

## Quantitative Seasonal Study on the Standing Crop of *Cystoseira myrica* along the Jeddah Coast, Red Sea

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**ABSTRACT.** The standing crop of *Cystoseira myrica* along the Jeddah coast was assessed. Two peaks were found during the year: a major one was observed in May and a minor in October. Spring proved to be the more productive season. The biomass values ranged from 0.78 kg m<sup>-2</sup> at Obhur in January to 3.9 kg m<sup>-2</sup> at Hatibah in May. The monthly average of the biomass in the whole area of study was estimated as 1.8 kg m<sup>-2</sup>. The biomass of *Cystoseira myrica* at North Jeddah is about three times of that observed at south Jeddah.

No sharp fluctuation in the seasonal values of biomass of *Cystoseira myrica* was noticed in Jeddah area, as a result of the relative stability of the environmental factors.

The productivity of *Cystoseira myrica* along the Jeddah coast is in general low, relative to that of *Cystoseira* spp. in the Mediterranean, Adriatic Sea and Black Sea.

Sixty species belonging to the main three classes of algae were found among the associations of *Cystoseira myrica*.

Knowledge of the distribution of the algal flora in the Red Sea is limited to some areas: Ghardaqa, Egyptian Coast (Nasr 1939, 1947), Gulf of Aden and South of the Red Sea (Newton 1953), Sinai Peninsula and Gulf of Aqaba (Rayss 1959, Rayss and Dor 1963), Ethiopian Coast (Taylor 1965) and Jeddah, Saudi Arabian Coast (Aleem 1978, Khalil and El Tawil 1982, Khafaji and Meinesz 1984 and Khalil *et al.* 1984). In addition, Papenfuss (1968) reported 366 species of algae in the Red Sea. However, Kalugina-Gutnik (1971) studied the benthic flora collected in 1966 by the Russian Research Vessel "Academician A. Kovalevsky" from some coastal and deeper areas along the Red Sea and she identified 416 species of the macrophytes, only 111 of them were recorded in the middle part of the sea.

Although the distribution of the macro-algae in the Red Sea has received considerable attention during the last few decades (the above references), only

limited attempts have been made to quantify the algal biomass in the Red Sea (Kalugina-Gutnik 1971 and Khalil *et al.* 1984).

Approximately 60 species of *Cystoseira* exist in warm subtropical and temperate waters (Chapman and Chapman 1973 and Roberts 1978). *Cystoseira* spp. can be regarded as a raw material for the production of alginic acid and alginates (Smith and Montgomery 1959, Hoppe 1969 and Decheva and Khardalov 1970) and it can be used as a fodder (Kalugina-Gutnik 1971).

*Cystoseira myrica* (Gmelin) C. Agardh is common in the supralittoral zone of Jeddah Coast, particularly in sheltered places and it often forms dense beds in rocky areas (Khalil and El Tawil 1982).

A preliminary survey on the biomass of the macrophytes in the Red Sea, South of Jeddah was done by Khalil *et al.* (1984).

No information was available, until this work, on the monthly variations in the algal biomass of Jeddah area. The present work is to be considered therefore, as the first attempt to survey and determine the monthly variations in the standing crop of the *Cystoseira myrica* beds at four sites along the Jeddah Coast, and to identify the accompanying algal species in its associations.

## Materials and Methods

### (a) *The study area*

The western coast of Saudi Arabia is bordered by a number of coral reefs which harbour a flourishing marine life. Behairy (1980), showed that the reefs extending along the Jeddah Coast are composed of fringing reefs and barrier reefs, exposed to the surf at the offshore area. In general, the flora of the fringing reefs is richer and more diversified than that of the offshore reefs.

The average salinity of the surface water of Jeddah area varied from 39.42 in January to 39.87 in August (MSKAU, unpublished report).

The area of study is extended to about 50 km stretch from site I (Desalination) to site IV (Hatibah). The sites from which the algal samples have been collected are shown on Fig. (1).

*Site I (Desalination)*: A relatively sheltered site, situated at about 5 km north of the Main Desalination Plant, with a depth ranging from 0.5 to 2 m. The substratum is mainly reef and it contains dispersed stones.

*Site II (Obhur):* A semi-exposed area, located at 2 km south of the Obhur Creek, with a depth varying from 0.5 to 2.5 m. The location is intermittently subjected to pollution at the times of dredging the mouth of Obhur Creek. The substratum varied from muddysand to rocky with scattered stones.

*Site III (Soud Palace):* A semi-exposed area, about 45 km north of Jeddah Center, with a depth varied between 0.8 and 2.8 m. The substratum is partly sandy,

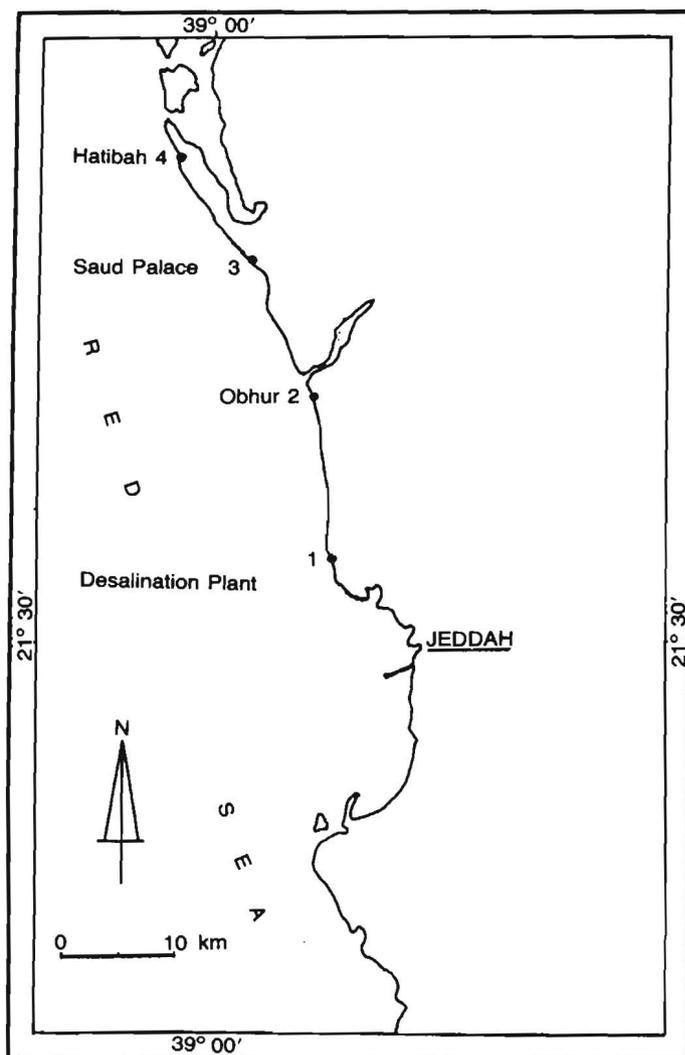


Fig. 1. Map of study sites in Jeddah, Red Sea.

muddy and rocky with some scattered boulders.

*Site IV (Hatibah):* A sheltered area, located at about 60 km north of Jeddah, with a depth ranging from 0.5 to 2 m. The substratum is mainly reef with dispersed stones.

**(b) Sampling and methods:**

A total of 280 samples of *Cystoseira myrica* associations were being collected monthly, using a 25×40 cm quadrat frame, over a one-year period from December 1980 to November 1981, at four sites along the Jeddah Coast (Fig. 1). From each site, at least five quadrats were randomly placed, and all the macro-algal species whose holdfasts originating within the quadrat frame were collected. The harvested algae were transported to the laboratory, then rinsed by fresh water to remove the surface silt. Each species was cleaned of epiphytes. The wet weight (WW) standing crop of *Cystoseira myrica* thalli (expressed as  $\text{kg m}^{-2}$ ) were determined on blotted material. Dry weight (DW) was calculated after drying the samples at 60°C for 48 hrs to a constant weight. The associated algal species which were found in the same quadrat in large quantities were also weighed. The biomass of the algal species and the percentage cover of vegetation at each site was calculated according to Kalugina (1969).

Subsamples of the associated algal species and epiphytes were preserved in 4% neutral formalin for further biological identification.

Surface water temperature was measured at the times the algal samples were collected.

### Results and Discussion

The community of *Cystoseira myrica* (Gmelin) C. Ag. is common in mid- and supralittoral zone of Jeddah. The *Cystoseira* settlements appeared as dense and prolific in the two sites I and IV, covering 70 to 85% of the reef substratum. Such settlements were, however, scattered on the other two sites and their percentage cover not exceeded 50% of the bottom.

The seasonal variations in the standing crop of *Cystoseira myrica* at each of the four locations showed two peaks during the year. A major peak was observed in May and a smaller one in October (Fig. 2).

The highest values of the WW biomass of *Cystoseira myrica* were recorded in May and reached 2.8 and 3.9  $\text{kg m}^{-2}$  at sites I and IV, respectively (Fig. 2). These

two sites are sheltered and are characterized by a rocky coral substratum with a relatively high coverage of algal vegetation. On the other hand, the lowest values of the WW biomass, in the whole area, were noted in January at the other two semi-exposed sites II (0.78 kg m<sup>-2</sup>) and III (0.84 kg m<sup>-2</sup>) (Fig. 2).

The seasonal average of WW biomass in the studied area varied markedly, and attained its maximum of 2.2 kg m<sup>-2</sup> in Spring, then decreased to 1.9 kg m<sup>-2</sup> in Summer, 1.5 kg m<sup>-2</sup> in Autumn and 1.3 kg m<sup>-2</sup> in Winter. However, the monthly

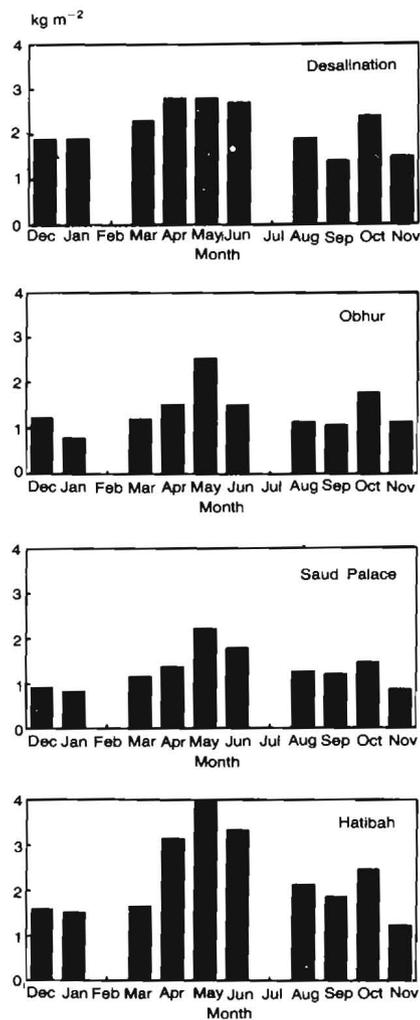


Fig. 2. Monthly variations in the standing crop of *Cystoseira myrica*, during 1980-1981, at four sites along Jeddah Coast.

average of biomass in the studied area was found to be  $1.8 \text{ kg m}^{-2}$ .

The Desalination and Hatibah sites are distinguished by dense beds of *Cystoseira* settled on the reef substratum, with a monthly average of 2.2 and  $2.3 \text{ kg WW m}^{-2}$ , with a remarkable increase in coverage of vegetation seaward.

The calculated dry weight of *Cystoseira myrica*, along Jeddah Coast was represented by an average of 21% of its WW biomass, varying from 18% in December to 29% in March. No tangible variation in the values of DW of *Cystoseira* was observed at the four locations. The marked increase of DW percentage in Spring indicates a phase of active photosynthesis owing to the prevalence of favourable environmental conditions such as light intensity, temperature, ...etc. as previously reported by Khalil and Ibrahim (1988). The gradual increase in the productivity of *Cystoseira myrica* from January to May (Fig. 2), was generally attributed to the appearance of new branchlets on the thalli, which grew faster and more densely in the early Spring, inducing a rapid increase in biomass till May. However, a decline in the standing crop began at early Summer (in June) and continued until September as a result of shedding of lateral branches. Nevertheless, a small peak in biomass was observed in October (Fig. 2), mainly due to a halt in the abscission of lateral branches. On the other hand the remaining branches on the thalli of *Cystoseira* continued to grow slowly. However, a drop in biomass was observed in November (Fig. 2).

According to the aforementioned data; Spring proved to be the more productive season (Fig. 3). The increment rate in standing crop in Spring attained about 39%, 74%, 80% and 87% of the observed values of WW biomass in Winter at the locations, I, II, III and IV, respectively (Fig. 3). Likewise, a monthly increase in biomass was noticed during the periods from March to May and from September to October. The maximum increment rate in biomass was recorded in April at Hatibah, reaching 90% of its WW value in March (Fig. 2). In the meantime, lower values of biomass accretion were observed at the other three localities.

According to the values of the monthly average of WW standing crops of *Cystoseira myrica* at each site of the study area, the locations can be arranged in the following decreasing order:

Site IV	>	Site I	>	Site II	>	Site III
(2.30±1.02)		(2.16±0.60)		(1.39±0.60)		(1.30±0.58)
$\text{kg m}^{-2}$		$\text{kg m}^{-2}$		$\text{kg m}^{-2}$		$\text{kg m}^{-2}$

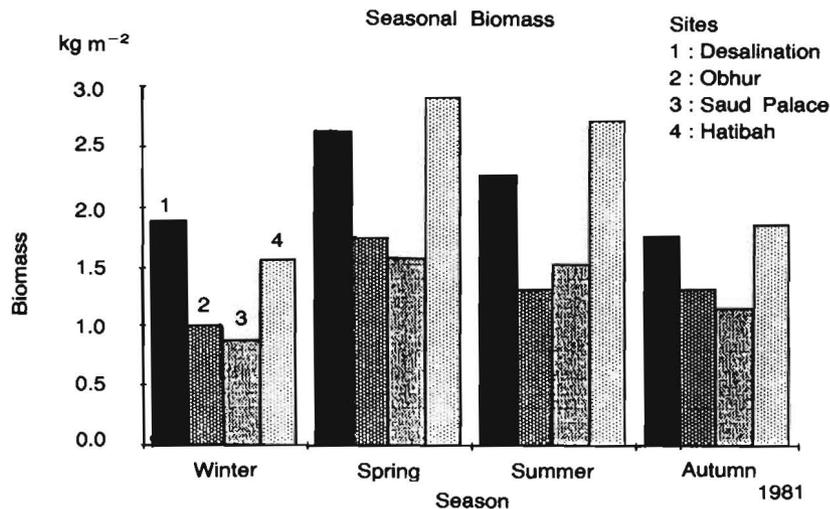


Fig. 3. Seasonal variations in the biomass of *Cystoseira myrica*, Jeddah Coast.

Sixty species belonging to the main three classes of algae (17 of the Chlorophyceae, 14 of the Phaeophyceae and 29 of the Rhodophyceae) were found among the associations of *Cystoseira myrica* in the studied area around the year (Table 1). Figure 4, summarizes the recorded number of the associated algal species in each site. The greatest number of species (47 species) was observed at site IV, whereas the lowest (28 species) at site II. The red algae were the most diverse group in sites I and IV, however, the green algae were ranked first in species diversity in the other two sites.

The species diversity increased from the onset of Winter, when the biological activity of the algae was accelerated. The highest recorded number in the studied area (49 species) was noticed during Spring, while the lowest (30 species) was observed in Summer. In general, as the temperature rose, the number of species diminished.

Although surface seawater temperature in the area of study followed an annual cycle of one minimum in January (24.8°C) and one maximum in August (31.7°C). However, the optimum temperature for the growth of algae in Jeddah area was 28°C during early Spring and late Autumn as observed from the relatively large biomass values and number of the associated species flourishing in the *Cystoseira* settlements.

From the sixty recorded algal species in the *Cystoseira* settlements, only twelve species were contributed to the biomass, in sporadic periods. Relatively low

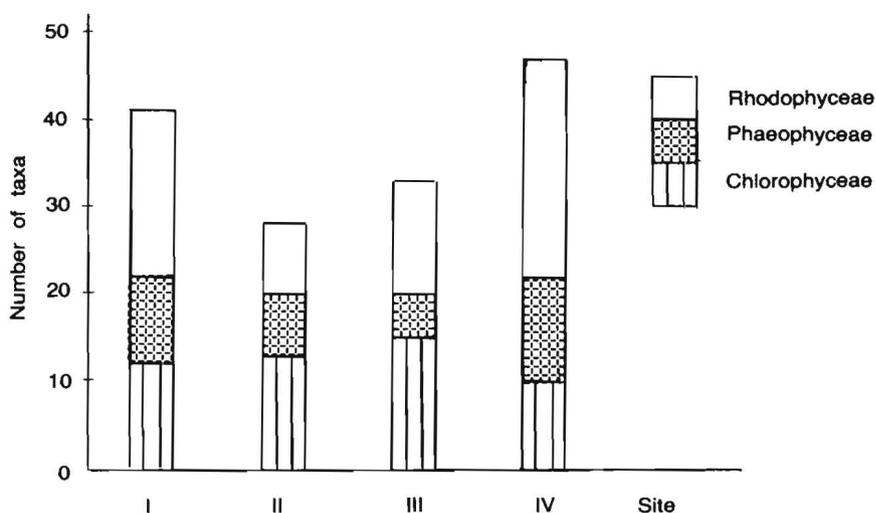


Fig. 4. Total number of the associated algal species at the four sites.

biomass was noticed for the associated algal species, compared with that of *Cystoseira myrica*. The WW biomass of these species ranged from  $55 \text{ g m}^{-2}$  for *Cladophora albida* to  $700 \text{ g m}^{-2}$  for *Sargassum subrepandum* (Table 2).

The type of the substratum found at any location influences either the occurrence or absence of many algal species; it can also determine the quantity and type of the existing vegetation. The results of this study show that *Cystoseira myrica* prefer biotops with hard substratum. This finding is agreeable with the observations of several authors (e.g. Schnetter and Schnetter 1981, Haritonidis *et al.* 1986 and Khalil *et al.* 1988).

The biomass and species composition of *Cystoseira myrica* associations along the Jeddah Coast showed pronounced spatial variations, depending upon the location and type of the substrata. In general, the present work shows that the standing crop of *Cystoseira myrica* at North Jeddah area is much higher than that observed at South Jeddah ( $0.66\text{-}0.98 \text{ kg WW m}^{-2}$ ; Khalil *et al.* 1984).

Compared to other localities from different biogeographic zones of the world as the Mediterranean Sea and the Black Sea (Table 3), the WW biomass of *Cystoseira myrica* in Jeddah area appears to be slightly lower than that of other *Cystoseira* species in Odessa, USSR (Khalil 1974) and Alexandria, Egypt (Khalil *et al.* 1988). Furthermore, the standing crop of *Cystoseira myrica* in Jeddah is much lower than that of Novorossisk Bay, USSR (Kalugina 1968), Marseille and Banyals-sur-mer, France (Bellan-Santini 1969 and Boudouresque 1969), Istria, Yugoslavia (Munda 1972) and Yalta, USSR (Khalil 1974).

**Table 1.** List of the associated algal species in the *Cystoseira myrica* beds of Jeddah area.  
Site 1- Desalination, 2- Obhur, 3- Soud Palace and 4- Hatibah

<b>Chlorophyceae</b>	
<i>Cladophora albida</i> (Hudson) Kützing	1,2,3,4.
<i>Boodlea composita</i> (Harvey) Brand	1,3,4.
<i>Dictyosphaeria cavernosa</i> (Forsskal) Borgesen	1,2,3,4.
<i>Valonia aegagropila</i> C. Agardh	1,3,4.
<i>V. ventricosa</i> J. Agardh	3.
<i>Bryopsis hypnoides</i> Lamouroux	1,2,3.
<i>Caulerpa lentillifera</i> J. Agardh	1,2,3,4.
<i>C. racemosa</i> var. <i>racemosa</i> J. Agardh	2,3.
<i>C. scilago</i> (Turner) C. Agardh	2,3.
<i>C. serrulata</i> (Forsskal) J. Agardh	1,2.
<i>Avrainvillea amadelpha</i> (Montagne) A. et E.S. Gepp	1,2,3.
<i>Halimeda discoidea</i> Decaisne	2,3,4.
<i>H. macroloba</i> Decaisne	1,2,3,4.
<i>H. opuntia</i> (Linnaeus) Lamouroux	1,2,3,4.
<i>H. tuna</i> (Ellis et Solander) Lamouroux	1,2,3,4.
<i>Tydemania expeditionis</i> W. V. Bosse	2,3.
<i>Udotca argentea</i> Zanardini	1,4.
<b>Phaeophyceae</b>	
<i>Sphacelaria furcigera</i> Kützing	4.
<i>S. tribuloides</i> Meneghini	1,4.

Table 1. (Contd.)

<i>Dictyota ciliolata</i> Kützing
1,2,3.
<i>D. dichotoma</i> (Hudson) Lamouroux
1,2,4.
<i>Dilophus fasciola</i> (Roth) Howe
2,4.
<i>Padina boryana</i> Thivy
1,2,3,4.
<i>P. pavonica</i> (Linnaeus) Thivy
1,2,3,4.
<i>P. tetrastromatica</i> Hauck
1,2,4.
<i>Colpomenia sinuosa</i> (Mertens ex Roth) Derbès et Solièr
4.
<i>Hydroclathrus clathratus</i> (C. Agardh) Howe
3.
<i>Sargassum dentifolium</i> (Turner) C. Agardh
1,4.
<i>S. latifolium</i> (Turner) C. Agardh
1,4.
<i>S. subrepandum</i> (Forsskal) C. Agardh
1,4.
<i>Turbinaria triquetra</i> (J. Agardh) J. Agardh
1,2,3,4.
<b>Rhodophyceae</b>
<i>Erythrotrichia carnea</i> (Dillwyn) J. Agardh
4.
<i>Liagora farinosa</i> Lamouroux
1,4.
<i>Actinotrichia fragilis</i> (Forsskal) Børgesen
1,3,4.
<i>Galaxaura cylindrica</i> (Ellis et Solander) Lamouroux
1,3,4.
<i>Gelidium crinale</i> (Turner) Lamouroux
1.
<i>Corallina tenella</i> (Kützing) Heydrich
1,3,4.
<i>Jania adhaerens</i> Lamouroux
1,2,4.
<i>Jania rubens</i> (Linnaeus) Lamouroux
1,2,4.

Table 1. (Contd.)

<i>Lithophyllum kaiseri</i> (Heydrich) Heydrich	1,2,3,4.
<i>Gracilaria arcuata</i> Zanardini	1.
<i>G. cacalia</i> (J. Agardh) Dawson	4.
<i>G. verrucosa</i> (Hudson) Papenfuss	1,4.
<i>Hypnea esperi</i> Bory	4.
<i>H. musciformis</i> (Wulfen) Lamouroux	4.
<i>Botryocladia leptopoda</i> (J. Agardh) Kylin	4.
<i>Centroceras clavulatum</i> (C. Agardh) Montagne	1,4.
<i>Ceramium diaphanum</i> (Lightfoot) Roth	1,3.
<i>C. tenuissimum</i> (Roth) J. Agardh	4.
<i>Griffithsia tenuis</i> C. Agardh	2,4.
<i>Heterosiphonia wurdemanni</i> (Bailey ex Harvey) Falkenberg	1,3,4.
<i>Acanthophora najadiformis</i> (Delile) Papenfuss	3,4.
<i>Chondria seticulosa</i> (Forsskal) C. Agardh	4.
<i>Digenia simplex</i> (Wulfen) C. Agardh	1,2,3,4.
<i>Herposiphonia tenella</i> (C. Agardh) Ambronn	2,3.
<i>Laurencia obtusa</i> (Hudson) Lamouroux	1,2,3,4.
<i>L. papillosa</i> (C. Agardh) Greville	1,3,4.
<i>L. pinnatifida</i> (Hudson) Lamouroux	1,3,4.
<i>Levillaea jungermannioides</i> (Hering et Martens) Harvey	1,2,4.
<i>Polysiphonia utricularis</i> Zanardini	1,3,4.

**Table 2.** The maximum wet weight biomass ( $\text{g m}^{-2}$ ) of some algal species found among the *Cystoseira myrica* association of Jeddah Coast

Species	The maximum wet weight ( $\text{g m}^{-2}$ )	Time 1980-81	Site
<b>Chlorophyceae</b>			
<i>Cladophora albida</i>	55	Nov. 81	Hatibah
<i>Dictyosphaeria cavernosa</i>	280	Sep. 81	Desalination
<i>Valonia aegagropila</i>	80	Dec. 80	Soud Palace
<i>Halimeda macroloba</i>	220	Aug. 81	Obhur
<b>Phaeophyceae</b>			
<i>Dictyota ciliolata</i>	325	Mar. 81	Obhur
<i>Padina boryana</i>	110	Nov. 81	Soud Palace
<i>Sargassum subrepandum</i>	700	Dec. 80	Desalination
<b>Rhodophyceae</b>			
<i>Jania rubens</i>	240	Nov. 81	Desalination
<i>Acanthophora najadiformis</i>	290	Nov. 81	Hatibah
<i>Digenia simplex</i>	325	Dec. 80	Hatibah
<i>Laurencia obtusa</i>	125	Mar. 81	Hatibah
<i>Laurencia papillosa</i>	485	Dec. 80	Hatibah

The above references show that the flourishing periods of standing crops of *Cystoseira* spp. at different biogeographic zones were begun from late Spring (in subtropical areas; Red Sea) to mid Summer (in temperate areas; Mediterranean and Black Sea). Otherwise, a sharp drop (to less than 10% of the highest values in Summer) in the standing crop of *Cystoseira* spp. was noticed during Winter at Banyals-sur-mer, France (Boudouresque 1969) and at Odessa, USSR (Khalil 1974). This reflects the acute changes in the environmental factors (sea water temperature, agitation ...etc.) affecting the biota of the coastal area (Khalil 1974). In comparison, the lowest value of biomass of *Cystoseira myrica* at the Jeddah area was also observed during Winter attaining 60% of the highest one in Spring. This reflects the relative stability in the environmental factors of the Jeddah area compared to those of the temperate region in the Mediterranean Sea and the Black Sea.

Khalil *et al.* (1988) indicated that salinity and temperature are of the most important environmental factors influencing the distribution and standing crop of *Cystoseira*, as well as this genus serve as good indicator of clear water and appears intolerant of nutrient enriched or polluted water.

**Table 3.** The standing crop values of *Cystoseira* species in some different biogeographic zones

Location	<i>Cystoseira</i> spp.	maximum value kg WW m <sup>-2</sup> (season)	Reference
<b>Red Sea</b>			
Jeddah (Saudi Arabia)	<i>C. myrica</i>	2.3 (late Spring)	Present study
<b>Mediterranean Sea</b>			
Alexandria (Egypt)	<i>C. compressa</i>	2.8 (early Summer)	Khalil <i>et al.</i> (1988)
Tremiti Is. (Italy)	<i>C. spicata</i>	6.9 (mid Summer)	Coassini-Lokar and Audoli-Tamburini (1967)
W. Istria (Yugoslavia)	<i>C. barbata</i>	9.5 (mid Summer)	Munda (1972)
Banyals-sur-mer (France)	<i>C. mediterranea</i>	10.1 (mid Summer)	Boudouresque (1969)
Marseille (France)	<i>C. stricta</i>	13.2 (mid Summer)	Bellan-Santini (1969)
<b>Black Sea</b>			
Caucas (USSR)	<i>C. barbata</i>	13 (mid Summer)	Kalugina (1968)
Novorossisk Bay (USSR)	<i>C. barbata</i>	21 (mid Summer)	Kalugina (1968)
Odessa (USSR)	<i>C. barbata</i>	4 (mid Summer)	Khalil (1974)
Yalta (USSR)	<i>C. barbata</i>	6.5 (early Summer)	Khalil (1974)
Yalta (USSR)	<i>C. crinita</i>	7.1 (early Summer)	Khalil (1974)

Further investigations are needed for other places along the Saudi Coast of the Red Sea, to give a complete picture about the distribution and biomass of macro-algal species.

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(Received 18/12/1988;  
in revised form 23/04/1989)

## دراسة موسمية كمية على انتاجية سيستوسيرا ميريكيا *Systoseira myrica* بساحل جدة، البحر الأحمر

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تم تقدير المحصول القائم لطحلب سيستوسيرا ميريكيا على ساحل جدة حيث أوضحت الدراسة وجود قمتين خلال العام، لوحظت العظمى في مايو بينما الصغرى تم تقديرها في أكتوبر. ويعتبر فصل الربيع الفترة المزدهرة في انتاجية هذا الطحلب بساحل جدة، وقد بلغت أعلى قيمة تم تسجيلها ٣,٩ كجم م - ٢ عند منطقة حطبية التي تبعد حوالي ٦٠ كم عن جدة، وقد يرجع ازدهار الطحالب بهذه المنطقة لبعدها عن مصادر التلوث المختلفة الناتجة عن النشاط البشري في عمليات البناء والصناعة ومياه الصرف . . . الخ .

كنتيجة للثبات النسبي في العوامل البيئية المحيطة بالطحلب بمنطقة البحث، لم يلاحظ أي اختلافات حادة في قيم المحصول القائم للطحلب، ومع ذلك فإن انتاجية هذا الطحلب بمنطقة البحث تعتبر محدودة بالمقارنة بأنواع السيستوسيرا في البحار المجاورة.

كما تم التعرف على ٦٠ نوعاً من الطحالب التابعة للمجموعات الثلاث الرئيسية والمصاحبة لطحلب السيستوسيرا بمنطقة الدراسة (١٧ أخضر، ١٤ بني و٢٩ أحمر). وقد لوحظ أن التباين النوعي يزداد مع نهاية فصل الشتاء وقد تم تسجيل ٤٩ نوعاً خلال الربيع، وكلما ارتفعت درجة حرارة المياه السطحية قلت أعداد الأنواع الطحلبية المصاحبة لطحلب السيستوسيرا.

وقد لوحظ أن درجة حرارة المياه السطحية التي تبلغ ٢٨°م خلال بداية فصل الربيع ونهاية فصل الخريف هي أفضل الأوقات لتواجد أنواع عديدة من الطحالب.