



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 most of the Gulf of Aqaba and only five (*Halodule uninervis*, *Halophila stipulacea*, *Halophila ovalis*, *Halophila decipiens* and *Thalassodendron ciliatum*) into much of the Gulf of Suez. Wadi El Gemal National Park (WGNP) encompasses a great diversity of habitats in a uniquely compact setting, representing a complete terrestrial/marine ecosystem characteristic of the Red Sea coast. The region is of phenomenal natural beauty and outstanding biological diversity.

The current study was aimed to investigate different ecological aspects of the seagrass communities. The scope items were: Surveying the marine area of Wadi El Gemal National Park (WGNP) by Demarking and mapping the main meadows in the study area and estimated the areas of seagrass meadow; Study the spatial variations in abundance and diversity of seagrasses with different depths.

Methods

Wadi El Gemal National Park (24° 45' N, 35° 3' E), is located about 35 km south of Marsa Alam City. 26 sites were selected to represent different conditions, i.e lagoon and sharms, in-shore and offshore, and shallow and deep waters (> 20m) (Fig. 1). The methods used to map the distribution of sea-

grass meadows varied according to the marine zone, water depth and water clarity. At the intertidal zone, demarcation of meadows was conducted at low tide when the seagrass meadow was exposed and its boundaries were cleared. This was carried out by walking around the outer boundaries of each meadow with (GPS, GARMIN etrix Vistae). Regarding the shallow subtidal zone (<10m depth), the method used to map and demarks seagrass meadows were based on depth and water clarity as follow:

In areas of high clarity, the boundaries of meadows mapped from a boat driven slowly (1-2 knots) around the perimeter of each meadow with single fixed position and recorded every 4 seconds (GPS set to "Track"). A snorkeling used to assist in identification of the presence of continuous or sparse meadows and the determination of deep edge meadows.

In the case of the deep water (>10m depth), the seagrass meadows were mapped, using a grid pattern or a combination of transects and spots, much in the same manner as when mapping shallow subtidal meadows, but completely based on SCUBA diving. Seagrass meadows were mapped using the GIS capabilities and application (ArcMap vers. 9.1).

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, (1988), 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* (Forsk.) den Hartog.

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)

Out of the eleven listed species, four species were sighted

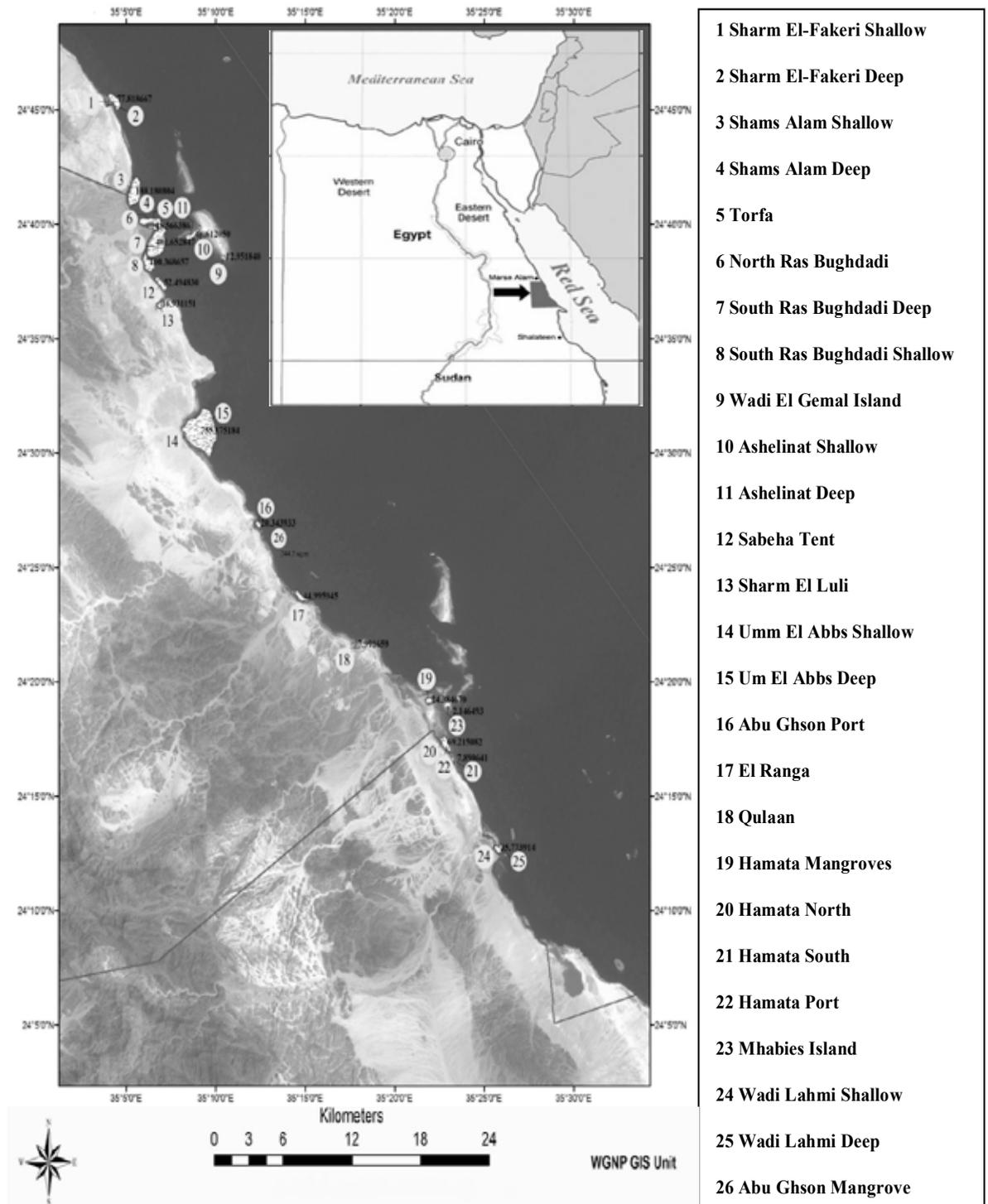


Fig. 1: Map of the Red Sea and the arrow refer to the study area

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

Table 1: Species list of seagrasses recorded in the study area

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).

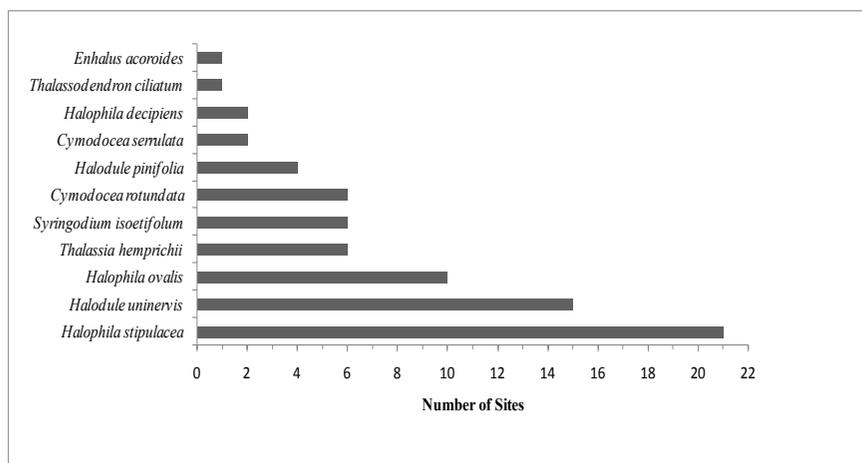


Fig. 2: Number of sites at which each seagrass was found in WGNP.

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' 20.1" 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 m ²)	0.001
Total Area (ha)	1783.0844				

Table 2: Area estimated for each of 26 recorded meadows along the coast of the study area

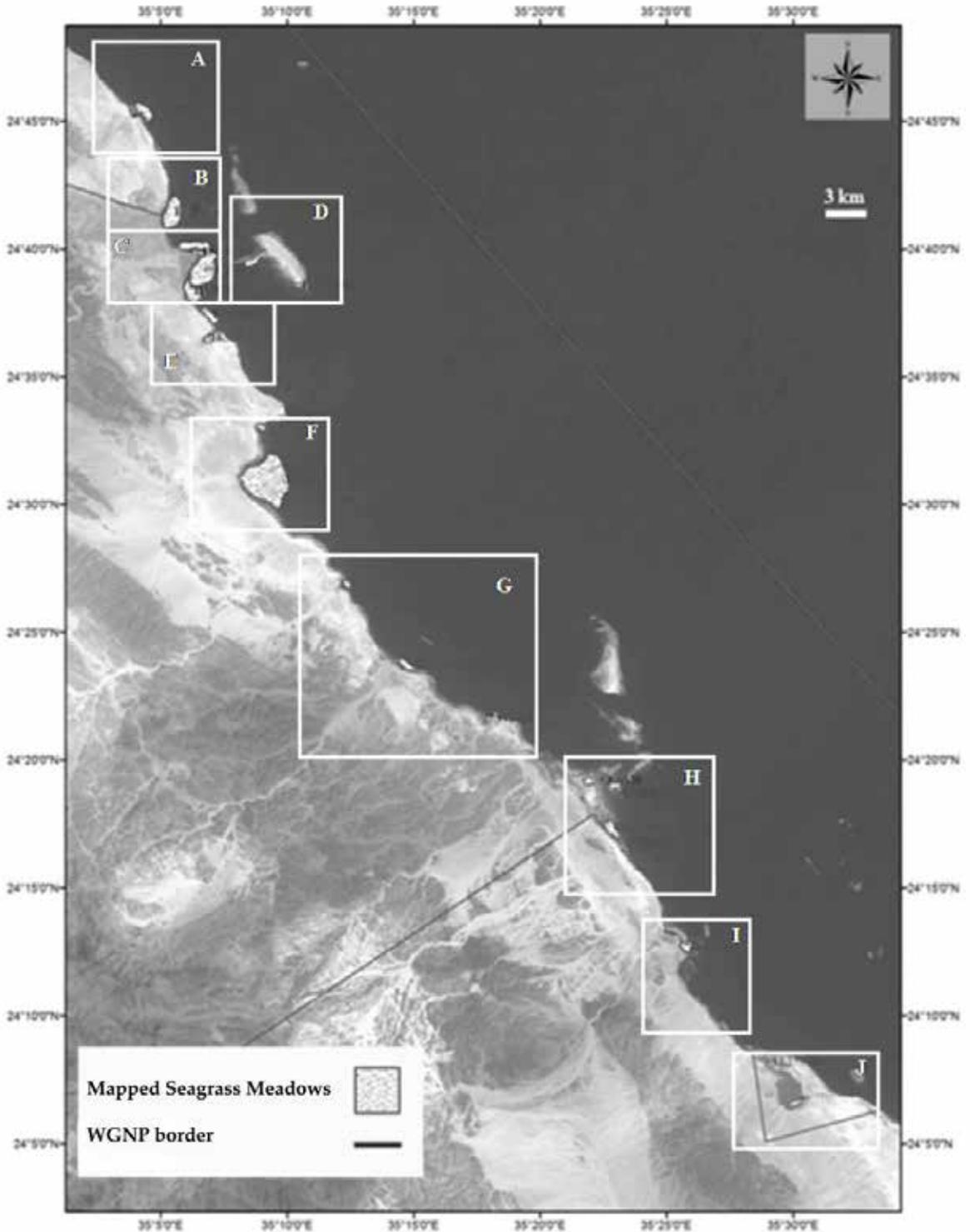
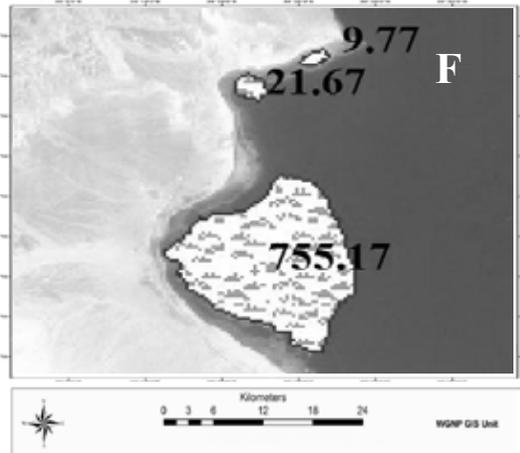
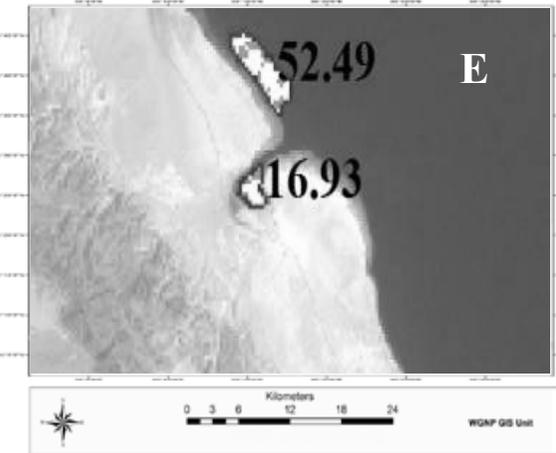
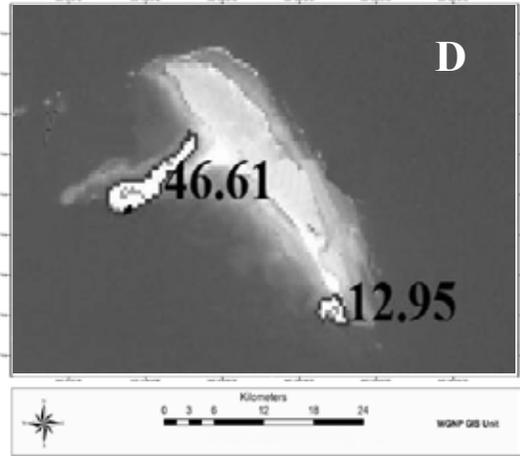
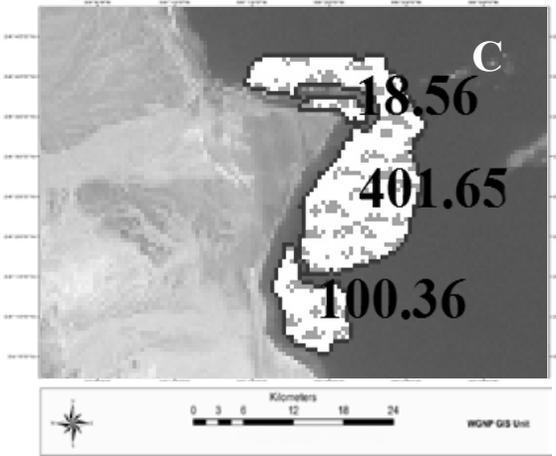
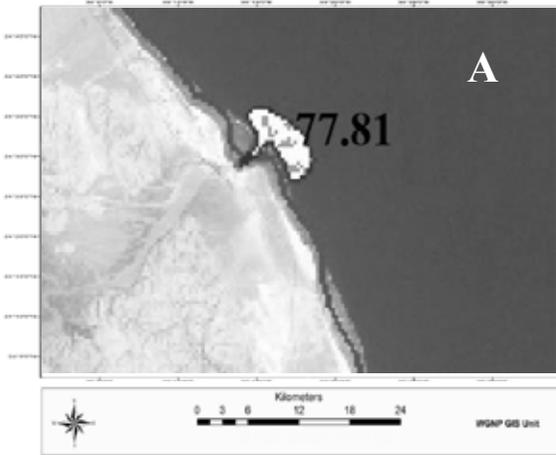


Fig. 3: the demarcation of the recorded meadows along the coast of the study area represented on satellite image. (Quickbird satellite image with spatial resolution: Panchromatic 60 cm & Multispectral 2.4 m image)



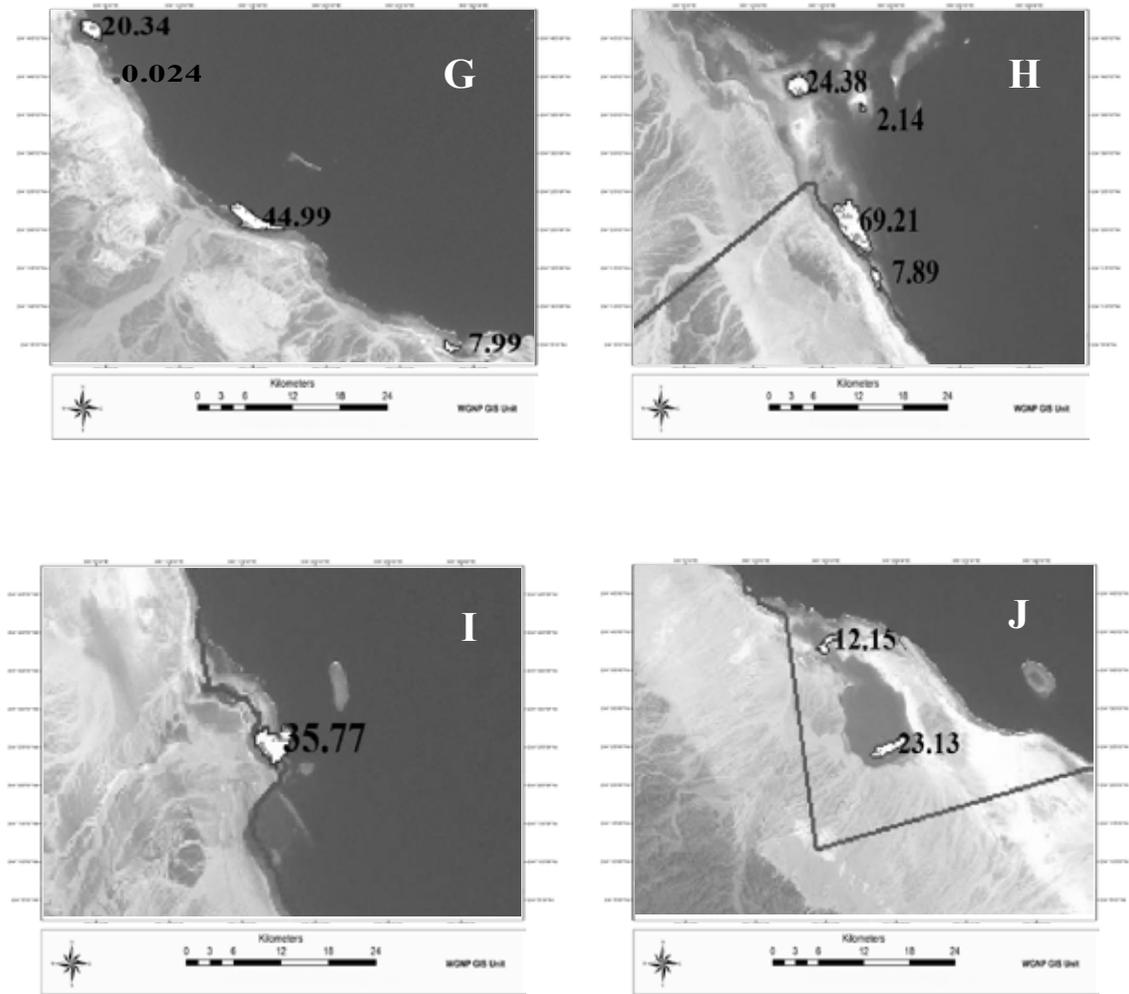


Fig. 4 (A, B, C, D, E, F, G, H, I and J): the demarcation of the surveyed seagrass meadows among WGNP represented with the estimated area by hectare. (Quickbird satellite image with spatial resolution: Panchromatic 60 cm & Multispectral 2.4 m image)

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

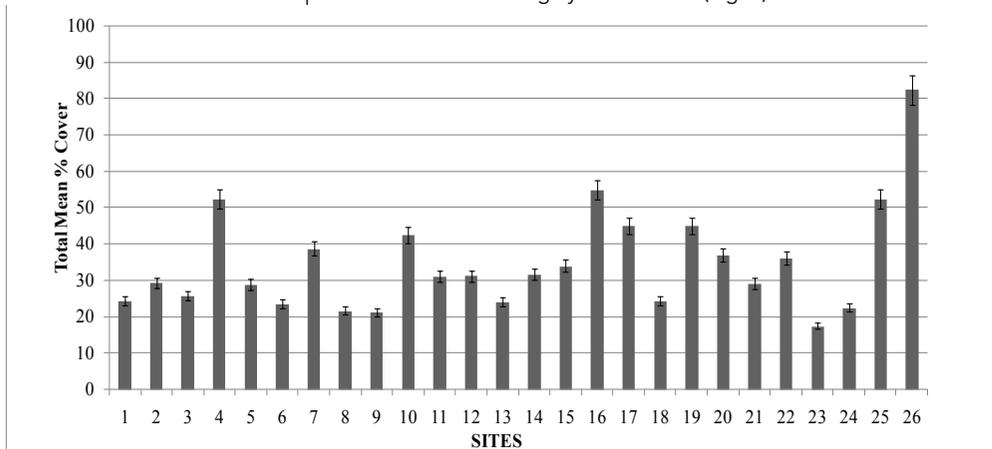


Fig. 5: The total mean coverage /m² of all seagrass species at the twenty six studied sits.

In comparison between seagrass coverage estimated at exposed and sheltered sites indicated generally that higher overall mean coverage of (37% \pm 32.5) recorded at sheltered sites than an overall mean of (29% \pm 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% \pm 23.4) and (50% \pm 11.3), rather than the middle depths of 5-10m, 10-15m and 15-20m, being (24% \pm 15.14), (35% \pm 21.6) and (29% \pm 15.9) respectively (Fig. 6). The effect of the interaction between depth and sheltering condition showed significant influence on total coverage of seagrasses ($p < 0.0001$).

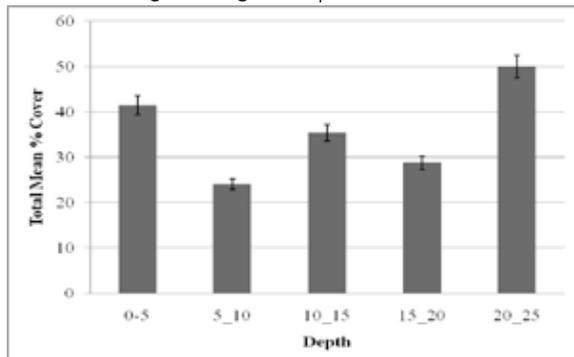


Fig. 6: The total mean coverage /m² of all seagrass species at different depths.

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

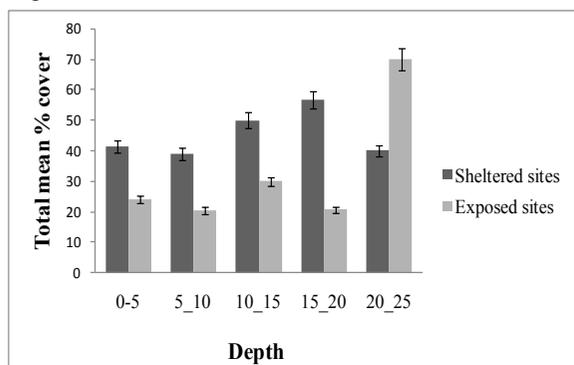


Fig. 7: The total mean coverage /m² of all seagrass species in different depths at the sheltered sites and exposed sites.

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 El Gemal 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 sighted 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 uninervis*, *Halophila ovalis* and *H. stipulacea* (Price et al., 1988). *Halodule uninervis*, *Halophila ovalis* and *H. stipulacea* are the only species to have penetrated the extreme north eastern Jordanian waters (Hulings, 1979; Wahbeh, 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., 2010). With the exception of *Halophila stipulacea*, all species recorded during this study were found only in waters \leq 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, *Thalassodendron 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 abundance and distribution depth of 15-20m. At the depth of 20-25, there was no effect of sheltering condition. It is explainable where at such depth wave action 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.

Acknowledgment

We would like to thank the managers of WGNP Dr. Mohamed Tahoon and Mr. Mohamed Gad for their support. Also thanks to all WGNP staff for their sincere help in Field work,

especially Mr. Mohamed Negm, Mr. Mohamed Ali and Mr. Ayman N. Morad.

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