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Contribution to the algal biodiversity study in the Moroccan Atlantic coast

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Abstract: At the end of this study we have shown that the study of oualidia to azemmour zone contains a very large algal diversity. However, species of economic interest such as *Gelidium Sesquipedale* (Clemente) Thuret were about to be degraded unconsciously and replaced by other harmful species such as *Sargassum muticum* (Yendo) Fensholt.
An important part of this degradation is from direct discharges into the sea (Domestic and Industrial), without any pretreatment and also the intensive grubbing species on the Atlantic coast. These direct or indirect impacts are not without effect on populations of algae; their effects on our resources are very strong and broad.

Keywords: algae, Atlantic coast, degradation, diversity.

I. INTRODUCTION

The importance of Moroccan marine algae resulting from abundances and their diversity along the Moroccan coast of the Atlantic Ocean; is a coastal area of over 3000 km where there are essentially: *Gelidium sesquipedale* (Clemente) Thuret, *Laminaria ochroleuca* (Bachelot de la Pylaie), *Gigartina pistillata* (S.G.Gmelin) Stackhouse, *Gracilaria multipartita* (Clemente) Harvey.
Gelidium exploitation began in Morocco in 1949. It is oriented towards the exploitation of the agar. Agar is a product extracted from *Gelidium sesquipedale* (Clemente) Thuret and *Gelidium spinulosum* (C.Agardh) J.Agardh species which represent 95% of marine algae collection (*Gelidium sesquipedale* alone represents 90%). Also, at the area constantly submerged, the algae collection is done by divers using the alguiers. Area swaying tide is operated by a heterogeneous workforce (small fishermen, farmers, women and children). They collect by grubbing algae attached to the substrate and pick up those that are rejected grounding. The red alga *Gelidium* develops relatively significant fields along the Moroccan Atlantic coast. The majority of algae collected is supplied to the processing industry comes from El-Jadida and Jorf Lasfar maritime area. We noticed in recent years that there is an overexploitation of this species by poaching and intensive collection. And is usually replaced by *Halopithys incurvus* (Hudson) Batters and other harmful algal species as *Sargassum muticum* (Yendo) Fensholt found in different parts of the coast [1].
Moroccan coasts contain significant economic and ecological interest species richness. However, several fringes of it are about to be degraded unconsciously and consequently incompatible with preservation of marine ecosystems actions. 612 taxa and stadiums (102 Chlorophyceae, 131 Fucophyceae and 379 Rhodophyceae) are determined for the Moroccan marine flora [2]. In the study area comprised between Oualidia and Azemmour Moroccan Atlantic coast, algal diversity found is very rich.
The objective of this part of research is the realization of investigations in both intertidal and subtidal zones along the Moroccan Atlantic coast (between Oualidia and Azemmour) to determine the composition and structure of algal species in all sites included in the study area. The qualitative study focused on the identification of different species collected, taking into account their spatial and temporal distribution. For the quantitative study, we limited our study to the cover index of this collection that each group of algae compared to the considered quadrate.

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II. METHODOLOGY

II.1. Location of sites

For the characterization of seaweed fields, the selected sites were identified between Oualidia and Azemmour, six sites were selected: Oualidia, Sidi Abed, Mly Abdellah, Sidi Bouzid, El Jadida and Azemmour, which geographical coordinates are 33° 00' - 33° 16' 09" N, 8° 30' - 8° 45' w (Fig. 1).

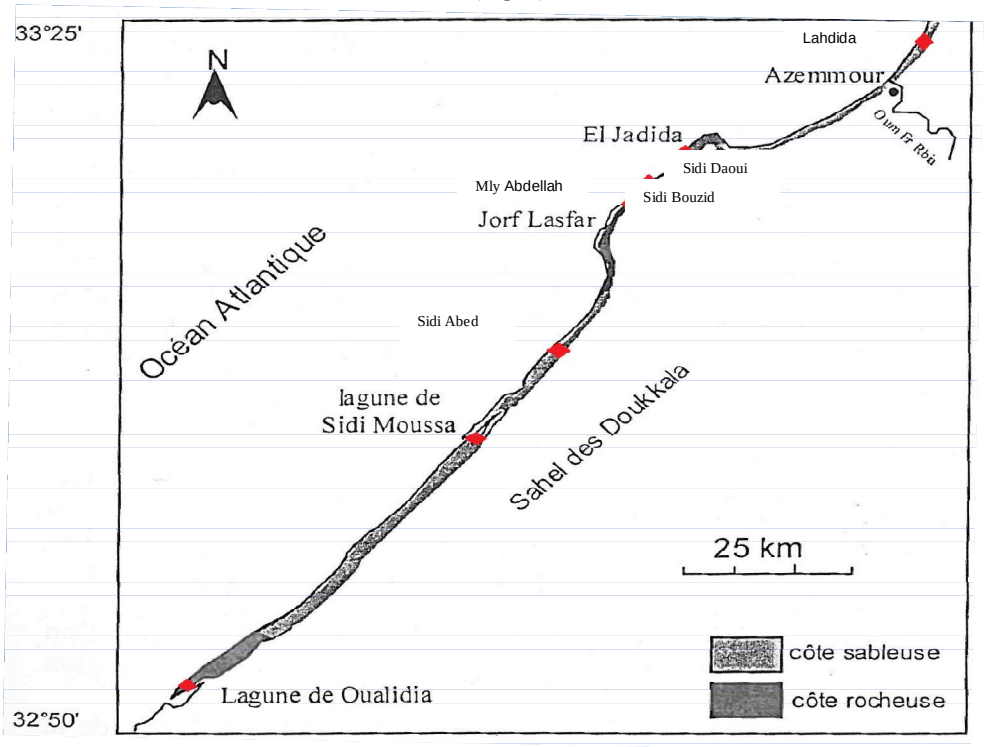

Fig. 1: Location of sampled sites on the foreshore.

These sites are defined in beaten middle by taking account the following factors:

-A tides balancing area is important with a wide rocky portion to allow colonization of the substrate by algae.

-A breakdown of the different sites on the entire coast between Oualidia and Azemmour.

-Coverage of polluted sites (Jorf Lasfar and Sidi Bouzid in the phosphate complex) and (El Jadida by wastewater effluent houses).

- The Azemmour site (Lahdida) has been integrated into the study because it's too near to the sandy areas and that the algal population could be biased by inputs of sediment and water influence of Oum Er Rabie. Rock slabs, strata and screes are the main facies present on t he sites (Fig. 2).

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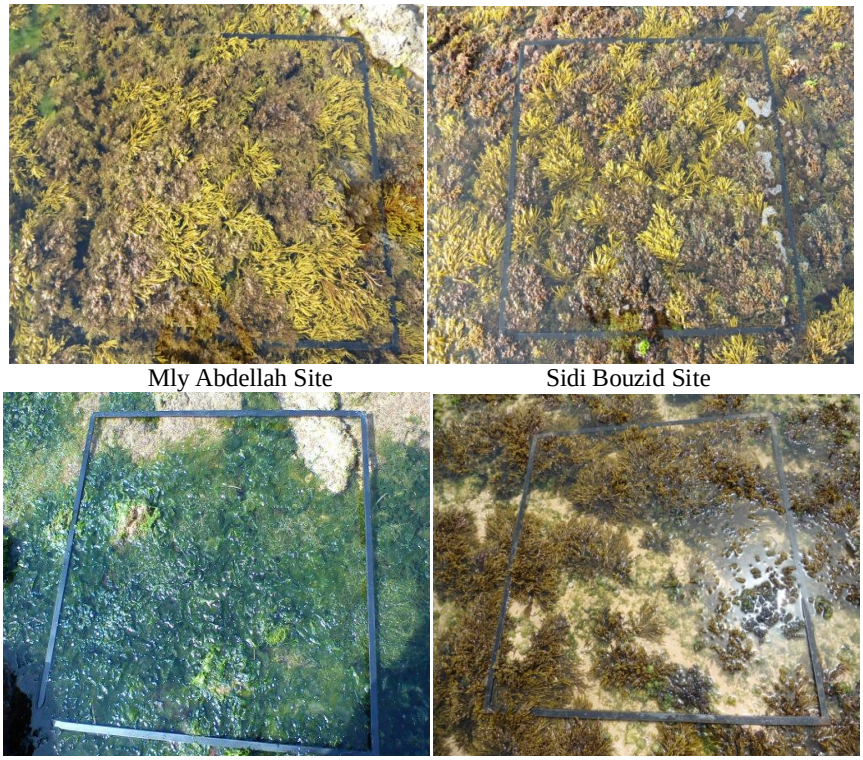

Mly Abdellah Site | Sidi Bouzid Site

Sidi Daoui site | Sidi Abed site

Fig. 2: Configuration example of some sampled sites.

II.2. Intervention schedule

The field surveys for both intertidal and subtidal parts colonized by algae are performed from November 2012 to November 2013. Appointments are fixed around 9 hr depending on the status of sea bass. To the extent possible, surveys are conducted with less than 1 m to 1.5 m waves to allow the tide to withdraw enough for proper sampling subtidal. For surveys in the subtidal zone will be to depths of 20m. The outputs will be on the day, with the possibility of ten dives per site.

II.3. Work done at each site

II.3.1. Implementation

A team of two puts a thirty meters end on the foreshore to materialize the work area and identify the coordinates with a GPS type Garmin ® 78. For each bathymetric level, quadrates (1 m^2) are positioned in separated points by 6 meters to perform the countings. They are positioned on a relatively homogeneous zones view terrain.

The number of quadrate carried in each site varies depending on the length of the foreshore. A minimum of 6 quadrates is provided for each bathymetric level. In the absence of available data, bathymetric levels are defined visually. In the subtidal zone, a boat will be reserved for the realization of investigations. The board equipment also consists of a Garmin GPS 78 ® types which allows locating from the surface. Sounder precises configuration and depth of the site. Two immersed scientific divers realize surveys on quadrates and a third ensures the safety of the surface and piloting the boat. Thus, the achievement of quadrates at different depths preferably is preceded by a phase of identifying to define the presence and abundance of core species (to apply the appropriate number of quadrates).

II.3.2. Criteria retained

Parameters taken into account are the global recovery index. There was a recovery index of algae present in each quadrate (Table 1). Counting the number of feet is carried for well differentiated algae.

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Table I: Classification grid of recovery index of algae present in the quadrates.

Cover index	
percentage	**index**
0-5%	1
5-25%	2
25-50%	3
50-75%	4
75-100%	5

The difficult algae to identify on site are harvested. They are examined in the laboratory under a binocular microscope, to establish the closest possible exhaustive list of species present in each quadrate. At the coast wide of the study area, it is considered "the most representative algae" those present at least 4 of the 6 selected sites.
The Jaccard index J presented by equation (1) was used to determine the level of difference and similarity between sites selected according to the species richness of sites [3]. When the index becomes close to 0, it indicates no similarity between two sites. When it's close to 1, the similarity is high.

$$(1) \qquad J = \frac{j}{(a + b - j)}$$

With:
- **J**: is the species common number to two sites;
- **a**: the species number present on the station A;
- **b**: the species number present on the station B.

Biological diversity is characterized for each site from a grouping of algae into three categories: green (Chlorophyceae), brown (Pheophyceae) and red (Rhodophyceae). These groupings are described by quadrate and site.

III. RESULTS

On all sites, several species of algae are identified (Appendix 1). The quadrate number site varies depending on the size of each site but also on the heterogeneity of the highly variable background depending on sites, it fluctuates from 6 to 30 quadrates. The sites with the most important algal biodiversity are those of Mly Abdellah and Oualidia. Conversely, the less diverse is Lahdida site. A freshwater input (Oum Er Rabie River) and a significant sand encroachment explain this low diversity.

III.1. Spatio-temporal variation in algal cover

III.1.1.Spatio-temporal distribution

The spatial distribution of marine algae identified varies from geographical station to another and it differs monthly (Fig. 3).

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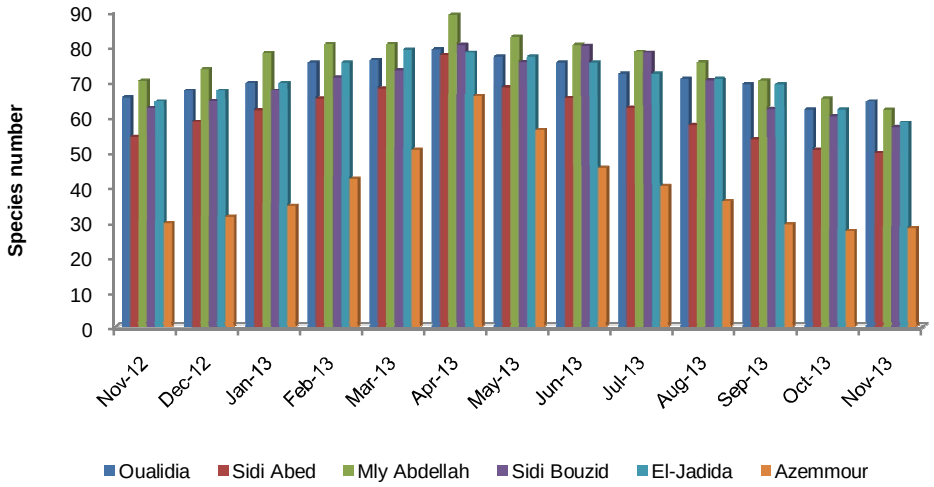

Fig. 3: Spatio-temporal distribution of the algae number in different stations.

The maximum number of algae was observed in April and May 2013. Then gradually decreases to a minimum in November and December. From January, the algae richness increases to its maximum in spring. A station that has a very important algal diversity is Mly Abdellah followed by Oualidia. However, this diversity is minimal in Azemmour.

III.1.2. Algea cover

We determined the covering index for three algae groups (Chlorophyceae, Phaeophyceae and Rhodophyceae). The results obtained show that this index is variable, on the one hand, in a same station, and the other, from one station to another for the same group of algae (Fig. 4).

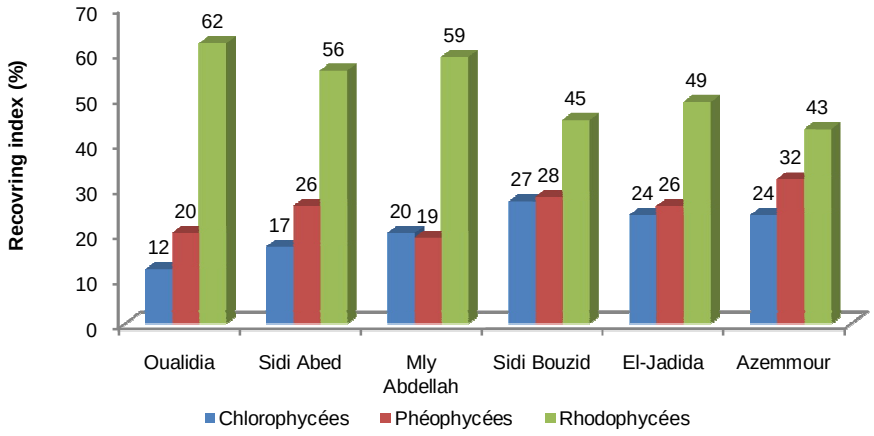

Figure 4: Spatial variation of the covering index for three classes of algae.

According to the results, we note that the Rhodophyceae are the most dominant compared to other algae groups in all of the stations concerned by the study.

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III.2. Sites comparison

The sites comparison shows that algal diversity in Azemmour differs significantly from other selected sites. The similarity index (Jaccard index) calculated is significantly lower than all other sites (table 2). For the other five assemblages of species are also different from one site to another.

Tableau II: Comparison of retained sites from Jaccard Index.

	Oualidia				
Sidi Bouzid	0,28	Sidi Bouzid			
Mly Abdellah	0,38	0,41	Mly Abdellah		
Sidi Abed	0,35	0,33	0,29	Sidi Abed	
El-Jadida	0,28	0,38	0,24	0,24	El-Jadida
Azemmour	0,21	0,27	0,2*	0,27	0,29

* There is a big viewpoint difference of seaweed species richness between two sites Azemmour and Mly Abdellah. The latter site is characterized by a very large and rich algal diversity; essentially red algae.

IV. DISCUSSION

The study of algal diversity has been used to characterize algal cover on the foreshore as well as different characteristic species of each study site. The results showed that the sites are relatively heterogeneous in terms of their species composition. However, the Lahdida site is distinguished from others by a particularly poor algal assemblage. This character is explained, in part, by the specific characters related to the configuration of site:

-Sand encroachment widespread throughout the site;

-Contributions of Oued Oum Er'Rabie freshwater.

Using macroalgae intertidal and subtidal parameter, the overall diversity varies from one station to another, this variation can be explained by the fact that the coastal water mass is subject. In the North (Azemmour), a regular freshening related to the presence of a dense hydrographic network and high rainfall. The principal freshwater and turbid sea vector is Oued Oum Er Rabie in the north of water mass; it drains polluted water at sea. This river is considered one of largest watersheds of the Kingdom, extends over an area of 35,000 km ² with an extension of 550 km. It takes its origin in the Middle Atlas 1800 m, crosses the chain of the Middle Atlas, the Tadla plain and coastal Meseta, and empties into the Atlantic Ocean about 16 km in the El Jadida north (Azemmour), [4]. Its effluents are considered as a source of marine pollution because it brings back with him intakes pollutants and reject it at sea.

The water mass in the study area is subjected to high anthropogenic pressure by discharge of domestic and industrial wastewater in many parts of the coast. However, there is a mobilization for improving water quality with the establishment of major remediation work to optimize the treatment of wastewater.

The overall physicochemical modifications of coastal waters influence on algal communities that develop. The results show a significant inter-site variability; the sites geomorphology and exposure to prevailing swells could affect the density and distribution of structuring algae and thus limit reflects an ecological site conditions. The investigations carried out in the framework of this study do not allow separating the anthropogenic or natural origin of the observed fluctuations.

The discovery of the species *Sargassum muticum* by B. Sabour & al. [1] in the coast between Oualidia and Casablanca for the first time in Africa shows that it has found favorable conditions to grow and reproduce quickly. According to the same author, this species creates competition up to the elimination of competing species. Competition for the occupation of space, to capture light, the use of nutrient salts is manifested first with respect to other algae located on the bottom. In planktonic algae *Sargassum* captures nitrogen and phosphorus, elements necessary for the development of phytoplankton. Therefore, the presence of this species causes an imbalance in the marine ecosystem; living environment of other species of marine flora and fauna of the sites studied.

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The presence of Ulva (*Ulva rigida* (C.Agardh)) and Enteromorpha (*Enteromorpha intestinalis* (Linnaeus) Nees) recognized as nitrophilous and indicator species of habitats rich in organic material gives a pollution vision of the marine environment of the site in which they arise. When pollutants are introduced into marine waters, the first reaction of vegetation is the perennial canoppeae degradation, those of *C. baccata* seems to be more sensitive to pollution compared to *G. sesquipedale*. The development of some of the most pollution-tolerant species such *P. complanata* (Clemente) Falkenberg or *Codium decorticatum* (Woodward) M.A.Howe is encouraged by the absence of canoppeae, and they become the dominant species of the community [5]. The algal abundance and diversity decrease if pollution increases; the perennial algae decline under the pollution effect is the first sign of the deterioration in living environment of these algae ([6]; [7]; [8]; [9]; [10]).

In the study area, perennial algae *Cystoseira* baccata (S.G.Gmelin) P.C.Silva and *Gelidium sesquipedale* are partially replaced by species *Halopithys incurvus* and *Codium adhaerens* (C.Agardh). This fact has been reported by several authors in the Basque coast west to Northern Spain ([11]; [10]) who emphasized the replacement of *Cystoseira spp.* by species of *Codium* in polluted areas, which development is encouraged by the water enrichment by nutrients. The phytobenthic communities in the study area which are moderately affected by pollution are less diversified and show an algal cover reduction. Raw wastewater from the El Jadida city are characterized by an average concentration of suspended material from 767.2 mg / L with a maximum concentration of 937.43 mg / L and a concentration of 542.8 mg / L. These contents registered of suspended matter are above the concentration limit of direct discharges (50 mg / L) and to concentration of indirect discharge (600 mg / L), [12]. The same applies to other physicochemical parameters (COD/BOD_5) they presents major pollution values that exceed relatively general limits of direct and indirect discharges. This causes direct and indirect effects on the macroalgae growth by increasing turbidity in marine waters where they can influence the development cycle and reproduction of algae species present in the study area.

The study conducted by Makroum K. [13] showed that the site near the solid-liquid collector of the phosphate complex is characterized by a sharp disturbance of the water quality, with an increase in temperature throughout the year compared to other sites, The pH is also very acidic, with low levels of dissolved oxygen and high concentrations in orthophsphates. For the site located in El Jadida, which is characterized by the presence of the domestic collector and industrial wastewater, it is characterized by low salinity and high turbidity with very high pollutants levels. The same author also showed that pollution indices by heavy metals are very high on the El Jadida coast, which causes actual danger to the species diversity in macroalgae present in this area. Pollution infects the macroalgae photosynthetic activity; the intensity of this activity may decrease in case of increase in the degree of pollutant parameters in the study sites.

The marine environment of the study area is characterized by a very advanced pollution with unfavorable parameters that do not allow normal development of macrophytes (very acidic pH, low oxygen and especially very high orthophosphate concentrations) [14], [15]. These characteristics explain macrophytes poverty in some parts of the study area. The relatively very high acidity and high temperature and significant levels of fluoride, orthophosphates, cadmium, copper, iron, lead and zinc are the causes of macrophytes poverty in Sidi Abed Site compared to sites Sidi Bouzid and Mly Abdellah remains relatively far from the source of this pollution rejection of Morocco Phosphorus [16].

Therefore, an urban or industrial discharge type is usually long-term biodegradable. Which could negatively affects the macroalgae survival in the studied sites. However, given the quantities discharged into the areas of habitats and the time required for the natural biodegradation, a treatment is necessary to accelerate the process.

V. CONCLUSION

Finally, algal diversity identified in intertidal and subtidal zones does not reflect all the algae species present along the coast between Oualidia and North of Azemmour. Geographical structure and anthropogenic changes at some sites prevented us to apply the sampling protocol correctly in all sites. All these difficulties minimize the surface of the sample (limited quadrate number). To determine the actual distribution of live algae in the study area, it is necessary that the sample surface is larger and quadrates distributed over the entire sampled surface. This experimental phase has not been carried out in this study because of geomorphological and environmental difficulties (exposure to prevailing swells ...); also insufficient time to materialize this survey limited sampling.

Species richness and diversity origins of marine life make the study area coast a reservoir of species plant of which economic potential and interest are considerable. Finally, we see that pollution and grubbing pose a serious threat to our marine resources. Without making rapid awareness of policy makers, the majority of algae resources would be in

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jeopardy. In this context, it becomes necessary to establish a management of biological resources with, as a first step, the development of appropriate legislation, in connection with the pollutants discharged into the sea, uncontrolled algae exploitation and occupation of the coastal area.

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APPENDEX: LIST OF IDENTIFIED SPECIES BY STATION

Annexe 1: List of algae species identified in Oualidia site (reference site).

Algae class	species	Order	Family
Cholorophyceae	*Codium tomentosum* (Kutzing)	Bryopsidales	Codiaceae
	Enteromorpha intestinalis (Link)	Ulvales	Ulvaceae
	Enteromorpha linza (Linnaeus) J. Agardh	Ulvales	Ulvaceae
	Enteromorpha muscoides (Clemente et Rubio)	Ulvales	Ulvaceae
	Ulva crispa (Lightfoot)	Ulvales	Ulvaceae
	Ulva lactuca (C. Agardh)	Ulvales	Ulvaceae
	Ulva fasciata (Delile) Montagne	Ulvales	Ulvaceae
	Ulva rigida (C.Agardh)	Ulvales	Ulvaceae
	Cladophora vagabunda (Linnaeus) C. Hoek	Cladophorales	Acrosiphoniaceae
	Bryopsis penata (J.V. Lamouroux)	Bryopsidales	Acrosiphoniaceae
	Codium adhaerens (C.Agardh)	Bryopsidales	Acrosiphoniaceae
	Chaetomorpha linum (O.F.Müller) Kützing	Cladophorales	Cladophoraceae
	Bryopsis balbisiana (J.V.Lamouroux)	Bryopsidales	Bryopsidaceae
	Bryopsis corymbosa (J.Agardh)	Bryopsidales	Bryopsidaceae
Pheophyceae	*Bifurcaria bifurcata* (R. Ross)	Fucales	Cystoséiraceae
	Cystoseira humilis (Kutzing)	Fucales	Cystoséiraceae
	Cystoseira tamariscifolia (Hudson) Papenfus	Fucales	Cystoséiraceae
	Cystoseira nodicaulis (Withering) M. Roberts	Fucales	Cystoséiraceae
	Cystoseira foeniculacea (Linnaeus) Greville	Fucales	Cystoséiraceae
	Fucus spiralis (Linnaeus)	Fucales	Fucaceae
	Fucus vesiculosus (Linnaeus)	Fucales	Fucaceae
	Laminaria ochroleuca (De La Pylaie)	Laminariales	Laminariaceae
	Taonia atomaria (Woodward) J.Agardh	Dictyotales	Dictyotaceae
	Sacchoriza bulbosa (Linnaeus) J. Agardh	Tilopteridales	Phyllariaceae
	Dictyota dichotoma (Hudson) J.V. Lamouroux	Dictyotales	Dictyotaceae
	Dictyopteris polypodioide De Candolle) J.V. Lamouroux	Dictyotales	Dictyotaceae
	Padina pavonica (Linnaeus) Thivy	Dictyotales	Dictyotaceae
	Sargassum acinarium (Linnaeus) Setchell	Fucales	Sargassaceae
	Sargassum muticum (Yendo) Fensholt	Fucales	Sargassaceae
	Halopteris scoparia (Linnaeus) Sauvageau	Sphacelariales	Stypocaulaceae
	Dictyota dichotoma (Hudson) J.V.Lamouroux	Dictyotales	Dictyotaceae
	Petalonia fascia (O.F.Muller) Kuntze	Scytosiphonales	Scytosiphonaceae
	Scytosiphon lomentaria (Lyngbye) Link	Scytosiphonales	Scytosiphonaceae
	Sphacelaria brachygonia (Montagne)	Sphacelariales	Sphacelariaceae
	Sphacelaria radicans (Dillwyn) C. Agardh	Sphacelariales	Sphacelariaceae
	Sphacelaria rigidata (Kutzing)	Sphacelariales	Sphacelariaceae
	Sphacelaria hystrix (Suhr ex Reinke)	Sphacelariales	Sphacelariaceae
	Laminaria ochroleuca (Bachelot de la Pylaie)	Laminariales	Laminariaceae
	Asparagopsis armata (Harvey)	Bonnemaisoniales	Bonnemaisoniaceae
	Titanoderma cystoseirae (Hauck) Woelkerling	Corallinales	Corallinaceae
	Mesophyllum lichenoides (J. Ellis) M. Lemoine	Corallinales	Corallinaceae
	Lithophyllum incrustans (Phillipi)	Corallinales	Corallinaceae
	Lithophyllum decussatum (J. Ellis et Solander) Phillipi	Corallinales	Corallinaceae
	Lithophyllum byssoides (Lamarck) Foslie	Corallinales	Corallinaceae
	Jania rubens (Linnaeus) J.V. Lamouroux	Corallinales	Corallinaceae
	Jania longifurca (Zanardini)	Corallinales	Corallinaceae
	Hydrolithon farinosum (J.V.Lamouroux) D. Penrose et Y.M.Chamberlain	Corallinales	Corallinaceae
	Amphiroa beauvoisii (J.V.Lamouroux)	Corallinales	Corallinaceae
	Corallina elongata (Ellis and Solander)	Corallinales	Corallinaceae
	Corallina officinalis (Ellis and Solander)	Corallinales	Corallinaceae
	Chondrus cripus (Linnaeus) J.Stackhous	Gigartinales	Gigartinaceae
	Gigartina acicularis (Roth) Lamoroux	Gigartinales	Gigartinaceae
	Caulacanthus ustulatus (Mertens ex Turner) Kutzing	Gigartinales	Calosiphonaceae
	Calliblepharis ciliata (Hudson) Kutzing	Gigartinales	Cystocloniaceae

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Rhodophyceae	*Rhodophyllis divaricata* (Stackhouse) Papenfuss	Gigartinales	Cystocloniaceae
	Chondracanthus acicularis (Roth) Fredericq	Gigartinales	Gigartnaceae
	Chondracanthus teedei (Mertens ex Roth) Kutzing	Gigartinales	Gigartnaceae
	Polysiphonia macrocarpa (C.Agardh) Sprengel	Ceramiales	Rhodomelaceae
	Gigartina pistillata (S.G. Gmelin)Stackhouse	Gigartinales	Gigartnaceae
	Hypnea musciformis (Wulfen) J.V.Lamouroux	Gigartinales	Hypneaceae
	Gelidium spinuloosum (J.Agardh) G.Furnari	Gelidiales	Gelidiaceae
	Gelidium pulchellum (Turner)Kutzing	Gelidiales	Gelidiaceae
	Gelidium crinale (Turner)Gaillon	Gelidiales	Gelidiaceae
	Gelidium sesquipedale (Turner) Thur	Gelidiales	Gelidiaceae
	Gracilaria multipartita (Clemente) J.Cremades	Gracilariales	Gracilariaceae
	Gracilaria dura (C.Agardh) J.Agardh	Gracilariales	Gracilariaceae
	Gracilaria cervicornis (Turner) J.Agardh	Gracilariales	Gracilariaceae
	Halopithys incurrvus (Hudson) Batters	Ceramiales	Rhodomelaceae
	Laurencia pinnatifida (Hudson) J.V. Lamouroux	Ceramiales	Rhodomelaceae
	Plocamium coccinum (P.S. Dixon)	Plocamiales	Plocamiaceae
	Pterosiphonia complanata (Clemente) Falkenberg	Ceramiales	Rhodomelaceae
	Porphyra umbilicalis (Linnaeus) Kutzing	Bangiales	Bangiaceae
	Acrochaetium daviesii (Dillwyn) Nageli	Rhodophycée	Florideophycideae
	Callophyllis laciniata (Hudson) Kutzing	Cryptonemiales	Kallymeniaceae
	Kallymenia reniformis (Turner) J.Agardh	Cryptonemiales	Kallymeniaceae
	Peyssonnelia squamaria (S.G. Gmelin) Decaisne	Cryptonemiales	Peyssonneliaceae
	Antithamnion cruciatum (C.Agardh) Nägeli	Ceramiales	Ceramiaceae
	Mastocarpus stellatus (Stackhouse) Guiry	Gigartinales	Nemastomataceae
	Gymnogongrus crenulatus (Turner)J.Agardh	Gigartinales	Phyllophoraceae
	Gymnogongrus patens (Goode Nough et Wood Ward) J.Agardh	Gigartinales	Phyllophoraceae
	Gymnogongrus griffithsiae (Turner) Martius	Gigartinales	Phyllophoraceae
	Phyllophora crispa (Hudson) P.S.Dixon	Gigartinales	Phyllophoraceae
	Scinaia furcellata (Turner) J.Agardh	Nemaliales	Galaxauraceae
	Nemalion helminthoides (Velley) Batters	Nemaliales	Liagoraceae
	Anotrichium furcellatum (J.A gardh) Baldock	Ceramiales	Ceramiaceae
	Callithamnion tetricum (Dillwyn)S.F.Gray	Ceramiales	Ceramiaceae
	Ceramium ciliatum (J.Ellis) Duchzeau	Ceramiales	Ceramiaceae
	Ceramium echionotum (J.Agardh)	Ceramiales	Ceramiaceae
	Ceramium penicillatum (Areschoug)	Ceramiales	Ceramiaceae
	Pterocladia capillacea (S.G.Gmelin) Bornet	Gigartinales	Pterocladiaceae
	Ceramium gaditanum (Clemente) Cremades	Ceramiales	Ceramiaceae
	Ceramium rubrum (C.Agardh)	Ceramiales	Ceramiaceae
	Antithamnion cruciatum (C.Agardh) Nägeli	Ceramiales	Ceramiaceae
	Pleonosporium borreri (J.E. Smith et Sowerby) Nageli	Ceramiales	Ceramiaceae
	Pterothamnion plumula (J.Ellis) Nageli	Ceramiales	Ceramiaceae
	Spyridia hypnoides (Bory) Papenfuss	Ceramiales	Ceramiaceae
	Griffithsia opuntioides (J.Agardh)	Ceramiales	Wrangeliaceae
	Centroceras clavulatum (C.Agardh) Montagne	Ceramiales	Ceramiaceae
	Dasya ocellata (Grateloup) Harvey	Ceramiales	Dasyaceae
	Acrosorium venulosum (Zanardini) Kylin	Ceramiales	Delesseriaceae
	Cryptopleura ramosa (Hudson) Kylin et L.Newton	Ceramiales	Delesseriaceae
	Erythroglossum lasitanicum (Ardré)	Ceramiales	Delesseriaceae
	Nitophyllum punctatum (Stackhouse) Greville	Ceramiales	Delesseriaceae
	Bostrychia scorpioides (Hudson) Montagne et Kutzing	Ceramiales	Delesseriaceae
	Chondria coerulescens (J.Agardh) Falkenberg	Ceramiales	Delesseriaceae
	Chondria dasyphylla (Wood Ward)C.Agardh	Ceramiales	Delesseriaceae
	Dipterosiphonia rigens (Schousboe et C.Agardh) Falkenberg	Ceramiales	Delesseriaceae
	Laurencia obtusa (Hudson) J.V.Lamouroux	Ceramiales	Delesseriaceae
	Osmundea pinnatifida (Hudson) Stackhouse	Ceramiales	Delesseriaceae
	Polysiphonia atlantica (Kaprann et J.N.Norris)	Ceramiales	Delesseriaceae
	Polysiphonia denudatan (Dillwyn) Greville et Harvey	Ceramiales	Delesseriaceae
	Polysiphonia scopulorum (Harvey)	Ceramiales	Delesseriaceae
	Pterosiphonia complanata (Clemente) Falkenberg	Ceramiales	Delesseriaceae
	Pterosiphonia pennata (C.Agardh) Sauvageau	Ceramiales	Delesseriaceae

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	Osmundea pinnatifida (Hudson) Stackhouse	Ceramiales	Rhodomelaceae

Annexe 2: List of algae species identified in Sidi Bouzid site.

Algae class	species	Order	Family
Cholorophyceae	*Codium tomentosum* (Kutzing)	Bryopsidales	Codiaceae
	Codium elongatum (Turner) Greville	Bryopsidales	Codiaceae
	Codium adhaerens (A. Agardh)	Bryopsidales	Codiaceae
	Codium effusum (Rafinesque) Delle Chiaje	Bryopsidales	Codiaceae
	Enteromorpha intestinalis (Link)	Ulvales	Ulvaceae
	Enteromorpha compressa (Linneaus) Kutzing	Ulvales	Ulvaceae
	Enteromorpha prolifera (O.F.Müller) J.Agardh	Ulvales	Ulvaceae
	Ulva fasciata (Delile)	Ulvales	Ulvaceae
	Ulva lactuca (C. Agardh)	Ulvales	Ulvaceae
	Bryopsis balbisiana (Hudson) C. Agardh	Bryopsidales	Bryopsidaceae
	Blidingia marginata (J.Agardh)P.Dangeard	Ulvales	Ulvaceae
	Enteromorpha linza (Linnaeus) J.Agardh	Ulvales	Ulvaceae
	Enteromorpha prolifera (O.F.Muller) J.Agardh	Ulvales	Ulvaceae
	Ulva bifrous (A. Ardré)	Ulvales	Ulvaceae
	Ulva rigida (C.Agardh)	Ulvales	Ulvaceae
	Chaetomorpha aerea (Dillwyn) Kutzing	Cladophorales	Cladophoraceae
	Chaetomorpha linum (O.F.Muller)Kutzing	Cladophorales	Cladophoraceae
	Cladophora albida (Nees) Kutzing	Cladophorales	Cladophoraceae
	Cladophora prolifera (Roth) Kutzing	Cladophorales	Cladophoraceae
	Bryopsis adriatica (J.Agardh)	Bryopsidales	Codiaceae
	Bryopsis pennata (J.V.Lamouroux)	Bryopsidales	Codiaceae
	Halicystis parvula (Schmitz et G.Murray Stadium)	Bryopsidales	Codiaceae
Pheophyceae	*Bifurcaria bifurcata* (R.Ross)	Fucales	Cystoseiraceae
	Cystoseira humilis (Kutzing)	Fucales	Cystoseiraceae
	Cystoseira baccata (S.G. Gmelin) P.C. Silva	Fucales	Cystoseiraceae
	Cystoseira tamariscifolia (Hudson) Papenfus	Fucales	Cystoseiraceae
	Fucus spiralis (Linnaeus)	Fucales	Fucaceae
	Dictyota dichotoma (Hudson) Lamouroux	Dictyotales	Dictyotaceae
	Taonia atomaria (Woodward) J.Agardh	Dictyotales	Dictyotaceae
	Dictyopteris polydioides (De Candolle) Lamouroux	Dictyotales	Dictyotaceae
	Sarrgassum muticum (Yendo) Fensholt	Fucales	Sargassaceae
	Saccorhiza bulbosa (J.Agardh)	Tilopteridales	Phyllariaceae
	Halopteris scoparia (Linneaus) Sauvageau	Sphacelariales	Stypocaulaceae
	Padina pavonica (Linnaeus) Thivy	Dictyotales	Dictyotaceae
	Cutleria adspersa (Mertens et Roth) De Notaris	Cutleriales	Cutleriaceae
	Dictyopteris polypodioides (De Candolle) J.V.Lamouroux	Dictyotales	Dictyotaceae
	Dictyota fasciola (Roth) J.V.Lamouroux	Dictyotales	Dictyotaceae
	Zonaria tournefortii (J.V.Lamouroux)	Dictyotales	Dictyotaceae
	Ectocarpus fasciculatus (Harvey)	Ectocarpales	Ectocarpaceae
	Laminaria ochroleuca (De La Pylaie)	Laminariales	Laminariaceae
	Sphacelaria hystrix (Suhr ex Reinke)	Sphacelariales	Sphacelariaceae
	Sphacelaria brachygonia (Montagne)	Sphacelariales	Sphacelariaceae
	Sphacelaria fusca (Hudson)S.F. Gray	Sphacelariales	Sphacelariaceae
	Sphacelaria rigidata (Kutzing)	Sphacelariales	Sphacelariaceae
	Halopteris scoparia (Linnaeus) Sauvageau	Sphacelariales	Stypocaulaceae
	Asparagopsis armata (Harvey)	Bonnemaisoniales	Bonnemaisoniaceae
	Corallina officinalis (Ellis and Solander)	Corallinales	Corllinaceae
	Gelidium sesquipedale (Turner) Thur	Gelidiales	Gelidiaceae
	Gelidium spinulosum (C.Agardh)G.Furnari	Gelidiales	Gelidiaceae
	Gelidium reptans (Suhr) Kylin	Gelidiales	Gelidiaceae
	Gelidium pulchellum (Turner) Kützing	Gelidiales	Gelidiaceae
	Caulacanthus ustulatus (Mertens et Turner) Kutzing	Gigartinales	Calosiphonaceae
	Chondracanthus teedei (Mertens et Roth) Kutzing	Gigartinales	Gigartinaceae
	Halopithys incurvus (Hudson) Batters	Ceramiales	Rhodomelaceae
	Laurencia pinnatifida (Hudson) J.V. Lamouroux	Ceramiales	Rhodomelaceae

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Rhodophyceae	*Hypnea musciformis* (Wulfen) J.V. Lamouroux	Gigartinales	Hypneaceae
	Palmaria palmata (Linnaeus) Kuntze	Palmariales	Palmariaceae
	Gracilaria multipartita (Clemente) Harvey	Gracilariales	Gracilariaceae
	Pterosiphonia complanata (Clemente) Sauvageau	Ceramiales	Rhodomelaceae
	Pterosiphonia pennata (C.Agardh) Sauvageau	Ceramiales	Rhodomelaceae
	Chondria dasyphylla (Woodward) C.Agardh	Ceramiales	Rhodomelaceae
	Acrosorium venulosum (Zanardini) Kylin	Ceramiales	Delesseriaceae
	Gigartina pistillata (S.G.Gmelin) Stakhouse	Gigartinales	Gigartinaceae
	Achrochaetium crassipes (Borgesen)	Acrochaetiales	Acrochaetiaceae
	Amphiroa rigida (J.V.Lamouroux)	Corallinales	Corallinaceae
	Peyssonnelia squamaria (S.G.Gmelin) Decaisne	Peyssonneliales	Peyssonneliaceae
	Corallina elongata (J.Ellis et Solander)	Corallinales	Corallinaceae
	Lithophyllum dentatum (Kutzing) Foslie	Corallinales	Corallinaceae
	Lithophyllum incrustans (Philippi)	Corallinales	Corallinaceae
	Melobesia membranacea (Esper) J.V.Lamouroux	Corallinales	Corallinaceae
	Grateloupia filicina (J.V.Lamouroux)	Cryptonemiales	Halumeniaceae
	Gymnogongrus crenulatus (Turner) J.Agardh	Gigartinales	Phyllophoraceae
	Gymnogongrus griffithsiae (Turner) Martius	Gigartinales	Phyllophoraceae
	Phyllophora crispa (Hudson) P.S.Dixon	Gigartinales	Phyllophoraceae
	Gracilaria armata (C.Agardh) Greville	Gracilariales	Gracilariaceae
	Gracilaria conferta (Schousboe et Montagne)	Gracilariales	Gracilariaceae
	Antithamnion cruciatum (C.Agardh) Nägeli	Ceramiales	Ceramiaceae
	Ceramium celiatum (J.Ellis) Duchzeau	Ceramiales	Ceramiaceae
	Heterosiphonia plumosa (J.Ellis) Batters	Ceramiales	Dasyaceae
	Chondria capillaris (Hudson) M.J. Wynne	Ceramiales	Rhodomelaceae
	Osmundea hybrida (A.P. De Candolle) K.W.Nam	Ceramiales	Rhodomelaceae
	Polysiphonia macrocarpa (C.Agardh) Sprengel	Ceramiales	Rhodomelaceae

Annexe 3: List of algae identified in Mly Abdellah site.

Algae class	species	Order	Family
Chlorophyceae	*Enteromorpha intestinalis* (Link)	Ulvales	Ulvaceae
	Ulva rigida (C.Agardh)	Ulvales	Ulvaceae
	Ulva lactuca (C. Agardh)	Ulvales	Ulvaceae
	Ulva fasciata (Delile) Montagne	Ulvales	Ulvaceae
	Blidingia minima (Nägeli ex Kützing) kylin	Ulvales	Kornmanniaceae
	Blidingia marginata (J.Agardh) P.Dangeard	Ulvales	Kornmanniaceae
	Bryopsis corymbosa (J.Agardh)	Bryopsidales	Bryopsidaceae
	Bryopsis adriatica (J.Agardh) Frauenfeld	Bryopsidales	Bryopsidaceae
	Bryopsis balbisiana (J.V.Lamouroux)	Bryopsidales	Bryopsidaceae
	halicystis parvula (F.Schmitz ex G.Murray)	Bryopsidales	Derbesiaceae
	Chaetomorpha aerea (Dillwyn) Kutzing	Cladophorales	Cladophoraceae
	Chaetomorpha mediterranea (Kutzing) Kutzing	Cladophorales	Cladophoraceae
	Chaetomorpha pachynema (Montagne) Kutzing	Cladophorales	Cladophoraceae
	Chaetomorpha linum (O.F.Müller) Kützing	Cladophorales	Cladophoraceae
	Cladophora pellucida (Hudson) Kutzing	Cladophorales	Cladophoraceae
	Cladophora prolifera (Roth) Kutzing	Cladophorales	Cladophoraceae
	Cladophora rupestris (Linnaeus) Kutzing	Cladophorales	Cladophoraceae
	Cladophora albida (Nees) Kutzing	Cladophorales	Cladophoraceae
	Codium tomentosum (Stackhouse)	Bryopsidales	Codiaceae
	Codium adhaerens (C.Agardh)	Bryopsidales	Codiaceae
	Codium effusum (Rafinesque) Delle Chiaje	Bryopsidales	Codiaceae
	Codium decorticatum (Wood Ward)M.A.Howe	Bryopsidales	Codiaceae
	Phyllariopsis brevipes (C.Agardh) E.C.Henry & G.R.South	Tilopteridales	Phyllariaceae
	Enteromorpha linza (Linnaeus) J. Agardh	Ulvales	Ulvaceae
	Enteromorpha clarathrata (Nees) Hauck	Ulvales	Ulvaceae
	Enteromorpha compressa (Linnaeus) Nees	Ulvales	Ulvaceae
	Enteromorpha muscoides (Clemente) Cremades	Ulvales	Ulvaceae
	Enteromorpha prolifera (O.F.Müller) J.Agardh	Ulvales	Ulvaceae
	Valonia utricularis (Roth) C.Agardh	Cladophorales	Valoniaceae
	Bifurcaria bifurcata (R.Ross)	Fucales	Fucaceae

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Pheophyceae	*Cystoseira humilis* (Kutzing)	Fucales	Cystoséiraceae
	Cystoseira tamariscifolia (Hudson) Papenfus	Fucales	Cystoséiraceae
	Fucus spiralis (Linnaeus)	Fucales	Fucaceae
	Laminaria ochroleuca (De La Pylaie)	Laminariales	Laminariaceae
	Elachista flaccida (Dillwyn) Fries	Chordariales	Elachistaceae
	Bachelotia antillarum (Grunow) Gerloff	Scytothamnales	Bachelotiaceae
	Colpomenia sinuosa (Mertens ex Roth) Derbès et Solier	Ectocarpales	Scytosiphonaceae
	Halopteris scoparia (Linnaeus) Sauvageau	Sphacelariales	Stypocaulaceae
	Halopteris filicina (Grateloup) Kützing	Sphacelariales	Stypocaulaceae
	Cystoseira baccata (S.G.Gmelin) P.C.Silva	Fucales	Cystoseiraceae
	Cystoseira elegans (Sauvageau)	Fucales	Cystoseiraceae
	Cystoseira mediterranea (Sauvageau)	Fucales	Cystoseiraceae
	Dictyopteris polypodioides (A.P.De Candolle) J.V.Lamouroux	Dictyotales	Dictyotaceae
	Dictyota fasciola (Roth) J.V.Lamouroux	Dictyotales	Dictyotaceae
	Dictyota dichotoma (Hudson) J.V.Lamouroux	Dictyotales	Dictyotaceae
	Dictyota spiralis (Montagne)	Dictyotales	Dictyotaceae
	Ectocarpus siliculosus (Dillwyn) Lyngbye	Ectocarpales	Ectocarpaceae
	Padina pavonica (Linnaeus) Thivy	Dictyotales	Dictyotaceae
	Saccorhiza bulbosa (Lightfoot) Batters	Laminariales	Phyllariacées
	Scytosiphon lomentaria (Lyngbye) Link	Ectocarpales	Scytosiphonaceae
	Sargassum vulgare (C.Agardh)	Fucales	Sargassaceae
	Sargassum muticum (Yendo) Fensholt	Fucales	Sargassaceae
	Ectocarpus fasciculatus (Harvey)	Ectocarpales	Ectocarpaceae
	Colpomenia sinuosa (Mertens ex Roth) Derbès et Solier	Scytosiphonales	Scytosiphonaceae
	Petalonia fascia (O.F. Muller) Kuntze	Scytosiphonales	Scytosiphonaceae
	Sphacelaria hystrix (Suhr ex Reinke)	Sphacelariales	Sphacelariaceae
	Sphacelaria radicans (Dillwyn)	Sphacelariales	Sphacelariaceae
	Saccorhiza bulbosa (J.Agardh)	Tilopteridales	Phyllariaceae
Rhodophyceae	*Asparagopsis armata* (Harvey)	Bonnemaisoniales	Bonnemaisoniaceae
	Corallina officinalis (Ellis and Solander)	Corallinales	Corallinaceae
	Amphiroa beauvoisii (J.V. Lamouroux)	Corallinales	Corallinaceae
	Gelidium spathulatum (Kützing) Bornet	Gelidiales	Gelidiaceae
	Gelidium sesquipedale (Turner) Thur	Gelidiales	Gelidiaceae
	Gelidium spinuloosum (J.Agardh) G.Furnari	Gelidiales	Gelidiaceae
	Gelidium pulchellum (Turner) Kützing	Gelidiales	Gelidiaceae
	Gelidium crinale (Hare ex Turner) Gaillon	Gelidiales	Gelidiaceae
	Gracilaria multipartita (Clemente) J.Cremades	Gracilariales	Gigartinaceae
	Gracilaria cervicornis (Turner) J.Agardh	Gracilariales	Gracilariaceae
	Halopithys incurrvus (Hudson) Batters	Ceramiales	Rhodomelaceae
	Pterosiphonia complanata (Clemente) Falkenberg	Ceramiales	Rhodomelaceae
	Ahnfeltiopsis devoniensis (Greville) P.C.Silva et DeCew	Gigartinales	Phyllophoraceae
	Banjia atropurpurea (Roth) C.Agarh	Bangiales	Bangiaceae
	Bornetia secundiflora (J.Agardh) Thuret	Ceramiales	Ceramiaceae
	Calliblepharis ciliata (Hudson) Kützing	Gigartinales	Cystocloniaceae
	Calliblepharis jubata (Goodenough & Woodward) Kützing	Gigartinales	Cystocloniaceae
	Callithamnion tetricum (Dillwyn) S.F.Gray	Ceramiales	Callithamniaceae
	Caulacanthus ustulatus (Mertens ex Turner) Kützing	Gigartinales	Caulacanthaceae
	Rhodophyllis divaricata (Stackhouse) Papenfuss	Gigartinales	Cystocloniaceae
	Centroceras clavulatum (C.Agardh) Montagne	Ceramiales	Ceramiaceae
	Ceramium diaphanum (Lightfoot) Roth	Ceramiales	Ceramiaceae
	Ceramium rubrum (C.Agardh)	Ceramiales	Ceramiaceae
	Ceramium penicillatum (Areschoug)	Ceramiales	Ceramiaceae
	Champia parvula (C.Agardh) Harvey	Rhodymeniales	Champiaceae
	Chondrocanthus acicularis (Roth) Frederiq	Gigartinales	Gigartinaceae
	Chondrocanthus teedei (Mertens ex Roth) Kutzing	Gigartinales	Gigartinaceae
	Acrochaetium microscopium (Nageli ex Kutzing)	Acrochaetiales	Acrochaetiaceae
	Chondria coerulescens (J.Agardh) Falkenberg	Ceramiales	Rhodomelaceae
	Chondria dasyphylla (Woodward) C.Agardh	Ceramiales	Rhodomelaceae
	Polysiphonia macrocarpa (C.Agardh) Sprengel	Ceramiales	Rhodomelaceae
	Corallina elongata (J.Ellis et Solander)	Corallinales	Corallinaceae

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	Cryptopleura ramosa (Hudson) L.Newton	Ceramiales	Delesseriaceae
	Dasya hutchinsiae (Harvey)	Ceramiales	Dasyaceae
	Dipterosiphonia rigens (Shousboe ex C.Agardh) Falkenberg	Ceramiales	Rhodomelaceae
	Gastroclonium ovatum (Hudson) Papenfuss	Rhodymeniales	Champiaceae
	Gigartina pistillata (S.G.Gmelin) Stackhouse	Gigartinales	Gigartinaceae
	Gracilaria cervicornis (Turner) J.Agardh	Gracilariales	Gracilariaceae
	Gracilaria conferta (Schousboe ex Montagne) Montagne	Gracilariales	Gracilariaceae
	Gracilaria verrucosa (Hudson) Papenfuss	Gracilariales	Gracilariaceae
	Gracilaria armata (C.Agardh) Greville	Gracilariales	Gracilariaceae
	Gymnogongrus crenulatus (Turner) J.Agardh	Gigartinales	Phyllophoraceae
	Gymnogongrus griffithsiae (Turner) Martius	Gigartinales	Phyllophoraceae
	Gymnogongrus patens (J.Agardh)	Gigartinales	Phyllophoraceae
	Hypnea musciformis (Wulfen) J.V.Lamouroux	Gigartinales	Cystocloniaceae
	Jania longifurca (Wulfen) J.V.Lamouroux	Gigartinales	Cystocloniaceae
	Jania rubens (Linnaeus) J.V.Lamouroux	Corallinales	Corallinaceae
	Rhodophyllis bifida (Greville) Kützing	Gigartinales	Cystocloniaceae
	Laurencia obtusa (Hudson) J.V.Lamouroux	Ceramiales	Rhodomelaceae
	Lithophyllum byssoides (Lamarck) Foslie	Corallinales	Corallinaceae
	Lithophyllum dentatum (Kützing) Foslie	Corallinales	Corallinaceae
	Lithophyllum incrustans (Philippi)	Corallinales	Corallinaceae
	Mesophyllum lichenoides (J. Ellis) M. Lemoine	Corallinales	Hapalidiaceae
	Phymatolithon tenuissimum (Foslie) W.H.Adey	Corallinales	Hapalidiaceae
	Pnephyllum fragile (Kutzing)	Corallinales	Corallinaceae
	Titanoderma pustulatum (J.V.Lamouroux) Nageli	Corallinales	Corallinaceae
	Contarinia squamariae (Meneghini) Denizot	Gigartinales	Rhizophyllidaceae
	Lomentaria articulata (Hudson) Lyngbye	Rhodymeniales	Lomentariaceae
	Mesophyllum lichenoides (J.Ellis) Me.Lemoine	Corallinales	Hapalidiaceae
	Myriogramme costata (P.J.L.Dangeard)	Ceramiales	Delesseriaceae
	Nitophyllum punctatum (Stackhouse) Greville	Ceramiales	Delesseriaceae
	Osmundea hybrida (A.P.de Candolle) K.W.Nam	Ceramiales	Rhodomelaceae
	Osmundea pinnatifida (Hudson) Stackhouse	Ceramiales	Rhodomelaceae
	Griffithsia opuntioides (J.Agardh)	Ceramiales	Wrangeliaceae
	Antithamnion cruciatum (C.Agardh) Nägeli	Ceramiales	Ceramiaceae
	Phyllophora crispa (Hudson) P.S.Dixon	Gigartinales	Phyllophoraceae
	Phyllophora heredia (Clemente) J.Agardh	Gigartinales	Phyllophoraceae
	Phyllophora pseudoceranoides (S.G.Gmelin) Newroth	Gigartinales	Phyllophoraceae
	Phyllophora sicula (Kützing) Guiry & L.M.Irvine	Gigartinales	Phyllophoraceae
	Plocamium cartilagineum (Linnaeus) P.S.Dixon	Plocamiales	Plocamiaceae
	Pterocladiella capillacea (S.G.Gmelin) Santelices & Hommersand	Gigartinales	Pterocladiaceae
	Pterosiphonia complanata (Clemente) Falkenberg in Schmitz & Falkenberg	Ceramiales	Rhodomelaceae
	Pterosiphonia pennata (C.Agardh) Sauvageau	Ceramiales	Rhodomelaceae
	Rhodophyllis divaricata (Stackhouse) Papenfuss	Gigartinales	Cystocloniaceae
	Rhodymenia pseudopalmata (J.V.Lamouroux) P.C.Silva	Rhodymeniales	Rhodymeniaceae
	Sphaerococcus coronopifolius (Stackhouse)	Gigartinales	Sphaerococcaceae
	Plocamium cartilagineum (Linnaeus) P.S.Dixon	Plocamiales	Plocamiaceae
	Lomentaria articulata (Hudson) Lyngbye	Rhodymeniales	Lomentariaceae

Annexe 4: List of algae identified in Sidi Abed site.

Algae class	species	Order	Family
Chlorophyceae	*Enteromorpha intestinalis* (Link)	Ulvales	Ulvaceae
	Enteromorpha linza (Linnaeus) J. Agardh	Ulvales	Ulvaceae
	Enteromorpha prolifera (O.F.Müller) J.Agardh	Ulvales	Ulvaceae
	Ulva crispa (Lightfoot)	Ulvales	Ulvaceae
	Ulva lactuca (C. Agardh)	Ulvales	Ulvaceae
	Cladophora vagabunda (Linnaeus) C.Hoek	Cladophorales	Cladophoraceae
	Bryopsis pennata (Hudson) C.Agardh	Bryopsidales	Bryopsidaceae
	Codium adhaerens (C.Agardh)	Bryopsidales	Codiaceae
	Codium tomentosum (Stakhouse)	Bryopsidales	Codiaceae

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	Halicystis parvula (Schmitz ex G.Murray Stadium)	Bryopsidales	Derbesiaceae
	Blidingia marginata (J. Agardh) P.Dangeard	Ulvales	Kornmanniaceae
	Bryopsis balbisiana (J.V.Lamouroux)	Bryopsidales	Bryopsidaceae
Pheophyceae	*Bifurcaria bifurcata* (R.Ross)	Fucales	Fucaceae
	Cystoseira humilis (Kutzing)	Fucales	Cystoséiraceae
	Cystoseira tamariscifolia (Hudson) Papenfus	Fucales	Cystoséiraceae
	Fucus spiralis (Linnaeus)	Fucales	Fucaceae
	Laminaria ochroleuca (de la Pylaie)	Laminariales	Laminariaceae
	Taonia atomaria (Woodward) J.Agardh	Dictyotales	Dictyotaceae
	Dictyota dichotoma (Hudson) J.V.Lamouroux	Dictyotales	Dictyotaceae
	Saccorhiza bulbosa (Linnaeus) J. Agardh	Tilopteridales	Phyllariaceae
	Dictyota fasciola (Roth) J.V.Lamouroux	Dictyotales	Dictyotaceae
	Sargassum vulgare (C.Agardh)	Fucales	Sargassaceae
	Elachista fucuicola (Velley) Areschoug	Ectocarpales	Chordariaceae
	Dictyopteris polypodioides (De Candolle) J.V.Lamouroux	Dictyotales	Dictyotaceae
	Dictyota dichotoma (Hudson) J.V.Lamouroux	Dictyotales	Dictyotaceae
	Dictyota spiralis (Montagne)	Dictyotales	Dictyotaceae
	Padina pavonica (Linnaeus) Thivy	Dictyotales	Dictyotaceae
	Saccorhiza polyschides (Lightfoot) Batters	Tilopteridales	Phyllariaceae
	Scytosiphon lomentaria (Lyngbye) Link	Ectocarpales	Scytosiphonaceae
	Petalonia fascia (O.F.Muller) Kuntze	Ectocarpales	Scytosiphonaceae
	Halopteris filicina (Grateloup) Kutzing	Sphacelariales	Stypocaulaceae
Rhodophyceae	*Asparagopsis armata* (Harvey)	Bonnemaisoniales	Bonnemaisoniaceae
	Chondracanthus teedei (Mertens ex Roth) Kützing	Gigartinales	Gigartinaceae
	Chondracanthus acicularis (Roth) Fredericq	Gigartinales	Gigartinaceae
	Corallina elongata (J.Ellis & Solander)	Corallinales	Corallinaceae
	Corallina officinalis (Ellis and Solander)	Corallinales	Corallinaceae
	Chondrus crispus (Linnaeus) J.Stackhouse	Gigartinales	Gigartinaceae
	Gelidium sesquipedale (Turner) Thur	Gelidiales	Gelidiaceae
	Gelidium spinulosum (J.Agardh) G.Furnari	Gelidiales	Gelidiaceae
	Gelidium crinale (Hare ex Turner) Gaillon	Gelidiales	Gelidiaceae
	Gelidium pusillum (Stackhouse) Le Jolis	Gelidiales	Gelidiaceae
	Gigartina pistillata (S.G.Gmelin) Stackhouse	Gigartinales	Gigartinaceae
	Gigartina acicularis (Roth) Lamoroux	Gigartinales	Gigartinaceae
	Gracilaria multipartita (Clemente) J.Cremades	Gracilariales	Gigartinaceae
	Gracilaria verrucosa (Hudson) Papenfuss	Gracilariales	Gracilariaceae
	Acrochaetium daviesii (Dillwyn) Nageli	Acrochaetiales	Acrochaetiaceae
	Amphiroa beauvoisii (J.V.Lamouroux)	Corallinales	Corallinaceae
	Hydrolithon farinosum (J.V.Lamouroux) D.Penrose	Corallinales	Corallinaceae
	Phymatolithon tenuissimum (Foslie) W.H.Adey	Corallinales	Hapalidiaceae
	Gelidium microdon (Kützing)	Gelidiales	Gelidiaceae
	Rhodophyllis divaricata (Stackhouse) Papenfuss	Gigartinales	Cystocloniaceae
	Phyllophora crispa (Hudson) P.S.Dixon	Gigartinales	Phyllophoraceae
	Gracilaria conferta (Schousboe ex Montagne) Montagne	Gracilariales	Gracilariaceae
	Peyssonelia squamaria (S.G.Gmelin) Decaisne	Peyssonneliales	Peyssonneliaceae
	Plocamium cartilagineum (Linnaeus) P.S.Dixon	Plocamiales	Plocamiaceae
	Ceramium rubrum (C.Agardh)	Ceramiales	Ceramiaceae
	Heterosiphonia plumosa (J.Ellis) Batters	Ceramiales	Dasyaceae
	Chondria dasyphylla (Woodward) C.Agardh	Ceramiales	Rhodomelaceae
	Osmundea pinnatifida (Hudson) Stackhouse	Ceramiales	Rhodomelaceae
	Rhodophyllis bifida (Greville) Kützing	Gigartinales	Cystocloniaceae
	Halopithys incurrvus (Hudson) Batters	Ceramiales	Rhodomelaceae
	Hypnea musciformis (Wulfen) J.V.Lamouroux	Gigartinales	Cystocloniaceae
	Laurencia pinnatifida (Hudson) J.V. Lamouroux	Ceramiales	Rhodomelaceae
	Centroceras clavulatum (C.Agardh) Montagne	Ceramiales	Ceramiaceae
	Caulacanthus ustulatus (Mertens ex Turner) Kützing	Gigartinales	Caulacanthaceae
	Polysiphonia macrocarpa (C.Agardh) Sprengel	Ceramiales	Rhodomelaceae
	Plocamium coccinum (P.S. Dixon)	Gigartinales	Plocamiaceae
	Pterosiphonia complanata (Clemente) Falkenberg	Ceramiales	Rhodomelaceae
	Osmundea hybrida (A.P.de Candolle) K.W.Nam	Ceramiales	Rhodomelaceae
	Antithamnion cruciatum (C.Agardh) Nägeli	Ceramiales	Ceramiaceae

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Annexe 5: List of algae identified in d'El-Jadida site.

Algae class	species	Order	Family
Cholorophyceae	*Blidingia minima* (Nägeli ex Kützing) Kylin	Ulvales	Kornmanniaceae
	Enteromorpha linza (Linnaeus) J.Agardh	Ulvales	Ulvaceae
	Blidingia marginata (J.Agardh) P.J.L.Dangeard	Ulvales	Kornmanniaceae
	Enteromorpha compressa (Linnaeus) Nees	Ulvales	Ulvaceae
	Enteromorpha prolifera (O.F.Müller) J.Agardh	Ulvales	Ulvaceae
	Chaetomorpha linum (O.F.Müller) Kützing	Cladophorales	Cladophoraceae
	Chaetomorpha aerea (Dillwyn) Kützing	Cladophorales	Cladophoraceae
	Cladophora albida (Nees) Kutzing	Cladophorales	Cladophoraceae
	Cladophora coelothrix (Kützing)	Cladophorales	Cladophoraceae
	Valonia utricularis (Roth) C.Agardh	Cladophorales	Valoniaceae
	Bryopsidella neglecta (Berthold) H.Rietema	Bryopsidales	Bryopsidaceae
	Bryopsis adriatica (J.Agardh) Frauenfeld	Bryopsidales	Bryopsidaceae
	Bryopsis pennata (J.V.Lamouroux)	Bryopsidales	Bryopsidaceae
	Bryopsis plumosa (Hudson) C.Agardh	Bryopsidales	Bryopsidaceae
	Codium decorticatum (Woodward) M.A.Howe	Bryopsidales	Codiaceae
	Codium vermilara (Olivi) Delle Chiaje	Bryopsidales	Codiaceae
	Halicystis parvula (F.Schmitz ex Murra)	Bryopsidales	Derbesiaceae
	Ulva rigida (C.Agardh)	Ulvales	Ulvaceae
	Ulva lactuca (Linnaeus)	Ulvales	Ulvaceae
	Ulva fasciata (Delile) Montagne	Ulvales	Ulvaceae
Pheophyceae	*Ectocarpus siliculosus* (Dillwyn) Lyngbye	Ectocarpales	Ectocarpaceae
	Elachista flaccida (Dillwyn) Fries	Ectocarpales	Chordariaceae
	Scytosiphon lomentaria (Lyngbye) Link	Ectocarpales	Scytosiphonaceae
	Cutleria adspersa (Mertens ex Roth) De Notaris	Cutleriales	Cutleriaceae
	Desmarestia ligulata (Stackhouse) J.V.Lamouroux	Desmarestiales	Desmarestiaceae
	Dictyopteris polypodioides (A.P.De Candolle) J.V.Lamouroux	Dictyotales	Dictyotaceae
	Dictyota dichotoma (Hudson) J.V.Lamouroux	Dictyotales	Dictyotaceae
	Dictyota fasciola (Roth) J.V.Lamouroux	Dictyotales	Dictyotaceae
	Taonia atomaria (Woodward) J.Agardh	Dictyotales	Dictyotaceae
	Dictyota spiralis (Montagne)	Dictyotales	Dictyotaceae
	Nemoderma tingitanum (Schousboe ex Bornet)	Nemodermatales	Nemodermataceae
	Cystoseira humilis (Schousboe ex Kützing)	Fucales	Sargassaceae
	Sargassum muticum (Yendo) Fensholt	Fucales	Sargassaceae
	Saccorhiza bulbosa (J.Agardh)	Tilopteridales	Phyllariaceae
	Padina pavonica (Linnaeus) Thivy in W.R. Taylor	Dictyotales	Dictyotaceae
	Halopteris filicina (Grateloup) Kützing	Sphacelariales	Stypocaulaceae
	Phyllariopsis brevipes (C.Agardh) E.C.Henry	Tilopteridales	Phyllariaceae
	Halopteris scoparia (Grateloup) Kützing	Sphacelariales	Stypocaulaceae
	Sphacelaria hystrix (Suhr ex Reinke)	Sphacelariales	Sphacelariaceae
	Pilinia rimosa (Kützing)	Ectocarpales	Ectocarpaceae
	Laminaria ochroleuca (Bachelot de la Pylaie)	Laminariales	Laminariaceae
	Sphacelaria radicans (Dillwyn) C.Agardh	Sphacelariales	Sphacelariaceae
Rhodophyceae	*Asparagopsis armata* (Harvey)	Bonnemaisoniales	Bonnemaisoniaceae
	Gelidium sesquipedale (Turner) Thur	Gelidiales	Gelidiaceae
	Gelidium pulchellum (Turner) Kützing	Gelidiales	Gelidiaceae
	Gelidium crinale (Hare ex Turner) Gaillon	Gelidiales	Gelidiaceae
	Gelidium latifolium (Bornet ex Hauck)	Gelidiales	Gelidiaceae
	Halopithys incurrvus (Hudson) Batters	Ceramiales	Rhodomelaceae
	Gigartina pistillata (S.G.Gmelin) Stackhouse	Gigartinales	Gigartinaceae
	Gracilaria multipartita (Clemente) Harvey	Gracilariales	Gracilariaceae
	Ahnfeltiopsis devoniensis (Greville) P.C.Silva	Gigartinales	Phyllophoraceae
	Caulacanthus ustulatus (Mertens ex Turner) Kützing	Gigartinales	Caulacanthaceae
	Chondracanthus teedei (Mertens ex Roth) Kützing	Gigartinales	Gigartinaceae
	Corallina elongata (J.Ellis & Solander)	Corallinales	Corallinaceae
	Corallina officinalis (Linnaeus)	Corallinales	Corallinaceae
	Sahlingia subinterga (Rosenvinge) Kornmann	Erythropeltidales	Erythrotrichiaceae
	Polysiphonia macrocarpa (C.Agardh) Sprengel	Ceramiales	Rhodomelaceae
	Rhodophyllis bifida (Greville) Kützing	Gigartinales	Cystocloniaceae

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	Acrochaetium crassipes (Børgesen) Børgesen	Acrochaetiales	Acrochaetiaceae
	Amphiroa rigida (J.V.Lamouroux)	Corallinales	Corallinaceae
	Lithophyllum byssoides (Lamarck) Foslie	Corallinales	Corallinaceae
	Lithophyllum incrustans (Philippi)	Corallinales	Corallinaceae
	Phymatolithon calcareum (Pallas) W.H.Adey & D.L.McKibbin	Corallinales	Hapalidiaceae
	Titanoderma pustulatum (J.V.Lamouroux) Nägeli	Corallinales	Corallinaceae
	Grateloupia lanceola (J.Agardh) J.Agardh	Halymeniales	Halymeniaceae
	Gymnogongrus griffithsiae (Turner) Martius	Gigartinales	Phyllophoraceae
	Rhodophyllis divaricata (Stackhouse) Papenfuss	Gigartinales	Cystocloniaceae
	Rhodophyllis bifida (Greville) Kützing	Gigartinales	Cystocloniaceae
	Mastocarpus stellatus (Stackhouse) Guiry	Gigartinales	Phyllophoraceae
	Ceramium ciliatum (J.Ellis) Ducluzeau	Ceramiales	Ceramiaceae
	Griffithsia opuntioides (J.Agardh)	Ceramiales	Wrangeliaceae
	Chondrea cappilaris (Hudson) M.J.Wynne	Ceramiales	Rhodomelaceae
	Hypnea musciformis (Wulfen) J.V.Lamouroux	Gigartinales	Cystocloniaceae
	Peyssonnelia squamaria (S.G.Gmelin) Decaisne	Peyssonneliales	Peyssonneliaceae
	Chondracanthus acicularis (Roth) Fredericq	Gigartinales	Gigartinaceae
	Grateloupia filicina (J.V.Lamouroux) C.Agardh	Halymeniales	Halymeniaceae
	Gymnogongrus patens (J.Agardh)	Gigartinales	Phyllophoraceae
	Jania rubens (Linnaeus) J.V.Lamouroux	Corallinales	Corallinaceae
	Laurencia obtusa (Hudson) J.V.Lamouroux	Ceramiales	Rhodomelaceae
	Osmundea pinnatifida (Hudson) Stackhouse	Ceramiales	Rhodomelaceae
	Lithophyllum lichenoides (J.Ellis) Me.Lemoine	Corallinales	Hapalidiaceae
	Boergeseniella fruticulosa (Wulfen) Kylin	Ceramiales	Rhodomelaceae
	Pterosiphonia complanata (Clemente) Falkenberg	Ceramiales	Rhodomelaceae
	Gelidium microdon (Kützing)	Gelidiales	Gelidiaceae

Annexe 6: List of algae identified in d'Azemmour site.

Algae class	species	Order	Family
Cholorophyceae	*Enteromorpha intestinalis* (Linnaeus) Nees	Ulvales	Ulvaceae
	Enteromorpha linza (Linnaeus) J.Agardh	Ulvales	Ulvaceae
	Enteromorpha prolifera (O.F.Müller) J.Agardh	Ulvales	Ulvaceae
	Cladophora albida (Nees) Kutzing	Cladophorales	Cladophoraceae
	Bryopsis pennata (J.V.Lamouroux)	Bryopsidales	Bryopsidaceae
	Bryopsis plumosa (Hudson) C.Agardh	Bryopsidales	Bryopsidaceae
	Blidingia marginata (J.Agardh) P.J.L.Dangeard	Ulvales	Kornmanniaceae
	Codium adhaerens (C.Agardh)	Bryopsidales	Codiaceae
	Cladophora pellucida (Hudson) Kutzing	Cladophorales	Cladophoraceae
	Ulva fasciata (Delile) Montagne	Ulvales	Ulvaceae
	Ulva rigida (C.Agardh)	Ulvales	Ulvaceae
	Chaetomorpha linum (O.F.Müller) Kützing	Cladophorales	Cladophoraceae
Pheophyceae	*Ectocarpus siliculosus* (Dillwyn) Lyngbye	Ectocarpales	Ectocarpaceae
	Sargassum muticum (Yendo) Fensholt	Fucales	Sargassaceae
	Nemoderma tingitanum (Schousboe ex Bornet)	Nemodermatales	Nemodermataceae
	Desmarestia ligulata (Stackhouse) J.V.Lamouroux	Desmarestiales	Desmarestiaceae
	Saccorhiza bulbosa (J.Agardh)	Tilopteridales	Phyllariaceae
	Dictyota dichotoma (Hudson) J.V.Lamouroux	Dictyotales	Dictyotaceae
	Sphacelaria hystrix (Suhr ex Reinke)	Sphacelariales	Sphacelariaceae
	Petalonia fascia (O.F.Muller) Kuntze	Ectocarpales	Scytosiphonaceae
	Colpomenia sinuosa (Mertens ex Roth) Derbès et Solier	Ectocarpales	Scytosiphonaceae
	Sphacelaria hystrix (Suhr ex Reinke)	Sphacelariales	Sphacelariaceae
	Scytosiphon lomentaria (Lyngbye) Link	Ectocarpales	Scytosiphonaceae
	Laminaria ochroleuca (de la Pylaie)	Laminariales	Laminariaceae
	Cutleria adspersa (Mertens et Roth) De Notaris	Cutleriales	Cutleriaceae
	Cystoseira tamariscifolia (Hudson) Papenfus	Fucales	Sargassaceae
	Halopteris filicina (Grateloup) Kützing	Sphacelariales	Stypocaulaceae
	Halopteris scoparia (Linnaeus) Sauvageau	Sphacelariales	Stypocaulaceae
	Gelidium sesquipedale (Turner) Thur	Gelidiales	Gelidiaceae
	Gelidium pulchellum (Turner) Kützing	Gelidiales	Gelidiaceae

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Rhodophyceae	*Halopithys incurrvus* (Hudson) Batters	Ceramiales	Rhodomelaceae
	Gigartina pistillata (S.G.Gmelin) Stackhouse	Gigartinales	Gigartinaceae
	Gracilaria multipartita (Clemente) Harvey	Gracilariales	Gracilariaceae
	Laurencia obtusa (Hudson) J.V.Lamouroux	Ceramiales	Rhodomelaceae
	Pterosiphonia complanata (Clemente) Falkenberg	Ceramiales	Rhodomelaceae
	Caulacanthus ustulatus (Mertens ex Turner) Kützing	Gigartinales	Caulacanthaceae
	Chondrea cappilaris (Hudson) M.J.Wynne	Ceramiales	Rhodomelaceae
	Lithophyllum byssoides (Lamarck) Foslie	Corallinales	Corallinaceae
	Gymnogongrus patens (J.Agardh)	Gigartinales	Phyllophoraceae
	Hypnea musciformis (Wulfen) J.V.Lamouroux	Gigartinales	Cystocloniaceae
	Corallina officinalis (Linnaeus)	Corallinales	Corallinaceae
	Heterosiphonia plumosa (J.Ellis) Batters	Ceramiales	Dasyaceae
	Polysiphonia macrocarpa (C.Agardh) Sprengel	Ceramiales	Rhodomelaceae
	Asparagopsis armata (Harvey)	Bonnemaisoniales	Bonnemaisoniaceae
	Phyllophora sicula (Kützing) Guiry & L.M.Irvine	Gigartinales	Phyllophoraceae
	Lomentaria articulata (Hudson) Lyngbye	Rhodymeniales	Lomentariaceae
	Palmaria palmata (Linnaeus) Kuntze	Palmariales	Palmariaceae
	Mastocarpus stellatus (Stackhouse) Guiry	Gigartinales	Phyllophoraceae