile, in Brgy Tangnan (non-MPA), the most abundant, was *T. hemprichii (65.23%),* followed by *H. ovalis (11.92%), S. isoetifolium (9.53%), C. rotundata (8.47%), and H. uninervis (4.85%),* respectively. A one-way ANOVA test showed a significant difference ($p > 0.05$) in *H. uninervis* (F (1, 4) = 49.85, p = 0.00) and *T. hemprichii* (F (1, 4) = 12.16, p = 0.03) relative abundance between Brgy Bil-isan (MPA) and Brgy Tangnan (non-MPA).

The most abundant and commonly observed seagrass species was *Thalassia hemprichii*. The findings of the study demonstrated that the *T. hemprichii* is very resilient to a variety of environmental factors. It usually dominates over the other seagrass species and can thrive on both coarse coral-sand and mud-coral-sand substrates in sheltered habitats (Meñez *et al.*, 1983). Moreover, it has longer lifespan, can store and maintain resources for extended periods of time, and can occupy area more permanently (Vermaat *et al.*, 1995). A study found that *T. hemprichii* can thrive even in the presence of algal blooms, enabling it to successfully colonize seagrass beds alongside other species. The two factors contributing to its resilience are the root system and the capacity for adaptation to the low concentration of light during algal blooms (Liu *et al.*, 2005). The largest seagrass, *E. acoroides,* was next to *T. hemprichii* in terms of abundance. The *E. acoroides* abounds on the shores of Tagbilaran. The high abundance of *E. acoroides* could be due to the effect of muddy-sandy substrate. The slow-growing *E. acoroides* is also a climax species that has been shown to be resilient to reduced light and increased sedimentation (Duarte, 1991; Vermaat *et al.*, 1995). The species *H. pinifolia* had the lowest relative abundance. The rarity of *H. pinifolia* suggests that it is less tolerant of the current hydrographic conditions compared to other seagrass species (Meñez *et al.*, 1983). One species, *S. isoetifolium* was observed in all sites of Dauis and Panglao (Panglao Island). Among the surveyed sites, Panglao Island had the highest horizontal visibility, and the substrate type is generally a combination of both sand and rock. Notably, this study shows that *S. isoetifolium* would prefer clear waters and sandy-rocky substrates. Moreover, seagrass such as *H. uninervis, H. ovalis,* and *C. rotundata* were also observed to be abundant in the sandy-rocky substrate. Meanwhile, pioneering species, such as *H. ovalis* is produced throughout the year in tropical waters, being the first to enter disturbed seagrass beds, and bare sand patches thus, it is recognized as a main colonizer (Waycott *et al.*, 2002). Seagrass species, such as *H. pinifolia, H. ovalis,* and *S. isoetifolium* have faster and continuous rhizome growth. They are able to inhabit relatively deeper waters by having low light requirements (Vermaat *et al.*, 1995). When it comes to depth, *E. acoroides* and *T. hemprichii* are indiscriminate seagrass species. Certainly, the biological and physico-chemical properties of the habitat affect the seagrass growth, abundance, and distribution.

Table 5. Analysis of variance (ANOVA) to test seagrass percentage cover among sampling stations (p < 0.05)

		Sum of Squares	Df	Mean Square	F	P-value
Cover Percentage	Between Groups	1655.914	3	551.971	1.452	0.258
	Within Groups	7602.517	20	380.126		
	Total	9258.431	23			

Based on the category index, Maribojoc Bay had an average value of 38.65% seagrass percentage cover, which can be classified as a "fair" seagrass condition (Fig. 5). Among sampling locations, the seagrass percentage cover revealed Maribojoc (45.53%), Panglao (43.93%), and Dauis (40.53%) with "fair" seagrass condition, while Tagbilaran City (24.61%) revealed a seagrass cover with "poor" condition. ANOVA analysis (Table 5) revealed no significant difference ($p > 0.05$) in seagrass percentage cover among sampling stations (F (3, 20) = 1.45, p = 0.26). In the municipality of Maribojoc, seagrass percentage cover revealed Brgy Dipatlong (60.00%) with "good" seagrass condition, while adjacent Brgy Bood (31.06%) had "fair" condition. There was no significant difference between the two barangays, as determined by one-way ANOVA (F (1, 4) = 5.85, p = 0.07). In Tagbilaran City, percentage cover revealed Brgy Manga (31.76%) is in "fair" condition, while adjacent Brgy Ubujan (17.45%) had "poor" seagrass condition. There was no significant difference between two barangays, as determined by one-way ANOVA (F (1, 4) = 3.17, p = 0.15). In the municipality of Dauis, percentage coverage revealed Brgy Tabalong (57.70%) is in "good" condition, while adjacent Brgy Bingag (23.36%) had "poor" condition. There was a significant difference between the two barangays, as determined by a one-way ANOVA (F (1, 4) = 9.50, p = 0.04). In the municipality of Panglao, percentage cover revealed Brgy Bil-isan (53.52%) is in "good" condition, while adjacent Brgy Tangnan (34.33%) had "fair" condition. There was no significant difference between the two barangays, as determined by one-way ANOVA (F (1, 4) = 1.28, p = 0.32).

The seagrass community structure of the surveyed sites varies from poor (17.45%) to good (60%) seagrass cover. Survey results of eight sites showed that three sites have good cover (51–75%), three sites have fair cover (26–50%), and two sites have poor cover (0–25%). The highest percentage cover was observed in Brgy Dipatlong, Maribojoc (non-MPA), and the lowest was observed in Brgy Ubujan, Tagbilaran (non-MPA). Among sampling stations, Maribojoc, Dauis, and Panglao revealed "fair" conditions, while Tagbilaran revealed a seagrass percentage cover with "poor" condition. The overall percentage cover of seagrass is 38.65%, indicating "fair" seagrass condition. Data from 26 sites in the Philippines revealed that seagrass cover is often low, usually not exceeding 20%, indicating that these surveyed areas have sparse coverage (BINU, 2005).

The result of the study indicates sparse seagrass cover and disappearances could be due to the deterioration of a once-continuous seagrass meadow. Possible causes were anthropogenic activities such as increased human settlements along coastal areas, the use of destructive fishing gear and the improper shoreline development. The use of the digging tool "sud-sud" by gleaners was observed in the study area. In Tagbilaran, it is highly likely a result of relatively high siltation and sedimentation brought about by inputs from the Abatan River directly to the seagrass beds. Additionally, there is nutrient loading and introduction of water-borne pollutants along the shores from industrial, domestic, and agricultural wastes. A nutrient indicator alga, *Padina sp.* proliferates in both Brgy Manga (MPA) and Brgy Ubujan (non-MPA) of Tagbilaran City. The high algal cover denotes high nutrient levels caused by pollution that contribute to the increase in sea nutrient levels (Fortes *et al.*, 2004).

Among the MPAs surveyed, only Brgy Bil-isan, Panglao obtained a "good" seagrass percentage cover, whereas Brgy Bood, Maribojoc and Brgy Manga, Tagbilaran have a "fair" seagrass conditions. Only Brgy Bingag, Dauis had "poor" percentage cover.

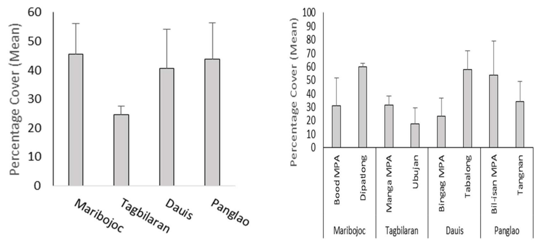


Fig. 5. Percentage cover of seagrass species among sampling stations and between MPAs and non-MPAs. Values with the same superscript showed significant difference based on percentage cover (error bars are standard deviation).

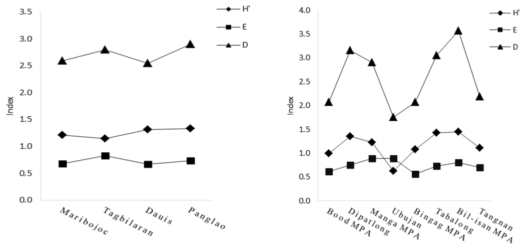


Fig. 6. Differences on seagrass species diversity, dominance and evenness among sampling stations and between sampling sites.

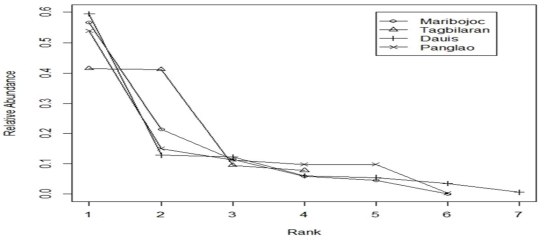


Fig. 7. Whittaker plot on seagrass species among sampling stations and between sampling sites.

The low seagrass cover in Bingag MPA could be attributed to biotic competition, wherein the coral community out competes the seagrass community. Unlike other MPAs in the bay area, Bingag MPA is completely enclosed with buoy markers, and human intrusion is prohibited because it was seeded with giant clams in 2013. It was observed that the nearshore portion is dominated by live coral growth. Bil-isan MPA, on the other hand, is partially enclosed and has "good" seagrass conditions. The buoy markers were installed about 25–30 meters from the shore at low tide. Meanwhile, fair seagrass conditions in two MPAs, Brgy Bood, Maribojoc and Brgy Manga, Tagbilaran may be due to the absence of marker buoys and a stationed sea guard "bantay-dagat" managing the area. Besides, these MPAs serve as access and docking areas for fishermen and gleaners. Among non-MPAs surveyed, Brgy Dipatlong, Maribojoc, and Brgy Tabalong, Dauis have "good" percentage cover. Meanwhile, Brgy Tangnan, Panglao had "fair" conditions and Brgy Ubujan, Tagbilaran had "poor" percentage cover. Out of eight sites surveyed, Brgy Dipatlong, Maribojoc had the highest percentage cover (60%), followed by Brgy Tabalong, Dauis, with 57.70%. Good segrass conditions in these non-MPAs could be attributed to the presence of mangrove sites in Brgy Dipatlong, Maribojoc and the landscape, cliff-rocky shore of Brgy Tabalong, Dauis. Meanwhile, Brgy Tangnan, Panglao serves as an access and docking area for fishermen. Brgy Ubujan, Tagbilaran on the other hand, is located in a high-use bay area that serves as an access point, docking port, swimming area and coastal settlement. In a comparison between MPAs and non-MPAs, the result showed that the percentage seagrass cover was higher in open access or unprotected areas. The "Protection and Seagrass" analysis by Eklof *et al.*, (2009) found that predation rates in protected areas were 3 times higher than in fished areas. Furthermore, an open access effect has led to the overfishing of certain fish that feed on seagrass and predate on other species, for example, sea urchins that feed on seagrass, thus resulting in the high abundance of seagrass species (Aboud and Kannah, 2017).

Seagrass diversity revealed, Panglao showed a higher seagrass diversity value (H' = 1.33), followed by Dauis (H' = 1.31), Maribojoc (H' = 1.21), and Tagbilaran (H' = 1.15), respectively (Fig. 6). Dominance was also higher in Panglao (D = 2.9), followed by Tagbilaran (D = 2.8), Maribojoc (D = 2.59), and Dauis (2.55). Meanwhile, evenness was higher in Tagbilaran (E = 0.83), followed by Panglao (E = 0.74), Maribojoc (E = 0.68), and Dauis (E = 0.67). Dominance among sampling stations had a higher value as compared to evenness and Shannon diversity. In the municipality of Panglao, Bgry Bil-isan (MPA) showed higher values in diversity (H = 1.44), dominance (D = 3.57), and evenness (E = 0.80) compared to adjacent Brgy Tangnan (non-MPA) with diversity (H' = 1.11), dominance (D = 2.18), and evenness (E = 0.69). In the municipality of Dauis, Brgy Tabalong (non-MPA) showed higher values in diversity (H' = 1.42), dominance (D = 3.05), and evenness (E = 0.73) compared to adjacent Brgy Bingag (MPA) with diversity (H' = 1.08), dominance (D = 2.07), and evenness (E = 0.56). In the municipality of Maribojoc, Brgy Dipatlong (non-MPA) showed higher values in diversity (H' = 1.35), dominance (D = 3.15), and evenness (0.75) compared to adjacent Brgy Bood (MPA) with diversity (H' = 0.99), dominance (D = 2.07), and evenness (E = 0.61). In Tagbilaran City, Brgy Manga (MPA) showed higher diversity (H' = 1.22) and dominance (D = 2.90) but lower evenness (E = 0.88) compared to Brgy Ubujan (non-MPA) with diversity (H' = 0.62) and dominance (D = 1.75), yet slightly higher in evenness (E = 0.89).

The overall biodiversity index values of the seagrass ecosystem in Maribojoc Bay were diversity (H' = 1.40), dominance (2.98), and evenness (0.72). The Shannon diversity index implies low diversity as the value is less than 2 (H'<2.0) based on the biodiversity index category by Odum (1983). The higher dominance and lower evenness could be attributed to the high abundance of *Thalassia hemprichii* in the seagrass beds. The presence of dominating species means that the community is less diverse and indicates low stability. Hence, the seagrass ecosystem in Maribojoc Bay is under threat from losses and degradation. In the Philippines, coastal development, sedimentation, eutrophication, destructive fishing, and waste disposal are some of the anthropogenic activities that pose the greatest impacts to seagrass ecosystems (Fortes 1995, 2013; Fortes and Santos, 2004).

The Whittaker plot, also known as the Rank-abundance Curves, revealed patterns of species diversity (Fig. 7). It shows *Thalassia hemprichii* as the most abundant species, and the slope indicates low evenness as *T. hemprichii* has a much higher abundance, thus a steeper gradient than the other species. The species richness showed the following order: Dauis > Panglao > Maribojoc > Tagbilaran. A steep gradient shows low evenness in Dauis in terms of species evenness, followed by Maribojoc and Panglao. In contrast, the high evenness observed in Tagbilaran could be due to the ubiquitous co-occurrence of *Thalassia hemprichii* and *Enhalus acoroides*. Moreover, abundance was higher in Dauis, followed by Maribojoc, Panglao, and Tagbilaran, respectively.

Panglao shows highest diversity index and dominance compared to the other stations. However, species richness was higher in Dauis. The higher evenness in Tagbilaran was due to *Thalassia-Enhalus* associations. The community structure in Maribojoc Bay implies low diversity based on the biodiversity index category by Odum (1983). Higher dominance and lower evenness were attributed to the extensive distribution of *Thalassia hemprichii*. Moreover, the presence of dominant species means that the community is less diverse and indicates low stability. Thus, the condition of Maribojoc Bay is under threat, both from natural factors and anthropogenic activities

Conclusion

A total of seven species of seagrass were identified in the surveyed sites, consisting of *Cymodocea rotundata, Enhalus acoroides, Halodule pinifolia, Halodule uninervis, Halophila ovalis, Syringodium isoetifolium,* and *Thalassia hemprichii*. Species richness showed the following order: Dauis > Panglao = Maribojoc > Tagbilaran. The most dominant seagrass was *T. hemprichii*, which obtained the highest relative abundance. The highest seagrass cover was observed in Brgy Dipatlong (non-MPA), followed by Brgy Tabalong (non-MPA), and Brgy Bil-isan (MPA). Seagrass relative abundance and percentage cover were higher in the municipality of Maribojoc, followed by Panglao, Dauis, and Tagbilaran, respectively. In terms of seagrass diversity, Panglao showed a higher value, followed by Dauis, Maribojoc, and Tagbilaran, respectively. Among sampling sites, seagrass diversity was higher in Brgy Bil-isan (MPA), followed by Brgy Tabalong (non-MPA), Bgry Dipatlong (non-MPA), Bgry Manga (MPA), Brgy Tangnan (non-MPA), Bgry Bingag (MPA), Brgy Bood (MPA), and Brgy Ubujan (non-MPA). Overall, seagrass percentage cover in Maribojoc Bay revealed a "fair" seagrass condition, and the seagrass community structure revealed low diversity and sparse distribution. As one of the most significant coastal ecosystems, the seagrass ecosystem needs greater attention in terms of monitoring, management, and conservation. In order to implement rehabilitation initiatives and improve the country's present management, further research on seagrass communities is recommended.

References

Aboud SA, Kannah JF. 2017. Abundance, Distribution and Diversity of Seagrass Species in Lagoonal Reefs on the Kenyan Coast. American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS) **37**(1), 52–67.

Bach SS, Borum J, Fortes D, Duarte C. 1998. Species composition and plant performance of mixed seagrass beds along a siltation gradient at Cape Bolinao, The Philippines. Marine Ecology Progress Series **174**, 247–256.

Biodiversity Indicators for National Use (BINU). 2005. Philippine Report on Coastal and Marine Ecosystems, UnepGep-Wcmc.Bfar-Pawb Quezon City, Philippines, 75.

Bulthuis DA. 1987. Effects of temperature on the photosynthesis and growth of seagrass. Aquat. Bot. **27**, 27 – 40.

Dan A, Moriguchi A, Mitsuhashi K, Terawaki T. 1998. Relationship between *Zostera marina* and bottom sediments, were action offshore in Naturo, Southern Japan. Fisheries Engineering **34**, 229–204.

Dennison WC, Orth RJ, Moore KA, Stevenson JC, Carter V, Kollar S, Bergstrom PW, Batituk RA. 1993. Assessing water quality with submersed aquatic vegetation. BioScience **43**, 86–94.

Duarte CM, Chiscano CL. 1999. Seagrass biomass and production: a reassessment. Aquat. Bot. **65**, 159e174. dx.doi.org/10.1371/journal.pone.0163091.

Duarte CM. 1991. Seagrass depth limits. Aquat. Bot. **40**, 363-377.

Eklof JS, Frocklin S, Lindvall A, Stadlinger N, Kimathi A, Uku JN, McClanahan TR. 2009. How effective are MPAs? Predation control and 'spill-in effects' in seagrass-coral reef lagoons under contrasting fishery management. Marine Ecology Progress Series **384**, 83–96. https://doi.org/10.3354/meps08024.

Fortes MD. 2017. An Interview retrieved at https://www.gaiadiscovery.com/naturebiodiversity/why-is-seagrass-important-to-biodiversity-yet-threatened.html

Fortes MD. 2013. A review: biodiversity, distribution and conservation of Philippine seagrasses. Philippine. J. Sci. **142**, 95–111.

Fortes MD, Santos KF. 2004. Seagrass ecosystem of the Philippines: Status, problems and management directions. 90-95. In DA-BFAR (Department of Agriculture-Bureau of Fisheries and Aquatic Resources). In Turbulent seas: The status of Philippine marine fisheries. Coastal Resource Management Project, Cebu City, Philippines, 378.

Green S, Monreal R, White A, Bayer T. 2002. Coastal Environmental Profile of Northwestern Bohol, Philippines. Coastal Resource Management Project, Cebu City, Philippines, 113p.

Gullström M, Bodin M, Nilsson PG, Öhman MC. 2008. Seagrass structural complexity and landscape configuration as determinants of tropical fish assemblage composition. Mar. Ecol. Prog. Ser. **363**, 241–255. doi: 10.3354/meps07427

Hall MO, Durako MJ, Fourqurean JW, Zieman JC. 1999. Decadal changes in seagrass distribution and abundance in Florida Bay. Estuaries **22**, 445–459.

Hemming MA, Duarte CM. 2000. *Seagrass Ecology*. Cambridge University Press

Jackson JB, Nemeth DJ. 2007. A new method to describe seagrass habitat sampled during fisheriesindependent monitoring. Estuaries and Coasts **30**, 171– 178.

Koch EW, Dawes CJ. 1991. Ecotypic differentiation in populations of *Ruppia maritima* L. germinated from seeds and cultured under algae-free laboratory conditions. J Exp Mar Biol Ecol **152**, 145– 159.

Lee Long WJ, Mellors JE, Coles RG. 1993. Seagrasses between Cape York and Hervey Bay, Queensland, Australia. Aust. J. Mar.Freshw. Res. **44**, 19–31.

Masini RJ, Manning CR. 1997. The photosynthetic responses to irradiance and temperature of four meadow-forming seagrasses. Aquat Bot **58**, 21– 36

Meñez EG, Phillips RC, Calumpong H. 1983. Seagrasses from the Philippines. Smithsonian contriib. Marine Science **21**, 40.

McKenzie LJ. 2008. Seagrass-Watch: Proceedings of a Workshop for Mapping and Monitoring Seagrass Habitats in North East Arnhem Land, Northern Territory, 18–20 October 2008. (Seagrass-Watch HQ, Cairns). 49p.

McKenzie LJ, Mellors JE. 2007. Seagrass-Watch: Guidelines for Monitoring Seagrass Habitats in the Burdekin Dry Tropics Region. Proceedings of a training workshop, Arcadian Junior Surf Life Saving Club Townsville, 18th March 2007 (DPI&F, Cairns). 24p.

McKenzie LJ. 2003. Guidelines for the rapid assessment of seagrass habitats in the western pacific, Department of Primary Industries Queensland, Northern Fisheries Centre PO Box 5396.

Nordlund LM, Koch EW, Barbier EB, Creed JC. 2016. Seagrass ecosystem services and their variability across genera and geographical regions. PLoS One 12;11(10):e0163091.

Odum EP. 1983. Basic ecology. Saunders College Pub.

Orth R, Carruthers T, Dennison W, Duarte C, Fourqueram J, Heck K, *et al.* 2006. A global crisis for seagrass ecosystems. Bioscience **56**, 987–996. DOI: 10.1641/0006-3568(2006)56.

Phillips RC, Milchakova NA. 2003. Seagrass ecosystems. Mar. Ecol. J. 2(2), 29-39.

Saenger P, Gartside D, Funge-Smith S. 2013. A Review of Mangrove and Seagrass Ecosystems and their Linkage to Fisheries and Fisheries Management. Bangkok: RAP Publication, FAO.

Short FT, Polidoro B, Livingstone SR, Carpenter KE, Bandeira S, Bujang JS, *et al.* 2011. Extinction risk assessment of the world's seagrass species. Biol. Conserv. **144**, 1961–1971. doi: 10.1016/j.biocon.2011.04.010.

Short FT, Koch E, Creed JC, Magalhaes KM, Fernandez E, Gaeckle JL. 2006. SeagrassNet monitoring across the Americas: case studies of seagrass decline. Marine Ecology **27**, 277–289.

Short F, Carruthers T, Dennison W, Waycott M. 2007. Global seagrass distribution and diversity: a bioregional model. J. Exp. Mar. Biol. Ecol. **350**, 3–20. http://dx.doi.org/10.1016/j.jembe.2007.06.012.

Van Katwijk MM, Hermus KCR. 2000. Effects of water dynamics on*Zostera marina*: Transplantation experiments in the intertidal Dutch Wadden Sea. Marine Ecology Progress Series **208**, 107–118.

Vermaat JE, Agawin NSR, Duarte CM, Fortes MD, Marba N, Uri JS. 1995. Meadow maintenance, growth and productivity of a mixed Philippine seagrass bed. Marine Ecology Progress Series **124**, 215- 225.

Waycott M, Duarte CM, Carruthers TJB, Orth RJ, Dennison WC, Olyarnik S. 2009. Accelerating loss of seagrasses across the globe threatens coastal ecosystems. Proc. Natl. Acad. Sci. U.S.A. **106**, 12377–12381.
DOI: 10.1073/pnas.0905620106