

## Ecological status of seagrass community in Sharm El-Moyia Bay, Egyptian Red Sea after its oil pollution in 1999

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### ABSTRACT

After four months of the oil pollution of Sharm El-Moyia Bay, the species composition, abundance, and distribution of seagrasses and associated macro-invertebrate fauna at oiled and non-oiled sites were investigated. The most abundant Seagrass, *Halophila stipulacea*, grows to a depth of 3m on soft bottom substrates with standing crop ranging from 25 to 280 gdw<sup>m</sup><sup>-2</sup>. Leaf morphology and indicators of vegetative and sexual growth suggested that the meadow of this species at different sites of the bay is still healthy, despite being exposed to oil pollution. Biometric analyses indicated that the seagrass *Halophila stipulacea* was experiencing a seasonal transition and initializing a normal growth pattern from low winter temperature to spring conditions. Based on the field observations it is concluded that while oil pollution may lead to local destruction of macro-invertebrate fauna associated with the seagrass, it also did not cause any degradation to the seagrass meadow. No evidence supports the idea that oil floating above seagrasses may damage them.

**KEYWORDS:** oil pollution, seagrasses, Gulf of Aqaba, Sharm El-Moyia Bay, Red Sea

### INTRODUCTION

At the end of 1998, Sharm El-Moyia Bay began to be polluted with oil. At first, the source of pollution was unknown. By August 1999, it was clear that the source of pollution was diesel oil dumped in areas close to the shore during the transfer of old power plant from the southern-western region of the bay (Ras Mohamed Marine Park, personal communications). This dumped oil continued to leak through rocks to the western water of the bay during 1999. At that time, huge amounts of oil were released into the bay. The tourist importance of the bay with its many luxury hotels promoted concern about the effects and possible treatment of this pollution. Through this concern, the ecology of oil spills and related environmental conditions were documented (Hanafy & Kotb 1999). A large part of the oil accumulated along the western and southern-western shore of the bay, polluting both the water and the sediment (Hanafy & Kotb 1999). Within these shallow sub-tidal areas grows the productive seagrass community (Gab-Alla 1996), favoured habitats for many species of invertebrates and fish (Ahmed 1992; Gab-Alla 1996).

This paper reports the results of field work examining the impact of the oil pollution on the ecology of the community of the seagrass *Halophila stipulacea*, the dominant species inhabiting Sharm El-Moyia Bay.

### MATERIALS AND METHODS

Sampling was conducted during April 1999 in Sharm El-Moyia Bay, located on the western coast of the Gulf of Aqaba between Sharm El-Sheikh City and its harbour (Fig. 1). Eleven sites were chosen at different locations in the bay according to the survey done by the Marine Sciences Department of Suez Canal University in March 1999 (Hanafy & Kotb 1999). These sites covered the entire area of the bay.

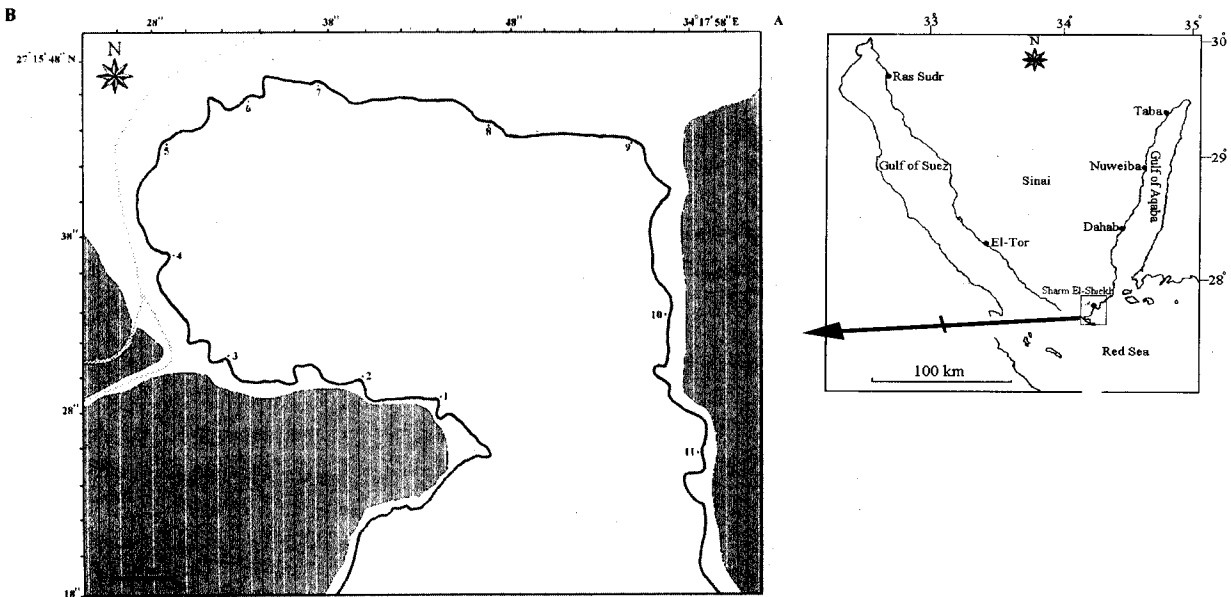


Figure 1. A) Map of the Southern Sinai Peninsula showing the location of Sharm El-Sheikh. B) Locations of the sampling sites at Sharm El-Moyia Bay (after Hanafy & Kotb 1999).

A pilot survey showed that the seagrass *Halophila stipulacea* and the seaweed *Caulerpa racemosa* were the flora with the greatest cover in the area of study. One or the other or both were represented in the vegetation inhabiting the different sampling sites. At each sampling site, I recorded the temperature (using a glass mercury thermometer), salinity (using a refractometer), and water depth, and carried out a quantitative sampling of the vegetation (seagrass and seaweed), together with semi-quantitative visual observations of the epiphytes and fauna of the seagrass.

The abundance of vegetation was quantified by three methods: 1) total biomass in grams dry weight per square meter ( $\text{gdwm}^{-2}$ ); 2) density of *Halophila stipulacea* in shoots per square meter ( $\text{m}^{-2}$ ); and 3) a modified Braun-Blanquet cover-abundance scale (Braun-Blanquet 1965).

Samples of seagrass were obtained at each site by using  $0.25\text{m}^2$  quadrat. To optimize the sampling process, four randomized samples were taken at each site (Kershaw 1980). Each sample consisted of all seagrass plant material with its roots and rhizomes to a depth of 15-20cm in the substratum. After the quadrat was placed on the sea bottom, a knife was used to cut around its inside edge. This ensured that attached plant material outside the quadrat was not taken in the sample. Each quadrat was placed in a bag (5mm mesh) and rinsed free of sediment. Macroscopic epiphytes (if present) were carefully scraped from the leaves, and the number of shoots were counted. At sites where seaweed *Caulerpa racemosa* was present, its biomass was estimated by collecting all seaweed material in four replicate  $1 \times 1\text{m}$  quadrats.

In the laboratory, the plant material was rinsed in 5% phosphoric acid to digest adhering carbon material, and then placed in an oven at  $60^\circ\text{C}$  and dried to a constant weight.

Braun-Blanquet cover-abundance scale: At each site, a minimum of four  $0.25\text{m}^2$  (*Halophila stipulacea*), or four  $1\text{m}^2$  (*Caulerpa racemosa*) quadrats were arbitrarily laid on the bottom. The seagrass or the seaweed occurring within the quadrats were assigned a cover-abundance scale value: 0.1- solitary, with low cover; 0.5- few, with low cover; 1- numerous, but less than 5% cover; 2- numerous, with 5-25% cover; 3- numerous, with 25-50% cover; 4- numerous, with 50-75% cover; 5- numerous, with more than 75% cover. The frequency of occurrence, abundance and density of the seagrass and seaweed were calculated by the following three formulae:

Frequency = no. of occupied quadrats/total no. of quadrats

Abundance = sum of Braun-Blanquet scale values/no. of occupied quadrats

Density = sum of Braun-Blanquet scale values/total no. of quadrats

**Statistical analysis:** Data for seagrass *Halophila stipulacea* (percentage cover, shoot density, and biomass) and seaweed *Caulerpa racemosa* (percentage cover and biomass) at polluted and non-polluted sites were tested statistically by analysis of variance (one-way ANOVA). Mean values were considered significant when  $p < 0.05$ .

## RESULTS

**Environmental conditions:** In the water column of Sharm El-Moyia Bay, the salinity ranged from 41 to 43‰, and temperature from 24°C to 26°C at different sites (Table 1). The bay bottom is mainly sedimentary covered with fine sand at different sites except at the entrance where small patches of rocks and corals exist. These coral patches do not exceed 10 % cover of the rocky substrates. Oil slicks were observed, floating over the water of the sites 2, 3, and 4. New man-introduced sandy sediments were covering the shore (sites 5, 6, 7, and 8) in the front of resorts and extending to sub-tidal region of the bay.

Table 1. Status (oiled, non-oiled), water depth, temperature and salinity of different sampling sites of Sharm El-Moyia Bay. Note that position and status of the sites were detected (according to Hanafy & Kotb 1999).

Site	Position	Status	Depth (m)	Temp. (°C)	Salinity ‰
1	27° 51' 29" N, 34° 17' 44" E	non-oiled	2	25 ± 2	42 ± 2
2	27° 51' 30" N, 34° 17' 40" E	oiled	1.5	26 ± 1	42 ± 2
3	27° 51' 31" N, 34° 17' 32" E	oiled	2	26 ± 1	43 ± 1
4	27° 51' 37" N, 34° 17' 29" E	oiled	2.5	24 ± 2	43 ± 1
5	27° 51' 43" N, 34° 17' 29" E	non-oiled	1.5	24 ± 2	42 ± 2
6	27° 51' 45" N, 34° 17' 33" E	non-oiled	1.5	24 ± 2	42 ± 2
7	27° 51' 46" N, 34° 17' 38" E	non-oiled	2.5	25 ± 1	43 ± 2
8	27° 51' 44" N, 34° 17' 47" E	non-oiled	2	25 ± 2	42 ± 1
9	27° 51' 43" N, 34° 17' 55" E	non-oiled	1	26 ± 1	43 ± 1
10	27° 51' 34" N, 34° 17' 57" E	non-oiled	1.5	26 ± 2	43 ± 1
11	27° 51' 26" N, 34° 17' 58" E	non-oiled	1.5	25 ± 2	43 ± 1

**Vegetation density and biomass:** Three seagrass species *Halodule uninervis*, *H. ovalis*, and *Halophila stipulacea* were recorded during this survey. The most abundant species is *H. stipulacea*. It has a wide distribution at sites 1, 2, 3, 4, 9, 10, and 11 along the bay. The other two species *Halodule uninervis* and *H. ovalis* were restricted only to the intertidal region of the site 2 in a very localized strip, parallel to the shore, of 1-2m wide. The seagrass meadow of *H. stipulacea* has a percentage cover ranging from 10% at sites 9, and 10; to 100 % at site 2 (Table 2). The highest shoot densities of *Halophila stipulacea* was higher at the oiled site 2 than the non-oiled site 1 (5000 and 4800 shoots m<sup>-2</sup>, respectively). The lowest shoot densities occurred at sites 9, and 10 (non-oiled), where about 1000 shoots m<sup>-2</sup> were recorded at each site (Table 2).

The seaweed *Caulerpa racemosa* was present in the sites 2, 3, 4, 5, 6, 7, and 8 and was only found at the north (sites 6, 7, 8) and western-north shore of the bay (site 5). Its percentage cover ranged from 30 % to 100 %. This cover was very high at the polluted area, representing 100 %, 90 %, and 70 % at sites 2, 3, and 4, respectively. Nevertheless its percentage cover was 30%, 30%, 40 % and 70 % at sites 6, 7, 8, and 5, respectively (Table 2).

The total biomass of *H. stipulacea* at the heavily oiled sites, ranged between 255 and 280 gdw m<sup>-2</sup>, while, the biomass value of seagrass at the non-oiled site 1 was 270 gdw m<sup>-2</sup>. The total biomass of the seaweed *C. racemosa* was higher in oiled sites than in non-oiled ones. The recorded biomass were 200,190, 125 gdw m<sup>-2</sup> at the oiled sites 2, 3, and 4, whereas it was 130, 45, 30, and 50 gdw m<sup>-2</sup> at sites 5, 6, 7, and 8, respectively. The difference between percentage cover, shoot density, and biomass for the seagrass *Halophila stipulacea* at site 1

and site 2 was not statistically significant ( $p>0.05$ ). Also, there was no obvious difference between percentage cover and biomass of the seaweed *Caulerpa racemosa* at site 4 and site 5 ( $p>0.05$ ). Other non-polluted sites showed significant difference from the polluted sites ( $p<0.05$ ), which may be attributed to the suitable environmental conditions at the west and south-west of the bay, leading to high biometric data for *H. stipulacea* and *C. racemosa* at the polluted sites.

Table 2. Biometric parameters of seagrass *Halophila stipulacea* and seaweed *Caulerpa racemosa* at different sampling sites of Sharm El-Moyia Bay. \* Stations 1-4: Climax seagrass community; \* Station 9 -11: New growing seagrass community

Species	Sites										
	1	2	3	4	5	6	7	8	9	10	11
<i>Halophila stipulacea</i>											
Percentage cover	98 ±2	100 ±0	85 ±5	80 ±5	-	-	-	-	10 ±2	10 ±2	15 ±5
Shoot density (No. of shoots m <sup>-2</sup> )	4800 ±200	5000 ±300	4500 ±100	4500 ±100	-	-	-	-	1000 ±50	1000 ±40	1200 ±100
Total biomass (D Wt m <sup>-2</sup> )	270 ±30	280 ±30	260± 25	255 ±25	-	-	-	-	30 ±5	25 ±3	27 ±3
Percentage cover	-	100 ±0	90 ±7	70 ±5	70 ±6	30 ±5	30 ±4	40 ±6	-	-	-
Total Biomass (D Wt m <sup>-2</sup> )	-	200 ±40	190 ±30	125 ±25	130 ±20	45 ±10	30 ±5	50 ±15	-	-	-

Braun-Blanquet cover-abundance (Table 3) showed that the seagrass *H. stipulacea* occurred with the highest frequency, abundance and density both at the oiled sites 2, 3, and 4, and non-oiled site 1; while, at other sites 9, 10, and 11, the seagrass with less abundance and density was highly frequent. The seaweed *Caulerpa racemosa* was relatively frequent, dense and abundant at the polluted sites, than the non-oiled ones. Comparing the non-oiled site 1, with the oiled sites 2, 3 and 4 suggests that there is no oil related impact on the seagrass distribution, frequency, density, abundance (Table 3), or biomass (Table 2). The complete absence of seagrasses from sites 5, 6, 7, and 8 is possibly due to the presence of unstable sediments covering the coast, which is unsuitable for the development of these plants.

**Other ecological aspects:** The seagrass community at the sites 9, 10, and 11 was growing newly (after wintering), and consisted of delicate sparse shoots. At different sites, seagrass shoots showed normal morphology, having new leaves, of both male and female flowers, recently grown rhizome apical meristems and central branches were also observed.

The leaves of the investigated seagrass species were nearly free from epiphytes. The microscopic examination showed very clean leaves in most cases. The algal epiphytes *Rivularia polyotis* and *Polysiphonia* sp. were rarely recorded on the leaves of seagrass *Halodule uninervis* (site 2), and *Halophila stipulacea* (sites 1 & 2).

Table 3. Summary of Braun-Blanquet data on frequency of occurrence, density and for seagrass *Halophila stipulacea* and seaweed *Caulerpa racemosa* from oiled and non-oiled sites at the El-Moyia Bay.

Status/site	<i>Halophila stipulacea</i>			<i>Caulerpa racemosa</i>		
	Frequency	Abundance	Density	Frequency	Abundance	Density
oiled						
2	1.00	5.00	5.00	1.00	5.00	5.00
3	1.00	5.00	5.00	0.75	5.00	3.75
4	1.00	5.00	5.00	0.50	4.00	2.00
Non-oiled						
1	1.00	5.00	5.00	-	-	-
5	-	-	-	0.75	4.00	3.00
6	-	-	-	0.50	3.00	1.50
7	-	-	-	0.50	3.00	1.50

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8	-	-	-	0.25	3.00	0.75
9	1.00	2.00	2.00	-	-	-
10	1.00	2.00	2.00	-	-	-
11	1.00	2.00	2.00	-	-	-

Invertebrate fauna of the seagrass community was less diverse in the oiled sites compared with the non-oiled site 1 (Table 4). Seven species were recorded at oiled sites, while 21 species were recorded at non-oiled one. The most common species were the gastropods *Conus arenatus*, *C. tessulatus*, *Strombus gibberulus*, *S. mutibilis* at the oiled sites 2, 3, and 4, while the species, *Botula cinnamomea*, and *Cerithium rupelli*, *Pinna muricata*, *Strombus gibberulus*, and *S. mutibilis* were commonly recorded at non-oiled site 1.

Table 4. A list of invertebrate species of seagrass community (oiled, non-oiled) at Sharm El-Moyia Bay during the present study. (-) Absent; (+) Present, <1 individual / m<sup>-2</sup>; (++) Common, >4 individuals / m<sup>-2</sup>

Species	Oiled sites	Non-oiled sites
<b><u>Mollusca</u></b>		
<i>Anadara antiquata</i> Linnaeus	-	+
<i>Botula cinnamomea</i> Lamarck	-	++
<i>Cerithium rupelli</i> Philippi	+	++
<i>Circe calipyga</i> Born	-	+
<i>Circe corrugata</i> Dillwyn	-	+
<i>Conus arenatus</i> Hwass im Bruguiere	++	+
<i>Conus tessulatus</i> Born	++	+
<i>Glycymeris pectunculus</i> Linnaeus	-	+
<i>Muricodrupa fiscellum</i> Gmelin	-	+
<i>Nassarius concinnus</i> Powys	-	+
<i>N. protrusidens</i> Melvill	-	+
<i>Natica gualteriana</i> Recluz	-	+
<i>Pinna muricata</i> Linnaeus	-	++
<i>Strombus fasciatus</i> Born	-	+
<i>Strombus gibberulus</i> Morch	++	++
<i>Strombus mutibilis</i> Swainson	++	++
<i>Strombus tricornis</i> Humphery	+	-
<b><u>Crustacea</u></b>		
<i>Alphus</i> sp.	-	+
<i>Clibanarius</i> sp.	+	+
<i>Paracleistostoma</i> sp.	-	+
<b><u>Echinodermata</u></b>		
<i>Tripneustes gratilla</i> Linnaeus	-	+
<b><u>Polychaeta</u></b>		
<i>Notopygos veribilis</i> Potts	-	+
Total number of species	7	21

**DISCUSSION**

The seagrass species *Halodule uninervis*, *Halophila ovalis*, *Halophila stipulacea* known to occur in Sharm El-Moyia Bay (Gab-Alla 1996), were investigated during the present work, where the west and south-west of the bay became heavily oiled according to Hanafy & Kotb (1999). Based on the frequency of occurrence, biomass and density analyses, *Halophila stipulacea* is the most common seagrass in this bay, while the other two species *Halodule uninervis* and *H. ovalis* are very rare and restricted only to site 2. *Halophila stipulacea* occurred in greatest abundance at the oiled sites 2, 3, and 4 as well as in the non-oiled site 1.

The density and biomass of the seagrass *Halophila stipulacea* and the seaweed *Caulerpa racemosa* in the oiled sites were comparable to non-oiled ones, and pre-pollution conditions previously described for this bay (Gab-Alla 1996). Shoot density of *Halophila stipulacea* at site 2 exceeded (5000m<sup>-2</sup>) the non-oiled meadow of the same species at site 1 at the same time (4800m<sup>-2</sup>) or during 1996 (3712m<sup>-2</sup>). In a study by Kenworthy *et al.* (1993) along the north eastern Saudi Arabian shore, after the Gulf War oil spill, they observed that

shoot densities were similar to, or exceeded, non-oiled meadows of the same species in the Gulf of Aqaba (Wahbeh 1984) and Australia (Larkum *et al.* 1989). The range in seagrass biomass (25-280 gdw<sup>m</sup><sup>-2</sup>) during this study was wider than that previously recorded by Gab-Alla (1996) in this bay (35-135 gdw<sup>m</sup><sup>-2</sup>). As well, the range in algal biomass of *Caulerpa racemosa* in this study (30 - 200 gdw<sup>m</sup><sup>-2</sup>) was wider than that previously recorded by Gab-Alla in 1996 (5-30 gdw<sup>m</sup><sup>-2</sup>). This may be attributed to the suitable environmental conditions at the west and south-west of the bay, e.g. stable bottom, low current regime, high organic matter content, high transparency and low suspended matter.

Unfortunately, many studies stress on seagrass biomass and productivity, while, neglect to report on shoot density, which may be a more relevant indicator for assessing the ecological status of seagrasses. Seagrass biomass (especially standing crop) usually displays a large seasonal fluctuation when experiencing different ambient temperatures and light regimes (Kenworthy 1992). The densities of *H. stipulacea* (climax community) observed at the heavily oiled sites resembled the relatively healthy seagrass bed (site 1) of the same species in the bay. These findings are in agreement with that of many authors (Eleuterius 1987; Fonseca *et al.* 1987; Pangallo & Bell 1988; Kenworthy 1992; Kenworthy *et al.* 1993; Gab-Alla 1996).

Qualitative observations revealed that all the recorded species were exhibiting good growth characteristics. New leaves were emerging and recently initiated rhizome apical meristems and lateral branches were also developing. Male and female flowers of *Halophila stipulacea* were recorded. This means that this common seagrass is completing its life history under these conditions and both sexual and asexual reproduction occurs. However, this seagrass is known worldwide for rapid asexual reproduction (Fonseca *et al.* 1987; Posluszny & Tomlinson 1990), as well as sexual reproduction (Josselyn *et al.* 1986; McMillan 1988a,b) and its ability to establish populations from seed or vegetative fragments (McMillan 1988b; Williams 1988; Larkum *et al.* 1989; Kenworthy 1992).

In the southeastern United States shores and in some areas of the Caribbean, *H. decipiens* recovers after seasonal and climatic perturbations almost exclusively by seed. *Halodule* and *Halophila* form overwintering, or even longer term, seed banks which could re-establish seagrass populations in environmentally or anthropogenically impacted sites. In Australia, *H. uninervis* and *H. ovalis* often represent the primary colonizing species and they may initiate the recovery of seagrasses in areas impacted by cyclones and other natural or man-induced perturbations (Poiner *et al.* 1989; Clarke & Kirkman 1989). Shepherd *et al.* (1989) confirmed that localized loss of seagrass at Cockburn Sound Bay in Australia detected after 7 years of discharge from oil refinery, and the commencement of rapid decline of the meadow after 14 years of discharge. Effluent from the oil refinery enters the bay was supplied to seagrass in aquaria, to test the possibility that it may have caused widespread losses of seagrasses (Cambridge *et al.* 1986). The plants proved rather insensitive to effluent. A significant reduction in growth only occurred at a concentration of hydrocarbons equivalent to that entering the bay, before extensive dilution by the waters of the bay.

Seedling recruitment recorded at different sites means that the seagrass bed is in the stage of maintenance and recovery in the east, west, and south west of the bay, while at the north the bay is still suffering a more stressful environmental conditions. The presence of unconsolidated moving sediments, probably limits the overall distribution and abundance of seagrasses in this area of the bay.

The macro-invertebrate fauna at oiled sites was obviously affected. They were less diverse than the non-oiled ones. In a review paper, Loya & Rinkevich (1980) stated that oil pollution usually kill and cause serious damages to the different macro-invertebrates.

Briefly speaking, the present status of seagrass in Sharm El-Moyia Bay suggests that it is not experiencing any degradation due to the oil pollution of the bay. Qualitative and

quantitative observations on the distribution, abundance, biomass, seedling recruitment and reproduction support the current conclusion that the seagrass itself was not experiencing a measurable impact from oil pollution in this bay during 1999, while macro-invertebrate fauna showed distorted community with low diversity.

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## الملخص العربي

الحالة البيئية لمجتمع الأعشاب البحرية في جونة شرم المية بساحل خليج العقبة بعد

التلوث البترولي في ١٩٩٩

على عبد الفتاح على جاب الله

قسم علوم البحار - كلية العلوم - جامعة قناة السويس - الإسماعيلية - جمهورية مصر العربية

خلال فترة التلوث البترولي لشرم المية عام ١٩٩٩، تم دراسة التركيب النوعي وكثافة كل من الحشائش واللافقاريات البحرية في مناطق مختلفة "ملوثة وغير ملوثة بالبترول" في جونة شرم المية. حيث وجد أن أكثر الحشائش انتشارا وكثافة هو *هوما لوفيليا استيبولاسا* الذي ينمو بعمق ١-٣ متر على التربة الرسوبية لهذه الجونة. وقد تراوح المحصول القائم ما بين ٢٥-٢٨٠ نوع جرام كتلة جافة /م<sup>٢</sup>. ولقد أوضح الشكل الظاهري علامات النمو الجنسي "التزهير" أن حقول هذا النوع من الحشائش في المناطق المختلفة من الجونة صحية ولم تتأثر بالتلوث البترولي وتتمو بطريقة عادية. ولهذا واعتمادا على هذه المعلومات فلفقد توصل البحث الى أن النباتات المكونة لمجتمع الحشائش البحرية بشرم المية لم تعاني أى تدهور نتيجة للتلوث البترولي الذى حدث، بينما أظهرت اللافقاريات القاطنة له تدهورا في التركيب النوعي والكثافة.