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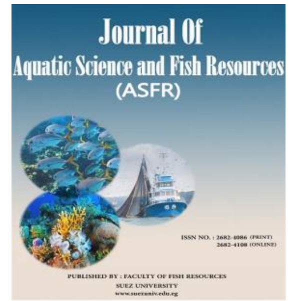

Status of Seagrass community in Northern Protected Islands, Hurghada, Red Sea, Egypt

Aldoushy Mahdy[1,*], Ahmed Ghallab[2], Hashem Madkour[3] and Alaa Osman[1]

1, Zoology Department, Faculty of Science, Al-Azhar University, Assiut Branch, 71524 Assiut, Egypt.

2, Egyptian Environmental Affairs Agency, Natural Conservation Sector, Red Sea Protectorates, Egypt

3, National Institute of Oceanography and Fisheries, Red Sea Branch, Hurghada 84511, Egypt

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ABSTRACT

The current research aims to understanding the abundance and distribution of seagrass communities in Northern protected Islands in order to support decision-makers in the management of the natural resource, in particular the bed of seagrass in northern protected areas. During winter 2017, eight Northern protected Islands were surveyed using diving and snorkeling (Tawila Island, Ashrafi Island, Ghanim Island, Small Gubal Island, North Um ElHimat Island, South Um Elhimat Island, North Geisum Island and South Geisum Island). Three species of seagrass, *Thalassodendron ciliatum*, *Halophila stipulacea*, and *Halodule uninervis*, were recorded. The result revealed that, in all Islands *Thalassodendron ciliatum* was the highest seagrass species abundance with mean coverage of 61%. The results showed that the mean coverage of the other two species were *Halophila stipulacea* 43% and *Halodule uninervis* 42%. There is no seagrass species were recorded in two Islands, Small Gubal and south Um ElHimat. Ashrafi Island was the highest abundance of seagrass with mean coverage of 59 % and the lowest was in Ghanim Island with mean coverage of 23%. Sea cucumber in Northern protected Island was represented only by one species *Holothoria area* with very low abundance (8 Individuals/ 750 m^2). The distribution of seagrass in northern Island was mapped using the GIS.

1. Introduction

Seagrass is a unique group of flowering plants that have been adapted to exist fully immersed in the sea, providing numerous significant environmental services to the marine environment (Costanza et al., 1997). For climate and food security, seagrass ecosystems are of global significance, but remain rather unknown and on the periphery of marine conservation (Duarte et al., 2008). Overall seagrasses play an important role in promoting a wide range of highly valuable ecosystem facilities compared to many more renowned and well-known ecosystems such as mangrove forests and coral reefs (Nordlund et al., 2016). They form, for instance, vast filters of the coastal environment, cycling nutrients and reducing disease-causing bacterial pathogens of humans and marine organisms.

* Corresponding author. Aldoushy Mahdy
E-mail addresses: aldoushy@gmail.com;
aldoushy@azhar.edu.eg
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In addition, for mega-herbivores such as green sea turtles and *Dugong dugongs*, seagrass is an important food source and provides critical habitat for many animals, including commercially and recreationally important fishing species (Flindt et al., 1999; Lamb et al., 2017). The various species of seagrass in the Red Sea form vast meadows from the tidal zone to depths of 70 m (Lipkin, 1979; Hulings, 1979; Head and Edwards, 1987; Lipkin et al., 2003).

Due to the soft-bottom sediments found in these regions, they tend to be concentrated in shallow water regions such as lagoons, sharms and mersas (Den Hartog, 1970). Two families have 12 seagrass species recorded in the Red Rea, family Cymodoceaceae contain (*Cymodocea rotundata*, *Cymodocea serrulate*, *Halodule pinifolia*, *Halodule uninervis*, *Syringodium isoetifolium*, and *Thalassodendron ciliatum*) and family Hydrocharitaceae that contain (*Exhales acoroides, Halophila decipiens, Halophila ovalis Halophila minor, Halophila stipulacea* and

Thalassia hemprichii) (Den Hartog, 1970; Lipkin and Zakai, 2003; El Shaffai, 2016).

Seven species were reported in the Gulf of Aqaba, however, and only *H. stipulacea, H. ovalis*, were reported at the extreme northern end (Wahbeh and Mahasne, 1980). Ten species of seagrass have been recorded along the Saudi shore, while the northern end of the Gulf of Aqaba has a low abundance of seagrass, where temperatures are cooler and the substratum is not suitable for seagrass growth (Rasul et al., 2015). From the Yemeni Red Sea coast, nine species of seagrass have been reported, of which only three have been recorded from the Gulf of Aden coast. On the other hand, from the western Indian Ocean, thirteen species of seagrass are known (Gullström et al., 2002). In the Red Sea the seagrass species, *Halophila stipulacea*, has been described as having a broad ecological range from intertidal to depths greater than 50-70 m generally (Fishelson, 1971; Lipkin, 1975, 1979; Hulings, 1979; Beer and Waisel, 1982; Lipkin et al., 2003; El Shaffai et al., 2011).

There are six main global challenges to seagrass conservation are (1) lack of awareness of what seagrasses are and a limited societal recognition of the significance of coastal systems for seagrasses; (2) the status of many seagrass meadows is unknown and up-to-date status and condition information is essential; (3) to target management actions accordingly, understanding of threatening activities at local scales is required; (4) it is essential to broaden the understanding of the interactions between the socio-economic and ecological components of seagrass systems in order to balance the needs of humans and the planet; (5) research into seagrass should be broadened to generate scientific research that supports conservation activities; (6) in order to adapt conservation accordingly, an increased understanding of the linkages between seagrass and climate change is needed (Unsworth, 2018).

Seagrass beds usually occur in lagoons and bays in protected shallow areas and are inhabited by a diverse fauna and are more prevalent in the shallow southern Red Sea (Rasul et al., 2015). Seagrass distribution is primarily controlled by water transparency, type of seabed, movement of water, salinity, and temperature. Mollusks, polychaetes, crustaceans, echinoderms, and fish are the major groups inhabiting seagrass beds (Osman, 2007), with perhaps about 10 % of the species in seagrass beds occurring nowhere else (Rasul et al., 2015). Wahbeh and Mahasne (1980) find more than 49 species of invertebrates (mostly molluscs) living in seagrass beds in the northern Gulf of Aqaba, either attached to the plant (gastropods) or buried in the sediment (bivalves). The same discovery was obtained by Osman (2007) from the Hurghada sites, who found that Gastropods and bivalves is the most dominant group linked to seagrass beds.

Red Sea seagrass beds' standing crops and productivity are comparable to those reported from other tropical regions of the world. Seagrass beds, as elsewhere in the Red Sea region, stabilize nearshore sediments, provide a juvenile habitat for a variety of commercially important crustaceans and fish, and provide food for important species (*Dugong dugong* and turtle), and probably nutrients and energy are likely to be exported to adjacent subtidal systems (Rasul et al., 2015).

Since 1995, 22 Islands in the Red Sea have been declared a protected area by Law 102/1983 of the Ministry of Environment in Egypt (nature conservation sector) from Gifton Island in front of Hurghada in the north to Halayeb Island in grade 22º to board Sudan. Eight protected Islands in the Red Sea were added to the northern Islands in 2006 (Tawila Island, Small Gubal Island, Ghanim Island, Ashrafi Island, North Um Elhimat Island, South Um Elhimat Island, North Geisum Island and South Geisum Island). Most of the northern Islands are remote and located close to the entrance to the Gulf of Suez, and are strategically important for maritime transport. They are also surrounded by some petroleum and fishing activities.

Therefore, the objective of the current work is to understand the abundance and distribution status of the seagrass community in Red Sea Northern protected Islands in order to support the decision-maker to manage the natural resource, in particular seagrass community.

2. Materials and methods

2.1. Geomorphology of the study Islands:

During the winter of 2017, eight Northern protected Islands were surveyed (Ghallab et al., 2020) using diving and snorkeling (Tawila Island, Ashrafi Island, Ghanim Island, Small Gubal Island, North Um ElHimat Island, South Um Elhimat Island, North Geisum Island and South Geisum Island) (Figure 1)

2.1.1. Tawila Island:

It is situated at 27°:35':15.24' N and 33°:45':52' E, with an area of 21.5 km^2 in total. It is about 22 km from the shore. The Island of Tawila has a sandy beach and many shallow lagoons surrounding it. It is used in sports tourism activities (snorkeling and diving). The construction of hotels began on the Island during the current research (Fig. 1).

2.1.2. Ashrafi Island:

It is located at 27°:45':57' N and 33°:42':4.49' E, with a total area of 1.4 km^2 and is approximately 12 km from the shore. The Ashrafi Island consists of three small longitudinal Islands situated at the entrance of the Gubal Strait. This coral-origin Island is characterized by submerged coral reefs separated by narrow channels (Fig. 1).

2.1.3. Ghanim Island:

It is located near the coast of Gabal El Zeit (Group of Petroleum Company) at 27°:46':23' N and 33°:35':51.7' E, with a total area of 4.6 km^2 and is about 3 km from the shore. Ghanim Island is a small Island near the popular Marsa Ras El Bahar (Fishermen's port). The Island is surrounded by submerged barrier reefs which extend to the Island of Ashrafi (Fig. 1).

2.1.4. Small Gubal Island:

It is located at 27°:41':23" N and 33°:46':34.6"E. It has a total surface area of 1.5km^2 and is about 30 km from the shore. This Island is located at the south entrance of the Suez Gulf and is characterized by a sandy beach used for tourism by safari boats. This Island is characterized by the activity of hawksbill turtles nesting (Fig. 1).

2.1.5. Northern Um Elhimat Island:

The Island is situated at 27°:39':9.1' N and 33°:38':19.45' E and is approximately 4.5 km from the coast (Ras Gemsa). It's surrounded by a submerged reef barrier. There is an oil platform located approximately 3 km east of the Island (Fig. 1).

2.1.6. South Um Elhimat Island:

This Island is situated at 27°:37':56.91' N and E33°:40':29.91' E. It lies to the south of the North Um Elhimat Island and the two Islands are surrounded by a submerged reef barrier (Fig. 1).

2.1.7. North Geisum Island

It locates at 27°:41':5.63" N and 33°:41':26.78"E and is about 0.5 km from the shore. It lies at the north of the South Geisum Island, but the two are separated by submerged back reef (Fig. 1).

2.1.8. South Geisum:

It locates at 27°:39':4.29" N and 33°:42':33.25"E, and is about 5 km west of Gubal Island, with a total area of about 9.7 km^2. This Island is characterized by a monospecific mangrove stand *Avicenna marina*, surrounded by submerged back reefs and few lagoons. This Island has an old harbor in the southern part, extends for 200 m long (Fig. 1).

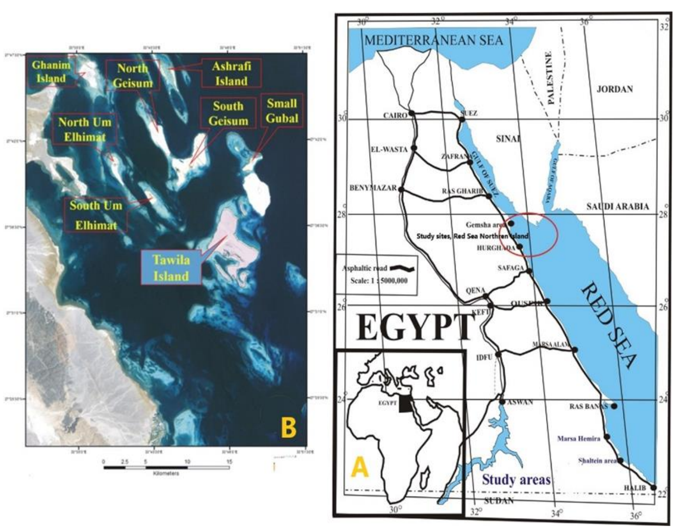


Figure. 1. Maps show the Red Sea and the general locations of Northern protected Island (A) and modern picture of Google earth 2019 show the different northern protected Islands, Red Sea, Egypt (B).

2.2. Field work:

The Line Transect method (LT) 25m length described by English et al. (1997) was used to describe the community structure of the seagrass meadows along the Red Sea Northern protected Islands (Fig. 2A). According to the seagrass meadow on each Island, the number of replicates of (LT) was different; for this purpose, 12 replicates were conducted at Tawila Island, 1 in Ghanim Island, 6 in Ashrafi Island, 4 in North Um ElHimat, 2 in North Geisum, 5 in South Geisum.

The mean coverage of the seagrass community was recorded using four times 0.25 m^2 for each line transect described by Geneid (2009) and data were recorded under the water (Fig. 2B). For the measurement of the seagrass coverage at each transect, the mean of the four quadrates was calculated. The seagrass communities were identified according to Waycott *et al.* (2004); Kuo and Den Hartog (2001); and El Shaffai (2016). In addition, 1 m^2 quadrate was used four times for each line transects (Fig. 2C) to record the abundance and distribution of associated Sea cucumber species in seagrass (Individual/m^2). The data collected was statistically analyzed using the Excel program and the results maps were used by the GIS program to explain the distribution of seagrass species at the studied sites and finally, it was signed on the GIS map (Fig. 5).

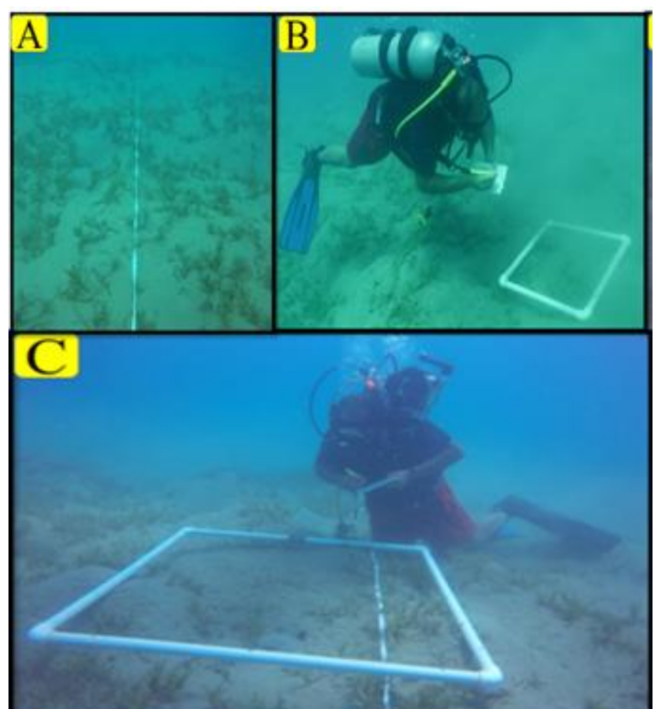


Fig. 2. Line transect (LN) defines the length of seagrass collection area (A), 0.25 m quadrate to identify the composition of seagrass species (B) and 1m^2 quadrate to record the abundance of sea cucumbers (C).

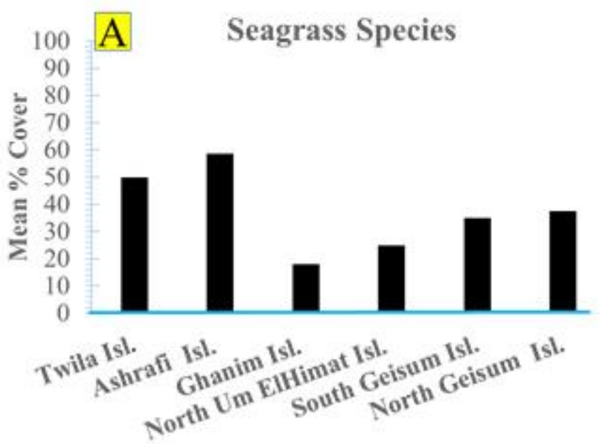
3. Result and Discussion

3.1 Results:

3.1. Species abundance of seagrass community in Northern Islands:

The abundance of seagrass community in the Northern Island showed that the higher mean coverage of seagrasses was recorded in Ashrafi Island (59%), and the lower was recorded (23%) in Ghanim Island (Table 1; Fig. 3A).

Three species of seagrass were recorded in the Northern Islands. The highest seagrass mean coverage was *Thalassodendron ciliatum* (61%), and the other two species were, *Halodule uninervis* (42%) and *Halophila stipulacea* (43%) (Table 1; Fig. 3B).



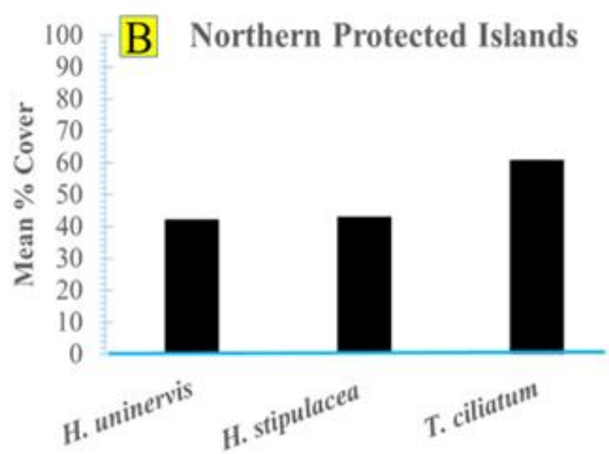


Fig. 3. Mean coverage (%) of seagrass community in different Red Sea Northern Islands (A) and Mean coverage (%) of seagrass species in all northern Islands (B).

Table 1. The occurrence of Seagrass species in different Northern protected Islands, where (-) mean seagrass species not found, (+) mean seagrass species coverage 5-40%, (++) mean seagrass species coverage 40-75% and (+++) mean seagrass species coverage 75-95%.

Islands	*Halodule uninervis*	*Halophila stipulacea*	*Thalassodendron ciliatum*
Tawila Island	++	++	++
Ashrafi Island	++	+	+++
Ghanim Island	++	+	-
Small Gubal	-	-	-
North Umm ElHimat Isl.	++	+	-
South Umm ElHimat Isl.	-	-	-
South Geisum Island	+	+	++
North Geisum Island	+	-	++

3.1.1. Tawila Island:

Three species of seagrass in Tawila Island were recorded with mean coverage were *Halophila stipulacea* 53%, *Thalassodendron ciliatum* 50%, and *Halodule uninervis* 46% (Table 1; Fig. 4A).

3.1.2. Ashrafi Island:

The result survey of seagrass species in Ashrafi Island showed that three species were recorded, Thalassodendron ciliatum 88%, Halophila stipulacea 34%, and Halodule uninervis 54% (Table 1; Fig. 4B).

3.1.3. Ghanim Island:

The result survey of seagrass species in Ghanim Island showed that two species were recorded, Halodule uninervis 42% and Halophila stipulacea 10% (Table 1; Fig. 4C).

3.1.4. North Um ElHimat Island:

The result survey of seagrass species in North Um ElHimat Island showed that two species were recorded, Halodule uninervis 41% and Halophila stipulacea 10% (Table 1; Fig. 4D).

3.1.5. South Geisum:

The result survey of seagrass species in South Geisum Island showed that three species were recorded, Thalassodendron ciliatum 43%, Halodule uninervis 33% and Halophila stipulacea 30% (Table 1; Fig. 4E).

3.1.6. North Geisum:

The result survey of seagrass species in North Geisum Island showed that two species were recorded, Thalassodendron ciliatum 45% and Halodule uninervis 30% (Table 1; Fig. 4F).

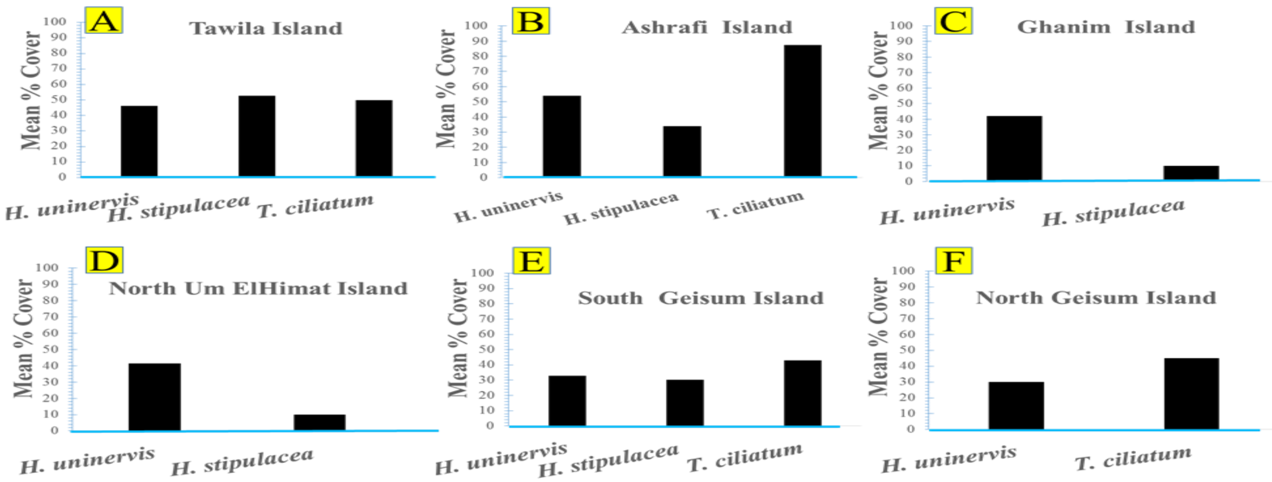


Fig. 4. Seagrass species Mean coverage (%) in Northern protected Islands. Tawila Island (A), Ashrafi Island (B), Ghanim Island (C), North Um ElHimat Island (D), South Geisum Island (E), and North Geisum Island (F).

3.2. GIS map of the distribution of seagrass species in northern protected Islands:

The distribution of the three seagrass species, *Halodule uninervis*, *Halophila stipulacea*, and *Thalassodendron ciliatum*) were recorded and mapped in all Northern Islands (Figs. 5).

3.3. Results Abundance of sea cucumber in seagrass in northern protected Islands:

Only one Sea cucumber species were recorded in the present study in all Northern protected Islands, *Holothuria atra* with very low abundance 8 Individuals/ 750 m^2 in all study sites (Table 2). The highest abundance of *H. atra* in the present study was in North Um ElHimat Island with mean abundance was 4 Individual/100 m^2 and the lowest mean was in Ghanim Island with 1 Individual/25 m^2. In three islands, Ashrafi, South Geisum and North Geisum, there is no Sea cucumber species were recorded (Table 2).

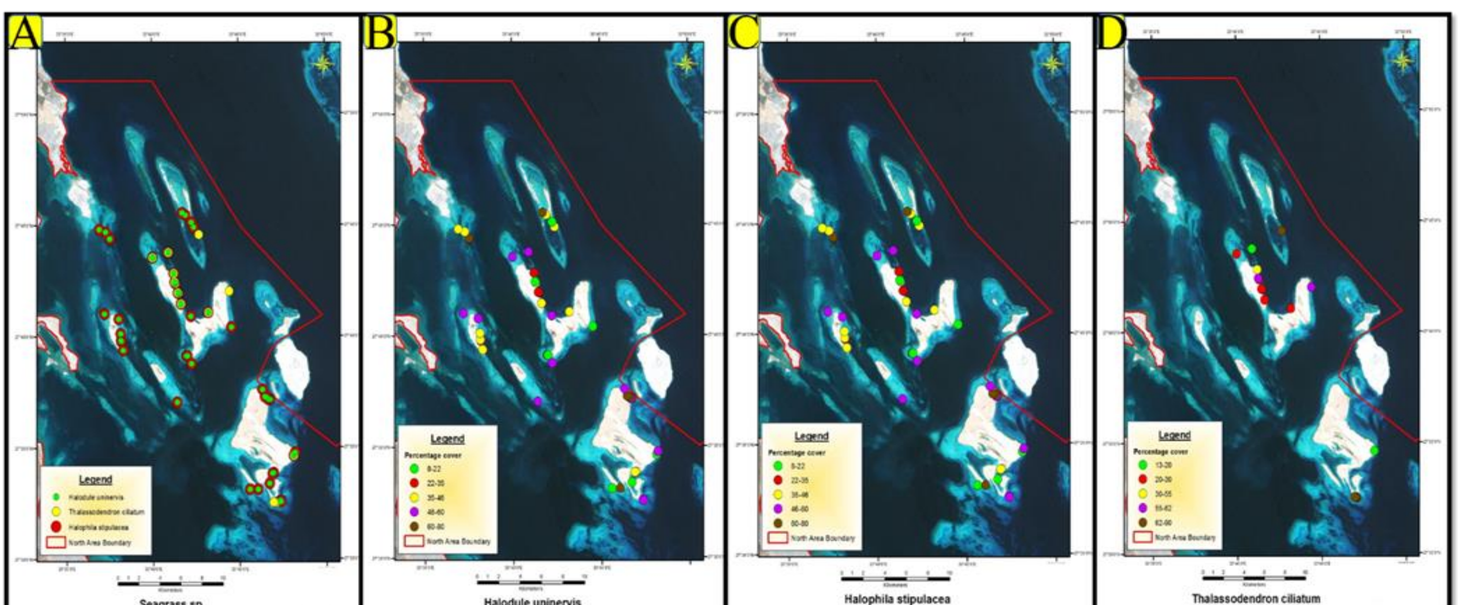


Fig.5. GIS map of seagrass species distribution in all Northern protected Islands (A), *Halodule uninervis* (B), *Halophila stipulacea* (C), and *Thalassodendron ciliatum* (D).

Table 2. The number of Sea cucumbers (*Holothuria atra*) recorded in seagrass beds in Red Sea Northern protected Islands.

Islands	Seagrass area m^2	Sea cucumber
Tawila Island	300	3
Ashrafi Island	150	0
Ghanim Island	25	1
North Um ElHimat Isl.	100	4
South Geisum Island.	125	0
North Geisum Island.	50	0
Total	750	8

3.2. Discussion:

Three species of seagrass beds in the Northern Islands, *Thalassodendron ciliatum, Halophila stipulacea*, and *Halodule uninervis*, were recorded from the twelve species of seagrass recorded in the Red Sea (Den Hartog, 1970; Lipkin and Zakai, 2003; El Shaffai, 2016). The higher mean coverage of seagrass beds in the current study were recorded in Ashrafi Island with mean coverage reach 59% and the lower coverage was recorded in Ghanim Island with 23%. No seagrass species was recorded in the Small Gubal Island and South Um ElHimat Island. In all Northern Island *Thalassodendron ciliatum* was the highest abundance of seagrass with percentage cover of 61%. In the other hand, the two species *Halophila stipulacea and Halodule uninervis* were more widely distributed than *Thalassodendron ciliatum* where they recorded in most northern Islands with abundance covering reach 43% and 42%, respectively. The present study agrees with most research on the northern Red Sea seagrass community. Al Rousan et al. (2011) they studded the distribution and abundance of seagrass communities in three sites along the Jordanian coast at the Gulf of Aqaba, Red Sea they find three species of seagrass, *Halophila stipulacea*, *Halodule uninervis* and *Halophila ovalis* and they find that in all locations, *Halophila stipulacea* has the widest distribution in all sites.

Our result was consistent with Geneid (2009), who examined seagrass distribution and abundance at 29 Egyptian Red Sea sites and observed six species of seagrass, *Halophila ovalis*, *Halophila stipulacea*, *Halodule uninervis*, *Thalassia hemprichii*, *Thalassodendron ciliatum* and *Syringodium isotifolium*. Two species of seagrass, *Halophila stipulacea* and *Halodule uninervis*, have been recorded on two northern Red Sea Islands (Tawila Island and Um ElHimat Island) (Geneid, 2009). The inconsistency between the current study and Geneid (2009) study, that we observed three species of seagrass and he observed two only, may be because we surveyed a large area of the islands (12 replicas in the current study in Tawila Island) as the island has a 21.5 km^2 area.

The Egyptian Red Sea coast's seagrass ecosystem is largely undisturbed by man-made impacts, with the exception of local areas near cities and larger towns.
Here, major local modification in the occurrence of the systems (e.g. Hurghada region and northern island). The impacts of landfill and coastal engineering cause degradation of nearshore seagrass beds either by direct covering or by reducing light through increased turbidity; the latter effect will affect wide areas of operations and sandmining surrounding the site. Increased nutrients produce blooms of plankton and higher biomass of periphyton that affect the accessibility of light to seagrass leaves. Small increases in nutrients in seagrass ecosystems can stimulate growth, but excessive loads of nutrients are destructive (Technical Repot, 1987).

In the present study, in all northern islands, very low abundance of sea cucumber was reported; only 8 individuals were cited in the field, with only one species of *Holothuria atra*. The low abundance can be associated with overfishing of Sea cucumbers. In the northern Red Sea, particularly in the northern city of Hurghada, the low abundance of sea cucumber was shown (Mahdy et al., 2018), and the decrease in sea cucumber in the Red Sea according to overfishing is documented by Ahmed and Lawrence (2007). Globally, the over-harvesting of sea cucumbers has led to the decline of wild stocks (Hamel et al., 2013). In the marine ecosystem, sea cucumbers play a useful role in helping to recycle nutrients, break down detritus and other organic matter, after which bacteria can continue the process of degradation. However, holothurian overfishing could have a negative impact on the productivity of seagrass systems (Wolkenhauer et al., 2010). The possible positive effects of holothurians on seagrass and algae could be through direct release or recycling of nutrients as they feed on bacteria, microalgae and organic detritus attached to sediment grains (Wiedemeyer, 1992), thus increasing nutrient levels in the water column in close proximity (Grall and Chauvaud, 2002).

Chemical and oil pollution will lead to destructive impacts that are trivial. The introduction of heavy metals into the ecosystem of seagrass, particularly from oil spills, can contaminate food chains without clearly affecting the structure of the system. Especially since the study areas are located in the oil production areas, which are the areas of the northern islands. On the Egyptian Red Sea coast, thermal discharge recognized as detrimental to tropical seagrass systems has local but limited effects. These challenges are compounded by a lack of developmental environmental assessment procedures, a lack of awareness of the importance of seagrasses, and a lack of information on their distribution. Seagrass beds are affected by the fauna, most notably turtles, *Dugong dugong*, commercial fish and crustaceans and birds, which depend on them. Global experience, on the other hand, indicates that seagrass beds are integral to the annual life cycle and recruitment process. Finally, the importance of seagrass meadows as structural components of coastal ecosystems has led to new research interests focusing on seagrass biology and ecology and on methods for mapping, monitoring and protecting critical habitats of seagrass.

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