Biodiversity, Distribution and Coverage of Seagrasses in the Myeik Archipelago and Rakhine Coastal Areas, in Myanmar

Abstract

Seagrasses provide ecological services to marine organisms that contribute towards food security and economic benefits to local communities living around their meadows. Surveys on seagrass taxonomy, distribution and extent were carried out in Myanmar in 14 sites within the Myeik Archipelago and along the Rakhine coast to assess the status of these important habitats. This study follows the guidelines of taxonomic monographs and the SeagrassNet manual to survey species diversity, percent cover and extent. A total of 11 species of seagrasses were recorded, including *Syringodium isoetifolium*, *Cymodocea rotundata*, *C. serrulata*, *Halodule uninervis*, *H. pinifolia*, *Enhalus acoroides*, *Thalassia hemprichii*, *Halophila beccarii*, *H. decipiens*, *H. ovalis* and *H. major*. Of these, *Halophila pinifolia* was the most commonly observed species and the only one to be distributed across all 14 study sites. In contrast, *Halophila beccarii* was only recorded at Ma Gyi along the Rakhine coast. Other unique species distributions include *Halophila major* which was solely found along the Rakhine coast and *H. ovalis* which was exclusively encountered along the Myeik Archipelago. The habitat types of seagrasses between the two Coastal Regions were also found to be different with seagrass meadows in Taninthayi most commonly observed in coastal intertidal habitat whereas those in Rakhine were recorded in the fringing reef and deep subtidal habitat. In terms of species diversity among the 14 study sites, Ma Gyi Gyaing and Pho Htaung Gyaing showed the highest in Rakhine with 9 species each while Zar Det Ngye I (East) and Pa Law Kar Kyaw I in Taninthayi contained 7 species each. Highest percentage cover of seagrass meadows was observed at Maung Shwe Lay Gyaing, in Rakhine with 67.00% and the highest coverage in Taninthayi at Lampi I (East) with 64.57%. Given the environmental services provided by seagrasses their protection within Myanmar is critical. All areas should be granted a certain level of protection although priority firstly needs to be given to Ma Gyi Gyaing in Rakhine given its species diversity, being the only site to contain the Vulnerable listed *Halophila beccarii* species and because of its high percent cover. Such an area should be gazetted as a Marine Protected Area (MPA) along with Maung Shwe Lay Gyaing and Pho Htaung Gyaing. In terms of species diversity and extent.

Keywords: Biodiversity; Conservation; Ecological accounts; Morphology; Local distribution; Myanmar; Percent cover; Rakhine Coastal Region; Taninthayi Coastal Region; Seagrasses taxonomy

Introduction

Seagrasses are a relatively small group of submerged flowering plants of approximately 72 species, representing less than 0.1% of the angiosperm taxa growing in shallow coasts of the tropical and subtropical regions. However, about 60% of seagrass meadows globally have been seen reductions in their distribution since 1980 [1,2]. The ecological importance of seagrass beds has been well documented and includes the provision of sheltered habitats and crucial feeding, spawning and nursery grounds for economically important species of marine invertebrates and fish species [3-7]. Furthermore they are key primary producers, involved in epibenthic and benthic production; provide important nutrients and contaminant filtration, producers of oxygen, recycles of nutrients [8]. However, since 1980 about 60% of seagrass populations globally have seen a reduction in their distribution due to habitat destruction and marine pollution [1,2].

Seagrasses occur all along three Coastal Regions of Myanmar, namely Rakhine, Ayeyarwady Delta and the Gulf of Mottama (Martaban) and Taninthayi. Ten species of seagrasses has been described in Myanmar and include, viz., *Syringodium isoetifolium* (Ascherson) Danty, *Cymodocea serrulata* (R. Brown) Ascherson et Magnus, *C. rotundata* Ehrenberg et Hemprich ex Ascherson, *Halodule uninervis* (Forsskal) Ascherson, *H. pinifolia* (Miki) Den Hartog [9], *Enhalus acoroides* (Linnaeus f.) Royle, *Thalassia*
Seagrasses such as 
emph{Thalassia hemprichii} (Ehrenberg) Ascherson, 
emph{Halophila beccarii} Ascherson, 
emph{H. decipiens} Ostenfeld and 
emph{H. ovalis} (R. Brown) Hooker f [10-15]. 
Their importance to Myanmar fishers is well known with local 
people calling seagrasses 
emph{Leik-Sar-Phat-Myet}, meaning the food of 
marine turtles. In addition, the seagrass meadows are known to 
serve as important feeding grounds for the sea cow, 
emph{Dugong dugon} which is recognized as endangered species under the IUCN Red 
list. Given their importance, both ecologically and economically, 
and the global decline in seagrass beds, the protection of seagrasses 
within Myanmar is seen as paramount. The objective of this study 
was to know the updated information on the current status of 
biodiversity, distribution and coverage of seagrasses at select 
sites within the Taninthayi and the Rakhine Coastal Regions of 
Myanmar. This information will be used to guide the creation of 
Marine Protected Areas within Myanmar to ensure such habitats 
are conserved and used for long term monitoring of seagrasses.

Materials and Methods

Ten study sites were selected in the Myeik Archipelago along 
the Taninthayi coast (Figures 1 & 2) and four study sites in 
Rakhine (Figures 1 & 3) to gain an understanding of their status 
and suitability for MPA designation. Surveys were conducted in 
2015 between the 6th of March to 4th of April in Taninthayi and 1st 
to the 31 May and included the following sites:

**Figure 1:** Map showing 14 study sites with the biodiversity and 
distribution of seagrasses growing in the Taninthayi and Rakhine 
Coastal Regions: 1. Zar Det Gyi; 2. Zar Det Ngye (West); 3. Zar Det Ngye 
(East); 4. Pa Law Kar Kyan I. (St Luke I); 5. Nyaung Wee I.; 6. Bo Cho I; 
7. Lampi I. (East); 8. Lampi I. (West); 9. Taw Wet I. (South); 10. Taw Wet 
I. (North); 11. Ohn Kyun I.; 12. Ma Gyi Gyaing (Shwe Thaung Yan); 13. 
Pho Htaung Gyaing; and 14. Maung Shwe Lay Gyaing.

**Abbreviations:**
- Si: Syringodium isoetifolium
- Cr: Cymodocea rotundata
- Cs: C. serrulata
- Hu: Halodule uninervis
- Hp: H. pinifolia
- Ea: Enhalus acoroides
- Th: Thalassia hemprichii
- Hb: Halophila beccarii
- Hd: H. decipiens
- Ho: H. ovalis and Hm: H. major

**Figure 2:** The survey sites of seagrass areas in the Myeik Archipelago, 
in the Taninthayi Coastal Region.

**Figure 3:** The survey sites of seagrass areas in the Rakhine coastal 
region.

**Taninthayi coastal region:**

Zar Det Gyi I.

Seagrass bed was located in front of the mangrove communities 
at Lat 10.0203°, Long 98.28963°. Substrates are muddy sand
and sandy mud to offshore. The area of seagrass bed was 32.80 ac. The percent cover of seagrasses along the cross-transects was estimated on March 23, 2015.

Zar Det Ngye I. (West)
Seagrass bed was located in front of the mangrove communities at Lat 10.11687º, Long 98.28199º. Substrates are muddy sand near shore becoming sand to offshore. The area of seagrass bed was 12.10 ac. The percent cover of seagrasses along the cross-transects was estimated on March 22, 2015.

Zar Det Ngye I. (East)
Seagrass bed was located in front of the mangrove communities at Lat 10.1251º, Long 98.3045º. Substrates are muddy sand inshore and sandy mud at offshore. The area of seagrass bed was 19.90 ac. The percent cover of seagrasses along the cross-transects was estimated on March 24, 2015.

Pa Law Kar Kyan (St. Luke)
Located in front of the mangrove communities at Lat 10.13461º, Long 98.21011º. Substrates are muddy sand nearshore and sandy mud to offshore. The area of seagrass bed was 83.00 ac. The percent cover of seagrasses along the cross-transects was estimated on March 21, 2015.

Nyaung Wee I.
Seagrass bed was located in front of the mangrove communities at Lat 10.50319º, Long 98.23227º. Substrates are muddy sand in nearshore, becoming sandy mud to offshore. The area of seagrass bed was 46.40 ac. The percent cover of seagrasses along the cross-transects was estimated on March 20, 2015.

Bo Cho I.
Located in front of the sandy beach without mangrove communities at Lat 10.66216º, Long 98.26º. Water depth 5m. Substrates are muddy sand in nearshore and sandy mud to offshore. The area of seagrass bed was 392.50 ac. The percent cover of seagrasses along the cross-transects was estimated on March 18, 2015.

Lampi I. (East)
Seagrass bed was located in front of the sandy beach without mangrove communities at Lat 10.70202º, Long 98.27984º. Substrates are muddy sand and sandy mud to offshore. The area of seagrass bed was 216.70 ac. The percent cover of seagrasses along the cross-transects was estimated on March 19, 2015.

Lampi I. (West)
Seagrass bed was located in front of the sandy beach without mangrove communities at Lat 10.88089º, Long 98.07436º. Substrates are muddy sand nearshore and sandy mud to offshore. The area of seagrass bed was 10.60 ac. The percent cover of seagrasses along the cross-transects was estimated on March 16, 2015.

Taw Wet I. (South)
Seagrass bed was located in front of the mangrove communities at Lat 11.37642º, Long 98.12234º. Substrates are muddy sand becoming sandy mud to offshore. The area of seagrass bed was 28.90 ac. The percent cover of seagrasses along the cross-transects was estimated on March 11, 2015.

Taw Wet I. (North)
Seagrass bed was located in front of the mangrove communities at Lat 11.40776º, Long 98.12032º. Substrates are predominantly muddy sand and becoming sandy mud to offshore. The area of seagrass bed was 45.50 ac. The percent cover of seagrasses along the cross-transects was estimated on March 11, 2015.

Rakhine Coastal Region:

Ohn Kyun I.
Seagrass bed was located in front of the sandy beach without mangrove communities at Lat 17.072122º, Long 94.451406º. Substrates are muddy sand nearshore and sandy mud to offshore. The area of seagrass bed was 94.22 ac. The percent cover of seagrasses along the cross-transects was estimated on May 1, 2015.

Ma Gyi Gyaing
Seagrass bed was located in front of the mangrove communities at Lat 17.170547º, Long 94.491739º. Substrates are muddy sand in nearshore and sandy mud to offshore. The area of seagrass bed was 94.22 ac. The percent cover of seagrasses along the cross-transects was estimated on May 2, 2015.

Maung Shwe Lay Gyaing
Seagrass bed was located in front of the sandy beach without mangrove communities at Lat 18.305367º, Long 94.329312º. Substrates are muddy sand in nearshore and sandy mud to offshore. The area of seagrass bed was 23.79 ac. The percent cover of seagrasses along the cross-transects was estimated on May 1, 2015.

Pho Htaung Gyaing
Seagrass bed was located in front of the mangrove communities at Lat 18.305367º, Long 94.329312º. Substrates are muddy sand in nearshore and sandy mud to offshore. The area of seagrass bed was 23.79 ac. The percent cover of seagrasses along the cross-transects was estimated on May 1, 2015.

Fresh and live materials of seagrasses growing in the natural beds of 14 study sites were sampled by uprooting the seagrasses with a small trowel or knife from 6-3-2015 to 31-5-2015. Snorkeling or scuba equipment was used for the submerged habitats of seagrasses growing in subtidal zone of the Rakhine coast indepths between 2-5m, while surveys were conducted during the ebb tide in the Myeik Archipelago. The collections were initially washed, cleaned and preserved in 10% formalin in seawater. Samples of seagrasses were examined mainly on the vegetative characters with a dissecting microscope, and then pressed on herbarium sheets to prepare as voucher specimens for each locality. As for taxonomic account, all specimens were identified using the standard monograph of seagrasses prepared by den Hartog & Kuo et al. [9,16]. This study had followed the
In relation to the ecological accounts, this study has followed the SeagrassNet protocol by Short et al. [18,19], 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 on a transect laid out seaward, perpendicular to the shore. Percentage cover of seagrasses was visually estimated within 12 randomly placed 0.25 m² quadrats along each cross-transect using a photo guide of percent cover. As noted above these works were done intertidally in the coastal areas of the Myeik Archipelago (Figure 4A) but subtidally in the Rakhine coastal areas using snorkeling or scuba equipment (Figure 4B). Positions and areas of seagrasses for each study site were recorded by GPS with extent being recorded by walking around the seagrass bed taking GPS points every 10 secs. The physical parameters, namely temperature using a mercurial thermometer, salinity using a refractometer, water depths using handheld sounder were measured in the field. The types of substrate were also recorded.

**Results**

In the present study, a total of 11 species of seagrasses were identified: including *Syringodium isoetifolium* (Ascherson) Danty, *Cymodocea rotundata* Ehrenberg et Hemprich ex Ascherson, *C. serrulata* (R. Brown) Ascherson et Magnus, *Halodule uninervis* (Forsskal) Ascherson, *H. pinifolia* (Mild.) den Hartog, *Enhalus acoroides* (Linnaeus f.) Reay, *Thalassia hemprichii* (Ehrenberg) Ascherson, *Halophila beccarii* Ascherson, *H. decipiens* Ostenfeld; 10. *H. ovalis* (R. Brown) Hooker I. and *H. major* (Zoll.) Miquel (Table 1). A detailed account of the taxonomy of these plants including identification guide, ecological accounts and supplementary survey data were shown in Appendices 1-8 of this report. Of these species, only one, *Halophila beccarii* is considered Vulnerable according to the IUCN RedList, with all other species listed as Least Concern.

*Syringodium isoetifolium* (AschersonDanty (Figure 5))

**a. Description:** Plants erect; the rhizome 1 mm thick, with internodes, 1.4-2.5 cm long; each node giving a shoot with 1-3 leaves; leaves terete, tapering to the tip, 5.5-12.5 cm in length (or longer), 1 mm wide, base covered by leaf sheath, 1-3 cm long.

**b. Local distribution:** (1) *The Taninthayi Coastal Region-* No data; (2) *The Rakhine Coastal Region*- Ma Gyì, Pho Htaung Gaing, Maung Shwe Lay Gaing (Figures 1,3).

*Cymodocea serrulata* (R. Brown) Ascherson et Magnus (Figures 6-7)

**a. Description:** Erect plants moderate in size; the rhizome 1mm in diameter; slightly larger than *C. rotundata*, internodes 2.2-3.3 cm long; shoots with 2-3 leaves at each node with lingula; leaf blade linear, flat, 4-13 cm long, 4.5-5.5 mm wide, margin entire with 9-15 nerves, apex serrulate, tapering at the base, leaf sheaths 1.5-3.0 cm long.

**b. Local distribution:** (1) *The Taninthayi Coastal Region*- Zar Det Gyì I., Zar Det Nyge I. (West & East), Pa Law Kar Kyi I. (St. Luke Island), Nyaung Wee I., Bo Cho I, Lampi I. (East & West), Taw Wet I. (North) (Figures 1,2); (2) *The Rakhine Coastal Region*– Ohn Kyun I., Shwe Thaung Yan (Ma Gyì), Pho Htaung Gaing, Maung Shwe Lay Gaing (Figures 1,3).
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Figure 5: *Syringodium isoetifolium*: A. Habit, and B. The natural bed.

Figure 6: *Cymodocea rotundata*: A. Habit, and B. The natural bed.

Figure 7: Deciduous form of *Cymodocea rotundata*: A. Habit, and B. The natural bed.
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**Figure 8:** *Cymodocea serrulata*: A. Habit, and B. The natural bed.

**Halodule uninervis (Forsskal) Ascherson** (Figure 9)

**a. Description:** Rhizome not exceeding than 1 mm thick; the internodes 1.8-3.5 cm long; erect shoot arising 1-3 flat, linear blades at each node with lingula; leaf blades flat, 13-25 cm long, 1-2 mm wide, margin entire, the black central vein at the leaf tip, which does not splits into two at the apex, leaf sheath present, 1.5-3.0 cm long.

**b. Local distribution:**

1. **The Taninthayi Coastal Region** - Zar Det Gyi I., Zar Det Ngye I. (West & East), Pa Law Kar Kyan I., Nyaung Wee I., Bo Cho I., Lampi I. (East)(Figures 1,2); Taw Wet (North); 2. **The Rakhine Coastal Region** - Ohn Kyun I., Shwe Thaung Yan (Ma Gyi), Pho Htaung Gyaing, Maung Shwe Lay Gyaing (Figures 1,3).

**Figure 9:** *Halodule uninervis*: A. Habit, and B. The natural bed.

**Halodule pinifolia (Miki) den Hartog** (Fig. 10)

**a. Description:** Plants small; the rhizome less than 1 mm, with internodes, 1.5-5.4 cm long; nodes bear erect shoots, each with 2-3 leaves; leaf blades flat, 4-25 cm long, not more than 1 mm wide, the black central vein at the leaf tip, which splits into two at the apex, lingua present at each node.

**b. Local distribution:**

1. **The Taninthayi Coastal Region** - Zar Det Gyi I., Zar Det Ngye I. (West & East), Pa Law Kar Kyan I. (St. Luke I.), Nyaung Wee I., Bo Cho I., Lampi I. (East & West), Taw Wet I. (South & North)(Figures 1,2); 2. **The Rakhine Coastal Region** - Ohn Kyun I., Ma Gyi, Pho Htaung Gyaing, Maung Shwe Lay Gyaing (Figures 1,3).

**Enhalus acoroides (Linnaeus f.) Royle** (Figure 11)

**a. Description:** Plant erect; the rhizome thick, about 1-2 cm in diameter with tough black fibers; shoots pronounced at the node, with 3-6 leaves; leaf blades flat and linear, 70-180 cm long, 0.8-2.0 cm wide, with 35-55 nerves and ribs at the margin, apex obtuse, base narrow without lingula, margin slightly serrulate in young leaves.
b. **Local distribution**: (1) *The Taninthayi Coastal Region* - Zar Det Ngye I. (East), St. Luke I. (Figures 1, 2); (2) *The Rakhine Coastal Region* - Pho Htaung Gyaing (Figures 1, 3).

*Thalassia hemprichii* (Ehrenberg) Ascherson (Figure 12)

a. **Description**: Plants moderate in size; intervals of internode 1.9-9.0 cm long; one root per node; rhizome creeping, less than 1 mm in diameter, distichously arranged and formed dendroid in shape; leaf blade linear, falcate, 1.5-15.0 cm long, 1.5-2.0 mm wide, petioles 0.1-1.1 cm long without lingula, leaf-tip obtuse, sometimes serrulate, nerves 8-11, joined by perpendicular cross veins with 9-13 nerve. Leaf tip rounded with very fine serrulations. A common species characterized by a thick rhizome prominently marked by several shoot scars between successive erect shoots with numerous relatively short internodes and a short erect stem bearing 2-6 leaves.

b. **Local distribution**: (1) *The Taninthayi Coastal Region* - Zar Det Ngye I., Zar Det Ngye I., St. Luke I., Naung Wee I., Bo Cho I., Lampi I. (East), Taw Wet (North) (Figs. 1, 2); (2) *The Rakhine Coastal Region* - Ohn Kyun I., Shwe Thaung Yan (Ma Gyi), Pho Htaung Gyaing, Maung Shwe Lay Gyaing (Figures 1, 3).

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Halophila ovalis (R. Brown) Hooker f. (Figures 1,3)

a. **Description:** Plants small; the rhizome less than 1 mm in diameter, slightly larger than *H. decipiens*, internodes 1.8-2.4 cm long; erect shoot at each node, bearing a pair of petiolated leaves; leaf blades lanceolate to obovate or elliptic, 1.5-2.2 cm long, 7-10 mm wide, margin entire, apex obtuse, base rounded, petiole 2.2-3.0 cm long, midrib prominent with 14-17 cross-veins, the distance between the intra-marginal vein and the lamina margin ratio 1:12 to 1:16.

b. **Local distribution:** (1) *The Taninthayi Coastal Region*: Zar Det Gyi I, Zar Det Ngwe I (West & East), Pa Law Kar Kyan I (St. Luke I), Nyaung Wee I, Bo Cho I, Lampi I (East), Taw Wet I (South & North) (Figures 1 & 2); (2) *The Rakhine Coastal Region*: No data.

Halophila major (Zoll.) Miquel (Figure 16)

a. **Description:** Plants moderate in size; slightly larger than *H. ovalis*, perennial; rhizomes slender to robust, fleshy, transparent, internodes 25-40 mm long, 1-2 mm diameter; roots up to 50 mm long, 1.5 mm diameter. Scales 2, glabrous, margins entire, petiole scale 3.5 x 1-2 mm, rhizome scale 4-55 x 1.0-2.5 mm; leaves petiolate, fleshy, purple to light green, 15-30 mm long, leaves bright to dark green, ovate, oblong to elliptic, 15-25 mm long, 9-11 mm wide, L/W ratio 1-3:1; apex acute or acuminate, base cuneate to attenuate, symmetrical; margins entire; surface glabrous; distance between intramarginal veins and lamina margin ratio 1:20-25:6; cross-veins distinct, 18-20, distance between adjacent cross veins 0.7-1.25 mm wide.

b. **Local distribution:** (1) *The Taninthayi Coastal Region*: No data; (2) *The Rakhine Coastal Region*: Ohn Kyun I., Ma Gyi, Pho Htaung Gyaing, Maung Shwe Lay Gyaing (Figure 1 & 3).
Htaung Gyaing showed the highest in Rakhine with 9 species each while in Taninthayi Zar Det Ngye I. (East) and Pa Law Kar Kyan I. contained 7 species each. Highest percentage cover of seagrass meadows was observed at Maung Shwe Lay Gyaing, in Rakhine with 67.36% and the highest coverage in Taninthayi at Lampi I. (East) with 64.57% (Table 2) (Figures 17-18). Although no statistical tests were undertaken no clear pattern was observed in terms of species diversity or density from inshore to offshore.

Discussion

The current study was able to develop an easily replicable baseline for 14 seagrass sites within Myanmar to allow for long term monitoring of seagrass beds and provide the ability to quantitatively measure the impact of management interventions aimed at seagrass conservation. Of the 14 sites surveyed, only four had been previously studied using the same methodology [14], which were located in the Taninthayi Region, and so comparisons can be made. Of the four only one, Lampi I. (East) showed an increase in percentage cover with 64.57% recorded in the current survey compared to 45% in the 2007 surveys [14]. A number of reasons maybe responsible for this increase such as a decrease in shrimp and fish catch in the area leading trawlers to search elsewhere for catch or from the increase in presence of Department of Forestry staffs at Marine National Park headquarters in the Lampi Island opposite to the seagrass bed, resulting of greater support by the the NGO community to the MPAs management. Two of the other sites, Taw Wet I. (North) and Nyang Wee I., did show a decrease in percentage cover but only by 9% and 11% respectively, with such a result potentially down to transect placement. These sites will however need to be monitored to ensure that its only statistical errors causing this decrease and not anthropogenic impacts such as bottom trawling. The final site, which had previously been surveyed in 2007, was Lampi I. (West) and this seagrass bed has seen an extensive loss in percentage cover with 18.75% recorded in this survey compared to 80% cover in 2007. Boat activity in this area was observed to be quite high during the surveys with this part of Lampi Island providing protection for many boats during periods of high winds and as such could be targeted by trawlers when conditions away from the island are unfavourable. These seagrass beds were noted to have a high cover of sand sediments smothering their stems. The current support being provided to manage this Marine National Park by organisations such as the Italian NGO Oikos may help to ensure this seagrass beds protection and long term conservation.

In the present study, however, unlike Kress [20] no specimens of *Zostrea marina* were recorded. This species normally occurs in temperate waters and known to extend into the higher latitudes of Myanmar waters and has previously been found in all three Coastal Regions of Myanmar. Further surveys are therefore needed to elucidate the status of this species within the country.

Seagrass meadows were mostly in intertidal zone encountered in front of the mangrove communities in Taninthayi whereas those in Rakhine are commonly found in the subtidal zone in front of the sandy beaches (except for the seagrass meadow Pho Htaung Gyaing located behind the mangrove swamp). For this reason, the luxuriant growth of seagrasses was observed in all coastal areas of Rakhine due to moderate and favourable environmental parameters but not in coastal areas of the Myeik Archipelago of Taninthayri Coastal Region due its natural habitat in the intertidal zone under heavy environmental stresses (Table 3). In the present study, other unique species distributions include *Halophila major* which was solely found along the Rakhine coast [21] and *H. ovalis* which was exclusively encountered along the coastal areas of the Myeik Archipelago.

Although Soe-Htun et al. [12] reported there were no stresses in the meadows of seagrasses in coastal areas of Myanmar, with these ecosystems showing pristine and climax conditions; they are now facing the problems such as smothering by sand as noted above. Such issues can arise from trawlers stirring up sediments.
or from land-slides where forest areas have been cleared such as those observed on Zar Det Gyi I. In general, seagrass beds in Myanmar are exposed to a number of threats including runoff from cities and towns and hazardous wastes and oil dispersals released from industrial zones located in the upper areas of natural seagrass beds are seen as serious threats to these habitats. Bottom trawlers also operate directly through seagrass beds targeting shrimps and other marine species destroying these habitats. Smoothening of seagrasses in sediments from sand mining operations in the Myeik Archipelago resulting in reduced ability of seagrasses to photosynthesize.

Table 1: Biodiversity of seagrasses distributed in 14 study sites in the Taninthayi and Rakhine Coastal Regions of Myanmar.
Table 2: Coverage of seagrass beds in the Myeik Archipelago and Rakhine coastal areas.

| Sr. No. | Locality (Date) | Position | Cover (%) | Cross-transect |
|---------|-----------------|----------|-----------|----------------|
|         |                 |          | A         | B             | C             | Total    |
| 1       | Zar Det Gyi I.  | (Lat 10.02003, Long 98.28963) | 23.33 | 54.58 | 56.25 | 44.72 |
| 2       | Zar Det Ngye I. (West) | (Lat 10.11687, Long 98.28199) | 18.00 | 29.25 | 30.00 | 25.75 |
| 3       | Zar Det Ngye I. (East) | (Lat 10.1251, Long 98.3045) | 41.91 | 55.83 | 69.58 | 55.77 |
| 4       | Pa Law Kar Kyan I. (St. Luke I.) | (Lat 10.13461, Long 98.21011) | 17.75 | 52.92 | 43.75 | 38.14 |
| 5       | Naung Wee I. | (20-3-15) | (Lat 10.50319, Long 98.23227) | 76.25 | 56.67 | 46.25 | 59.72 |
| 6       | Bo Cho I. | (18-3-15) | (Lat 10.66216, Long 98.26) | 9.67 | 22.5 | 30.5 | 20.89 |
| 7       | Lampi I. (East) | (19-3-15) | (Lat 10.70202, Long 98.27948) | 78.3 | 70.83 | 44.58 | 64.57 |
| 8       | Lampi I. (West) | (16-3-15) | (Lat 10.80089, Long 98.07436) | 28.83 | 23.75 | 3.68 | 18.75 |
| 9       | Taw Wet I. (South) | (11-3-15) | (Lat 11.37642, Long 98.12234) | 29.17 | 24.17 | 47.91 | 33.75 |
| 10      | Taw Wet I. (North) | (8-3-15) | (Lat 11.40776, Long 98.12032) | 15.85 | 45.67 | 60.00 | 40.5 |
| 11      | Ohn Kyun I. | (8-5-15) | (Lat 16.388785, Long 94.229125) | 75.00 | 70.25 | 43.75 | 63.00 |
| 12      | Ma Gyi | (1-5-15) | (Lat 17.072122, Long 94.451406) | 22.50 | 30.67 | 64.83 | 39.33 |
| 13      | Pho Htaung | (2-5-15) | (Lat 17.170547, Long 94.491739) | 85.67 | 89.17 | 25.42 | 66.75 |
| 14      | Maung Shwe Lay | (15-5-15) | (Lat 18.305367, Long 94.329312) | 49.17 | 81.25 | 71.67 | 67.36 |
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. However 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 prioritise 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 (Tables 1-4). Although all sites should receive some level of protection, six sites stood out in terms of the above parameters with Ma Gyi Gyaing (39.83 ac) in Rakhine considered the most important site being 1) one of the most diverse, 2) the only site to contain *Halophila beccarii*, the most threatened of all the 12 species recorded with a ranking of Vulnerable under the IUCN Redlist, and 3) because of its high percentage cover. Moreover, in terms of species diversity of seagrasses, Ma Gyi and Pho Htaung Gyaings showed the highest in the Rakhine Coastal Region with 9 species while Zar Det Ngey (East) I. and Pa Law Kar Kyan I. represented highest in the Myeik Archipelago waters including 7 species of seagrasses (Tables 1). Highest percentage cover of seagrass meadows was observed at Maung Shwe Lay Gyaing, in Rakhine Coastal Region with 67.36% whereas the lowest was at Lampi I. (West) with 18.75% (Tables 2), (Figures 17-18). Other sites worthy of immediate protection include Pho Htaung Gyaing (94.22 ac), Zar Det Ngey I. (East) (19.90 ac), Pa Law Kar Kyan I. (St. Luke I.) (83.00 ac), Ohn Kyun I. (17.30 ac) and Maung Shwe Lay Gyaing (23.79 ac) (Tables 3). As a first step, these sites should be provided some level of protection either as strict no-take MPAs or have carefully managed gear restricted areas with a strong emphasis on bottoms trawlers and other gears which may negatively impact the seagrass.
Table 4: Seagrass sites ranked according to uniqueness, species richness and percentage cover with 1 being the highest priority for protection and 5 the least. Shaded boxes indicate priority sites.

| Sr. No. | Site                | Uniqueness | Species richness | % Cover | Cumulative score | Rank |
|---------|---------------------|------------|------------------|---------|------------------|------|
| 1.      | Zar Det Gyi I.      | 9          | 3                | 2       | 14               | 5    |
| 2.      | Zar Det Ngye I. (West) | 9    | 3                | 3       | 15               | 5    |
| 3.      | Zar Det Ngye I. (East) | 3     | 2                | 1       | 6                | 3    |
| 4.      | Pa Law Kar Kyan I.  | 3          | 2                | 2       | 7                | 4    |
| 5.      | Nyaung Wee I.       | 9          | 3                | 1       | 13               | 5    |
| 6.      | Bo Cho I.           | 9          | 3                | 3       | 15               | 5    |
| 7.      | Lampi I. (East)     | 9          | 4                | 1       | 14               | 5    |
| 8.      | Lampi I. (West)     | 10         | 5                | 3       | 18               | 5    |
| 9.      | Taw Wet I. (South)  | 9          | 5                | 2       | 16               | 5    |
| 10.     | Taw Wet I. (North)  | 9          | 4                | 2       | 15               | 5    |
| 11.     | Ohn Kyun I.         | 3          | 3                | 1       | 7                | 4    |
| 12.     | Ma Gyi Gyaing       | 1          | 1                | 2       | 4                | 1    |
| 13.     | Pho Htan Gyaing     | 3          | 1                | 1       | 5                | 2    |
| 14.     | Maung Shwe Lay Gyaing | 3    | 3                | 1       | 7                | 4    |
Such processes can however take time and require human capacity and various other resources to manage such interventions. As such a number of required actions have been recommended which are seen as necessary for effective management of seagrasses in Myanmar and designed to guide decision makers in developing conservation plans for seagrasses to ensure these habitats are protected as follows:

1. Designation of key seagrass areas as marine protected areas (MPAs) linked with wider spatial planning exercises for the two main coastal areas with seagrass beds notably Taninthayi and Rakhine Coastal Regions.

2. Encourage international support and form partnerships with regional bodies for the conservation of seagrass ecosystems.

3. Share the results of local and regional research on seagrass ecosystem functions and values, and establish national and regional ecological networks and corridors for the management of seagrass ecosystems.

4. Provide financial and technical support to various Myanmar institutions such as government departments and universities, including capacity-building for community-based biodiversity conservation efforts.

5. Improve public knowledge and recognition of the importance of seagrass habitats through nationwide education and awareness programmes targeting policy and decision makers, fishers and local communities and those involved in activities which impact seagrass beds.

6. Strengthen national, regional and international efforts to ensure invasive alien species are controlled, which could cause great biodiversity loss in seagrass communities. This should include the development of an effective work programme on invasive alien species.

7. Intensify water pollution prevention for industrial hazardous wastes from the special economic zone and hazardous wastes from the special economic zone and marine areas by establishing monitoring systems and effective legal frameworks for conservation of seagrass meadows.

8. Ensure seagrass conservation is included in any coastal development projects and in all regional/state development plans.

9. Undertake further detailed research on seagrass habitats including surveys of the ecosystem services provided by seagrass beds with a special focus on their importance to fisheries;

10. Regularly monitor the status of seagrass ecosystems along the coast of Myanmar including on ground surveys and satellite remote sensing analysis.

11. Identify the potential impacts on seagrasses from climate which may cause these habitats to degrade leading to food security issues for local communities.

**Conclusion**

A total of 14 study sites- ten study sites, viz., Zar Det Gyi I, Zar Det Nyge I (West), Zar Det Nyge I (East), Pa Law Kar Kyan I (St. Luke I), Naung Wee I, Bo Cho I, Lampi I (East), Lampi I. (West), Taow Wet I (South) and Taow Wet I (North) in the Myeik Archipelago of the Taninthayi Coastal Region and four study sites, namely Ohn Kyun L, Ma Gyi Gyaing, Pho Htaung Gyaing and Maung Shwe Lay Gyaing in the Rakhine Coastal Region, were surveyed to assess the current status of seagrasses growing along the coastal areas of Myanmar. Eleven species of seagrasses were recorded from the Myeik Archipelago and Rakhine coastal areas of Myanmar, including *Syringodium isoetifolium*, *Cymodocea rotundata*, *C. serrulata*, *Halodule uninervis*, *H. pinifolia*, *Enhalus acoroides*, *Thalassia hemprichii*, *Halophila beccarii*, *H. decipiens*, *H. ovalis* and *H. major*. Taxonomic key to the species of seagrasses collected from the two study areas in Myanmar:

Of the 11 species of seagrasses collected in this study, only one, *Halophila beccarii* is considered Vulnerable according to the IUCN RedList, with all other species listed as Least Concern. *Halophila beccarii* was only recorded at Ma Gyi Gyaing. Of these species, *Halodule pinifolia* was the most commonly observed species. Ma Gyi Gyaing, being the only site to contain the Vulnerable listed *Halophila beccarii* species and because of its high percent cover, should be gazetted as a Marine Protected Area (MPA) along with Pho Htaung Gyaing, and Zar Det Nyge (East) given their species diversity and extent.

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**Conflict of Interest**

None.

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