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Ecological Quality of the Macroalgal Communities Along the Algerian West Coast (South Mediterranean Sea)

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ABSTRACT

Macroalgae are important elements in coastal ecosystems. Their diversity and distribution are influenced by local ecological conditions, justifying their use in coastal ecosystem assessments. This study aimed to analyze the ecological status of macroalgal communities along the Algerian west coast. Four coastal departments (Mostaganem, Oran, Ain Temouchent and Ghazaouet) with ten sites were sampled in spring 2024. The results showed that there were 82 species of macroalgae grouped into 23 orders, 38 families, 56 genus and four classes: Floridaophyceae (47.56%), Phaeophyceae and Ulvophyceae (25.60%) and Chlorophyceae (1.21 %). The structural analysis revealed a clear dominance of Florideophyceae, with 39 species identified. The highest macroalgae diversity was found at the Ain Témouchent and Mostaganem sites, with 58 and 56 species, respectively. Statistical analyses revealed significant differences between stations, indicating a non-random species distribution influenced by environmental conditions. Management of macroalgae resources is needed to maintain the sustainability of the coastal ecosystem, through a national coastal monitoring program should be established.

INTRODUCTION

Macroalgae are used as biological indicators of ecosystem health **(D'Archino & Piazzi, 2021)**. Algal diversity in aquatic environments can help assess the health status of ecosystems, provide information about invasions of new species and inform species diversity changes according to environmental conditions **(Ramdani *et al.,* 2020; Bouiadjra *et al.*, 2021; Ghellai *et al.*, 2021)**. Macroalgae have long been used as biological indicators of marine ecosystem health worldwide due to their ecological importance and sensitivity to environmental stress **(Han *et al.,* 2023)**. Algerian west coastal areas are highly vulnerable to human pressure and are among the most exploited by anthropic activities **(Mehtougui *et al.*, 2018; Kalakhi *et al.*, 2023)**. The consequences are measured in terms of the weakening of the most remarkable habitats, the reduction of marine productivity, the erosion of biodiversity, the scarcity of the most vulnerable species and the appearance of opportunistic and invasive species **(Khadidja *et al.*, 2018; Hellal *et al.*, 2021; Mansouri *et al.*, 2021; Mansouri & Kerfouf, 2025)**. This study aimed to determine the species composition, the spatial distribution and ecological quality of the macroalgal communities in the coastal ecosystems along the Algerian west coast.

MATERIALS AND METHODS

1. Study sites

The study area is located on the Algerian west coast between the Algerian-Moroccan border and the Chellif River estuary (Fig. 1). This area is exposed to pollution and other degradation resulting from the development of multiple socio-economic activities: urbanization, tourism, fishing and commercial ports **(Djad *et al.*, 2015; Mehtougui *et al.*, 2015; Kies *et al.*, 2020)**.

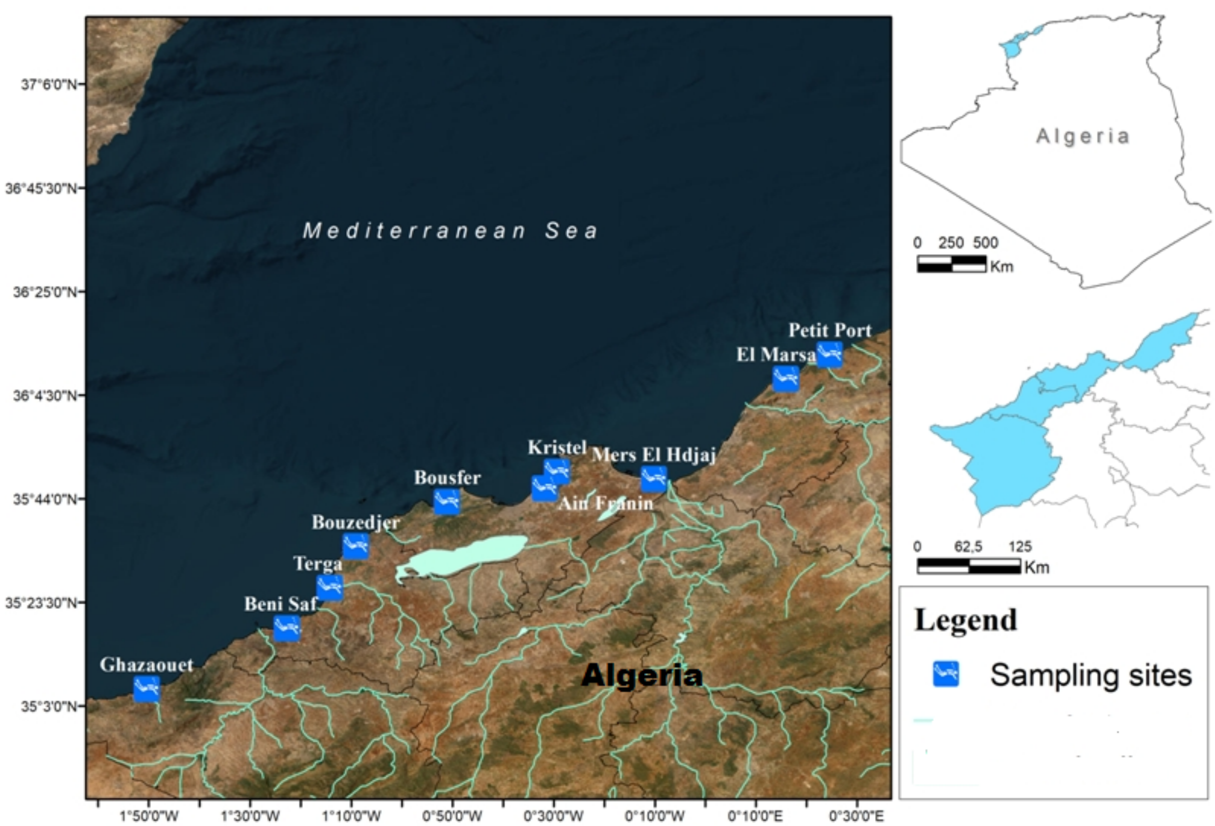

Fig. 1. Geographical location of sampling sites

2. Sampling

The method used for the inventory of marine macroalgae is that of the minimum recommended area for phytosociological samples. The samples were taken on an elementary surface constituting a survey using a quadra with a surface of 50x50cm^2, corresponding to the minimum area adopted for the study of macroalgae community **(Boudouresque, 1971)**. Two major factors were taken into consideration when choosing the sampling period: season and pollution. To establish a floristic checklist, ten stations were randomly sampled from seven quadrats per station at depths between 1 and 2m. Sampling was taken out in the intertidal zone from March to April 2024.

The Algerian west coast is divided into 4 maritime districts: Mostaganem (3 sites: El Marsa, Petit Port, Mars El Hdjaj), Oran (3 sites : Kristel, Ain Franine, Bousfer), Ain Témouchent (3 sites ; Bouzdjer, Terga, Beni Saf) and Ghazaouet with a single site (Table 1).

In the laboratory, the species were separated, cleaned and dried as quickly as possible. Each paper folder was labeled with an identification number on the outside, along with data on species color and habitat, all recorded in a field notepad. The code of the macroalgae, the date and the place of harvest were indicated on a sheet. Macroscopic characters such as color, shape, size and also location facilitated the determination of species. A number of species identification keys were used **(Cabioc'h *et al.,* 2006; Fischer *et al.,* 2007)**, including AlgaeBase and World Register of Marine Species (WoRMS).

3. Data analysis

The cover rate for all individuals of a given species was calculated and estimated visually on a scale ranging from 5 to + 5: species covering more than ¾ (75%) of the surface; 4: from ½ to ¾ (50%-75%); 3: ½ to ¼ (50%-25%); 2: abundant species but covering less than ¼ (5%-25%); 1: species well represented but covering less than 5%; +: species present but negligible. The Ri cover rate was the first of the two main coefficients assigned to each species **(Boudouresque, 1971)**. This is the approximate percentage of the substrate area projected by species i. Total survey cover over the total number of surveys: Ri n R=1 /Nr (n is the number of survey species, Nr: the number of surveys).

At each step (class) of the cover coefficient Ri assigned to the n species i of a survey corresponds a conventional mean value (class center) named average cover: Absence = 0; + = 0.1%; 1 = 2.5%; 2 = 15.0%; 3 = 37.5%; 4 = 62.5%; 5 = 87.5%. The GAC (Global Average Cover) for species i in a set of N records is therefore the average of its successive average cover: GAC= Ri n p =1 / N.

In a survey divided into quadra, the frequency Fi of species i is, expressed as a percentage. It is the ratio of the number of quadra where it is present in the total number of quadra: F (%) = ni/N X100. F characterized five classes: 0< F <20%: Class I: Very rare species; 20% <40%: Class II: Rare species; 40%< F < 60%: Frequent species; 60%< F < 80%: Abundant species; 80%<F<100%.

Table 1. Geographical coordinates and physical characteristics of the studied sites

Coastal department	Site	Latitude	Longitude	Depht (m)	Surface temperature **(°C)**
Mostaganem	El Marsa (S1)	36°07'47.3"N	0°16'01.0"E	1	14
	Petit Port (S2)	36°12'34.0"N	0°24'39.3"E	1.5	15
	Mers El Hdjaj (S3)	35°47'58.7"N	0°10'06.9"W	1.2	15
Oran	Kristel (S4)	35°49'24.5"N	0°29'17.7"W	2	14
	Ain Franin (S5)	35°46'05.8"N	0°31'43.6"W	1.8	14
	Bousfer (S6)	35°43'27.4"N	0°50'59.9"W	1	14
Ain Témouchent	Bouzedjer (S7)	35°34'40.8"N	1°09'02.4"W	2	15
	Terga (S8)	35°26'27.7"N	1°14'12.8"W	1.5	14
	Beni Saf (S9)	35°18'26.5"N	1°22'44.8"W	1.5	15
Ghazaouet	Ghazaouet (S10)	35°06'27.5"N	1°50'24.9"W	28	14

ANOVA was conducted to assess the variance between factors, followed by a Tukey HSD post-hoc analysis, which allowed for the comparison of mean algal group abundances across stations and the identification of significant differences. All statistical analyses were performed using Excel-Stat 2024.

As null models analysis, a species presence/absence matrix was constructed, with the species in rows and the sites in columns. Thirdly a Checkerboard score ("C-score") was calculated which is a quantitative index of occurrence that measures the extent to which species co-occur less frequently than expected by chance **(Gotelli, 2000)**. A community is structured by competition when the C-score is significantly larger than expected by chance **(Gotelli, 2000; Tondoh, 2006; Tiho & Josens, 2007)**. Thirdly, co-occurrence patterns were compared with null expectations via simulation. **Gotelli and Ellison (2013)** suggested the as statistical null models Fixed-Fixed: in this model the row and column sums of the matrix are preserved. Thus, each random community contains the same number of species as the original community (fixed column), and each species occurs with the same frequency as in the original community (fixed row). The null model analyses were performed using the software R (R Development Core Team, 2023) and the package EcosimR **(Gotelli & Ellison, 2013; Carvajal-Quintero *et al.*, 2015)**.

RESULTS

The results showed that there were 82 species (Table in Annex) of macroalgae grouped into 23 orders, 38 families, and 56 genera, divided into four classes: Floridaophyceae (47.56%), followed by Phaeophyceae and Ulvophyceae each representing 25.60% and Chlorophyceae accounting for only 1.21%.

1. Specific diversity

The surveys showed a dominance of Florideophyceae with 39 species, representing 47.56%. They were followed by Ulvophyceae and Phaeophyceae, with 21 species, with 25.60% each. Chlorophyceae were the least represented, with only one species, making up 1.21% (Fig. 2).

When analyzing the results by station, it appeared at the Mostaganem station, Ulvophyceae dominated with 36.84%, followed by Phaeophyceae and Florideophyceae, both showing equal percentages of 31.57%. At the Oran station, Florideophyceae were the most abundant with 48.93%, followed by Phaeophyceae (27.65%) and Ulvophyceae (23.40%).

At the Témouchent station, Florideophyceae also dominated with 50%, followed by Phaeophyceae (25.88%) and Ulvophyceae (22.41%). Chlorophyceae were very poorly represented (1.72%).

Finally, in Ghazaouet, Florideophyceae maintained their dominance with 46.42%, followed by Ulvophyceae and Phaeophyceae, which showed equal values of 25%, while Chlorophyceae were the least present at 3.57%.

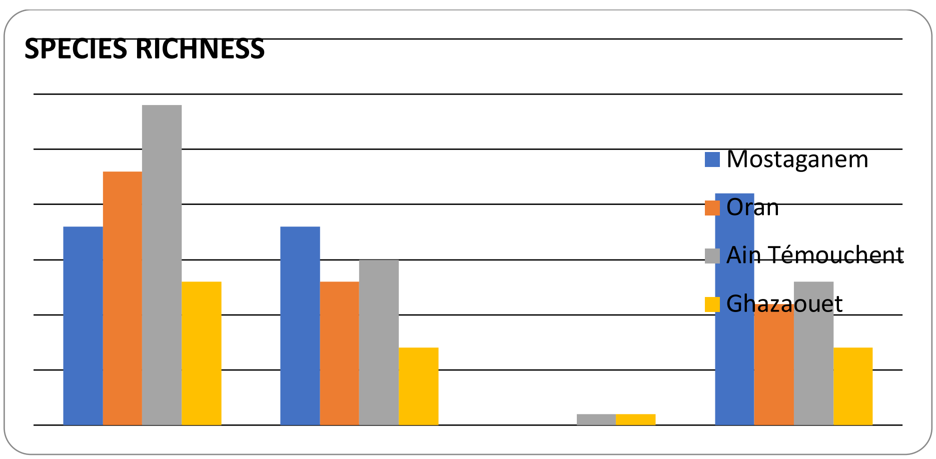

Fig. 2. Specific diversity of sampling sites

The Shannon index (H'), presented moderate to high diversity at the Ain Témouchent station and Mostaganem station, with an index of 3,904 and 3,806, respectively. Additionally, the Ghazaouet station presented the lowest diversity (3,03). The differences between Pielou index (J') and Simpson index (S) were very slight, suggesting a relatively balanced distribution of individuals between species at each station (Fig. 3).

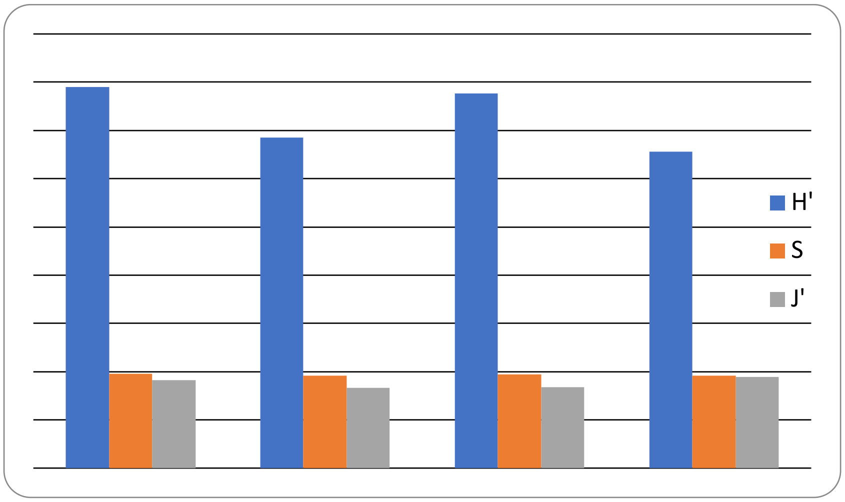

Fig. 3. Diversity index and specific richness of the sampled stations
(*Shannon and Weaver index (H'), Simpson index (S), Pielou index (J'))*.

2. **Frequency**

The algae species present at the studied stations varied according to their frequency of occurrence, and they were divided into five classes based on their abundance (Fig. 4).

Class I included very rare species (0% < F < 20%), such as *Ahnfeltia plicata* (Phaeophyceae), which shows a frequency of 14.28% at Ain Temouchent and Oran. *Corallophila cinnabarina* (Phaeophyceae) presented 4.76% at Mostaganem and Ain Temouchent; similarly, *Gloiocladia repens* (Phaeophyceae) was observed with 4.76% at Oran and Ain Temouchent, and with 14.88% at Ghazaouet.

Class II consisted of rare species (20% < F < 40%). In the *Florideophyceae* family, species such as *Asparagopsis taxiformis* and *Asparagopsis armata* were recorded with a frequency of 28.56% at Mostaganem and Ain Temouchent. Other species like *Corallina officinalis* and *Jania virgata* also exhibited a rare frequency in these stations. Additionally, *Halopitys incurva* appeared at 23.80%, while *Hypnea musciformis* were observed at 38.09% in Oran. In the *Phaeophyceae* family, *Padina pavonica* were recorded at 38.09% in Mostaganem and 28.56% in both Oran and Ain Temouchent.

Class III included frequent species (40% < F < 60%) such as *Ulva rigida*, *Ulva prolifera*, *Ulva lactuca*, and *Caulerpa cylindracea* from the Ulvophyceae family. In the Phaeophyceae family, there were *Sargassum muticum*, *Padina pavonica*, and *Dictyota dichotoma*. For the Florideophyceae, *Asparagopsis armata* and *Ellisolandia elongata* were included. These species have frequencies ranging from 42.85 to 57.14% across the different stations.

Class IV corresponded to abundant species (60% < F < 80%). Among them, *Ulva lactuca* (Ulvophyceae) reaching a frequency of 61.9% at Ain Temouchent, while *Dictyota dichotoma* (Phaeophyceae) recorded 71.42% in the same area, indicating its notable abundance. In Class V, which includeed very frequent species (F > 80%), *Ulvaria obscura*, belonging to the *Ulvophyceae* family, were recorded with a frequency of 85.71% at Ain Temouchent, classifying it as a constant species at this station.

The most abundant species in the four studied coastal circonscriptions was *Ulva lactuca* (Ulvophyceae), classified as abundant (Class IV) at Ain Temouchent with a frequency of 61.9%. It was also frequent (Class III) at Oran with 52.37% and at Ghazaouet with 42.85%, while at Mostaganem, it had a frequency of 38.09%. *Asparagopsis armata* (Florideophyceae) was frequent (Class III) at Mostaganem with 52.37% and at Oran with 42.85%, and was also present at Ain Temouchent with 28.56% and at Ghazaouet with 14.28%. *Ellisolandia elongata* (Florideophyceae) showed notable distribution across the stations, with 57.14% at Oran (Class III, frequent), 48.85% at Mostaganem, 28.57% at Ain Temouchent, and 14.28% at Ghazaouet. *Padina pavonica* (Phaeophyceae) were widely observed, with 42.85% at Ghazaouet (Class III, frequent), 38.09% at Mostaganem, and 28.57% at both Oran and Ain Temouchent. *Ulvaria obscura* (Ulvophyceae) and *Dictyota dichotoma* (Phaeophyceae) were very abundant at the two study sites, with *Ulvaria obscura* showing 85.71% (Class V) at Ain Temouchent and *Dictyota dichotoma* with 71.42% (Class IV) at Oran. Both species were frequent (Class III) at Ghazaouet and Ain Temouchent with frequencies of 42.85%.

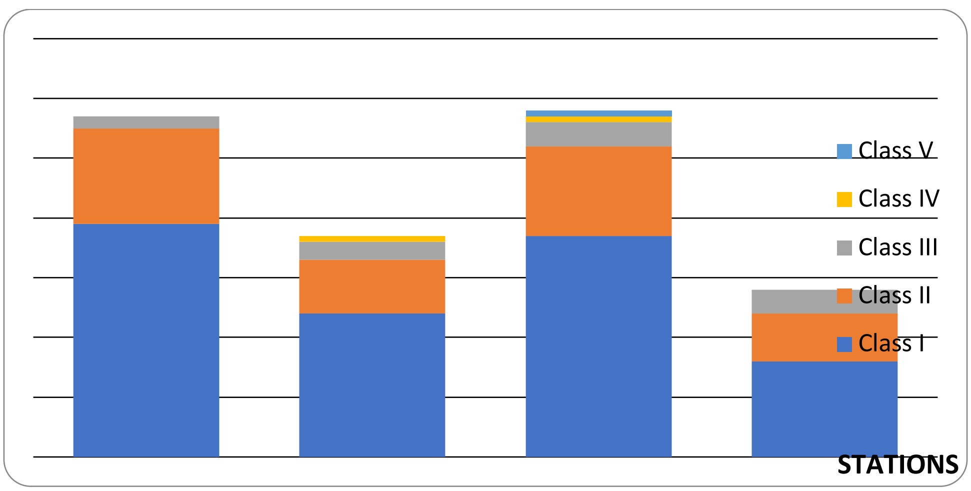

Fig. 4. The frequency for species by class of the sampled stations

The most frequent macroalga at the sampled stations was *Ulva lactuca* (Chlorophyceae), classified as very abundant. It was present in Oran, Mostaganem, Ain Témouchent, and Ghazaouet, making it the most widely distributed species. However, at Ain Témouchent station, *Ulva obscura* were the most abundant, with a frequency of 85.71%, surpassing *Ulva lactuca* (61.9%). *Asparagopsis armata* dominated at Mostaganem station, while *Dictyota dichotoma* was well represented at Oran station

(71.42%). At Ghazaouet station as well, the most commonly observed taxa were *Padina pavonica* and *Sargassum muticum* (Fig. 5).

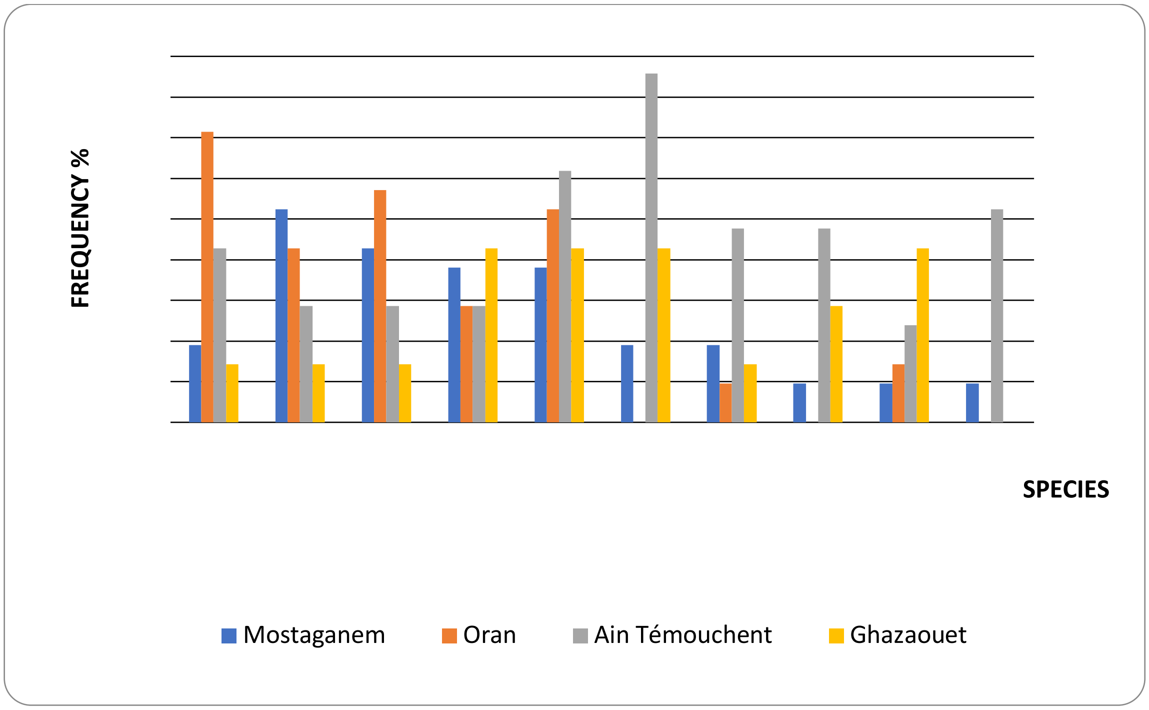

Fig. 5. The frequency of the most abundant species of the sampled stations

3. Cover rate

The analysis of the average coverage of benthic macrophytes highlighted significant differences between the stations. Florideophyceae dominated in Mostaganem (60.32%), followed by Aïn Témouchent (55.58%) and Oran (50.03%), while they were less abundant in Ghazaouet (33.57%). Phaeophyceae were particularly present in Ghazaouet (50.36%) and Oran (41.92%), with lower values in Mostaganem (36.17%) and Aïn Témouchent (30.98%). Ulvophyceae reached their highest level in Aïn Témouchent (66.87%), but remained lower in Mostaganem (32.57%), Oran (19.89%), and Ghazaouet (24.29%). Finally, Chlorophyceae were almost absent, except in Ghazaouet (0.71%) and Aïn Témouchent (0.25%), where they remained marginal (Fig. 6).

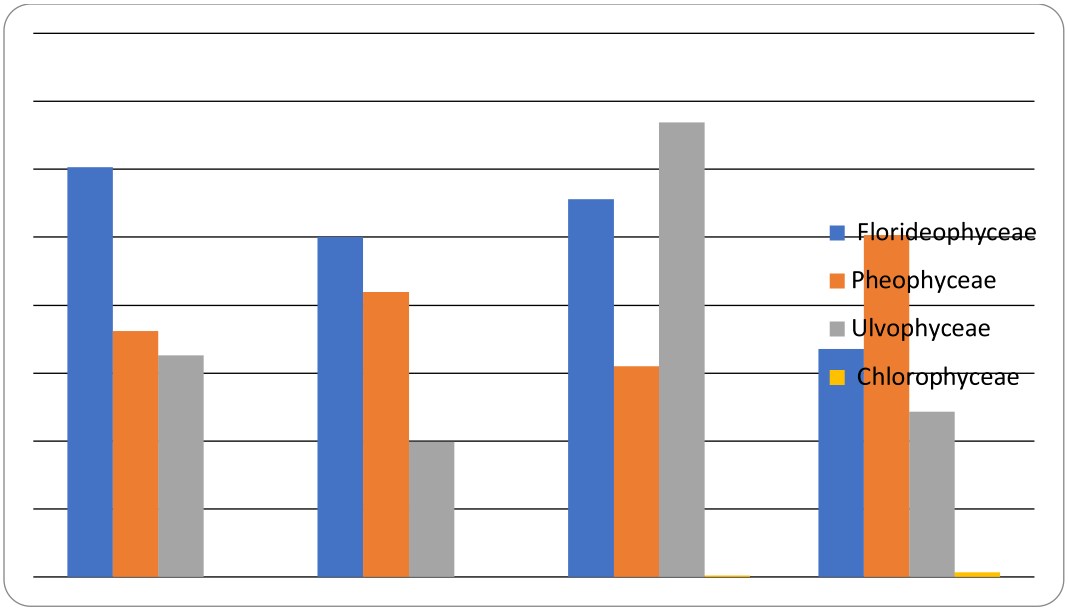

Fig. 6. Global average cover (GAC) of the sampled stations

At Mostaganem station, 57 species of benthic macrophytes were identified, distributed among 21 Ulvophyceae (36.84%), 18 Phaeophyceae (31.57%), and 18 Florideophyceae (31.57%). Among the dominant species, *Asparagopsis armata*, *Mesophyllum lichenoides* and *Ellisolandia elongata* were observed in abundance in Mers El Hadjaj, while *Ulva prolifera* dominated in some surveys in El Marsa. Other species, though less dominant, were still highly present, with a coefficient of 3 (covering 25% to 50%). These included *Ulva lactuca* and *Ulva compressa* at Mers El Hadjaj, as well as *Cystoseira compressa*, *Jania rubens*, and *Corallina officinalis*, recorded in significant quantities at Petit Port. Species with a coefficient of 2 or 1 were less dominant, covering between 5 and 25% of the substrate in certain surveys. Among them were *Corallina officinalis* at El Marsa, *Asparagopsis taxiformis*, and *Gelidium spinosum*. Finally, some species were recorded only sporadically, with a coefficient below 1, indicating low abundance. These included *Acrothamnion preissi* at Petit Port, *Acetabularia acetabulum* at El Marsa, as well as *Codium bursa olivi*, *Bryopsis hynoides*, and *Taonia atomaria*, which were observed in very limited quantities in various surveys.

At Oran, 47 species of benthic macrophytes were identified, including 11 Ulvophyceae (23,40%), 13 Phaeophyceae (27.65%), and 23 Florideophyceae (48,93%). Among the recorded species, *Cystoseira compressa* stood out as dominant in certain surveys (coefficient of 4), particularly at Kristel. Only one species reached coefficient 5, indicating exceptional presence in a specific survey: *Osmundea pinnatifida*, which was found in high abundance at Kristel. Species with a coefficient of 3 (moderate abundance, 25%-50% cover) included *Ellisolandia elongata*, *Hypnea musciformis* (Kristel), *Rhodothamniella floridula* (Bousfer), and *Padina pavonica* (Aïn Franine). Finally, most other recorded species exhibited a more moderate coverage (coefficient 1 and 2), such as

Cladophora laetevirens, *Ulva lactuca f. rigida*, *Caulerpa racemosa f. laxa*, *Peyssonnelia squamaria*, and *Furcellaria lumbricalis*.

Among all studied stations, Aïn Témouchent recorded the highest species diversity, with a total of 58 species of benthic macrophytes. The coast of Ain Temouchent is an area less affected by pollution than other areas of the west coast. This richness was distributed among 13 Ulvophyceae (22.41%), 15 Phaeophyceae (25.86%), and 29 Florideophyceae (50%) and 1 Chlorophyceae (1.72%). Certain species were highly dominant in specific surveys, reaching a coefficient of 4, such as *Caulerpa racemosa f. laxa*, observed in survey 2 at Beni Saf, and *Cladophora prolifera* at Terga. Other species, though less dominant, remained highly present in multiple surveys (coefficient of 3, 25%-50% coverage). These included *Ellisolandia elongata* (Bouzedjer, surveys 6 and 7), *Halopteris scoparia*, *Ulvaria obscura*, *Ulva rigida*, and *Ulva lactuca*. Species with a coefficient of 2 or 1 were moderately abundant, covering 5-25% of the substrate. These included *Asparagopsis armata*, *Gelidium lubrica*, *Dictyota fascida*, and *Cystoseira compressa*, which were recorded in several surveys. Finally, some species were observed only occasionally, appearing in just one or two surveys, such as *Halopteris scoparia*, *Sargassum flavifolium* at Terga, and *Spongomorpha aeruginosa* at Bouzedjer and Terga.

At Ghazaouet, 28 species were recorded, distributed among 7 Ulvophyceae (25%), 7 Phaeophyceae (25%), and 13 Florideophyceae (46.42%) and 1 Chlorophyceae (3.57%). Due to the limited sampling at a single site, this station had a lower species count than the other studied locations. Some species, although less frequent across the entire station, reached a coefficient of 4, including *Halopteris filicina*, which was dominant in survey 5, and *Cystoseira amentacea var. stricta*, recorded only in survey 7. Other species showed notable abundance (coefficient of 3, 25-50% coverage), such as *Hypnea musciformis*, *Osmundea osmunda*, and *Osmundea pinnatifida*. However, the majority of observed species exhibited low coverage, with coefficients of 2 and 1. Among them were *Bryopsis duplex*, *Spongomorpha aeruginosa*, *Ulva lactuca*, *Ulva prolifera*, *Ulva rigida*, and *Ulvaria obscura*.

Multivariate statistical processing shows that the most similar species are grouped into pairs due to their many common characteristics. Among the closest pairs are species like *Hypnea spinella* and *Spongomorpha aeruginosa*, *Ericaria brachycarpa* and *Ericaria amentacea*, *Ulva lactuca* with *Hincksia sandriana*, *Acrothamnion preissii* and *Gongolaria montagnei*, *Chondria coerulescens* and *Caulerpa cylindracea Sonder*, *Jania virgata* and *Pterocladiella capillacea*, *Phyllophora herediae* and *Fucus serratus Linnaeus*, *Chondracanthus acicularis* and *Ahnfeltia plicata*, *Polysiphonia Greville* and *Rhodothamniella floridula*, *Cystoseira amentacea* and *Padina pavonica*, *Acrothamnion preissii* and *Asperococcus turneri f. profundus*, as well as *Furcellaria lumbricalis* and *Codium decorticatum*. Other groups exhibit more moderate similarities, with a later fusion, such as *Cystoseira amentacea*, *Padina pavonica*, *Acrothamnion preissii*, and

Asperococcus turneri, *Furcellaria lumbricalis* and *Codium decorticatum*, indicating more pronounced differences. The set of species can be divided into four major groups, each clearly distinguished and comprising multiple species sharing common characteristics (Fig. 7).

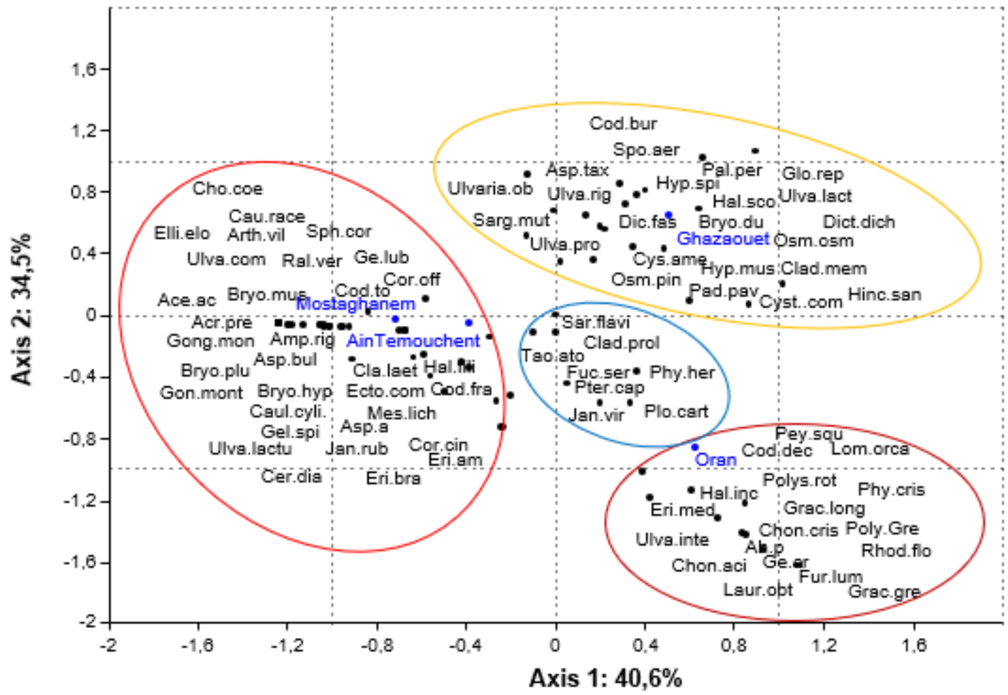

Fig. 7. Factorial design of correspondence factorial analysis

The first group included species such as *Ulva lactuca*, *Dictyota fascida*, and *Cystoseira amentacea*, which share common traits. The second group consisted of *Gelidiella lubrica*, *Jania rubens*, and *Gongolaria montagnei*. The third group was composed mainly of *Corallophila cinnabarina*, *Fucus serratus*, and *Cladophora prolifera*. Finally, the fourth group included species like *Gracilaria Greville*, *Peyssonnelia squamaria*, and *Ericaria mediterranea* (Fig. 8).

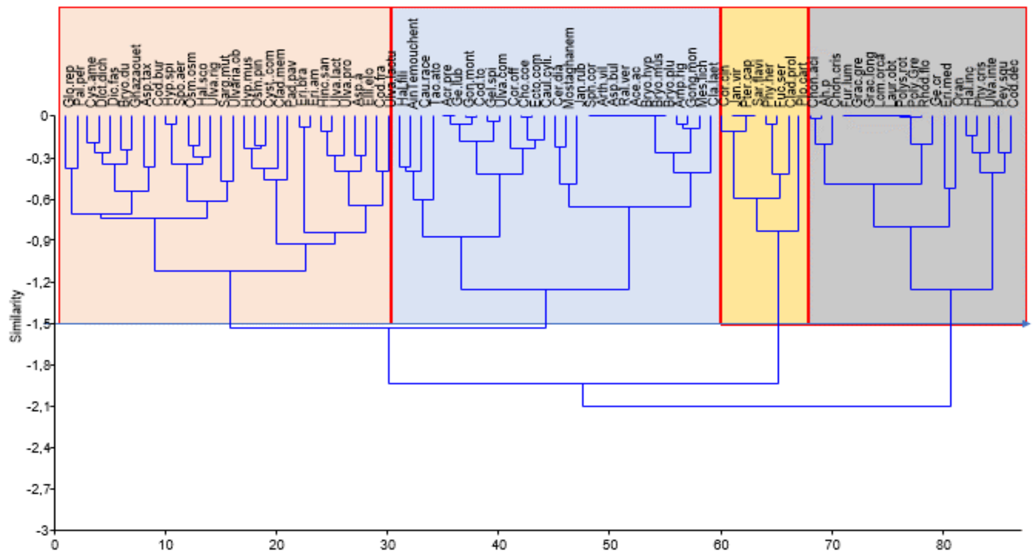

Fig. 8. Hierarchical ascending classification of study stations

The analysis of variance (ANOVA) conducted on the set of algal species revealed a highly significant statistical difference between groups (*P*= 0.000), indicating that the observed variations are not due to chance (Table 2). The F-value = 3.02 confirmed that interspecific variability is notable compared to intra-group variability, although its magnitude remains moderate. The examination of adjusted sums of squares showed that the proportion of variance explained by differences between species (32967) is almost equivalent to that attributed to intra-group variations (33149). This suggests that, although clear distinctions exist between species, other factors not considered in this analysis—such as environmental conditions or ecological interactions—may also influence their distribution and abundance. Finally, the adjusted coefficient of determination (R^2 adjusted = 49.86%) indicates that nearly half of the total variance is explained by differences between species, highlighting the importance of these variations in structuring algal communities.

Table 2. Analysis of One-way ANOVA of the sampled stations: Frequency versus species

	DF	Sum of squares	Mean squares	F-values	*P*-values
Model	81	32967	407	3,02	0***
Error	246	33149	134,8		
Total	327	66116			

(***: very highly significant)

The results of null models revealed that species associations are structured, this means that these are not random for fixed-fixed model, that is the most robust species co-occurrence null models whereas the results of fixed-equiprobable and fixed proportional revealed that species associations are random due the presence of many repeated species for the studied sites. In this scenario, the species associations have a kind of structured pattern because the results of fixed-fixed model happened with this robust model, then it would be necessary explain potential environmental factors that explain the species associations observed (Table 3).

Table 3. Results of species co-occurrence null models analysis

	Mean index	Observed index	Variance	Standard effect size	*P*
Fixed-fixed	3.7204	3.8196	0.0003	5.6391	0.0010*
Fixed-equiprobable	4.1944	3.8196	0.0599	-1.5307	0.9280
Fixed-proportional	3.9548	3.8196	0.0029	-2.4987	0.9800

(***: very highly significant).

DISCUSSION

The analysis of mean abundance highlights a marked structuring of algal communities within the studied ecosystem. Certain species stand out due to their particularly high abundance, such as *Ulva lactuca* (48.8), followed by *Ulvaria obscura* (36.9), *Dictyota dichotoma* (36.9), *Ellisolandia elongata* (35.71), and *Padina pavonica* (34.52). The relatively wide confidence interval associated with these values underscores their dominant presence and suggests that they thrive under favorable environmental conditions. Conversely, other species exhibit more moderate abundances, such as *Cystoseira compressa* (22.02), *Sargassum muticum* (22.62), and *Osmundaria pinnatifida* (24.4). Although they are regularly present, their lower abundance indicates a less pronounced distribution within the ecosystem. Finally, some species are particularly rare or even absent. This is the case for *Rhodomenia floridula* (1.19), *Polysiphonia rotundata* (0.0), and *Hincaria sanctae-crucis* (0.0), whose confidence intervals including zero confirm their negligible occurrence or effective absence. The analysis of data dispersion, through standard deviation, reveals significant spatial or temporal variability for certain species. *Ulvaria obscura*, *Dictyota dichotoma*, and *Caulerpa cylindracea* exhibit high standard deviations, indicating a heterogeneous distribution within the ecosystem. In contrast, species such as *Fucus serratus* and *Rhodomenia floridula* display a more homogeneous distribution, characterized by lower variability in their abundance.

To identify specific differences between algal species, a pairwise comparison was performed using the Tukey HSD test (Honestly Significant Difference). This test groups species based on their mean values and determines which differences are statistically significant. The results indicate the presence of four main groups:

Group A: *Ulva lactuca* has the highest mean value (48.8), distinguishing it significantly from other species. It is significantly different from species in groups C and D.

Group A-B: Some species, such as *Ulvaria obscura* and *Dictyota dichotoma* (36.9), share characteristics with *Ulva lactuca* while also overlapping with species in group B.

Group B-C-D: Most species fall within an intermediate range (10 to 35), showing considerable variability but no highly distinct differences between them.

Group C-D: Species such as *Rhodothamniella floridula* (1.19) and *Polyides rotunda* (0.0) have the lowest mean values, indicating a significant difference from species in groups A and B.

These results suggest that certain species, such as *Ulva lactuca*, are particularly abundant or well-adapted to the studied ecosystem, while others, such as *Polyides rotunda* appear to be less prevalent or less suited to the environmental conditions.

The current analysis of the distribution of benthic macroalgae in the Algerian west coast shows that the distribution of the three algae groups (green, red and brown) was heterogeneous. The Phaeophyceae registered on the Algerian west coast is low in comparison with its total number for the entire Mediterranean Sea: 180 taxa **(Antolic *et al.,* 2010)** and 214 taxa **(Furnari *et al.,* 2010)**. However, it is similar to other south Mediterranean countries such as Tunisia and Libya with 91 and 53 taxa, respectively **(Guiry & Guiry, 2013)**.

CONCLUSION

In conclusion, the analysis of average benthic macrophyte coverage reveals a general dominance of Florideophyceae in Mostaganem and Oran, of Ulvophyceae in Ain Témouchent, while Phaeophyceae are more widespread in Ghazaouet.

These findings provide valuable insights into the macroalgal biodiversity of Algerian coastal waters and underscore the role of macroalgae as bioindicators for coastal ecosystem monitoring. They also emphasize the need to integrate these data into conservation strategies and the sustainable management of marine resources, especially in response to increasing anthropogenic pressures. Long-term monitoring is essential to assess the impact of climate change and human activities on these communities, as well as to explore the potential of macroalgae for ecological restoration and bioremediation.

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الملخص

تُعد الطحالب الكبيرة عناصر مهمة في النظم البيئية الساحلية، حيث يتأثر تنوعها وتوزيعها بالظروف البيئية المحلية، مما يبرر استخدامها في تقييم النظم البيئية الساحلية. تهدف هذه الدراسة إلى تحليل الحالة البيئية لمجتمعات الطحالب الكبيرة على طول الساحل الغربي الجزائري. تم أخذ العينات في أربع ولايات ساحلية (مستغانم، وهران، عين تموشنت، والغزوات) عبر عشرة مواقع خلال ربيع 2024. أظهرت النتائج تسجيل 82 نوعًا من الطحالب الكبيرة، مصنفة ضمن 23 رتبة، و38 فصيلة، و56 جنسًا، تنتمي إلى أربع طوائف:

Florideophyceae (47.56%)، Phaeophyceae (25.60%) و Ulvophyceae لكل منهما، و Chlorophyceae (1.21%).

يبرز التحليل البنيوي سيادة واضحة لـFlorideophyceae ، التي تضمنت 39 نوعًا. سُجِّل أعلى تنوع للطحالب الكبيرة في موقعي عين تموشنت ومستغانم، حيث بلغ عدد الأنواع المسجلة 58 و56 نوعًا على التوالي. كشفت التحليلات الإحصائية عن اختلافات معنوية بين المحطات، مما يشير إلى توزيع غير عشوائي للأنواع، يتأثر بالظروف البيئية. يُوصى بإدارة موارد الطحالب الكبيرة للحفاظ على استدامة النظام البيئي الساحلي، من خلال إنشاء برنامج وطني لرصد السواحل.

الكلمات المفتاحية: الطحالب الكبيرة، Florideophyceae، Phaeophyceae، Ulvophyceae، Chlorophyceae، الحالة البيئية، الساحل الغربي الجزائري.

Table Annex. Faunistic list

Class 04	Subclass	Order 23	Superfamily	Family 38	Genus 56	Species 82	Abbreviation
Ulvophyceae		Ulvales		Ulvaceae	Ulvaria	*Ulvaria obscura* (P.Gayral ex C. Bliding, 1969).	Ulvaria.ob
					Ulva	*Ulva lactuca* (Linnaeus.C. 1753).	Ulva.lact
						Ulva lactuca f. rigida (C.Agardh) Hylmö	Ulva.lactu
						Ulva compressa Linnaeus, 1753	Ulva.com
						Ulva rigida (C. Agardh, 1823).	Ulva.rig
						Ulva intestinalis Linnaeus, 1753	Ulva.inte
						Ulva prolifera O.F.Müller, 1778	Ulva.pro
		Bryopsidales		Bryopsidceae	Bryopsis	*Bryopsis plumosa (Hudson) C.Agardh,* 1823	Bryo.plu
						Bryopsis muscosa J.V.Lamouroux, 1809	Bryo.mus
						Bryopsis hypnoides J.V.Lamouroux, 1809	Bryo.hyp
						Bryopsis duplex De Notaris, 1844	Bryo.du
				Codiaceae	Codium	*Codium decorticatum* (M. A. Howe, 1911)	Cod.dec
						Codium bursa (Olivi) C.Agardh, 1817	Cod.bur
						Codium tomentosum Stackhouse, 1797	Cod.to
						Codium fragile (Suringar) Hariot, 1889	Cod.fra
				Caulerpaceae	Caulerpa	*Caulerpa cylindracea* Sonder, 1845	Caul.cyli.
						Caulerpa racemosa f. laxa (Greville) Weber Bosse, 1898	Cau.race
		Cladophorales		Cladophoraceae	Cladophora	*Cladophora laetevirens* (Dillwyn)Kűtzing, 1843.	Cla.laet
						Cladophora prolifera (Roth) Kützing, 1843	Clad.prol
	Dasycladales			Boodleaceae	Cladophoropsis	*Cladophoropsis membranacea* Bang ex C.Agardh) Børgesen, 1905	Clad.mem
				Polyphysaceae	Acetabularia	*Acetabularia acetabulum* (Linnaeus) P.C. Silva, 1952	Ace.ac

Chlorophyceae	Acrosiphoniales		Acrosiphoniaceae	Spongomorpha	*Spongomorpha aeruginosa* (Linnaeus) Hoek 1963.	Spo.aer
Phaeophyceae	Dictyotophycidae	Sphacelariales	Stypocaulaceae	Halopteris	*Halopteris scoparia* (Linnaeus) Sauvageau, 1904.	Hal.sco
					Halopteris filicina (Grateloup) Kützing 1843.	Hal.fili
		Dictyotales	Dictyotaceae	Dictyota	*Dictyota dichotoma* (Hudson) J.V.Lamouroux 1809.	Dict.dich
					Dictyota fascida J.Agardh, 1898	Dic.fas
				Padina	*Padina pavonica* (Linnaeus) Thivy 1960.	Pad.pav
				Taonia	*Taonia atomaria* (Woodward) J.Agardh, 1848	Tao.ato
	Fucophycidae	Fucales	Sargassaceae	Cytoseira	*Cytoseira compressa* (Esper) Gerloff, Nizamuddin 1975.	Cyst..com
					Cystoseira amentacea var. stricta Montagne, 1846	Cys.ame
				Ericaria	*Ericaria amentacea* (C.Agardh) Molinari & Guiry, 2020	Eri.am
					Ericaria mediterranea (Sauvageau) Molinari & Guiry, 2020	Eri.med
					Ericaria brachycarpa (J.Agardh) Molinari & Guiry, 2020	Eri.bra
				Sargassum	*Sargassum muticum* (Yendo) Fensholt 1955.	Sarg.mut
					Sargassum flavifolium Kützing, 1849	Sar.flavi
				Gongolaria	*Gongolaria montagnei (*J.Agardh) Kuntze, 1891	Gong.mon
					Gongolaria Boehmer, 1760	Gong.boe
			Fucaceae	Fucus	*Fucus serratus* Linnaeus, 1753	Fuc.ser
		Ectocarpales	Ectocarpaceae	Ectocarpus	*Ectocarpus commensalis* Setchell & N.L.Gardner, 1922	Ecto.com
			Acinetosporaceae	Hincksia	*Hincksia sandriana* (Zanardini) P.C.Silva, 1987	Hinc.san

		Ralfsiales		Chordariaceae	Asperococcus	*Asperococcus turneri f. profundus* (Feldmann) M.Cormaci & G.Furnari, 1992	Asp.bul
				Ralfsiaceae	Ralfsia	*Ralfsia verrucosa var. erythraea* Piccone & Gunow, 1884	Ral.ver
		Desmarestiales		Arthrocladiaceae	Arthrocladia	*Arthrocladia villosa* (Hudson) Duby, 1830	Arth.vil
Florideophyceae	Rhodymeniophycidae	Ceramiales		Rhodomelaceae	Halopitys	*Halopitys incurva* (Hudson) Batters 1902.	Hal.inc
					Osmundea	*Osmundea osmunda* (S.G.Gmelin) K.W.Nam & Maggs, 1994	Osm.osm
						Osmundea pinnatifida (Hudson) Stackhouse 1809.	Osm.pin
					Laurencia	*Laurencia obtusa* (Hudson) J.V.Lamouroux, 1813	Laur.obt
					Palisada	*Palisada perforata* (Bory) K.W.Nam, 2007	Pal.per
					Chondria	*Chondria coerulescens* (J.Agardh) Sauvageau, 1897	Cho.coe
			Ceramioideae	Ceramiaceae	Corallophila	*Corallophila cinnabarina* (Grateloup ex Bory) R.E.Norris, 1993	Cor.cin
					Ceramium	*Ceramium diaphanum* (Lightfoot) Roth, 1806	Cer.dia
					Acrothamnion	*Acrothamnion preissii* (Sonder) E.M.Wollaston, 1968	Acr.pre
		Gracilariales	Gracilarioideae	Gracilariaceae	Gracilariopsis	*Gracilariopsis longissima* (S.G.Gmelin) Steentoft, L.M.Irvine & Farnham, 1995	Grac.long
					Gracilaria	*Gracilaria Greville*, 1830	Grac.gre
					Polysiphonia	*Polysiphonia Greville*, 1823	Poly.Gre
		Gigartinales		Gigartinaceae	Chondracanthus	*Chondracanthus acicularis* (Roth) Fredericq 1993	Chon.aci
					Chondrus	*Chondrus crispus Stackhouse*, 1797	Chon.cris
				Phyllophoraceae	Phyllophora	*Phyllophora crispa* (Hudson) P.S Dixon 1964.	Phy.cris
						Phyllophora herediae (Clemente) J.Agardh, 1842	Phy.her
				Cystocloniaceae	Hypnea	*Hypnea spinella* (C.Agardh) 1847	Hyp.spi
						Hypnea musciformis (Wulfen) J.V.	Hyp.mus

					Lamouroux 1813.	
			Polyidaceae	Polyides	*Polyides rotunda* (Hudson) Gaillon, 1828	Polys.rot
			Sphaerococcaceae	Sphaerococcites	*Sphaerococcites Sternberg*, 1833 †	Sph.cor
			Furcellariaceae	Furcellaria	*Furcellaria lumbricalis* (Hudson) J.V.Lamouroux, 1813	Fur.lum
	Peyssonneliales		Peyssonneliaceae	Peyssonnelia	*Peyssonnelia squamaria* (S.G.Gmelin) Decaisne ex J.Agardh 1842.	Pey.squ
	Gélidiales		Pterocladiaceae	Pterocladiella	*Pterocladiella capillacea* (S.G.Gmelin) Santelices & Hommersand, 1997.	Pter.cap
			Gelidiaceae	Gelidium	*Gelidium crinale* (Hare ex Turner) Gaillon, 1828	Ge.cr
					Gelidium spinosum (S.G.Gmelin) P.C.Silva, 1996	Gel.spi
				Gelidiella	*Gelidiella lubrica* (Kützing) Feldmann & Hamel, 1934	Ge.lub
	Bonnemaisoniales		Bonnemaisoniaceae	Asparagopsis	*Asparagopsis armata* (Harvey, 1855).	Asp.a
					Asparagopsis taxiformis (Delile) Trevisan de Saint-Léon, 1845	Asp.tax
	Rhodymeniales		Faucheaceae	Gloiocladia	*Gloiocladia repens* (C.Agardh) N.Sanchez &Rodriguez-Prieto 2007.	Glo.rep
			Lomentariaceae	Lomentaria	*Lomentaria orcadensis* (Harvey) Collins, 1937	Lom.orca
	Plocamiales		Plocamiaceae	Plocamium	*Plocamium cartilagineum* (linnaeus) P.S Dixon 1967.	Plo.cart
Ahnfeltiophycidae	Ahnfeltiales		Ahnfeltiaceae	Ahnfeltia	*Ahnfeltia plicata* (Hudson) E.M.Fries 1836.	Ah.p
Corallinophycidae	Corallinales	Corallinoideae	Corallinaceae	Corallina	*Corallina officinalis* Linnaeus, 1758	Cor.off
				Ellisolandia	*Ellisolandia elongata* (J.Ellis & Solander) K.R.Hind & G.W.Saunders, 2013	Elli.elo
				Jania	*Jania virgata* (Zanardini) Montagne,	Jan.vir

					1846	
					Jania rubens (Linnaeus) J.V.Lamouroux, 1816	Jan.rub
		Lithophylloideae	Lithophyllaceae	Amphiroa	*Amphiroa rigida* J.V.Lamouroux, 1816	Amp.rig
	Hapalidiales		Mesophyllumaceae	Mesophyllum	*Mesophyllum lichenoides* (J.Ellis) Me.Lemoine, 1928	Mes.lich
Nemaliophycidae	Palmariales		Rhodothamniellaceae	Rhodothamniella	*Rhodothamniella floridula* (Dillwyn) Feldmann, 1978	Rhod.flo