

# Seagrass surveys in the southern Rakhine coastal region, Myanmar: biodiversity, distribution and coverage

## Abstract

Seagrass surveys were conducted at 9 study sites, in the southern Rakhine Coastal Region, to assess the species diversity, percent cover and extent of seagrasses for the better understanding of the current status and suitability of seagrass meadows for MPA designation. Among 9 study sites, except for Ma Gyi and Pho Htaung, the remaining 7 sites such as Tharthanar Dauk, Ngwe Saung, Wet Thay, Baw Di, Chan Pyin, Yay Myet Taung and Gyaing Kauk were newly recorded sites in the present surveys. There are two types of seagrass habitats: 1) intertidal habitats, mainly in shallow rock-pools at Baw Di and Yay Myet Taung; and 2) predominantly subtidal habitats at the remaining study sites. In the present surveys, a total of 10 species of seagrasses, namely *Syringodiumisoetifolium*, *Cymodoceaserrulata*, *C. rotundata*, *Haloduleuninervis*, *H. pinifolia*, *Enhalusacoroides*, *Thalassiahemprichii*, *Halophilabecarii*, *H. decipiens* and *H. major* had been recorded. Among these, only one, *Halophilabecarii* was listed as Vulnerable on the IUCN RedList, while all other species were listed as Least Concern. *Halophilabecarii* was only recorded at Pho Htaung. *Halodulepinifolia* was the most commonly observed species which was found in the remaining eight study sites. Pho Htaung, with the highest number of species (10 species) and coverage (66.9%), and as the only site to contain the Vulnerable *Halophilabecarii*, should be assigned to a Marine Protected Area (MPA), as well as along with Ma Gyi and Chan Pyin given their high species diversity and coverage.

**Keywords:** selective transfer, superficial layer, structural analysis, intensity x-rays, width of diffraction lines, crystalline network constant

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## Introduction

Seagrasses are a group of submerged flowering plants of approximately 72 species, representing a relatively small group, less than 0.1% of the angiosperm taxa growing in shallow coasts of the tropical and subtropical regions.<sup>1,2</sup> Seagrasses provide a wide range of valuable ecosystem services, both direct and indirect.<sup>3</sup> About 60% of seagrass meadows globally have been seen reductions in their distribution since 1980 due to habitat destruction and marine pollution.<sup>13</sup> Rates of decline have accelerated from 0.9% yr<sup>-1</sup> before 1940 to 7% yr<sup>-1</sup> since 1990.<sup>4</sup>

Seagrasses occur all along three Coastal Regions of Myanmar (Rakhine, Ayeyarwady Delta and the Gulf of Mottama (Martaban), and Tanintharyi). Eleven species of seagrasses has been recorded in Myanmar, including *Syringodiumisoetifolium* (Ascherson) Danty, *Cymodoceaserrulata* (R. Brown) Ascherson et Magnus, *C. rotundata* Ehrenberg et Hemprich ex Ascherson, *C. sp.*, *Haloduleuninervis* (Forsskal) Ascherson, *H. pinifolia* (Miki) den Hartog, *Enhalusacoroides* (Linnaeus f.) Royle, *Thalassiahemprichii* (Ehrenberg) Ascherson, *Halophilabecarii* Ascherson, *H. decipiens* Ostenfeld and *H. ovalis* (R. Brown) Hooker f. and *H. major* (Zoll.) Miquel.<sup>5,10</sup>

Myanmar people call seagrasses as *Leik-Sar-Phat-Myet* in Myanmar, meaning the food of marine turtles. Myanmar seagrass meadows support five species of marine turtles, all of which are IUCN-listed threatened species; the olive ridley turtle (*Lepidochelylivacea*;

Vulnerable), loggerhead turtle (*Caretta caretta*; Vulnerable), green turtle (*Cheloniemydas*; Endangered), hawksbill turtle (*Eretmochelysimbricata*; Critically Endangered), and the leatherback turtle (*Dermodochelyscoriacea*; Vulnerable).<sup>8,12</sup> In addition, the seagrass meadows along the Rakhine Coastal Region are known to serve as important feeding grounds for the sea cow, *Dugong dugon*, which is listed as Vulnerable on the IUCN Red list.<sup>10,12</sup>

This study was undertaken to provide updated information on the current status on biodiversity, distribution and coverage of seagrasses at selected sites along the southern Rakhine Coastal Region of Myanmar, comprising southernmost coastal areas of the Rakhine State, and west coastal areas of the Ayeyawady Region. This information will be used to inform the establishment of Marine Protected Areas (MPAs) within the southern Rakhine Coastal Region to ensure such habitats which should be conserved. The results of this study will provide a baseline for long term monitoring studies on seagrasses. This study was carried out under the project entitled "Capacity Building for Coastal Biodiversity Monitoring: Mawdin Coast Partnership, Myanmar, Phase I: (2016) of Fauna & Flora International (FFI)".

## Materials and methods

### Study sites

The Rakhine Coastal Region is located in the western part of Myanmar, facing the Bay of Bengal, between the Naaf River of

Myanmar- Bangladesh Border and the Mortin Point between the Cape Negrea is and mouths of the Ayeyawady River (Figure 1). The salinity ranges and temperature ranges of coastal waters of the Rakhine Coastal Region are 32-34‰ and 30-32°C, respectively, during the study period of March and November 2016. Tides in all study sites regularly occur twice a day throughout a year. The tidal range is about 3 m in height along the Rakhine Coastal Region.

In the administrative point of view, the Rakhine Coastal Region was divided into 2 parts: 1) Ayeyawady Region in the southern part; and 2) Rakhine State in the northern part. Five study sites in Ayeyawady Region and four study sites in the south of Rakhine State were selected for surveys on seagrasses (Figure 1)(Table 1). Coordinates for each study site were recorded by GPS and given in Table 2. The following sites (with relevant acronyms) were surveyed:

**Table 1** Diversity of seagrasses distributed in nine study sites in the Ayeyawady Region and Rakhine State in the southern Rakhine coastal region of Myanmar.

Sr. No.	Species	Study sites									Total (Sites)
		Ayeyawady region					Rakhine state				
		Tharthanar Dauk	Ngwe Saung	Ma Gyi	Wet Thay	Pho Htaung	BawDi	Chan Pyin	Yay Myet Taung	Gyaing Kauk	
1	<i>Syringodium isoetifolium</i>	-	-	+	+	+	-	-	-	-	3
2	<i>Cymodocea rotundata</i>	-	-	+	-	+	-	-	-	-	2
3	<i>C. serrulata</i>	+	-	+	+	+	+	+	-	-	6
4	<i>Halodule univervis</i>	+	-	+	+	+	+	+	+	-	7
5	<i>H. pinifolia</i>	-	+	+	+	+	+	+	+	+	8
6	<i>Enhalus acoroides</i>	-	-	-	-	+	-	+	-	-	2
7	<i>Thalassia hemprichii</i>	-	-	+	-	+	-	-	+	-	3
8	<i>Halophila beccarii</i>	-	-	-	-	+	-	-	-	-	1
9	<i>H. decipiens</i>	-	+	+	-	+	-	+	-	-	4
10	<i>H. major</i>	+	-	+	+	+	-	-	-	+	5
Total (Diversity)		3	2	8	5	10	3	5	3	2	

Symbols: + = Present; - = Absent. Total (Sites) = Occurrence.

*Ayeyawady Region*: All study sites are subtidal.

- Tharthanar Dauk (TD): Located in the corner of northern MiChaungGaung, with sand-mud substrate.
- Ngwe Saung (NS): Located in the corner of MwayKyun Island, with sandy substrate.
- Ma Gyi (MG): Located in the corner of Ma Gyi tidal creek, with sand-mud substrates.
- Wet Thay (WT): Located in the northern corner of Wet Thay, with sand-mud substrates.
- Pho Htaung (PH): Located in front of mangroves, with mud-sand substrates.
- Rakhine State: Twostudy sites are intertidal and another 2 study sites are subtidal.
- Baw Di (BD): Located in front of a rocky shelf without mangroves. This site is Intertidal with sandy substrate in very shallow rock-pools.

- Chan Pyin (CP): Located in front of mangrove communities in the northern part of Gwa Aw, with mud-sand substrates, subtidal.
- Yay Myet Taung (YMT): Located in front of the rocky platform with mangrove communities. This site is Intertidal with sandy substrates in very shallow rock-pools.
- Gyaing Kauk (GK): Located in front of a sandy beach without mangroves, with sandy substrates in the subtidal zone from nearshore to offshore.

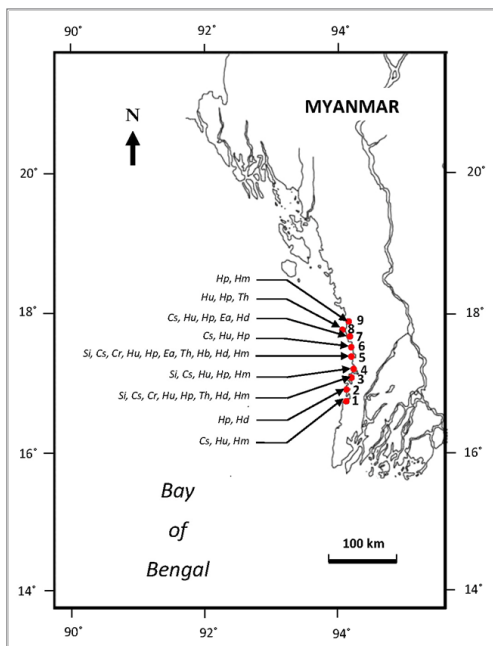
### Taxonomic studies

Fresh and live materials of seagrasses growing in the nine study sites were sampled by uprooting the seagrasses with a small trowel or knife in depths between 0-5 m in March and November 2016. The collections were washed, cleaned and preserved in 10% formalin in seawater. Samples of seagrasses were examined mainly on the vegetative characters under a dissecting microscope, and then pressed on herbarium sheets to prepare as voucher specimens for each locality. All specimens were identified using the standard

monograph of seagrasses prepared by den Hartog<sup>13</sup> & Kuo et al.<sup>14</sup> This study followed the classification system used by Fortes.<sup>15</sup> All voucher specimens were deposited at the Herbarium of the Department of Marine Science, Patheingyi University, Myanmar.

**Ecological studies**

This study has followed the SeagrassNet protocol by Short et al.,<sup>16,17</sup> consisting of three fixed, parallel, 50 m cross-transects referred to as cross-transects A, B and C, with cross-transect A closest to shore and C most seaward; B, midpoint of these cross-transects were established laid out seaward, perpendicular to the shore. Percentage of seagrasses was visually estimated within 12 randomly place quadrats (50cm x 50cm, 0.25m<sup>2</sup>) along each cross-transect using a photo guide of percent cover. As noted above, these works were done intertidally in the coastal areas of Baw Di and Yay Myet Taung but subtidally in the remaining study sites, using snorkeling or scuba equipment.



**Figure 1** Map showing the biodiversity and distribution of seagrasses growing along 5 study sites in the Ayeyawaddy Region: 1. Tharthanar Dauk; 2. Ngwe Saung; 3. Ma Gyi; 4. Wet Thay; 5. Pho Htaung; and 4 study sites in the southern Rakhine State: 6. Baw Di; 7. Chan Pyin; 8. Yay Myet Taung; 9. Gyaing Kau. Abbreviations: Si, *Syringodiumisoetifolium*; Cr, *Cymodocearotundata*; Cs, *C. serrulata*; Hu, *Haloduleuninervis*; Hp, *H. pinifolia*; Ea, *Enhalusacoroides*; Th, *Thalassiahemprichii*; Hb, *Halophilabecarii*; Hd, *H. decipiens*; and Hm, *H. major*.

**Results**

A total of 10 species of seagrasses (Figures 2-11) collected from the southern Rakhine Coastal Region, were identified: *Syringodiumisoetifolium* (Ascherson) Danty; *Cymodocearotundata* Ehrenberg et Hemprich ex Ascherson; *C. serrulata* (R. Brown) Ascherson et Magnus; *Haloduleuninervis* (Forsskal) Ascherson; *H. pinifolia* (Miki) den Hartog; *Enhalusacoroides* (Linnaeus f.) Royle; *Thalassiahemprichii* (Ehrenberg) Ascherson; *Halophilabecarii* Ascherson; *H. decipiens* Ostfeld; and *H. major* (Zoll.) Miquel (Table 1). Determination was based on the following characters used as taxonomic key to the species of seagrasses collected from the southern Rakhine Coastal Region:

1a. Leaf blade cylindrical.....

*Syringodiumisoetifolium*

1b. Leaf blade flat.....

2a. Leaves strap-shaped.....3

2b. Leaves paddle-shaped.....8

3a. Leaves with ligula.....4

3b. Leaves without ligula.....7

4a. Leaf tip smoothly rounded.....

*Cymodocearotundata*

4b. Leaf tip distinctly dentate or serrated.....5

5a. Leaf tip distinctly serrated .....*C. serrulata*

5b. Leaf tip bi- or tri-dentate .....6

6a. Leaf tip tri-dentate, the black central leaf vein not split at the tip.....*Haloduleuninervis*

6b. Leaf tip bi-dentate, the black central leaf vein split into two at the tip.....*H. pinifolia*

7a. Leaves 10-15 mm wide with ribs at the margin, leaf margins enrolled, rhizomes with long black fibrous bristles .....*Enhalusacoroides*

7b. Leaves 4-10 mm wide without ribs at the margin, leaf margins not enrolled, rhizomes with triangular leaf.....*Thalassiahemprichii*

8a. Leaves linear to lanceolate, 1 - 3 mm wide with 1-3 parallel veins ..... *Halophilabecarii*

8b. Leaves lanceolate to oblong, 3-10 mm wide with 6-20 cross-veins.....9

9a. Leaves blade small and lanceolate, margin serrate, with hairs on one or both sides of the blade.....*H. decipiens*

9b. Leaves blade large and ovate, margin entire, smooth without hairs on one or both sides of the blade.....*H. major*

Distribution of seagrasses at the nine sites was very patchy, ranging between 0 and 100% cover at the quadrat level, and 3 and 69% at the transect level. BD had the lowest cover, with 12.1% (± 2.7, S.E.) cover over the site, while PH had the highest cover, 66.9% (± 6.3, S.E.) (Figure 12)(Table 2).

Some areas of seagrass were extensive, and coverage varied from high to very sparse or may be restricted to a few plants amongst rocks. At two sites (YMT and BD), seagrasses were confined to patches of sediment trapped on intertidal rocky platform, with no subtidal components. Seagrasses in the Rakhine coastal area range from intertidal meadows to solely subtidal areas, with the majority of sites extending into the subtidal. In the sites surveyed during the monsoon season (which ended around 6 weeks later than normal in 2016), many seagrasses were partially buried by muddy sand.

The most common species found in the study sites were *Halodulepinifolia*, which was found at eight sites, and *H. uninevis*, which was found at seven sites (Table 1). There was a mean number of 4.7 (±0.9, S.E.) species per site, varying from two to ten species. No surveyed sites were monospecific. The two sites with the least diversity (only two species each) included both the most northerly site (GK) and the most southerly (NS).

**Table 2** Coverage of seagrasses in 9 study sites in the southern Rakhine Coastal Region of Myanmar.

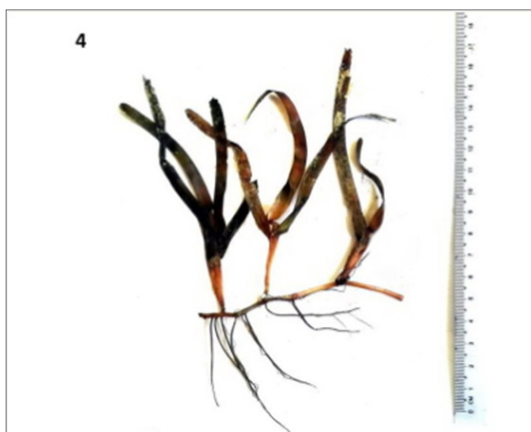
Region/State	Sr.No.	Study site (Date)	Position	Cover (%) / Cross-transect			
				A	B	C	Total ± S.E
Ayeyawady Region	1	Tharthanar Dauk (4-11-2016)	Lat 16.60744, Long 94.32393	52.9	32.3	23.8	36.3 ±3.0
	2	Ngwe Saung (14-3-2016)	Lat 16.89036, Long 94.37624	35.5	48.6	53.6	45.9 ±2.9
	3	Ma Gyi (12-3-2016)	Lat 17.072122, Long 94.451406	34.2	40.8	36.6	37.2 ±5.7
Rakhine Coastal Region	4	Wet Thay (12-11-2016)	Lat 17.14155, Long 94.46521	28.5	46.7	52.5	42.6 ±3.5
	5	Pho Htaung (12-3-2016)	Lat 17.170547, Long 94.491739	69.2	64.6	-	66.9 ±6.3
Rakhine State	6	Baw Di (17-3-2016)	Lat 17.48720, Long 94.55687	3.3	18.3	14.6	12.1 ±2.7
	7	Chan Pyin (16-3-2016)	Lat 17.633333, Long 94.55	67.9	37.3	61.7	55.6 ±4.6
	8	Yay Myet Taung (19-3-2016)	Lat 17.7, Long 94.53333	44.6	54.2	14.8	37.9 ±4.8
	9	Gyaing Kauk (18-3-2016)	Lat 17.78935, Long 94.48626	28.8	49.2	34.7	37.4 ±3.2



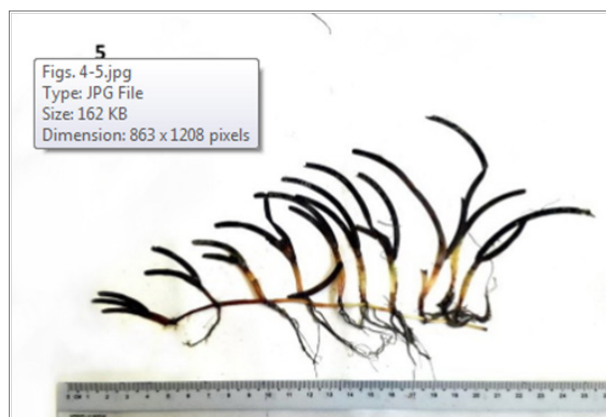
**Figure 2** Habitats of Seagrasses. *Syringodium isoetifolium* (Ascherson) Danty.



**Figure 3** *Cymodocea rotundata* Ehrenberg et Hemprich ex Ascherson.



**Figure 4** Habits of seagrasses. *C. serrulata* (R. Brown) Ascherson et Magnus.



**Figure 5** *Halodule uninervis* (Forsskal) Ascherson.



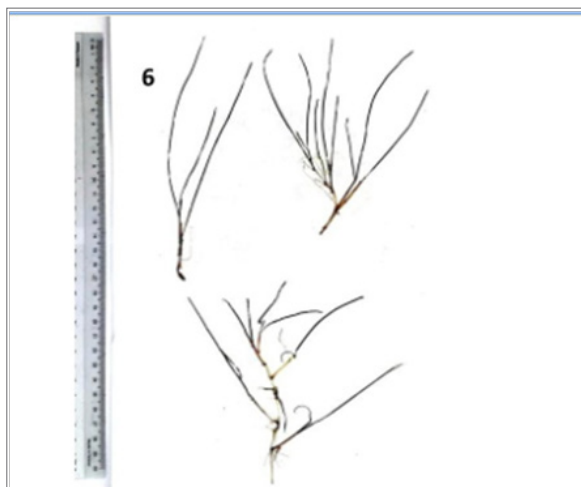


Figure 6 Habits of seagrasses. *Halodule pinifolia* (Miki) den Hartog.

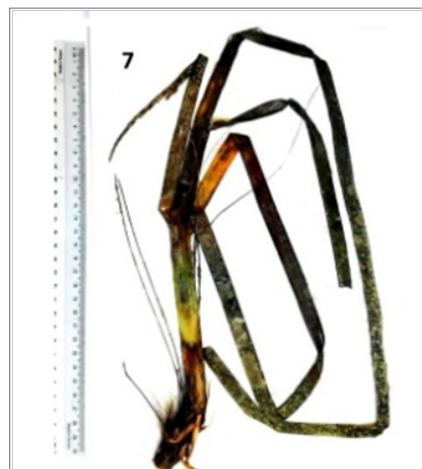


Figure 7 *Enhalusacoroides* (Linnaeus f.) Royle.



Figure 8 Habits of seagrasses. *Thalassia hemprichii* (Ehrenberg) Ascherson.

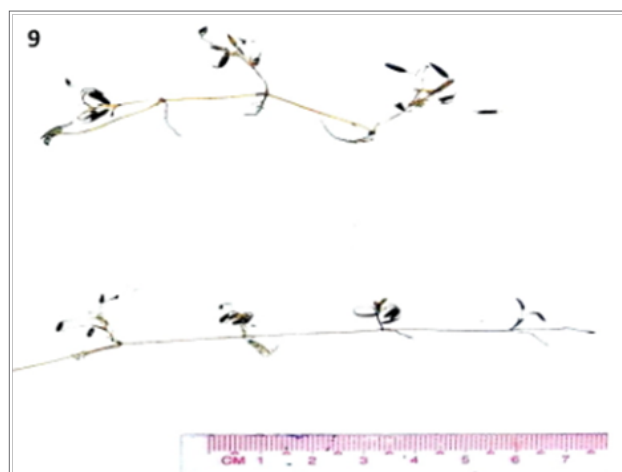


Figure 9 *Halophilabeccarii* Ascherson.



Figure 10 Habits of seagrasses. *Halophiladecipiens* Ostenfeld.

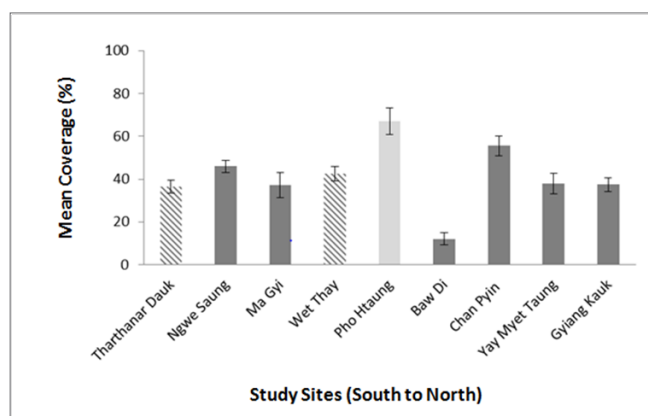


Figure 11 *H. major* (Zoll.) Miquel.

## Discussion

Ten species of seagrasses were found in the present study as of a previous study in 2015.<sup>10</sup> Of these species, only *Halophilabeccharii* is considered as Vulnerable, along with all other species which are listed as Least Concern according to the IUCN RedList.

Figure 12 generally showed the coverage of most of the study site was estimated with means of 36 quadrats  $\pm$  standard error, where as that of one study site had missing data, notably PH where fading light meant one transect was not surveyed, hence  $n=24$ . PH showed a very high species composition and cover. Surveys were completed in March 2016 (solid bars) and November 2016 (hatched).



**Figure 12** Mean coverage of seagrasses at nine sites in the southern Rakhine Coastal Region.

Of the 9 sites surveyed, only MG and PH had been previously studied using the same methodology,<sup>10</sup> and so comparisons can be made. In such comparison, the percentage covers recorded in this study and in that of 2015 were similar: 39.3% and 37.2% in MG; 66.8% and 66.9% in PH, respectively. The remaining 7 sites of TD, NS, WT, BD, CP, YMT, and GK were newly recorded sites in the present seagrass surveys.

The highest percentage cover of seagrass meadows was observed at PH, in the Ayeyawady Region, with 66.9% and the highest coverage in Rakhine State at CP with 55.6%, whereas the lowest was at BD with 12.1% (Figure 12)(Table 2). Luxuriant growth of seagrasses was observed in MG, WT and PH in the Ayeyawady Region and CP in the southern Rakhine State.

Two types of habitats of seagrasses were observed: 1) intertidal habitats of the rocky platforms- very shallow rock-pools at BD and YMT and 2) subtidal habitats at the remaining study sites. Seagrasses growing in YMT are associated with the agarophyte species, *Gracilaria edulis* (S.G.Gmelin) P.C.Silva which are daily collected by the coastal people for making salads.

Although Soe-Htun et al.<sup>7</sup> reported there were no stresses in the meadows of seagrasses in coastal areas of Myanmar, with these ecosystems showing pristine, climax conditions, they are now facing problems such as smothering by sand of nearby runoffs during the monsoon season, extensive coastal development and clearing of mangroves, and other anthropogenic impacts such as bottom trawling and using beach seine nets on seagrass beds. Some bottom trawlers and fishers using beach seine nets also operate directly through seagrass beds targeting shrimps and other marine species, destroying these habitats.

**Table 3** Seagrass sites ranked according to uniqueness, species richness and percentage cover with 1 being the highest priority for protection and 5 the least.

Sr. No.	Site	Uniqueness	Species richness	% Cover	Cumulative score	Rank
1.	TharthanarDauk	5	7	2	14	4
2.	NgweSaung	4	7	2	13	4
3.	Ma Gyi	2	3	2	7	<b>2</b>
4.	Wet Thay	3	5	2	10	<b>3</b>
5.	Pho Htaung	1	1	1	3	<b>1</b>
6.	Baw Di	6	7	3	16	5
7.	Chan Pyin	2	6	1	9	<b>3</b>
8.	Yay MyetTaung	3	7	2	12	4
9.	GyaingKauk	5	7	2	14	4

- Uniqueness: 1= site has a species only found here; 2= site has species found here and at one other site, 3= site has species found here and at one other site etc.
- Species richness: 1=10 species; 2 = 9 species; 3= 8 species; 4=7 species; 5 =6 species; 6=5species;7= <4 species.
- % Cover: 1= 50-69%; 2= 30-49; 3= <29%.
- Bolded indicate priority sites.

Management actions are therefore required immediately to ensure these habitats are not lost which would have devastating consequences for both the aquatic environment and for people's livelihoods. Given the limited resources available in Myanmar to manage all these areas, focus must be steered towards those sites which could be considered key biodiversity areas. Therefore, to prioritize the most important sites and focus management interventions a simple ranking system was developed for the surveyed areas using uniqueness (in terms of species representation), species richness and percentage seagrass cover (Table 3). Although all sites should receive some level of protection, six sites stood out in terms of the above parameters with PH in the Ayeyawady Region being ranked the most important site being 1) one of the most diverse, 2) the only site to contain *Halophilabeccharii*, the most threatened of all the 10 species recorded with a ranking of Vulnerable under the IUCN Redlist, and 3) because of its high percentage cover. Other sites worthy of immediate protection include MG and WT in Ayeyawady Region, and CP in Rakhine State. As a first step these sites should be provided some level of protection either as strict no-take MPAs or with carefully managed gear restricted areas with a strong emphasis on bottom trawlers and other gears which may negatively impact the seagrass.

The current study will allow the development of a baseline data for nine seagrass sites along the southern Rakhine Coastal Region, to allow for long-term monitoring of seagrass beds and provide the ability to quantitatively measure the impact of development as well as management interventions aimed at seagrass conservation.

## Conclusion

This study provides the updated information on the current status on the biodiversity, distribution and coverage of seagrasses growing in nine selected sites along the southern Rakhine Coastal Region of Myanmar. The present seagrass surveys record 7 new study sites, namely Tharthanar Dauk, NgweSaung, Wet Thay, Baw Di, Chan Pyin, Yay Myet Taung and Gyaing Kauk, in addition to the previously recorded 2 study sites, Ma Gyi and Pho Htaung. In the present surveys, there are two types of seagrass habitats- intertidal and subtidal habitats. Baw Di and Yay Myet Taung present as the type of intertidal habitats while the remaining sites show all subtidal habitats of seagrass beds. Of the 10 species collected, only *Halophilabeccharii* is considered as Vulnerable, while all the others are listed as Least Concern according to the IUCN RedList. *Halophilabeccharii* is recorded only at Pho Htaung whereas *Halodulepinifolia* is commonly predominant in 8 study sites except for one site of Tharthanar Dauk. It is necessary to do researches on the distribution of seagrasses growing along the southernmost coastal areas from the Mortin Point to the Ngayoke Aw of the Rakhine Coastal Region. Results here serve as information for the management of seagrass ecosystem in the southern Rakhine Coastal Region. Pho Htaung shows the highest species diversity (10 species) and percentage cover (66.9%) in the Ayeyawady Region, while Chan Pyin represents as highest species diversity (5 species) and percentage cover (55.6%) in Rakhine State. For that reason, Pho Htaung, being the only site to contain the Vulnerable listed *Halophilabeccharii* species and because of its high percent cover, should be assigned to a Marine Protected Area (MPA) along with Ma Gyi, Wet Thay and Chan Pyin which revealed their high species richness and coverage of seagrasses.

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## Conflicts of interests

Author declares that there is no conflict of interest.

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