Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 26(2): 17 – 29 (2022)
www.ejabf.journals.ekb.eg

Distribution of Seagrass Communities and associated sea cucumbers in North Red Sea Protectorates, Hurghada, Egypt

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ARTICLE INFO

Article History:
Received: Jan. 14, 2022
Accepted: Jan. 27, 2022
Online: March 2, 2022

Keywords:
Seagrass,
Density,
Halophila stipulacea,,
Sea cucumber,
Red Sea,
Egypt

ABSTRACT

The current research was carried out to understand the diversity and distribution of seagrass beds and the associated sea cucumbers in order to support decision makers in the management of the natural resources. During 2019, six sites were surveyed using scuba diving and snorkeling; two of them are located within the boundaries of the Northern Protected Islands (Shaab Saad and El Fanader reefs), two sites around Hurghada offshore islands (Abu Monqar Island and south El Gifton Island). For the other two sites, one lies offshore (Shabrour El Sheraton) while the other is known as Milia Pharoun and is found inshore near the Hurghada coast. Two species of seagrass; namely, *Halophila stipulacea* and *Thalassodendron ciliatum* were recorded. Results revealed that in all sites, *H. stipulacea* showed the highest abundance with a mean coverage of 50%, while *T. ciliatum* was detected with a cover percentage of 10. Abu Monqar Island has the highest abundance of seagrass with a mean coverage of 65% compared to the lowest mean coverage of 15 % at Shabrour El Sheraton. The sea cucumbers recorded at all study sites represented five species, including *Holothuria atra*, *H. fuscogliva*, *H. scabra*, *Actinopyga mauritiana* and *A. miliaris*; all occurred at a low abundance.

1. INTRODUCTION

The northern Red Sea has a variety of habitats especially coral reefs **(Ghallab *et al*., 2020)** and an abundance and diversity of seagrass **(Mahdy *et al.*, 2020)**. The diversity of ecosystems in Hurghada gains the attraction of ecotourism, where the activities of diving, snorkeling, fishing and a lot of daily tripsand safari boats are found **(Ghallab *et al.*, 2020, Mahdy *et al*., 2020)**. 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 marine environment **(Costanza *et al*., 1997)**. For climate and food security, seagrass ecosystems possess a global significance, but they remain rather unknown and on the periphery of marine conservation **(Duarte *et al*., 2008)**. Six main global challenges are encountering seagrass conservation, among which the followings are considered: (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, which is unknown, and hence 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 requirements of humans and the planet; (5) research into seagrass should be broadened to generate scientific research that supports conservation activities; and (6) in order to adapt conservation accordingly, an increased understanding of the linkages between seagrass and climate change is needed **(Unsworth, 2018)**.

It is well known that, 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 ecosystem and coral reefs **(Nordlund *et al.*, 2017)**. They form, for instance, vast filters of the coastal environment, cycling nutrients and reducing disease-causing bacterial pathogens of humans and marine organisms. In addition, for mega-herbivores such as green sea turtles and *Dugong dugon*, 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 sea grasses in the Red Sea form vast meadows from the tidal zone to the depths of 70 m **(Hulings, 1979; Lipkin, 1979; Head & Edwards, 1987; Lipkin *et al*., 2003)**. Due to the soft-bottom sediments in these regions, they tend to concentrate in shallow water habitats, including lagoons, sharms and mersas **(Den Hartog, 1970)**. Two families with 12 seagrass species were recorded in the Red Rea. Family Cymodoceaceae contains *Cymodocea rotundata, Cymodocea serrulate, Halodule pinifolia, Halodule uninervis, Syringodium isoetifolium*, and *Thalassodendron ciliatum*, while family Hydrocharitaceae contains *Exhales acoroides, Halophila decipiens, Halophila ovalis Halophila minor, Halophila stipulacea* and *Thalassia hemprichii* **(Den Hartog, 1970; Lipkin and Zakai, 2003; El Shaffai, 2016)**. Three species of sea grasses were recorded in the northern Red Sea Protected Islands, among which *Halophila Stipulacea, Thalassodendron Ciliatum* and *Halodule uninervis* were identified. Remarkably. the species of *Thallasodendron ciliatum* showed the highest abundance **(Mahdy *et al*., 2020)**. Seven species were reported in the Gulf of Aqaba, however, only *H. stipulacea* and *H. ovalis* were reported at the extreme northern end **(Wahbeh & Mahasneh, 1980)**.

On contrast, ten species of seagrasses were recorded along the Saudi Arabian shore, while the northern end of the Gulf of Aqaba recorded a low abundance of seagrass, since 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 were detected, of which only three were recorded from the Gulf of Aden coast. On the other hand, with respect to the western Indian Ocean, thirteen species of seagrasses were identified **(Gullström *et al.*, 2002)**. In the Red Sea, the seagrass species, *Halophila stipulacea* was defined with a broad ecological range from the intertidal to depths greater than 50-70 m **(Fishelson, 1971; Lipkin, 1975, 1979; Hulings, 1979; Beer & Waisel, 1982; Lipkin *et al*., 2003; El Shaffai *et al*., 2011)**. Seagrass beds usually occur in lagoons and bays in protected shallow areas. Moreover, they are inhabited by a diverse fauna and are more prevalent in the shallow southern area of the Red Sea **(Rasul *et al*., 2015)**. The distribution of seagrasses 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)**, perhaps about 10% of the species in seagrass beds occurs nowhere else **(Rasul *et al*., 2015)**. **Wahbeh and Mahasneh (1980)** found more than 49 species of invertebrates (mostly mollusks) living in seagrass beds in the northern Gulf of Aqaba, either attached to the plant (gastropods) or burried in the sediment (bivalves). Similar finding was attained in the study of **Osman (2007)** regarding the Hurghada sites. The previous author found that gastropods and bivalves are the most dominant groups 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, forming a juvenile habitat for a variety of commercially important crustaceans and fish. In addition, they provide food for important species (*Dugong dugon* and turtles) and probably nutrients and energy are likely to be exported to adjacent subtidal systems **(Rasul *et al*., 2015)**. **Ahmed and Lawrence (2007)** reported the decline of sea cucumber in the Red Sea as a result of over-fishing.

The objective of the current work was to understand the abundance and distribution of the seagrass communities at different sites of the northern Red Sea in order to support decision-makers to manage the natural resources, particularly seagrass communities.

2. MATERIALS AND METHODS

2.1. Study sites

During 2019, six sites were surveyed using scuba diving and snorkeling, including Shaab Saad, El Fanader reef, Abu Monqar Island, South El Gifton Island, Shabrour El Sheraton and Milia Pharoun **(Fig. 1)**.

2.1.1. Shaab Saad: This site is located north to Hurghada City. It takes about 45 min from Hurghada Harbor to reach it using a diving boat. This site lies inside the boundary of North Islands Protectorates. It contains a big reef batch, surrounded by a vast extended meadows of seagrass bed (Fig. 1 & Table 1).

2.1.2. El Fanader Reefs: It is a submerged reef island located north of Hurghada port at about 30 minutes distance with a diving boat and is also located inside the boundary of North Islands Protectorates. Four low small rocky patches over the reef flat characterize this reef. The seagrass bed extends at the entire lagoon of El Fanader (Fig. 1 & Table 1).

2.1.3. Abu Monqar Island: This island lies in front of Hurghada Port at about 15 minutes distance with a diving boat and is also located inside the boundary of Red Sea Protectorates. There is a big mangrove standing in this island, which marks the island. it The seagrass bed surrounds the south side of this island (Fig. 1 & Table 1).

2.1.4 South El Gifton Island: This site is named Shaab El Skalla. It is a fringing reef surrounding Big Gifton Island. It lies at the south east side of the island in front of Hurghada Port at about 45 minutes distance with a diving boat. It is located inside the boundary of Red Sea Protectorates (Fig.1 & Table 1).

2.1.5. Shabrour El Sheraton: This site comprises submerged reefs located south of Hurghada Port at about 30 minutes distance with a diving boat, but it lies out of the boundary of the North Red Sea Protectorates. There are several coral patches scattered in this area surrounded by seagrass beds in addition to dead coral patches (Fig 1 & Table 1).

2.1.6. Milia Pharoun: It is a fringing reef located in front of Milia Pharoun Resort south of Hurghada, and this is the only on shore site in this study located out of the boundary of the Northern Red Sea Protectorates. Seagrass beds extend in front of the reefs (Fig. 1 & Table 1).

Table 1. The coordinates and names of the study sites

		Coordinates	
No.	Site name	Latitude (N)	Longitude (E)
1	Shaab Saad	27 11 16.7	33 56 21.4
2	El Fanader	27 13 1.2	33 53 29
3	Abu Monqar Island	27 19 2.2	33 46 44.4
4	South Gifton Island	27 17 3.7	33 49 49.2
5	Shabrour Sheraton	27 10 20.1	33 51 4.4
6	Milia Pharoun	27 05 25.76	33 51 19

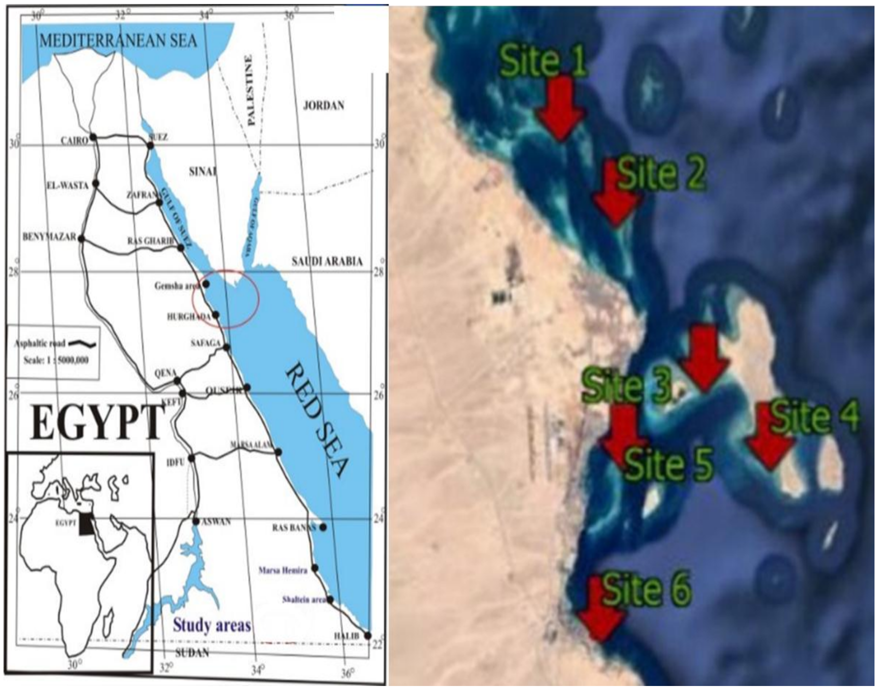

Fig. 1. Map showing the study sites

2.2. Field work

2.2.1. Seagrass percentage covers

The Line Intercept Transect method (LIT) (25m length) described by **English *et al*. (1997)** was used to describe the percentage cover and abundance of the seagrass meadows along the study sites. At each LIT, four replicates of quadrates ($0.25m^2$) were used to collect the data about the percentage cover and abundance of each species occurring in each quadrates. The obtained data were recorded on underwater sheet, and then the mean of the four quadrates was calculated for each intercept, and the total mean for the ten intercept was calculated to measure the percentage cover of seagrass at each transect. The seagrass species were identified following the descriptions of**Kuo and Den Hartog (2001)**, **Waycott *et al*. (2004)**, **Geneid (2009)** and **El Shaffai (2016)**.

2.2.2. Sea cucumber abundance and species identification

A quadrate of $1m^2$ was used four times to collect the field data about the number of individuals of each species of the sea cucumber occurring in each quadrate. The obtained data were recorded on the underwater sheet, and then the mean of the four quadrates was calculated to know the number of sea cucumber/m^2. The sea cucumber species were identified according to the description of **Nasser *et al*. (2019)**.

3. RESULTS

3.1. Species abundance of seagrass communities in the study sites

The abundance of seagrass community in the study sites showed that the highest mean coverage of seagrasses was recorded at Abu Monqar Island (65%), and the lowest was 15%, recorded at Shabrour El Sheraton (Table 2 & Fig. 2). Two species of seagrasses, *Halophila stipulacea* and *Thalassodendron ciliatum* were recorded in the study sites. The first species *H. stipulacea* recorded the highest seagrass mean coverage (50%), while the second species *T. ciliatum* had only 2% percentage cover (Fig. 3).

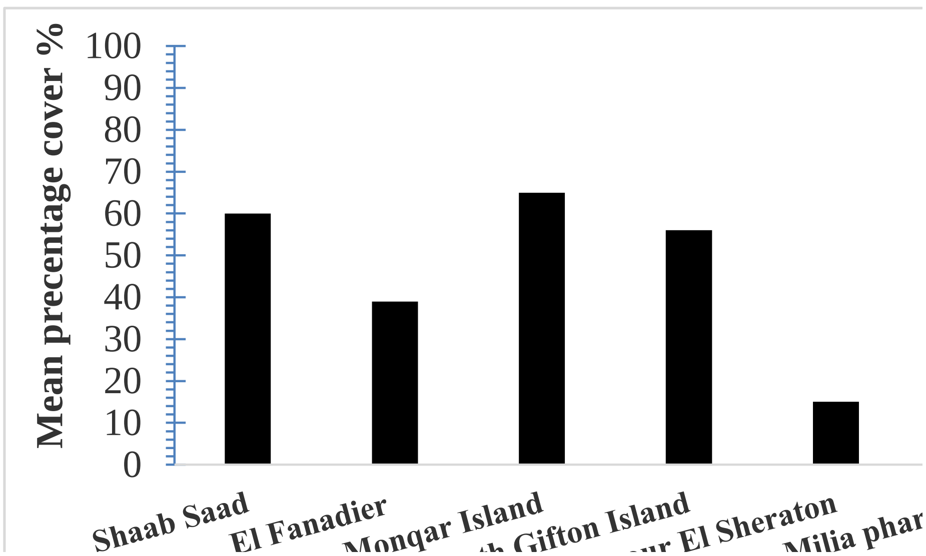

Fig. 2. A histogram showing the percentage cover (%) of seagrass communities at the study sites.

Table 2. The occurrence of seagrass species at the study sites

Site \ Seagrass species	*Thalassodendron ciliatum*	*Halophila stipulacea*
Abu Monqar Island	-	++
South Gifton Island	-	++
Shaab Saad	-	++
El Fanader Reef	-	+
Shabrour El Sheraton	-	+
Milia Phroun	+	++

Note that: (-) means seagrass species not found, (+) seagrass species coverage 5-40%, (++) seagrass species coverage 40-75%.

3.2 Spatial variations in seagrass beds

The field survey of seagrass showed that, only one species, *Halophila stipulacea*, was recorded at the following five sites: Abu Minqar Island, Shaab Saad, Milia Pharoun, South El Gifton Island, El Fanader Reefs and Shabrour El Sheraton. The percentage cover was variable and averaged 65%, 60, 60, 56%, 60%, 39% and 15 % at those sites, respectively (Table 2 & Fig. 2). Contrarily, the two species of seagrasses, *Halophila stipulacea* and *Thalassodendron ciliatum* were recorded, with percentage cover of 50% and 10 %, respectively (Fig.3).

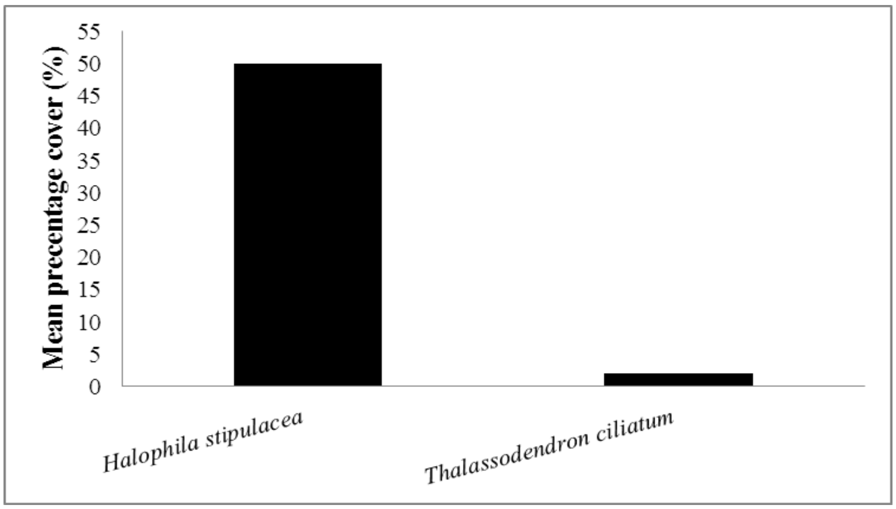

Fig. 3. Percentage cover (%) of seagrasses *H. stepulacea* and *T. ciliatum* recorded at the study sites

3.3. Density of sea cucumber at seagrass communities of the study sites

Five species of sea cucumbers were recorded at different sites, including *Holothuria atra*, *Actinopyga miliaris. Actinopyga mauritiana Holothuria fuscogliva* and *Holothuria scabra* (Table 3 & Fig. 4,5). These species were recorded with very low abundance in all study sites. It was found that, the highest number of sea cucumber species (4 species) was registered at Milia Pharoun, with only one species at Shaab Saad (Table 3 & Fig. 5). The means population density of sea cucumber species are given in Table (3) and Fig. (4,5). In all sites, the highest sea cucumber density was *H. atra*, with total mean in all sites of 9.8 Ind./200m^2, while the lowest mean was *A. miliaris*, with 1.6 Ind./200m^2 (Fig. 5). In addition, *H. atra* was recorded in three sites with the hugest density (5 Individuals /200m^2) at Milia Pharoun, followed by El Fanader Reefs (3.2 Ind./200m^2), while the densities of other species were similar at other sites (Table 3 & Fig.5).

Table 3. The mean values of sea cucumber density recorded at seagrass beds at the study sites

Sea cucumber species	Site	No. of Individual/200m^2	Summation of Individual/200m^2
Holothuria atra	El Fanader Reefs	3.2	9.8
	Shabrour El Sheraton	1.6	
	Milia Pharoun	5.0	
Actinopyga miliaris	Shaab Saad	1.6	1.6
Actinopyga mauritiana	Abu Monqar Island	1.6	3.2
	Milia Pharoun	1.6	
Holothuria fuscogliva	Shabrour El Sheraton	1.6	3.2
	Milia Pharoun	1.6	
Holothuria scabra	Shabrour El Sheraton	1.6	3.2
	Milia Pharoun	1.6	

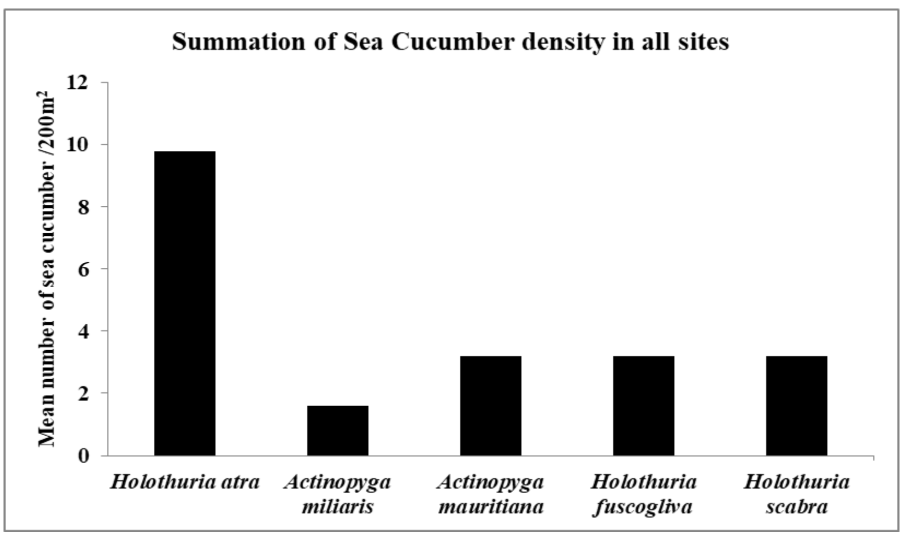

Fig. 4. A histogram showing the values of population density of sea cucumber species recorded at different study sites

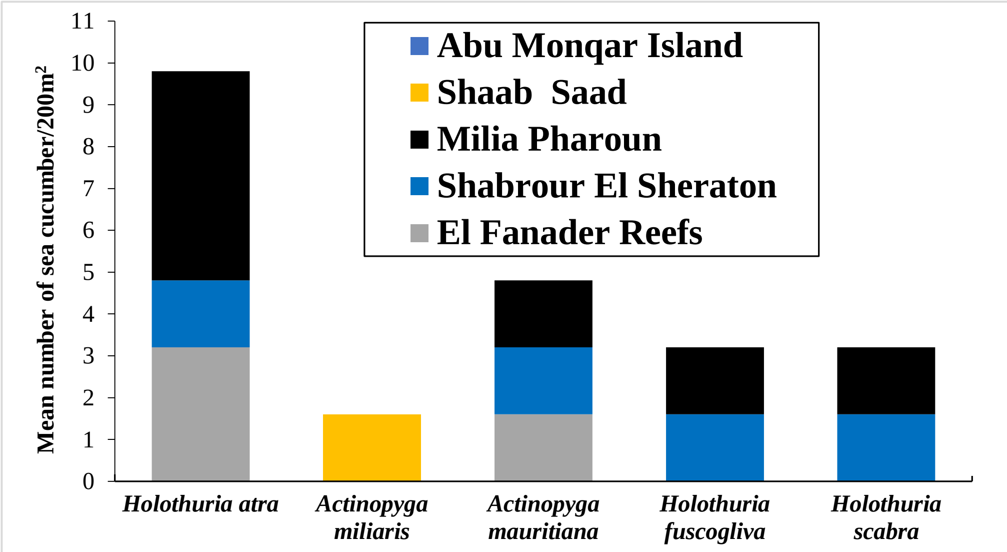

Fig. 5. A histogram showing the values of population density of sea cucumber species recorded at different study sites

4. DISCUSSION

Two species of seagrasses were recorded at study sites; namely, *Halophila Stipulacea* and *Thalassodendron ciliatum* out of the twelve speciesrecorded in the Red Sea th**(Den Hartog, 1970; Lipkin & Zakai, 2003; El Shaffai, 2016)**. The higher mean coverage of seagrass beds in the current study was recorded at Abu Monqar Island, with mean coverage reaching 65%, and the lower coverage was 15% at Shabrour El Sheraton. At all study sites, *Halophila stipulacea* showed the highest percentage cover (50%). On the other hand, *Thalassodendron ciliatum* was found only in one site (Milia Pharoun) with percentage cover of 2%. The number of seagrass species recorded in the current study agree with most researches conducted on the northern Red Sea. **Mahdy *et al*. (2020)** studied the distribution of seagrass at the Northern Islands of the Red Sea and recorded three species , *Thalassodendron ciliatum*, *Halophila stipulacea* and *Halodule uninervis*. The higher mean coverage of seagrass beds was recorded at Ashrafi Island, with a mean coverage that reached 59%, compared to the lowest coverage of 23% at Ghanim Island. No seagrass species were recorded around either the Small Gubal Island or the South Um El-Himat Island. It was also noted that at all Northern Islands, *Thalassodendron ciliatum* was the most abundant and showed the highest percentage cover of 61%. On the other hand, the other two species, *Halophila stipulacea* and *Halodule uninervis* were more widely distributed than *Thalassodendron ciliatum*, where they were recorded in most of the northern Islands, with percentage covers reaching 43% and 42%, respectively.

The present results agree with that of **Al Rousan *et al*. (2011)**. They studied the distribution and abundance of seagrass communities in three sites along the Jordanian coast at the Gulf of Aqaba, Red Sea. The previous authors recorded three species of seagrass, *Halophila stipulacea, Halodule uninervis* and *Halophila ovalis* and reported that *Halophila stipulacea* had the widest distribution at all sites. Additionally, the obtained result concurs with that of **Geneid (2009)**. He examined seagrass distribution and abundance at 29 Egyptian Red Sea sites and recorded six species of seagrass; namely, *Halophila ovalis, H. stipulacea, Halodule uninervis, Thalassia hemprichii, T. ciliatum* and *Syringodium isotifolium*. Only two species of seagrass, *H. stipulacea* and *H. uninervis*, were recorded in two northern Red Sea Islands (Tawila Island and Um El-Himat Island). With the exception of isolated areas around cities and larger towns, the Egyptian Red Sea coast's seagrass ecology remains generally unaffected by man-made impacts. Here, there is a significant change in the incidence of the systems on a local level (e.g. Hurghada region and northern islands). Landfill and coastal engineering impacts degraded nearshore seagrass meadows either by direct covering or by lowering light through increased turbidity; the latter effect would influence vast areas of operations and sand mining around the site. Increased nutrients cause plankton blooms and periphyton biomass, which impact the accessibility of light to seagrass leaves. Small increases in nutrients can help seagrass ecosystems develop, while excessive amounts of nutrients might be harmful **(Technical Repot, 1987)**.

In the present study, very low density of sea cucumber was reported and comprised five species recorded in the field, including *Holothuria atra, Holothuria fuscogliva, Holothuria scabra, Actinopyga mauritiana* and *Actinopyga miliaris*. The low density of recorded species can be attributed to the over-fishing of sea cucumbers. In the northern Red Sea, particularly in the city of Hurghada, the low abundance of sea cucumber was remarkable **(Mahdy *et al*., 2018, 2020)**.The decrease in sea cucumber in the Red Sea is due to over-fishing documented in the study of **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 recycling nutrients, breaking down detritus and other organic matters, after which bacteria can continue the process of degradation. However, holothurian over-fishing 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 determined through direct release or recycling of nutrients as they feed on bacteria, microalgae and organic detritus attached to sediment grains **(Wiedemeyer, 1992)**, and thus increasing nutrient levels in the water column in close proximity **(Grall & Chauvaud, 2002)**. Finally, in spite of the remarkable abundance and extended distribution of seagrass community in the north Red Sea at Hurghada city, it is associated with the low abundance of sea cucumber due to over-fishing. It would definitely take a lot of effort in the future to save these resources and stop their reduction caused by the over-fishing of sea cucumber. For the sake of this purpose, decision makers should follow the monitoring program and the marine survey related to the seagrass in the northen Red Sea.

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