Distribution, Abundance and Species Composition of Seagrasses in Wadi El Gemal National Park, Red Sea, Egypt

KEYWORDS

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ABSTRACT

Distribution, coverage and the species composition for seagrasses along 89 km of the shoreline of Wadi El Gemal National Park (WGNP) in the southern of Egyptian Red Sea coast. 26 meadows of seagrass were marked, mapped and seagrass diversity and abundance were investigated. Eleven species of seagrasses were recorded; four species were new records to the whole Red Sea, the Egyptian waters of the Red Sea and WGNP.

Halodule pinifolia (Miki) den Hartog is newly recorded to the whole Red Sea, while Enhalus acoroides (L.f.) Royle, represents a new record to the Egyptian waters of the Red Sea. Halophila decipiens Ostenfeld and Cymodocea serrulata (R.Brown) Ascherson were recorded for the first time in the area of WGNP. The total area of meadows estimated 1783.08 ha with range 498.2 ha to 0.024 ha. The seagrass coverage ranged between (82.5% ± 8.7) and (17.5% ± 8) in different sites. However, the higher overall mean coverage was recorded at sheltered sites than exposed sites. H. stipulacea was the most dominant species. The total coverage of seagrass found to be higher at shallower and deeper waters, rather than the middle depths of 5-20m. The highest richness value was 1.001 in front of Wadi El Gemal catchment basin, while the depth 0-5m (1.495) had the highest richness and evenness.

Introduction

Seagrasses are defined as marine flowering plants (angiosperms). As such, they live and complete their whole life cycle submerged in seawater (including underwater flowering, pollination, distribution of seeds and germination into new plants). Seagrasses grow in a wide range of habitats ranging from the intertidal to depths of over 70 m (Jones et al., 1987; Long et al., 1996).

The Red Sea harbors 11 seagrass species, all of tropical origin, which penetrated through its relatively narrow mouth at Bab al Mandab. (den Hartog, 1970; Aleem, 1979; Jacobs and Dicks, 1985). Only a single plant of Halophila decipiens has hitherto been reported from the Red Sea, grabbed from 30 m (Jacobs and Dicks, 1985). Enhalus acoroides seems not to reach much beyond the Tropic of Cancer, whereas the other ten species continue to the northwestern part of the Red Sea proper, but only seven (the above listed species excluding Enhalus acoroides, Cymodocea serrulata, Halophila ovata and Halophila decipiens) penetrate into much of the Gulf of Suez. Wadi El Gemal National Park (WGNP) encompasses a great diversity of seagrasses, 26 transects ranges between 25m to 250m length each perpendicular to the shore. In each transect seagrass diversity and abundance was estimated. Four quadrates of 1m x 1m (1m²) each were laid randomly per transect.

At each meadow, the shore profile and seagrass distribution were plotted. To estimate the diversity and abundance of seagrasses, 26 transects ranges between 25m to 250m length each perpendicular to the shore. In each transect seagrass diversity and abundance was estimated. Four quadrates of 1m x 1m (1m²) each were laid randomly per transect.

Identification of seagrass species was based on: Phillips and Menez, (1998), Kuo and Den Hartog (2001) and Waycott et al. (2004). Additional advice on the taxonomic status of the genus Halodule in the Indian Ocean was provided by Pro. F. T. Short (founder of SeagrassNet organization)

Results

Eleven species of seagrasses were recorded from the area of WGNP: namely Halophila stipulacea (Forsskal) Ascherson, Halophila ovalis (R.Brown) Hooker f., Halophila decipiens Ostenfeld, Thalassia hemprichii (Ehrenberg) Ascherson, Enhalus acoroides (L.f.) Royle, Halodule uninervis (Forsskal)
Ascherson, *Halodule pinifolia* (Miki) den Hartog, *Cymodocea rotundata* Ehrenberg & Hemprich ex Ascherson, *Cymodocea serrulata* (R.Brown) Ascherson, *Syringodium isoetifolium* (Ascherson) Dandy and *Thalassodendron ciliatum* (Forsskal) den Hartog.

Out of the eleven listed species, four species were slighted as new records to the whole Red Sea, the Egyptian waters of the Red Sea and WGNP. *H. pinifolia* is newly records to the whole Red Sea (Red Sea proper & Gulf of Suez and Gulf of Aqaba), while *E. acoroides*, represents a new recorded to the Egyptian waters of the Red Sea and *H. decipiens* and *C. serrulata* were recorded for the first time in the area of WGNP. (Table 1)

Fig. 1: Map of the Red Sea and the arrow refer to the study area
Table 1: Species list of seagrasses recorded in the study area

| Family                      | Species                        | First Recording in the Red Sea                                                                 |
|-----------------------------|--------------------------------|-------------------------------------------------------------------------------------------------|
| Hydrocharitaceae            | Halophila stipulacea (Forsskal) Ascherson | Suez Gulf & Aqaba Gulf (Lipkin, 1972), Asian coast & African coast (Lipkin, 1975)               |
|                             | Halophila ovalis (R.Brown) Hooker f. | Suez Gulf & Aqaba Gulf (Lipkin, 1972), Asian coast & African coast (Lipkin, 1975)               |
|                             | Halophila decipiens Ostenfeld     | Suez Gulf (Jacobs, 1972), African coast WGNP (EGYPT) present study                              |
|                             | Thalassia hemprichii (Ehrenberg)  | Aqaba Gulf (Rayss, 1959), Asian coast & African coast (Lipkin, 1975) WGNP (EGYPT) present study |
|                             | Enhalus acoroides (L.f.) Royle     | Asian coast (Aleem, 1979) and African coast (Lipkin, 1975), WGNP (EGYPT) present study          |
|                             | Halodule uninervis (Forsskal) Ascherson | Suez Gulf & Aqaba Gulf (Lipkin, 1972), Asian coast & African coast (Lipkin, 1975)               |
|                             | Halodule pinifolia (Miki) den Hartog | WGNP (EGYPT) present study                                                                      |
| Cymodoceae                  | Cymodocea rotundata Ehrenberg & Hemprich ex Ascherson | Aqaba Gulf (Lipkin, 1972), Asian coast & African coast (Lipkin, 1975) |
|                             | Cymodocea serrulata (R.Brown) Ascherson | Asian coast (Aleem, 1979) and African coast (Lipkin, 1975), WGNP (EGYPT) present study          |
|                             | Syringodium isoetifolium (Ascherson) | Aqaba Gulf (Lipkin, 1972), Asian coast & African coast (Lipkin, 1975) WGNP (EGYPT) present study |
|                             | Thalassodendron ciliatum (Forsskal) den Hartog | Suez Gulf & Aqaba Gulf (Lipkin, 1972), Asian coast & African coast (Lipkin, 1975)               |

Seagrass distribution and area estimation.

In total, 26 seagrass meadows were recorded and mapped along the coast of the study area (89 km shoreline) within a depth range between zero and 25m. The area for each meadow was estimated in hectare. At the 26 studied site, the total area of meadow estimated 1783.08 ha (Fig. 3&4). The largest meadow of 498.2 ha was estimated at site 15, while the smallest one of 0.024 ha was found at site 26 (Table 2).

The most common species was Halophila stipulacea, found at 21 sampling sites, followed by Halodule uninervis and Halophila ovalis at 15 and 10 sampling sites, respectively (Fig. 2).

Fig. 2: Number of sites at which each seagrass was found in WGNP.
| Site name                        | Site number | Coordinates                    | Sheltering condition | Area (ha) | *% |
|---------------------------------|-------------|--------------------------------|----------------------|-----------|----|
| Sharm El-Fakeri shallow         | 1           | 24° 45' 45.5" N 35° 03' 51.5" E | Sheltered site       | 20.41     | 1.1|
| Sharm El-Fakeri deep            | 2           | 24° 45' 20.3" N 35° 03' 46.0" E | Sheltered site       | 57.4      | 3.2|
| Shams Alam shallow              | 3           | 24° 41' 12.2" N 35° 05' 04.8" E | Exposed site         | 55.95     | 3.1|
| Shams Alam deep                 | 4           | 24° 41' 27.4" N 35° 05' 08.8" E | Sheltered site       | 132.23    | 7.4|
| Torfa                           | 5           | 24° 39' 54.8" N 35° 06' 35.6" E | Sheltered site       | 18.56     | 1.0|
| North Ras Bughdadi              | 6           | 24° 40' 14.0" N 35° 06' 46.6" E | Exposed site         | 85.67     | 4.9|
| South Ras Bughdadi (deep)       | 7           | 24° 39' 29.8" N 35° 06' 38.5" E | Sheltered site       | 67.92     | 3.9|
| South Ras Bughdadi (Shallow)    | 8           | 24° 39' 23.2" N 35° 06' 16.6" E | Sheltered site       | 248.06    | 13.9|
| Wadi El Gemal Island            | 9           | 24° 38' 44.9" N 35° 10' 35.0" E | Sheltered site       | 12.95     | 0.7|
| Ashelinat shallow               | 10          | 24° 39' 46.9" N 35° 09' 07.3" E | Sheltered site       | 19.81     | 1.1|
| Ashelinat deep                  | 11          | 24° 39' 34.6" N 35° 08' 31.1" E | Sheltered site       | 26.8      | 1.6|
| Sabeha Tent                     | 12          | 24° 35' 37.2" N 35° 08' 19.0" E | Exposed site         | 52.49     | 2.9|
| Sharm El-Luli                   | 13          | 24° 36' 28.9" N 35° 06' 51.9" E | Sheltered site       | 16.93     | 0.9|
| Umm El-Abbs shallow             | 14          | 24° 30' 53.4" N 35° 08' 15.4" E | Sheltered site       | 256.97    | 14.4|
| Umm El-Abbs deep                | 15          | 24° 31' 07.5" N 35° 08' 55.4" E | Exposed site         | 498.2     | 27.9|
| Abu Ghson port                  | 16          | 24° 27' 10.1" N 35° 12' 20.6" E | Sheltered site       | 20.34     | 1.2|
| El-Ranga                        | 17          | 24° 23' 54.0" N 35° 14' 28.7" E | Sheltered site       | 44.99     | 2.5|
| Qulaan                          | 18          | 24° 21' 49.5" N 35° 17' 45.4" E | Exposed site         | 7.99      | 0.4|
| Hamata Mangrove                 | 19          | 24° 20' 13.6" N 35° 20' 02.4" E | Sheltered site       | 24.38     | 1.4|
| Hamata North                    | 20          | 24° 18' 12.1" N 35° 22' 23.4" E | Sheltered site       | 41.22     | 2.3|
| Hamata South                    | 21          | 24° 16' 44.0" N 35° 23' 18.5" E | Sheltered site       | 7.89      | 0.4|
| Hamata port                     | 22          | 24° 17' 35.5" N 35° 22' 44.4" E | Exposed site         | 27.99     | 1.6|
| Mhabies Island                  | 23          | 24° 19' 04.9" N 35° 23' 02.1" E | Sheltered site       | 2.14      | 0.1|
| Wadi Lahmi (shallow)            | 24          | 24° 12' 50.3" N 35° 25' 22.9" E | Sheltered site       | 6.98      | 0.4|
| Wadi Lahmi (deep)               | 25          | 24° 12' 19.3" N 35° 26' 03.0" E | Sheltered site       | 28.79     | 1.6|
| Abu Ghson Mangrove              | 26          | 24° 22' 54.8" N 35° 15' 43.1" E | Sheltered site       | 0.02442 (244.2 m²) | 0.001|
| Total Area (ha)                 |             |                                |                      | 1783.0844 |    |

Table 2: Area estimated for each of 26 recorded meadows along the coast of the study area
Fig. 3: the demarcation of the recorded meadows along the coast of the study area represented on satellite image.

(Quickbird satellite image with spatial resolution: Panchromatic 60 cm & Multispectral 2.4 m image)
Fig. 4 (A, B, C, D, E, F, G, H, I and J): the demarcation of the surveyed seagrass meadows among WGNP represented with the estimated area by hectare.

(Quickbird satellite image with spatial resolution: Panchromatic 60 cm & Multispectral 2.4 m image)

Seagrass coverage:
The total coverage of seagrasses was found to be influenced significantly by depth (p = 0.0001), and non significantly by sites (p = 1.000). Although the variations in seagrass coverage in sheltering condition found to be non-significant (p=0.396), the interaction between sheltering condition and depth were found to be significant (p<0.0001) in addition, the two way interaction between site and depth found to influence highly significant (p = 0.0001) the total coverage of seagrasses.

According to sites, the highest seagrass coverage of (82.5% ±8.7) was recorded at site 26, in contrast the lowest coverage of (17.5% ±8) was estimated at site 23. The coverage of seagrasses at other sites was fluctuated between the mentioned values (Fig. 5).

Fig. 5: The total mean coverage /m² of all seagrass species at the twenty six studied sits.
In comparison between seagrass coverage estimated at exposed and sheltered sites indicated generally that higher overall mean coverage of (37% ± 32.5) recorded at sheltered sites than an overall mean of (29% ± 14.1) estimated at exposed sites.

Regarding to depth, the total coverage of seagrass found to be higher at shallower and deeper waters (i.e. at depth of 0-5m and 20-25m) being (41% ± 23.4) and (50% ± 11.3), rather than the middle depths of 5-10m, 10-15m and 15-20m, being (24% ± 15.1), (35% ± 21.6) and (29% ± 15.9) respectively. (Fig. 6). The effect of the interaction between depth and sheltering condition showed significant influence on total coverage of seagrasses (p<0.0001).

Fig. 6: The total mean coverage /m² of all seagrass species at different depths.

At both sheltered and exposed sites the total coverage of seagrasses showed a general trend of increasing with depth (Fig. 7).

Fig. 7: The total mean coverage /m² of all seagrass species in different depths at the sheltered sites and exposed sites.

Seagrass diversity at sites and depths
The diversity index of the seagrasses species at different sites shows the highest value of richness was 1.001 in front of Wadi Usm El Abbs catchment basin (Main catchment area), while the lowest value richness was 0.2261 Southern Wadi El Ringah drainage (Low catchment area).

The highest richness was recorded at depth 0-5m (1.495), while the lowest richness was recorded at depth 15-20m (0.4473). Similarly the evenness of the seagrasses species, at different depths showed that the depth 0-5m has the highest value of evenness (0.9379), while the depth 15-20m has the lowest one (0.8478).

Discussion
Out of twelve seagrass species known from Red Sea (Aleem, 1979; Jacobs and Dicks, 1985; Lipkin and Zakai, 2003; El Shaffai, 2011), eleven species were recorded from the marine area of the Wadi El Gemal National park (WGNP), four species were slighted as new records to the whole Red Sea and the Egyptian waters of the Red Sea (WGNP), where (Lipkin, 1977; Hulings and Kirkman, 1982) reported only 7 species. The northern parts of the Saudi Arabian coast of Gulf of Aqaba are characterized by an impoverished seagrass flora, apparently constituting only 4 species. i.e. Syringodium isoetifolium, Halodule unineuris, Halophila ovalis and H. stipulacea (Price et al., 1988). Halodule unineuris, Halophila ovalis and H. stipulacea are the only species to have penetrated the extreme north eastern Jordanian waters (Hulings, 1979; Wābbeh, 1980; Hulings and kirkman, 1982) and the north western, Sinai waters (Lipkin, 1977; 1979) of the Gulf of Aqaba. Price et al. (1988) concluded that interactions of environmental factors probably control the occurrence of individual seagrass species.

The estimated area of 1783.08 ha of seagrass in WGNP is extended inshore and offshore from depths 0-45m. The largest meadow of 498.2 ha was estimated in front of Wadi Umm El Abbs catchment basin, while the smallest one of 0.024 ha was found far from Wadi Abu Ghson catchment basin by 4 km south. The study area is subdivided by a number of major wadis (TDA, 2003) which considered as the main sources of organic matter, essential minerals and sediment characteristics for seagrass meadows in WGNP. The input of organic matter and the accumulation of seagrass detritus in the sediments increase the amount of microbial substrates in the sediments (Gacia and Duarte, 2001). Also, the deposition of finer sediments as an important factor limiting seagrass distribution in the studied site (Larkum et al., 2006; Eslam Osama et al., 2008). With the exception of Halophila stipulac-ea, all species recorded during this study were found only in waters ≤ 20 m. Jones et al. (1987) reported that most species in the Red Sea are abundant only in waters < 10 m. However, specimens of at least five species have been collected at > 20 m. In the Gulf of Aqaba, Thalasodendron ciliatum has been collected from 30 m (Lipkin, 1977) and Halophila ovalis from 28 m (Hulings and Kirkman, 1982). In addition, Jacobs and Dicks (1985) recorded Halophila decipiens and Halophila ovata at 30 m and 20 m, respectively, in the Gulf of Suez.

During the present work it was found that Halophila ovalis, generally declined in abundance with depth. In contrast, the percent cover of Halophila stipulacea was more abundant at intermediate depths. Although light is the primary agent determining the abundance of seagrasses with depth, other factors such as temperature, sediment composition, water motion and salinity (Backman and Barilotti, 1976) and sheltering condition (Larkum, 2006) are limiting factors for distribution and abundance of seagrasses. During this study the total coverage of seagrasses showed a general trend of increasing with depth. Sheltering condition showed significant effect on seagrass and distribution. In both sheltering condition water motion and salinity had no effect. Backman and Barilotti (1976) decided that wave action is considered as limiting factor for seagrass abundance and distribution.

Like the northern Red Sea, H. stipulacea is the most widespread species in Wadi El Gemal national park. It has the greatest depth range in the Red Sea having been recorded from the intertidal to 70 m in the Gulf of Aqaba (Lipkin, 1979). With assistance from humans, its distribution has expanded into the eastern Mediterranean Sea (Lipkin, 1977) western Atlantic Ocean (Ruiz and Ballantine, 2004) and previous study at the same study areas recorded H. stipulacea at 45 m with coverage 20% (Salam Pers. comm.). We confirmed that H. stipulacea has considerable ecological tolerance, being abundant from 0.5 m to at least 45 m depth in our study area.

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