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# Distribution of phytobenthos along the coast of Lebanon (Levantine Basin, East Mediterranean)

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## Abstract

*A phytosociological study of the phytobenthos was carried out along the coast of Lebanon during 1996-97. Samples were collected seasonally at six sites, some of which showed distinct pollution signature. Quadrates of 0.04 m$^{-2}$ were taken at selected stations fixed on transects perpendicular to the rocky shore and covering the supralittoral, the mediolittoral and infralittoral zones. The taxonomic composition, the abundance and species diversity of algal community were analysed in relation to environmental factors. A total of 230 taxa were identified during the period of survey. Several sources of pollution, resulted in the reduction of macroalgae biomass and of the taxonomic diversity. Several Indo-Pacific species were found within the different phytocoenoses of the area; most of them were introduced into the Levantine Basin through the Suez Canal. These species, that were introduced into the Eastern Mediterranean, formed permanent populations; some of them were highly spread and dominated over other endemic species or even they replaced them.*

**Keywords**: Macroalgae, Distribution, Lebanon, Diversity, Phytosociology.

## Introduction

If the macroalgae in the western Mediterranean Sea are well studied (FELDMANN, 1958; PERES, 1967), on the contrary, few information and data are available regarding the phytobenthos of the Eastern Mediterranean coasts, and particularly the coasts of the Levantine Basin (RAYSS, 1941; ALEEM, 1950). Marine Flora of the Levantine Basin, including the coast of Lebanon belongs to the Atlanto-Mediterranean province (GIACCONE, 1968). However, the occurrence of several introduced thermophile species of Indo-Pacific origin, establishing permanent populations in the area, may attribute to this region a certain tropical characteristic (LAKKIS, 1971; POR, 1978; VERLAQUE, 1994; LAKKIS *et al., 1*996). These circumtropical species present in the area, may be either endemic or relques from the Tethys period or migrant species introduced, directly or indirectly, through the Suez Canal pathway to the Mediterranean (RIBERA &

BOUDOURESQUE, 1995).

Knowledge related to macroalgea of the Lebanese coast is very scarce; few studies were performed showing the coastal distribution and zonation of the community species and the negative effect of pollution on the distribution of benthic algae (BASSON *et al.*, 1976; LAKKIS *et al.*, 1996). Few studies were done in adjacent seas such as the Syrian coast (MAYHOUB, 1976), Palestinian coast (RAYSS, 1954, 1955; PAPENFUS, 1968; SAFRIEL & RITTE, 1986) and Mediterranean Egyptian littoral (ALEEM, 1948). In their study on the distribution of algae along the coast of Lebanon, BASSON *et al., (*1976) mentioned the presence of about 200 species and three phanerogams. They also noticed the negative effects of the pollution on the abundance and diversity, brown algae being the less tolerant to organic pollution.

In this paper we present further information concerning the composition and distribution of the algal species community along the Lebanese coast.

## Material and Methods

### The study area

Situated in the Central part of the Levantine Basin (East Mediterranean), the Lebanon is geographically limited by latitude 33°-35°N and longitude 35°30'-36°20'E. It belongs entirely to the South-East Mediterranean, showing a warm temperate climate. The Lebanese shoreline of 220 km is formed by 75% limestone rocky shores of Cenomanian Cretaceous origin; few other rocky shores were formed during the Miocene. The Mount of Lebanon rising up to 3000m and being covered by snow during 3-4 months, constitutes a permanent reservoir to numerous springs and small rivers; whose deep valleys carry a lot of freshwater to the sea. Several rocky clifts rarely exceed 20-30m; they are formed by soft limestone, poorely resistant to the sea wave erosion; they form in some places large plateforms of 75-100m rising 20-30cm above sea level. The mechanical and chemical action of the waves and seawater produced different structures of erosion crevasses, ponds, basins (SANLAVILLE, 1977). Several species formed populations in this rocky environment, mainly polychetes, molluscs such as *Vermetus triqueter, V. gigas* and several calcareous algae creating a typical "trottoirs" formations similar to those of *Lithophyllum tortuosum* in the western Mediterranean. Fresh water input from rivers along the coast is about 2500 millions $m^3$, not including the biggest river, Oronte, which discharges 2739 million $m^3$ in the sea near Antioche (DE VAUMAS, 1954). The majority of rocky shores are exposed to strong waves, except in protected embayments and harbours. The prevailing wind, which is from SW, is the main generator of the waves which are strongest in winter (December-April). The tide is of semi-diurnal type, but the amplitude is very low (20-25 cm) like in most of the Eastern Mediterranean coasts. During equinoxes we can distinguish the difference between high-water level and low-water on the rocky shores and clifts. However, atmospheric pressure and meteorological perturbations affect the sea level and conceal the amplitude variations of the tide.

The mean surface current is flowing from SW to N parallel to the shoreline and two miles offshore, with an average maximum speed of 50cm/sec in winter (February) and an average minimum of 15cm/sec in summer (GOEDICKE, 1972). Small eddies detached from the main current form cyclonic flow structures in bays and semi-enclosed areas.

### The sites

Six sampling stations were chosen along the coast of Lebanon from approximately 10 km south (34°55'N; 35°33'E) to 71 km north of Beirut, (33°55'N-35°28'E) covering polluted and unpolluted areas (Fig.1). The stations were:

1- *Aramane*. 400m north of the Tripoli oil refinery;
2- *Silaata*. 100m north of the chemical fertilizer plant.
3- *Batroun*. Station were no evident potential pollution source.
4- *Barbara*. Clean unpolluted coast.
5- *Zouk Mikayel*.A rocky island reef about 100m north of Jounieh thermo-electric power plant.
6- *Khalde*. 200m south of a major untreated sewage effluent.

All stations were typical coastal limestone platforms in the subtidal to wave-wash zone. The stations were sampled in two seasons: spring (April-May) and summer (July-August) during 1996-97. A marked transect line up to 30m length was laid out perpenticular to the shoreline from the supralittoral to the lower infralittoral. Six sampling points were chosen on each transect in order to cover the upper and lower levels of the supralittoral, the mediolittoral and the infralittoral zones, according to MOLINIER (1960) and PERES (1967). A 0.04 $m^2$ quadrate was placed at each point from were all algae were collected and placed in plastic bags for transport to the laboratory. Seawater samples were collected in polyethylene bottles for laboratory nutrient and salinity analysis. The pH and temperature of the water were measured *in situ*. In upper zones, sampling was carried out directly, while in subtidal and in infralittoral we used scuba diving for samples collection and for photography by using a Nikonos submarine camera.

In the laboratory the algae were separated from small invertebrates and sand grains. A preliminary taxa detection was conducted for each sample; for each registered qua-

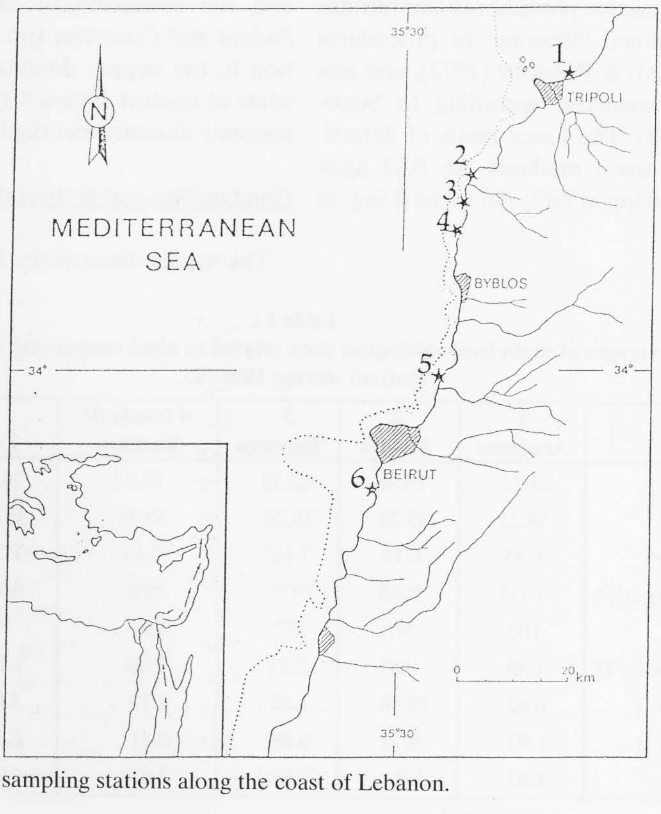


***Fig.1:*** Location of sampling stations along the coast of Lebanon.

drate, the samples were weighted for wet biomass before measuring dry weight. Representative samples from each quadrate were preserved in 5% neutral formaline for a further detailed taxonomic study. The index of taxonomic diversity in relation to the biomass and species richness was determined accor-ding to PIELOU (1975) by using the formula: D=S-1/log B, where S is the number of species found in the quadrate; log B is the logarithm of the algal biomass of quadrate in $g/m^{-2}$. D being the taxonomic diversity.

In addition to the biomass measures, it was interesting to define different biocenosis and estimate the percentage of coverage used by BOUDOURESQUE (1971a, 1971b). Fresh representative samples were used to establish a dry reference herbarium on separate cardboards. Each plate has its reference number with the scientific name and collection data. Nutrients were analyzed colorimetrically; reactive phosphorus and nitrates were determined following the procedures of STRICKLAND & PARSONS (1972), and ammonia was analyzed according to SOLORZANO (1969). The lower limits of detectibility using these methods are 0.03 μg.at $PO_4$-P/$l^{-1}$, 0.05μg.at $NO_3$-N/$l^{-1}$ and 0.5μg. at $NH_4$-N/ $l^{-1}$.

## Results and Discussion

### Hydrobiological data

The annual thermic cycle presents two phases: 1) a cold phase during December-March characterized by a cool water (minimum 16°C in February) with moderate salinity (S=39.25‰) and homothermic conditions in the water column 2). A warm phase during May-November with a thermocline in the layer 35-75m, accompained with a stratification of subsurface water layers. The highest temperature of 30°C and salinity (S=39.65‰) are recorded in August. Hydrographical and biological data are presented in Table 1.

The dumping of untreated sewage and other organic pollutants on the coast results in cases of eutrophication characterized by the excessive development of species from *Enteromorpha, Ulva* and *Cladophora* genera and the reduction of brown algae like *Padina* and *Cystoseira* spp. At polluted station 6, the degree dominance is very low, while at control station 4 (Barbara), the taxonomic diversity was the highest.

### Composition and vertical distribution

The marine flora of the Lebanese coast is

**Table 1**
**Annual averages of main hydrobiological data related to algal community at six sampling stations during 1996-'97.**

| Station Nb.<br>Locality | 1<br>Aramane | 2<br>Silaata | 3<br>Batroun | 4 (control)<br>Barbara | 5<br>Zouk | 6<br>Khalde |
|---|---|---|---|---|---|---|
| T °C | 23.33 | 23.48 | 23.35 | 23.32 | 24.12 | 23.25 |
| S‰ | 39.25 | 39.25 | 39.28 | 39.45 | 39.25 | 39.10 |
| Oxygen ml/ $l^{-1}$ | 6.45 | 6.15 | 7.10 | 7.45 | 5.75 | 4.68 |
| Wet weight ($g/m^{-2}$) | 1034 | 1048 | 1975 | 2850 | 850 | 650 |
| Nb.of taxa | 102 | 58 | 172 | 191 | 79 | 41 |
| Taxon. Diversity D | 1.46 | 0.83 | 2.25 | 2.40 | 1.16 | 0.62 |
| $PO_4$ (μg at $l^{-1}$) | 0.62 | 19.60 | 1.82 | 1.78 | 1.08 | 1.51 |
| $NO_3$ (μg at $l^{-1}$) | 1.90 | 0.72 | 0.38 | 0.41 | 2.11 | 2.00 |
| $NH_4$ (μg $l^{-1}$) | 4.10 | 4.00 | 3.53 | 2.67 | 4.31 | 7.60 |

poor in biomass but rich in taxonomic diversity. In total, 243 species were recorded including 25 *Cyanophyta*, 58 *Chlorophyta*, 29 *Phaeophyta*, 127 *Rhodophyta*, 3 *Monocotyledones* and one *Xanthophyta*. The Phanerogams are represented by *Halophyla stipulacea*, *Cymodocea nodosa* and *Zostera noltii*, the only Xanthophyte representative was *Vaucheria* sp. (Fig.2).The general composition and the vertical distribution of algae are more or less similar to that of the western Mediterranean because of the similarity in the bionomic zonation (PERES, 1967). However, an important difference with regard to the abundance and the distribution of the species still exists between the two Mediterranean basins. The most distinctive feature in the composition of the marine flora of this area is the presence of several introduced species.

Supralittoral

The few species growing in the supralittoral zone (13 species) are very tolerant to changing ecological conditions such as the moistening by seawater, the dumping of freshwater and pollutants from the land, etc. In this zone the epilithic *Cyanophyceae* are dominant, along with benthic diatoms. The species associations characterizing the supralittoral are:

-Algal association: *Hormathonema sphaericum, Hyella caespitosa, Anabaena* sp., *Oscillatoria nigroviridis, Chroococcus turgidus, Hydrocoleus lyngbyaceus, Phormidium ambiguum, Rivularia mesenterica, R.atra.*

-Dominant animals: *Littorina punctata (L. syriaca), Chtamalus stellatus, Ligia italica*

Stations 1,2,3 and 4 present similar characteristics in the supralittoral; they show same environmental conditions and species assemblages. Stations 5 and 6 are different from others; station 5 is formed by an artificial rocky platform, the supralittoral is not as rich as at other stations. Sandy supralittoral station 6 is slighly different in group-species composition from all other rocky stations. In general the supralittoral is poor in species and in biomass; the total number of species encountered at all supralittoral stations did not exceed 20 species.

Mediolittoral (Intertidal)

Taxonomic diversity is high and the eco-

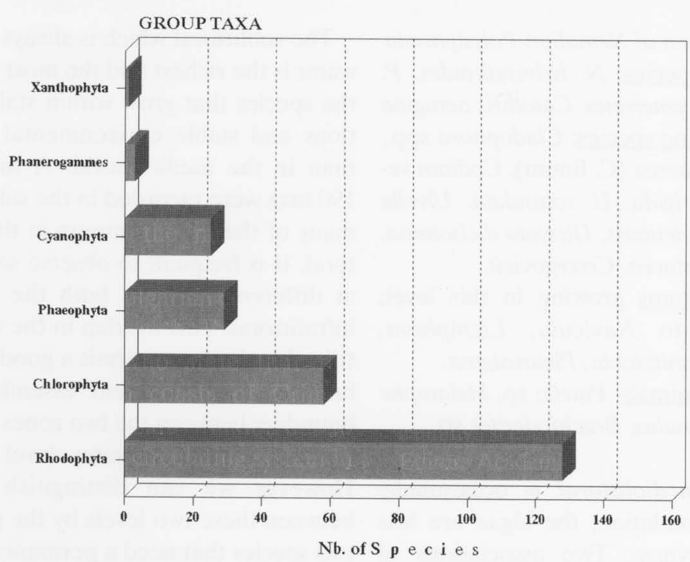


***Fig.2:*** Number of species found along the coast of Lebanon.

logical conditions are variable and correspond to the water level changes which show irregular emersion and submersion. The maximum number of species found in all mediolittoral stations were approximately 148. Stations 1,2,3,4 present similarity in the distribution and abundance of species; while at stations 5 and 6, the mediolittoral is not as rich as in other sites.

***Upper mediolittoral*** is characterized by group of species tolerating long-time exondation and dessication.Two associations characterize this level:

a) Association of *Porphyra leucostica-Enteromorpha compressa*:

-Dominant species: *E.flexuosa, E.aragoensis, Chaetomorpha aerea, Bangia fucopurpurea (B.atropurpurea)*

-Accompanying species: *Anabena* sp., *Oscillatoria nigroviridis,Lyngbya confervoides, L. aestuarii, Brachitrichia balani, Calothrix aerugina, Anadiomene stellata.*

-Benthic diatoms: A*mphora* sp., *Achnanthis longipes, Pseudonitzschia lanceolata, Pleurosigma* spp., *Navicula* spp.

-Animal species: *Patella* sp., *Melaraphe punctata.*

b) Association of *Nemalion-Polysiphonia*

-Dominant species: *N. helminthoides, P. sertularoides, P. tenerrima, Calothrix aerugina*

-Accompanying species: *Cladophora* spp., *Chaetomorpha aerea* (C. linum), *Codium vermilaria, Ulva rigida, U. rotundata, Ulvella lens, Valonia utricularis, Dictyota dichotoma, Cystoseira amentacea, Cercegovicii.*

-Benthic diatoms growing in this level; they belong to *Navicula*, *Licmphora*, *Synedra*, *Pseudonitzschia*, *Pleurosigma*.

-Dominant animals: *Patella* sp, *Melaraphe punctata*, *Chtamalus, Brachiodontes* sp.

*The* ***lower mediolittoral*** is occasionally exposed to exondation; the algae are less tolerant to dryness. Two associations of species characterize this level:

a) Association of photophile species of *Vermetus* platforms:

-Dominant species: *Neogoniolithon notarisii Laurencia papillosa, Cladophora* spp., *Enteromorpha* spp., *Jania rubens.*

-Accompanying species: *Hydroclathrus clathratus, Cystoseira* spp., *Gelidium pulchellum, Corallina granifera, C. mediterranea Ceramium ciliatum, C. diaphanum, Spyridia filamentosa, Alsidium, Sphacelaria furcigera.*

-Dominant animals are: *Vermetus triqueter, V. gigas, Patella* sp., *Chtamalus stellatus, Balanus* sp.

b) Association of *Laurencia papillosa*

-Characteristic species: *L. papillosa, L. obtusa, L. pinnatifida, Jania rubens.*

-Accompanying species: *Gelidium crinale, G. pectinatum, Cystoseira fimbriata, Padina pavonica, Neogoniolithon notarisii, Dictyota dichotoma, Dilophus fascio*la, *Hypnea musciformis, Falkinbergia hildenbrandii, Colpomenia sinuosa, Lithophyllum incrustans, Sphacelaria furgicera, S. tribuloides, Acrocaetium savianum, Spyridia filamentosa, Herposiphonia secunda.*

Infralittoral (Subtidal)

The sublittoral which is always covered by water is the richest and the most diversified; the species that grow within stable associations and stable environmental conditions than in the mediolittoral. A maximum of 190 taxa were recorded in the subtidal zone; many of them are common in the mediolittoral. It is frequent to observe same species at different strata in both the medio and infralittoral. This overlap in the vertical distribution does not permit a good distinction between their different assemblages. The boundary between the two zones is not clear because of the seawater level variations. However we can distinguish the limit between these two levels by the presence of two species that need a permanent and constant immersiom. These species are: the *Cy-*

*stoseira* spp. and the *Sargassum vulgare*, indicators of low-water tide; similar to *C. stricta* and *C. mediterranea* indicating this phenomenon in the western Mediterranean. On the other hand the subtidal zone in the Leva-ntine Basin is characterized by the presence of tropical and subtropical species and also by the occurrence of introduced Lessepsian species of Indo-Pacific origin. The rocky bottom in all stations presents similar characteristics, the control station 4 showed the highest number of species and the highest abundance of algae than all other stations.

***Upper Infralittoral*** *characterized by two assemblages*:

a) Assemblage of Jania-Bryopsis-Liagora includes two groups of species:

-Dominant species: *J. rubens, Bryopsis mucosa, B.hypnoides, Liagora farinosa, Anadyomene stellata, Lophocladia lallemandii, Hydroclathrus clathratus, Sargassum vulgare. Bryopsis, Corallina elongata.*

-Accompanying species: *Cladophora pellucida, C. prolifera, Dasycladus vermicularis, Derbesia tenuissima, Colpomenia sinuosa, Padina pavonica, Bryopsis plumosa, B. pennata, Dilophus fasciola, L.incrustans, Taonia atomaria, Stypopodium schimperi, Stypocaulon scoparium, Acrochaetium savianum, Acanthophora delilei, Fosliella farinosa, Amphiroa rigida, Polysiphonia denudata, Hypnea hamulosa, H. cervicornis.*

b) Association of Jania-Padina-Dasycladus characterized by a calm photophile environment. In this association comprises two groups of species:

-Dominant species: *Padina pavonica, Jania rubens, Dasycladus vermicularis, Udotea petiolata.*

-Accompanying species: *Bryopsis pennata, Derbesia tenuissiima, Ralfsia verrucosa, Rivularia atra, Giffordia mitchellae, Stypopodium shimperi, Padina pavonica, Dilophus fasciola, Polysiphonia ferulacea, Sargassum vulgarae, Cystoseira* spp.*, Acanthophora delilei, Rytiphlea tinctoria, Siphonocladus pusillus, Cladophora sp., Derbesia tenuissima, Gelidium pectinatum, Acetabularia mediterranea, A. moebii, Bryopsis hypnoides, Asparagopsis taxiformis.*

***Lower Infralittoral*** extends down to 40m is characterized by two assemblages:

a) Sciaphile species assemblage of rocky bottom substrat with two group of species:

-Dominant species: *Acanthophora delilei, Rytiphlaea tinctoria, Siphonocladus pusillus.*

-Accompanying species: *Cladophora prolifera, V. utricularis, Bryopsis hypnoides, B. pennata, Lithophillum incrustans, L. lenormandii, Jania sp., Spiridia filamentosa, Derbesia tenuissima, Acetabularia, mediterranea, Gelidium* sp.

b) Assemblage of sediment bottom substrat, with two group of species:

-Dominant species: *Phanerogams Zostera noltii, Cymodocea nodosa and Halophila stipulacea, Caulerpa scalpelliformis, C.racemosa, C. prolifera.*

-Accompanying species: *Udotea petiolata, Halopteris scoparia, Jania sp., Ceramium diaphanum, C. gracillimum, Fosliella lejolisii, Halimenia floresia, Caulerpa prolifera, C. racemosa, Corallina elongata, Peyssonelia squamaria.*

Algal community of the Levantine basin is characterized by the presence of the genus *Caulerpa*. This genus includes about one hundred species spread in all warm temperate and tropical seas. Two species are autochtones in the Mediterranean: *C. prolifera* and *C. olivieri*. Three species are of Indo-Pacific origin, introduced by the Suez Canal, *C. scalpelliformis*, *C. mexicana* et *C. racemosa*. Four species are regularely present on the Lebanese coast: *C. scalpelliformis, C. prolifera, C. racemosa*, and *C. mexicana*, the two first being the most common (LAKKIS, 1998; LAKKIS & NOVEL-LAKKIS, 1999).

Abundance and Distribution of algal community

A total of 243 species of benthic algae were recorded in all stations, the control station No 4 was the richest amounting 191, while the more polluted station No 6 only 41 species were recorded (Fig.3). Several species have not been previously recorded in the Eastern Mediterranean. The complete taxonomic list and their distribution is given in Table 2.

At Station 1, north of the Tripoli oil refinery, phosphate concentration was low while nitrogen relatively high. Biomass was only 41% of the control station 4.The taxonomic diversity annual average was 1.46, while in station 4 it was the highest 2.40.

At station 2, near the Silaata chemical fertilizer plant, phosphate concentration was extremly high reaching an average of 19.60 μg.at/ $l^{-1}$ of seawater. Biomass was reduced to 37% and taxonomic diversity to only 37% of the control station.

At station 3 with no proximate pollution source, phosphate concentration was relatively high, while nitrate and ammonia were low. Biomass was averaging 70% of the control station, which it is only 5 km away. Number of taxa (76 species) and taxonomic diversity index (D=2.25) were slighly lower of the control station.

Station 4 (control) was more remote from both potential pollution and river inflow than other stations. Phosphate and nitrate concentrations, were undetectable in spring time; ammonia concentrating mean was lower (average 2.67μg.at. $l^{-1}$) than any other stations. Biomass (2850 g $m^{-2}$), number of taxa (191) and taxonomic diversity (D=2.40) were higher than any other stations (Fig.4).

Station 5 situated near Zouk Mychael thermoelectrical power plant showed no significant phosphorus or nitrogen enrichment, but temperature at least in August (T=35°C) was much higher than either the control or the mean value (29.75 °C) for all other stations at that time of the year .The rise in temperature was apparent on a smaller scale as one approached the cooling water effluent of the power plant. Biomass was markedly reduced to 30% of the control value. Taxo-nomic diversity was likewise greatly reduced with an average of 1.16.

Station 6, south of sewage Khalde outfall, was high in phosphate concentrations (1.51μg at $l^{-1}$) and the highest in nitrate and ammonia concentrations compared to other stations (see Table 1).

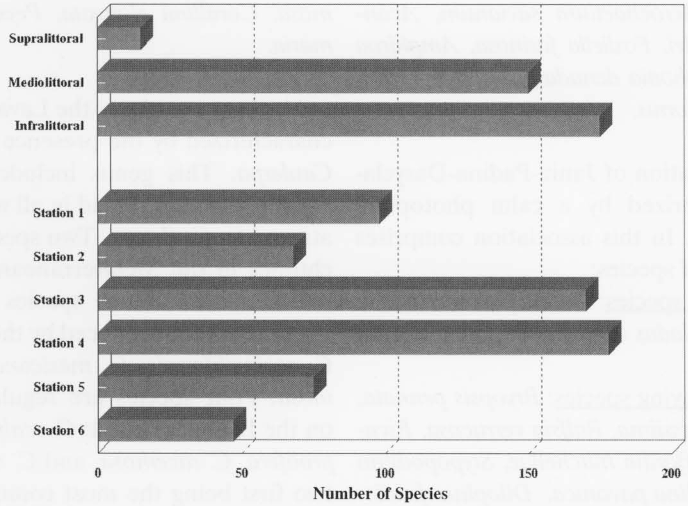


***Fig.3:*** Horizontal and vertical distribution of the number of species along the coast of Lebanon.

**Table 2**

**Distribution of macrophytobenthos species found along the coast of Lebanon. The relative abundance of each species is estimated as % of covering in six sampling stations and at different levels.**

| SPECIES / LEVELS / STATIONS | Sup | Med | Inf | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|---|
| *CYANOPHYCEAE (CYANOBACTERIA)* | | | | | | | | | |
| ***Anabaena** sp. | 3 | 3 | - | - | - | 2 | 3 | 2 | 1 |
| **Brachytrichia** balani.(Lloyd)Born et Flash. | 1 | 2 | - | - | 1 | 1 | 2 | - | - |
| +**Calothrix** aerugina (Kutzing)Thuret. | - | 1 | - | - | - | 1 | 1 | - | - |
| *+C.crustacea Thur. | - | 1 | - | - | - | - | - | - | 1 |
| C.nidulans Setchell et Gardner. | - | 1 | 1 | - | - | - | - | 1 | - |
| +**Chroococcus** turgidus (Kutz.) Nag. | 1 | 1 | - | 1 | - | 1 | 1 | - | - |
| **Hormathonema** sphaericum Erceg. | 3 | 2 | - | - | 2 | 1 | 3 | - | - |
| +**Hydrocoleus** lyngbyaceus (Kutz.). | 2 | 1 | - | - | 1 | 1 | 2 | - | - |
| +**Hyella** caespitosa Born.et Flash. | 3 | 1 | - | 2 | - | 2 | 3 | 1 | - |
| **Lyngbya** aestuarii Liebm. | - | 2 | - | - | - | 2 | 1 | 1 | 1 |
| *+L.confervoides C.Ag. | - | 1 | - | 1 | - | 1 | - | 1 | - |
| +L.lutea Gom. | - | 1 | - | - | - | 1 | - | - | - |
| L.martensiana Menegh. | - | 1 | - | - | - | - | 1 | - | - |
| Lyngbya sp. | - | 2 | - | 2 | 1 | 2 | 1 | - | - |
| +**Mastigocoleus** testarum Lagerheim. | 1 | 2 | - | - | - | 2 | 1 | - | - |
| **Microchaete** sp. | 1 | 1 | - | - | - | 1 | - | - | - |
| +**Microcoleus** chthonoplastes Thuret. | - | 1 | - | 1 | - | 1 | - | - | - |
| **Oscillatoria** formosa Bory. | - | 2 | - | 1 | - | 1 | 1 | 1 | 1 |
| +O.nigroviridis Thwaites. | - | 4 | - | - | - | 4 | 1 | 1 | 1 |
| O.tenuis var.tergestina Rabenhorst | - | 2 | - | - | - | 1 | 1 | - | - |
| Oscillatoria sp. | 1 | 1 | - | 1 | 1 | 1 | 1 | 1 | 1 |
| **Phormidium** ambiguum Gom. | 1 | 1 | - | 1 | 1 | 1 | - | - | - |
| +**Placoma** vesiculosa(Sch.) Epiphyte on Cor.... | - | 1 | - | 1 | - | 1 | 1 | - | 1 |
| +**Rivularia** mesenterica Thuret | 2 | 2 | - | 2 | - | 2 | - | - | 1 |
| +R.atra Roth. | 1 | 2 | - | 1 | 1 | 1 | - | - | - |
| *XANTHOPHYCEAEA* | | | | | | | | | |
| **Vaucheria** sp. | 1 | 1 | - | 1 | - | 1 | - | - | - |
| *CHLOROPHYCEAE* | | | | | | | | | |
| *+**Acetabularia acetabulum** (Linn.)Silva | - | 1 | 2 | - | - | 1 | 2 | - | - |
| Syn.*A.mediterranea* Lamoureux | | | | | | | | | |
| * A. moebii Solms. | - | 1 | 1 | - | 1 | 1 | 1 | - | - |
| A.parvula Solms-Laubach. | - | - | 2 | - | - | 2 | 1 | - | - |
| +**Anadyomene** stellata (Wulfen) C.Ag. | - | 1 | 3 | - | - | - | 3 | 1 | 1 |
| Syn.*A.flabellata* Lamoureux | | | | | | | | | |
| +**Bryopsis** adriatica (J.Agardh) Meneghini. | - | 2 | 2 | - | - | 2 | - | 1 | 1 |
| Syn.*B.plumosa* (Hudson) var.adriatica | | | | | | | | | |
| B.cupresina Lamour. | - | 1 | 1 | 1 | 1 | - | - | - | 1 |
| **Bryoposis** cupressoides (Kutz.). | - | 1 | 1 | 1 | - | 1 | - | - | - |
| B.disticha (J.Ag.) (Kutz.). | - | 1 | 1 | 1 | - | 1 | - | - | - |
| Syn.*B.balbisiana* Kutzing | | | | | | | | | |

**Table 2 (continued)**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *+B.hypnoides Lamoureux.................................... | - | 3 | 2 | - | 1 | - | 3 | - | 1 |
| +B muscosa Lamoureux.................................... | - | 3 | 2 | 2 | - | 3 | - | 1 | 1 |
| +Bryopsis pennata Lamour.................................... | - | 2 | 4 | - | - | 4 | 2 | - | - |
| +B.plumosa (Huds.) C.Ag.................................... | - | 1 | 2 | 1 | - | 2 | 1 | - | - |
| Syn.B.arbuscula Lamoureux | | | | | | | | | |
| *+**Caulerpa** prolifera(Forsk.)Lamour.................. | - | - | 2 | 1 | - | 2 | 2 | - | 1 |
| *+C.racemosa(Forsk.) J.Ag.................................... | - | - | 2 | 1 | - | 2 | 2 | 1 | 1 |
| *+C.scalpelliformis(Brown) Ag.......................... | - | - | 3 | - | - | 2 | 3 | - | - |
| *+**Chaetomorpha**.aerea (Dillwyn)Kutzing......... | - | 3 | 2 | - | - | 3 | 3 | - | - |
| Syn.*C.linum* (O.F.Muller) Kutz | | | | | | | | | |
| *C.dalmatica,C.vasta* Kutzing | | | | | | | | | |
| *C.setacea,C.rigida* Kutzing | | | | | | | | | |
| +C.capillaris (Kutz.)Boerg.................................. | - | 1 | 1 | 1 | - | - | 1 | 1 | - |
| ***Cladophora** coelothrix Kutz.............................. | - | 3 | 2 | - | - | - | 3 | - | 2 |
| Syn.*C.arachnoides* Schiffner in Rechinger | | | | | | | | | |
| *C.dalmatica* Kutzing | | | | | | | | | |
| C.echinus (Biasolleto.). Kutzing........................ | - | 3 | 1 | - | - | - | - | 1 | 1 |
| Syn.*C.cornea* Kutzing | | | | | | | | | |
| C. hutchinsiae (Dillwyn.)Kutz........................... | - | 2 | 2 | 1 | - | - | - | 1 | 1 |
| Syn.*C.rissoana* Montagne ex Kutzing | | | | | | | | | |
| +C. laetevirens(Dillw.)Kutz................................ | - | 2 | 1 | 1 | - | - | 2 | - | - |
| Syn.*C.affinis* Schiffner | | | | | | | | | |
| *C.meneghiana* Kutzing | | | | | | | | | |
| *C.repens* (J.Ag.)v.*meneghiana* Hauck | | | | | | | | | |
| *C.utriculosa* Kutz.v.*laetevirens* Hauck | | | | | | | | | |
| C.nigrescens Zanard ........................................ | - | 1 | - | 1 | 1 | - | - | - | - |
| +C.pellucida (Huds.)Kutz.................................... | - | 3 | 1 | - | - | 1 | 3 | 1 | 1 |
| Syn.*C.feredayi* Harvey | | | | | | | | | |
| *C.trichotoma* Kutzing | | | | | | | | | |
| C.rupestris (L.) Kutz........................................ | - | 1 | - | - | - | 1 | 1 | 1 | - |
| *+C.sericea (Huds.) Kutz.................................... | - | 1 | - | - | - | - | 1 | - | - |
| Syn.*C.gracilis* (Griffiths) | | | | | | | | | |
| *C.nitida* Kutzing | | | | | | | | | |
| *C.pecticornis* | | | | | | | | | |
| C.vagabunda (L.) C.Van den Hoek.................. | - | 2 | 1 | - | 1 | - | 1 | - | - |
| Syn.*C.crystallina* (Roth) Kutzing | | | | | | | | | |
| *C.crystallina* v.*tenuissima* Ercegovic | | | | | | | | | |
| *C.crystallina* v.*subdichotoma* Erceg. | | | | | | | | | |
| *C.fracta*(Mull. ex Vahl) Kutz.f.*marina* | | | | | | | | | |
| *C.flavovirens* Kutzing | | | | | | | | | |
| *Clad. glomerata* (Linn.) Kutz.f.*marina* | | | | | | | | | |
| *C.gracea* Shiffner | | | | | | | | | |
| Cladophora sp. ............................................... | - | 1 | - | - | - | - | 1 | 1 | - |
| **Cladophoropsis** membranacea (Ag.)Boerg....... | - | 2 | 1 | 1 | - | - | 2 | 1 | 1 |
| Syn.*Siphonocladus membranaceus* (C.Ag.) | | | | | | | | | |
| *S.caespitosa* (Bory) Kutzing | | | | | | | | | |

**Table 2 (continued)**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| +C. modonensis (Kutz.)Boerg........................... | - | 1 | - | 1 | - | 1 | - | - | - |
| Syn.*Cladophora modonensis* Kutzing | | | | | | | | | |
| **Codium** bursa (L.) C.Agardh.............................. | - | 2 | 3 | - | - | 1 | 3 | - | - |
| C.tomentosum. (Hudson) Stackhouse................ | - | 2 | 2 | 2 | - | - | 2 | 1 | - |
| C.vermilara (Olivi) delle Chiaje......................... | - | 2 | 2 | 1 | 1 | 1 | - | - | - |
| +**Dasycladus** vermicularis (Scopoli ) Krasser....... | - | 2 | 2 | 2 | - | 2 | 2 | 1 | - |
| Syn.*D.clavaeformis* (Roth)Agardh | | | | | | | | | |
| *Myrsidium bertoloni* Bory | | | | | | | | | |
| *Acetabularia clavaeformis* (Roth)Ag. | | | | | | | | | |
| *+**Derbesia** tenuissima ( De Not.) Crouan........... | - | 1 | 2 | 1 | - | - | 2 | - | - |
| Syn.*Halicystis* cf.*parvula* Schmitz | | | | | | | | | |
| **Endoderma** viride (Reinke) Lagerh.................... | - | 1 | 1 | - | - | - | 1 | - | - |
| **Enteromorpha** aragoensis Blid.......................... | - | 2 | 1 | 1 | - | 1 | 2 | 1 | - |
| *+E.clathrata (Roth) Greville ............................ | - | 2 | 1 | 1 | - | - | - | 2 | - |
| *+E.compressa (Linnaeus)Greville ...................... | - | 3 | - | 2 | 2 | 1 | 2 | - | 2 |
| Syn.*E.complanata* Kutzing | | | | | | | | | |
| *Solenia compressa* Agardh | | | | | | | | | |
| +E.flexuosa (Wulfen ex Roth) ) J.Agardh........... | - | 2 | - | 2 | 2 | - | 1 | - | - |
| Syn.*E.jurgensii* Kutzing | | | | | | | | | |
| +E.flexuosa subsp.paradoxa (Dillwyn) Blid......... | - | 2 | - | 2 | - | - | 1 | 1 | 1 |
| E.hendayensis Dang. Et Parr............................. | - | 1 | - | - | - | 1 | - | - | 1 |
| *+E.intestinalis (L.) Link. var.intestinalis Blid..... | - | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Syn.*E.lingulata* J.Agardh | | | | | | | | | |
| E.prolifera (Mull.) J.Ag subsp.prolifera Blid...... | - | 3 | 2 | - | 3 | 2 | 2 | 2 | 1 |
| E.ralfsii Harv.......................................................... | - | 1 | 1 | 1 | - | 1 | 1 | - | 1 |
| E.torta (Mert.) Reinb............................................ | - | 1 | 1 | 1 | - | - | 1 | - | - |
| Enteromorpha sp................................................ | - | 1 | - | - | 1 | 1 | 1 | 1 | 1 |
| *+**Halimeda** tuna (Ellis & Solender) Lam. ........... | - | 1 | 3 | - | 1 | 3 | 3 | 1 | - |
| *+**Phaeophyla** dendroides (Crouan) Batt............. | - | 1 | 1 | 1 | - | 1 | 1 | - | - |
| +**Pseudobryosis** myura (J.Ag.)Berthold.............. | - | - | 2 | - | - | - | 2 | - | - |
| **Rhizoclonium** kochianum Kutzing....................... | - | 1 | 2 | - | - | 1 | 2 | - | - |
| +**Udotea** petiolata (Turra) Borgesen ................ | - | 1 | 2 | - | - | 1 | 2 | - | - |
| Syn.*U.daisfontaini* Lamoureux | | | | | | | | | |
| ? *U.minima* Ernst | | | | | | | | | |
| **Ulva** olivascens Dang............................................ | - | 1 | 3 | - | 2 | 3 | 3 | - | - |
| *+U. rigida C. Agardh.... ........................................ | - | 3 | - | - | - | 1 | 2 | 3 | 3 |
| Syn.*U.lactuca* Lin.v..*rigida* (C.Ag.) Le Jol. | | | | | | | | | |
| U.rotundata Blid................................................. | - | 4 | 1 | 3 | 2 | 2 | 3 | 3 | 2 |
| **Ulvella** lens. Cxrouan ........................................ | - | 2 | - | 1 | - | 2 | 2 | - | - |
| *+**Valonia** utricularis................. ......................... | - | 2 | 2 | - | 2 | - | 2 | - | - |
| Syn.*V.caespidula* Zanardini | | | | | | | | | |
| ***PHAEOPHYTA*** | | | | | | | | | |
| *+**Colpomenia** sinuosa (Roth) Derbes & Sol..... | - | 2 | 3 | 1 | - | 2 | 3 | - | - |
| Syn.*Hydraclathrus sinuosus* (Mert.)Zanard. | | | | | | | | | |
| *Asperococcus sinuosus* Bory | | | | | | | | | |
| *+**Cystoseira** amentacea Bory.............................. | - | 3 | 3 | - | - | 2 | 3 | - | - |

**Table 2 (continued)**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Syn.C.spicata Ercegovic | | | | | | | | | |
| C.stricta (Mont.)Sauvageau | | | | | | | | | |
| +C.compressa (Esper) Gerloff et Nizamuddin....... | - | 3 | 4 | 2 | - | - | 4 | - | - |
| Syn.C.abrotanifolia Agardh | | | | | | | | | |
| C.fimbriata (Desfontaines)Bory | | | | | | | | | |
| C.filicina Bory | | | | | | | | | |
| C.ercegovicii Giacconi........................................ | - | 3 | 2 | 1 | - | - | 3 | - | - |
| C.mediterranea Sauvageau .................................. | - | 1 | 1 | - | - | - | - | - | - |
| Syn.C.selaginoides Valiante | | | | | | | | | |
| C.sauvageauana Hamel | | | | | | | | | |
| +C.spinosa Sauvageau.......................................... | - | 2 | 1 | 1 | 1 | 1 | - | - | - |
| Syn.C.erica-marina lamoureux | | | | | | | | | |
| +C. zosteroides C.Agardh .................................... | - | 1 | 1 | - | - | - | 1 | - | - |
| *+**Dictyopteris** membranacea (Stackh.)Batt.......... | - | 2 | 2 | - | - | 1 | 2 | 1 | - |
| Syn.D.polypodioides (Desfont.)Lam. | | | | | | | | | |
| ? Halyseris polypodioides (Desf.) Ag. | | | | | | | | | |
| *+**Dictyota** dichotoma (Huds.) Lamoureux ........... | - | 4 | 2 | 2 | 1 | 2 | 4 | - | 1 |
| *+**Dilophus** fasciola (Roth) Howe ........................ | - | 2 | 3 | 2 | - | 3 | 3 | 1 | - |
| +D.spiralis (Montagne) Hamel............................ | - | 2 | 2 | 1 | - | 2 | 2 | 1 | - |
| Syn.D.ligulatus (Kutzing) Feldman | | | | | | | | | |
| Dictyota ligulata Kutzing | | | | | | | | | |
| +Ectocarpus confervoides (Roth) Le Jolis......... | - | 2 | 2 | 1 | - | - | 2 | 1 | - |
| Syn. E.arctus Kutzing | | | | | | | | | |
| E.siliculosus Bory | | | | | | | | | |
| E.penicillatus (C.Ag.)Kjellman | | | | | | | | | |
| Auduinella siliculosa Bory | | | | | | | | | |
| **Feldmannia** irregularis ( Kutz) Hamel................ | - | 2 | 1 | 1 | - | 1 | - | - | - |
| Syn.Ectocarpus irregularis Kutzing | | | | | | | | | |
| *+**Giffordia** mitchellae (Harvey) Hamel................ | - | 2 | 1 | - | - | 1 | 2 | - | - |
| Giffordia sp....................................................... | - | 1 | - | - | - | 1 | 1 | - | - |
| *+**Halopteris** scoparia (Linn.) Sauvageau............. | - | - | 3 | 1 | - | 1 | 3 | - | - |
| Syn.Stypocaulon scoparium (Linn.) Kutz. | | | | | | | | | |
| Sphacelaria scoparia Lyngbye | | | | | | | | | |
| *+**Hydroclathrus** clathratus (Bory) Howe............ | - | 2 | 1 | 1 | - | - | 2 | - | - |
| **Litocarpus** sp..................................................... | - | 1 | - | - | - | - | 1 | - | - |
| *+**Padina** pavonica (L.) Thivy............................. | - | 4 | 2 | 3 | 1 | 1 | 4 | 2 | - |
| Syn.P.pavonia (Linnaeus)Gaillon | | | | | | | | | |
| P.mediterranea Bory | | | | | | | | | |
| Zonaria pavonia (Linn.)Agardh | | | | | | | | | |
| *+**Ralfsia** verrucosa (Aresch.)J,Ag........................ | - | 2 | 1 | 1 | - | 1 | 2 | - | - |
| +**Sargassum** vulgare C.Agardh.......................... | - | 3 | 4 | - | - | 2 | 4 | - | - |
| Syn.S.salisifolium Lamoureux | | | | | | | | | |
| S.diversifolium Agardh | | | | | | | | | |
| Sargassum acinarium (Linnaeus) C.Agardh....... | - | 1 | - | - | - | - | 1 | - | - |
| Syn.S.linifolium (Turner) J.Agardh | | | | | | | | | |
| S.obtusatum Bory | | | | | | | | | |

**Table 2 (continued)**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *+**Scytosiphon** lomentaria ( Lyngbye) Endl.......... | - | 1 | 2 | - | - | 2 | 2 | - | - |
| +**Sphacelaria** furcigera Kutzing ........................ | - | 3 | 1 | 2 | - | - | 3 | 1 | - |
| *+S.tribuloides Meneghini .................................. | - | 1 | 2 | - | - | 2 | - | 2 | - |
| +S.hystrix Suhr & Reinke ................................ | - | 1 | 2 | 2 | - | 2 | 2 | - | - |
| **Stypocaulon** scoparium (L.) Kutzing................ | - | 1 | 2 | - | - | 1 | 2 | - | - |
| Syn. *Halopteris scoparia* (Linn.) Sauv. | | | | | | | | | |
| *Sphacelaria scoparia* Lyngbye | | | | | | | | | |
| *+**Stypopodium** schimperi (Buch.ex Kutz.).......... | - | 1 | 5 | 3 | 2 | 4 | 5 | 2 | 2 |
| +**Taonia** atomaria.(Woodward)J.Agardh........... | - | 2 | 4 | 2 | 3 | 2 | 3 | 3 | 2 |
| Syn.*Padina phasiana* Bory | | | | | | | | | |
| *RHODOPHYTA* | | | | | | | | | |
| *+**Acanthophora** delilei Lamour.......................... | - | - | 3 | - | 2 | 2 | 3 | - | - |
| **Acrochaetium** caespitosum (J.Ag.) Nag............ | - | - | 2 | - | - | 1 | 2 | - | - |
| A.crassipes Borges.......................................... | - | - | 1 | - | - | - | 1 | - | - |
| A.daviesii (Dillwin) Nag.................................... | - | - | 1 | - | - | 1 | - | - | - |
| A.leptonema( Rosenv.) Borges......................... | - | - | 1 | - | - | 1 | 1 | - | - |
| A.microscopicum Nag ..................................... | - | - | 1 | - | - | - | 1 | - | - |
| A.parvulum (Kylin) Hoyt................................. | - | - | 2 | - | - | - | - | - | - |
| +A.savianum (Meneghini) Nageli..................... | - | 1 | 1 | 1 | - | 1 | 1 | - | - |
| A.subpinnatum Born ...................................... | - | - | 1 | - | - | 1 | - | - | - |
| A.subtilissimum (Kutzing) Hamel..................... | - | - | 1 | - | - | 1 | 1 | - | - |
| A.thuretii(Born.) Coll. et Harv.......................... | - | - | 1 | 1 | - | - | - | - | - |
| +A.trifilum( Buff.) Batt.......................... .......... | - | - | 1 | - | 1 | - | - | - | - |
| A.virgatulum (Harv.) J.Ag. f. luxurians ........ | - | - | 1 | - | - | - | - | - | - |
| Acrochaetium sp............................................. | - | - | 1 | - | - | - | - | - | - |
| +**Aglaotamnion** neglectum G.Feldmann. ........ | - | - | 2 | - | 1 | 1 | 2 | 1 | - |
| +A. scopolorum (C.Ag.) J.Ag......................... | - | - | 1 | - | - | 1 | 1 | - | - |
| A. tennuissimum (Bonn.) Kutz...................... | - | - | 1 | - | - | 1 | 1 | - | - |
| +A. tripinnatum (Grateloup) G.Feldmann...... | - | - | 1 | - | - | - | - | - | - |
| +**Alsidium** corallinum C.Ag.............................. | - | - | 3 | - | - | 1 | 3 | 1 | 1 |
| Syn.*Gigartina denudata* Bory | | | | | | | | | |
| +A.helminthochorton (La Tourrette) Kutz..... | - | - | 3 | 1 | 1 | - | 2 | - | - |
| +**Amphiroa** cryptarthrodia Zanard ............... | - | 1 | 3 | - | - | 1 | - | 2 | - |
| A.rigida Lamoureux ...................................... | - | 2 | 2 | - | 1 | 2 | 2 | - | - |
| +**Antithamnion** cruciatum ( C.Ag.)Naegeli..... | - | - | 2 | 1 | 2 | 1 | 2 | - | 1 |
| Syn.*A.cruciatum* f.*fragilissima* Hauck | | | | | | | | | |
| A.genuina Hauck | | | | | | | | | |
| Asterocystis ornata ( C.Ag) Hamel ................ | - | - | 3 | - | 2 | 1 | 3 | 1 | - |
| *Asparagopsis taxiformis (Delile) Trevisan....... | - | 1 | 4 | - | 3 | 1 | 4 | 2 | - |
| +Bangia fuscopurpurea(Dill.)Lyng................... | - | 1 | 1 | - | - | - | 1 | 1 | - |
| Syn.B.atropurpurea (Roth) C.Agardh | | | | | | | | | |
| +**Botryocladia** botryoides ( Wulf.) Feldmann..... | - | - | 3 | 1 | 2 | - | 3 | 1 | - |
| Syn.*B.uvaria* ( Wulfen) Kylin | | | | | | | | | |
| *Chrysimenia uvaria* J.Agardh | | | | | | | | | |
| *Gastroclonium uvaria* (Wulf.) Kutz. | | | | | | | | | |

**Table 2 (continued)**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| +**Callithamnion** granulatum(Ducluz.)C.Ag.......... | - | 1 | 1 | - | 1 | - | - | - | - |
| *__Centroceras__ clavulatum Montagne...................... | - | - | 3 | - | - | - | 3 | 1 | - |
| +**Ceramium** ciliatum (Ellis)................................ | - | 1 | 4 | 2 | 3 | 1 | 4 | 3 | - |
| Syn.<u>C.julaceum</u> Kutzing | | | | | | | | | |
| <u>Boryna ciliata</u> Grateloup | | | | | | | | | |
| C.codii ( Richards) Mazoyer............................ | - | - | 1 | - | 1 | - | 1 | - | - |
| Syn.<u>Ceramothamnion adriaticum</u> Schiller. | | | | | | | | | |
| C.comptum Borg............................................ | - | - | 3 | - | - | 2 | 2 | - | - |
| *+C.diaphanum ( Roth.) Harv............................ | - | 1 | 4 | 1 | - | 4 | 4 | - | - |
| Syn.<u>Boryna diaphana</u> Greteloup | | | | | | | | | |
| *+C.gracillimum var. byssoides (Harv.) G.Feld.... | - | - | 3 | - | - | 3 | - | 2 | 1 |
| Syn.<u>C.flaccidum</u> (Kutzing) Ardisson | | | | | | | | | |
| *+C.rubrum ( Hudson) C.Ag............................ | - | - | 3 | - | 2 | 3 | 3 | - | 1 |
| +**Champia** parvula (C.Ag.) Harv...................... | - | - | 3 | - | - | - | 3 | - | - |
| **Chondria** coerulescens (Crouan) Falkenb....... | - | 1 | 2 | - | - | 2 | 2 | 1 | - |
| *+C.tenuissima ( Good. & Wood.) C.Ag.......... | - | 1 | 1 | - | - | 1 | 1 | - | - |
| Syn.<u>Alsidium subtile</u> Kutzing | | | | | | | | | |
| +C. mairei G. Feldmann.................................. | - | - | 1 | 1 | - | - | - | - | - |
| **Chylocladia** pelagosae Ercegovic.................. | - | - | 1 | - | - | - | 1 | - | 1 |
| **Corallina** elongata Ellis et Solander.............. | - | 1 | 5 | 3 | 2 | 5 | 5 | 2 | 2 |
| +C.granifera Ellis & Solander.......................... | - | 1 | 3 | - | - | 3 | 3 | - | - |
| Syn.<u>C.virgata</u> Zanardini | | | | | | | | | |
| +C.mediterranea Areschoug in J.Ag................ | - | 1 | 5 | 2 | 2 | 5 | 5 | 2 | - |
| *+**Crouania** attenuata (C.,Ag.) J.Ag. ................. | - | 1 | 1 | - | - | 1 | 1 | - | - |
| +**Dasya** arbuscula (Dillwyn) C.Agardh............. | - | - | 3 | - | - | 3 | 3 | - | - |
| Syn.<u>D.hutchinsiae</u> Harvey in Hooker | | | | | | | | | |
| D.ocellata (Grateloup) Harvey.......................... | - | - | 2 | 2 | - | 2 | 1 | - | - |
| +D.rigidula (Kutzing) Ardisson......................... | - | - | 2 | - | - | 2 | 1 | - | - |
| **Dermatolithon** littorale Sun............................ | - | - | 2 | 1 | - | 2 | 2 | - | - |
| D.pustulatum.(Lamoureux) Foslie .................. | - | - | 3 | - | - | 3 | 2 | - | - |
| Syn.<u>Melobesia pustullata</u> Lamoureux | | | | | | | | | |
| <u>Lithophyllum pustulatum</u> (Lam.) Foslie | | | | | | | | | |
| *+**Dudresnaya** verticillata (Wuth.) Le Jolis......... | - | - | 1 | - | - | - | 1 | - | - |
| +**Erythrocladia** subintegra Rosenvinge............ | - | - | 2 | - | - | 1 | 2 | - | - |
| Syn.<u>E.irregularis</u> Rosenvinge | | | | | | | | | |
| *+**Erythrotrichia** carnea ( Dillwyn) J.Agardh...... | - | - | 2 | 1 | - | 1 | 2 | 1 | - |
| Syn.<u>Erythrotrichia ceramicola</u>(Lyng.)Aresch. | | | | | | | | | |
| <u>Erythrotrichia investiens</u> (Zanard.)Born. | | | | | | | | | |
| E.reflexa ( Crouan) Thur................................ | - | - | 3 | - | - | 3 | 1 | - | - |
| *__Falkinbergia__ hildenbrandii (Born.) Falk ........... | - | - | 4 | - | - | 4 | 4 | - | - |
| (=Sporophyte of *Asparagopsis taxiformis*) | | | | | | | | | |
| *+**Fosliella** farinosa (Lamour.) Howe................. | - | - | 3 | - | - | 3 | 3 | - | - |
| Syn.<u>Melobesia farinosa</u> Lamoureux | | | | | | | | | |
| *+F.lejolisii (Rosanoff) Howe .......................... | - | - | 2 | - | - | 1 | 1 | - | - |
| **Furcellaria** fastigiata(Hudson) Lamoureux....... | - | - | 2 | 2 | - | 2 | 2 | - | - |
| *+**Galaxaura** oblongata.( Ellis et Sol.) Lamour.... | - | - | 3 | 2 | - | 3 | 3 | - | - |

**Table 2 (continued)**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Syn. *G.adriatica* Zanardini | | | | | | | | | |
| **Gelidiella** tenuissima.(Thur.) J.Feld &Hamel........... | - | - | 2 | - | - | 1 | 2 | - | - |
| +**Gelidium** crinale (Turner)Lamoureux.................. | - | 3 | 2 | 2 | - | 3 | 3 | 2 | - |
| +G.latifolium (Creville.) Bornet & Thuret........... | - | - | 2 | - | - | 2 | 2 | - | - |
| Syn.*G.latifolium* v.*histrix* J.Agardh | | | | | | | | | |
| G pectinatum (Schousb.)Mont. ......................... | - | - | 3 | - | - | 3 | 3 | 2 | - |
| Gelidium pulchellum (Turner ) Kutzing.............. | - | - | 1 | - | - | 1 | 1 | - | - |
| *+G.pusillum (Stackhouse.) Le Jolis...................... | - | 1 | 2 | - | - | 2 | 2 | - | - |
| *+G.spathulatum.( Kutz) Born.............................. | - | 1 | 1 | 1 | - | 1 | 1 | - | - |
| +**Gigartina** acicularis (Wulfen) Lamoureux......... | - | 1 | 3 | 1 | - | 1 | 1 | 1 | - |
| +Gigartina teedii (Roth) lamoureux................. | - | - | 1 | - | - | 1 | - | - | - |
| Syn.*Chondroclonium teedii* (Roth) Kutz. | | | | | | | | | |
| **Goniotrichum** alsidii (Zanard.) Howe................ | - | 1 | 2 | - | - | 2 | 1 | - | - |
| *+**Gracilaria** verrucosa. (Hudson) Papenfuss....... | - | 1 | 2 | 1 | - | 2 | 2 | 1 | - |
| Syn.*G.confervoides*(L.) Greville | | | | | | | | | |
| *Sphaerococcus confervoides* (L.) Kutz. | | | | | | | | | |
| *Gigantina confervoides* Lamoureux | | | | | | | | | |
| *+G.compressa. (Agardh) Greville..................... | - | - | 1 | - | - | 1 | 1 | 1 | 1 |
| Syn.*G.bursa-pastori*(Gmelin) Silva | | | | | | | | | |
| *+G.dura ( Agardh) J.Agardh............................. | - | - | 1 | - | - | 1 | - | - | - |
| Syn.*Spaerococcus durus* Agardh | | | | | | | | | |
| +**Gymnogongrus** griffithsiae ( Turn.) Martius...... | - | - | 3 | - | - | 3 | - | 1 | - |
| *+**Halymenia** floresia (Clem.)C.Ag..................... | - | - | 2 | 1 | - | 2 | 2 | - | - |
| Syn.*H.flor*.v.*macroplera* & v.tripinnata Kutz. | | | | | | | | | |
| *Rhodomela pinastroides* Agardh | | | | | | | | | |
| +H. latifolia Kuzing........................................... | - | - | 1 | - | - | 1 | 1 | - | - |
| +**Halopithys** incurvus ( Hudson) Batters.......... | - | 1 | 2 | - | - | 2 | 2 | - | - |
| Syn.*H.pinastroides* (Gmelin) Kutzing | | | | | | | | | |
| **Herposiphonia** secunda (C.Ag.) Ambronn....... | - | 1 | 3 | - | - | 2 | 3 | - | - |
| Syn.*Polysiphonia secunda* C.Agardh | | | | | | | | | |
| H.tenella (C.Agardh) Ambronn...................... | - | 1 | 2 | 1 | - | - | 2 | - | - |
| +**Hildenbrandia** prototypus Nardo................ | - | - | 3 | - | - | 3 | - | - | - |
| +**Herposiphonia** secunda(C.Ag.) Ambronn..... | - | - | 2 | - | - | - | 2 | 1 | - |
| Syn.*Polysiphonia secunda* C.Agardh | | | | | | | | | |
| *+H.tenella(Ag.) Nag........................................ | - | - | 2 | 2 | - | - | - | - | - |
| *+**Hypnea** hamulosa (Lam.) ............................ | - | - | 3 | 3 | 2 | - | 2 | 1 | - |
| Syn. *H.cornuta* | | | | | | | | | |
| *+H.musciformis (Wulf) Lamoureux.................. | - | 5 | 3 | 3 | 3 | 5 | 5 | 2 | 2 |
| H.cervicornis J. Agardh ................................ | - | 2 | 2 | 1 | - | - | 2 | 1 | - |
| *+**Jania** rubens(L.)Lamoureux.......................... | - | 5 | 5 | 5 | 3 | 5 | 5 | 5 | 5 |
| Syn.*Corallina rubens* Linnaeus | | | | | | | | | |
| *+**Laurencia** obtusa (Huds.) Lamour................. | - | 3 | 1 | - | - | 3 | 3 | 1 | 1 |
| +L.paniculata.(C.Ag.) J.Ag................................ | - | 3 | 1 | - | - | 3 | 3 | 3 | - |
| *+L.papillosa (Forsk.) Greville........................... | - | 5 | 1 | 3 | 2 | 5 | 5 | 4 | 4 |
| L.perforata. Mont............................................. | - | 1 | - | - | - | 1 | 1 | - | - |
| *+L.pinnatifida (Huds.) Lamoureux .................... | - | 2 | 1 | 1 | 1 | 2 | 2 | 1 | - |

**Table 2 (continued)**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Laurencia sp........................................................ | - | 1 | - | - | - | - | 1 | - | - |
| *+**Liagora** farinosa Lamoureux.......................... | - | - | 4 | 2 | 2 | 4 | 4 | 3 | - |
| +L.viscida ( Forsskal) C.Ag.. ............................ | - | - | 2 | - | - | 2 | 2 | - | - |
| Syn.<u>L.cladoniaeformis</u> Bory | | | | | | | | | |
| *+**Litholepis** mediterranea. Foslie ...................... | - | 2 | 1 | - | - | 2 | 2 | - | - |
| *+**Lithophyllum** incrustans. Hauck...................... | - | 3 | 2 | 2 | 1 | 3 | 3 | 2 | 2 |
| L.lenormandii (Aresch.) Fosl.......................... | - | 2 | 1 | 1 | - | 2 | 2 | 1 | - |
| *+**Lophocladia** lallemandii (Mont.) Schm........... | - | 1 | - | - | - | 1 | 1 | - | - |
| **Lophosiphonia** cristata Falk............................ | - | 1 | 1 | - | - | 1 | - | - | - |
| +L.obscura ( C.Ag.) Falk.................................. | - | 1 | 1 | - | - | 1 | - | - | - |
| +L.subadunca ( Kutz.) Falk.............................. | - | 1 | 1 | - | - | - | 1 | - | - |
| **Mesophyllum** lichenoides (Ellis) Lemoine...... | - | 1 | 1 | 1 | - | 1 | 1 | - | - |
| +**Nemalion** helminthoides ( Velley) Batters...... | - | 3 | 1 | 3 | 1 | 3 | 3 | 1 | 1 |
| Syn.<u>N.multifidum</u> (Web.& Mohr) J.Ag. | | | | | | | | | |
| <u>Alcyodinium nemalion</u> Bory | | | | | | | | | |
| +**Neogoniolithon** notarisii(Aresch.) Fosl............ | - | 4 | 1 | - | - | 4 | 4 | - | - |
| **Nitophyllum** punctatum ( Stackh.) Grev.......... | - | 2 | 2 | - | - | 2 | 2 | - | - |
| **Peyssonelia** inamoena. Pilger.......................... | - | 1 | 2 | 2 | - | 2 | 2 | - | - |
| *P.rubra (Grev.) J.Agardh................................ | - | 1 | 2 | 2 | - | 2 | 2 | 1 | - |
| *+P.squamaria ( Gmelin.) Decaisne .................... | - | - | 4 | 3 | 2 | 4 | 4 | 3 | 2 |
| Syn.<u>Padina squamaria</u> & P.<u>sanguinea</u> Bory | | | | | | | | | |
| **Polysiphonia** atra Zanard.................................. | - | - | 2 | - | - | 2 | 2 | 1 | - |
| P.breviarticulata (C.Ag.) Zanard......................... | - | - | 2 | - | - | 2 | 2 | - | - |
| +P.dichotoma Kutzing........................................ | - | - | 4 | 2 | 3 | 4 | 4 | 2 | - |
| +P.ferulacea (Suhr.) J.Ag.................................. | - | - | 3 | - | - | 2 | 3 | - | - |
| P.montagnei. Zanard........................................ | - | - | 1 | - | - | 1 | - | - | - |
| +P.opaca (C.Ag.).............................................. | - | - | 4 | 2 | - | 4 | 4 | - | - |
| P.parvula Suhr. ............................................. | - | - | 2 | 1 | - | - | 2 | - | - |
| +P.sertularioides. (Gratel.)J.Ag......................... | - | - | 1 | 1 | - | - | 1 | - | - |
| P.subtilissima Kutzing...................................... | - | 1 | 2 | 1 | - | 1 | 2 | - | - |
| +P.tenerrima. Kutzing....................................... | - | - | 2 | - | - | 1 | 2 | - | - |
| +Polysiphonia tripinnata. J.Ag.......................... | - | - | 2 | 1 | - | - | 2 | - | - |
| +**Porphyra** leucosticta Thur............................ | - | 2 | - | - | - | 2 | - | - | - |
| Syn.<u>P.atropurpurea</u> (Olivi) De Toni | | | | | | | | | |
| *+**Pseudolithophyllum** expansum.(Phil.) Lem..... | - | - | 2 | 1 | - | - | 2 | - | - |
| +**Pterocladia** capillacea (Gmel.)Born................ | - | 2 | 1 | 1 | - | 2 | 2 | - | - |
| Syn.<u>P.pinnata</u> (Hudson) Papenfuss | | | | | | | | | |
| <u>Celidium corneum</u>(Hud.)Lam.v.<u>pinnatum</u> | | | | | | | | | |
| **Ptilophora** mediterranea (H.Huve) Norri......... | - | 1 | 1 | 1 | - | - | - | - | - |
| *+**Rytiphlaea** tinctoria (Clem.) C.Ag................. | - | - | 3 | 2 | - | 2 | 3 | - | - |
| +**Spermothamnion** flabellatum. Born................ | - | - | 3 | 2 | - | - | 3 | 1 | - |
| *+**Spyridia** filamentosa (Wulf.) harvey................. | - | - | 4 | - | 1 | 3 | 4 | 2 | 1 |
| Syn.<u>S.cuspidata</u> Kutzing | | | | | | | | | |
| +**Taenioma** macrourum Born et Thur................ | - | 2 | 1 | - | - | 2 | 2 | - | 1 |
| **Tenaria** undulosa Bory...................................... | - | - | 1 | - | - | 1 | - | - | - |
| Syn.<u>T.tortuosa</u>(Esper) Lemoine | | | | | | | | | |

**Table 2 (continued)**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| <u>Lithophyllum tortuosum</u> f.<u>cristata</u> Foslie | | | | | | | | | |
| +**Vidalia** volubilis (L.)J.Ag.................................. | - | - | 1 | - | - | - | 1 | - | - |
| +**Wurdmannia** miniata (Drap) Feld.& Hamel.... | - | - | 1 | - | - | 1 | 1 | - | - |
| ***MONOCOTYLEDONEAE*** | | | | | | | | | |
| **Halophila** stipulacea.(Forsk.) Asch................... | - | - | 2 | 1 | - | 2 | 2 | 1 | - |
| **Cymodocea** nodosa ........................................... | - | 3 | 3 | 2 | - | 1 | 3 | 2 | 2 |
| **Zostera** noltii Hornem (= Z.nana).................. | - | 1 | 1 | 1 | 1 | - | 1 | 1 | 1 |

Symbols: 1 = 1-10% covering; 2 = 11- 30%, 3 = 31-60%, 4 = 61-80%, 5 > 81 %.
* = Species present in the Red Sea, + = Species mentioned on Syrian coast.
Sup = Supralittoral, Med= Mediolittoral, Inf=Infralittoral; Stations Nb. 1, 2, 3, 4, 5, 6

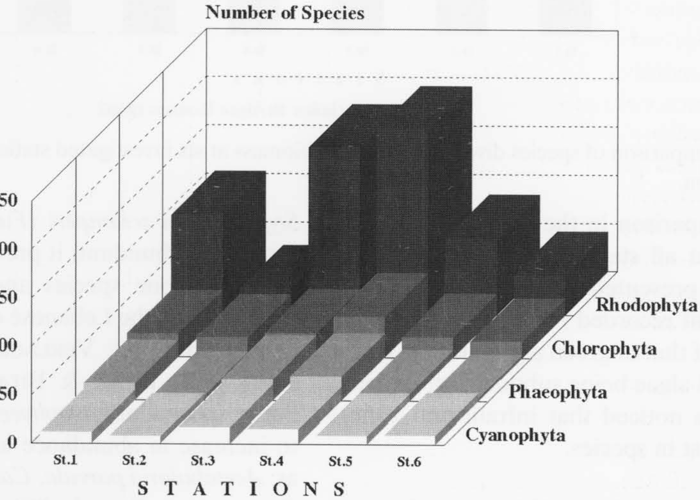


***Fig.4:*** Distribution of the four major macroalgae groups at six sampling sites on the coast of Lebanon during 1996-97.

Total nitrogen averaged 3.5 times greater than at control station. This sewage nutrient enrichment was accompanied by a marked reduction in biomass to only 23% of the control and a significant reduction in species richness to 26% of the control station 4. Taxonomix diversity (I=0.62) was the lowest of all stations. We noticed that the abundance of algae and the number of species are the highest at control station 4 and tend to decrease in either north or south direction along the most highly populated portion of the Lebanese coastline. It is clear that the algal community is strongly affected by pollution, those more close to sources of pollution are poor either in biomass or in diversity. The number of *Phaeophyta* species averaged 12% of the control station and 12 to 15% of the total species at other stations, except at station 2 where high concentrations of phosphate were observed. At this station, the number of *Phaeophyta* drops to only 5% (Fig.5). Furthermore, the reduction in percentage of *Phaeophyta* in response to higher phosphate levels appeared to be a general and significant phenomenon. Nutrient enrichment at stations 2 and 6 also seemed to lead to a decrease in the percentage of *Rhodophyta* and an increase in the *Chlorophyta species*. Also a reduction in total algal biomass and diversity are recorded in these polluted stations.

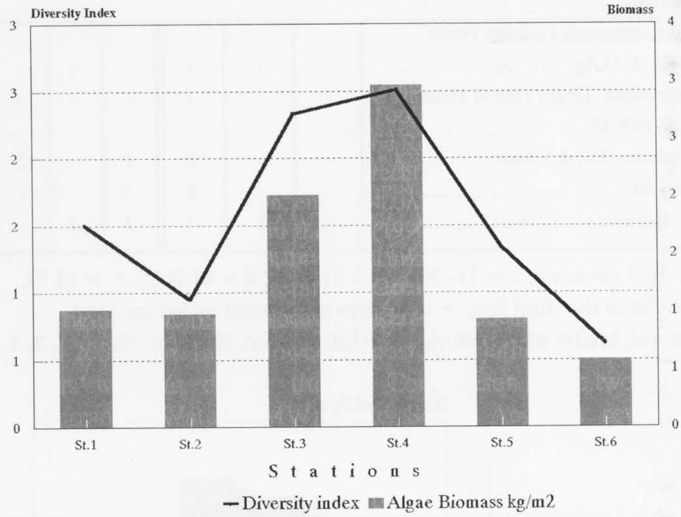


***Fig.5:*** Comparison of species diversity and alagal biomass at six investigated stations along the coast of Lebanon.

The comparison in the distribution of the species at all stations and at the different levels is presented in Figures 2, 3, 5. The number of recorded red algae is more than double of that of green algae and the majority of red algae being subtidal. On the other hand, we noticed that infralittoral zone is the richest in species.

## Introduced species and biogeography

### *Lessepsian migration*

Among the marine lessepsian species (which are about 100) mentioned in the Eastern Mediterranean, the algae are the most important (POR, 1978; LAKKIS, 1997). Seve-ral Indo-Pacific and Eritrean species were introduced from the Red Sea through the Suez Canal to the Levantine Basin where they established permanent populations. Some of them prevailed over other species and occupied large spaces. Among the introduced red algae species we mention: *Acanthophora delilei, Asparagopsis taxiformis, Hypnea hamulosa, H.cornuta, Liagora farinosa, Lophocladia lallemandii.* During the last decade, the invading species *Stypopodium schimperi (Fucophyceaea)* became very abundant; it prevailed over several autochtone species and became widespread along the Lebanese coast (MAYHOUB & BILLARD, 1991; VERLAQIE & BOUDOURESQUE, 1991; BITAR & BITARKOULI, 1995a). Some species of *Ulvophyceae* often appear to increase in abundance and number such as: *Acetabularia parvula, Caulerpa mexicana, C. racemosa, C. scalpelliformis.* The phanerogam Halophila stipulacea is also one of the introduced species confined only to the Eastern Mediterranean (VERLAQUE, 1994; LAKKIS *et al.*, 1996). Some of these lessepsian tropical species start to invade other Mediterranean regions. For instance, *C. racemosa* appeared recently in the Gulf of Saronikos (PANAYOTIDIS & MONTESANTO, 1999) and on the coast of Sicily (DI MARTINO, 1999). It reached the Thyrrenian Sea at Livorno (PIAZZI *et al.*, 1999) and Ligurian Sea where it was recorded in the Gulf of Genoa (MATRICARDI & PIATTI, 1999). This fast spread of *C. racemosa* in the Western Mediterranean seems to be a natural phenomenon. However anthropogenic activities may be responsible for this spread of the introduced species some of which happened

*C. taxifolia*. The species *Caulerpa taxifolia*, is an introduced species; it was not observed in the western Mediterranean before 1984 when it was accidentally recorded in the Ligurian sea (MEINESZ & HESSE, 1991).

*Biogeography*

Comparing the distribution of species present in the Eastern Mediterranean and with those in adjacent seas, we notice that 60% of the species present on the Lebanese coast are mentioned on Syrian coast (MAYHOUB, 1976) and 33% are common with the Red Sea (ALEEM, 1948; RAYSS, 1954. The majority of the later are Indo-Pacific species introduced in the East Mediterranean through the Suez Canal (Table 3).

The algal populations characterizing the Levantine coast, including the Lebanon, may be divided into six biogeographical groups:

-Mediterranean Group type: *Corallina elongata Cystoseira* spp.

-Tropical and Temperate Atlanto-Mediterranean type: Cladophora prolifera, Amphiroa rigida, Dasycladus vermicularis, Anadyomene stellata.

-Circumtropical Group: *Hypnea musciformis, H. hamulosa, H. cervicornis, Gelidium crinale, Gigartina acicularis, Bryosis plumosa, Asparagopsis taxiformis.*

Warm Boreal: *Porphyra leucosticta, Callithamnion corymbosum, Taonia atomaria.*

Circumboreal: *Enteromorpha intestinalis, E. clathrata, Ulva rigida.*

Indo-Pacific group: *Liagora farinosa, Acetabularia parvula, Stypopodium schimperi, Asparagopsis taxiformis, Caulerpa racemosa, C. mexicana, C. scalpelliformis*

Geographic conditions of the Levantine basin provide special biogeographical and ecological characteristics to the marine flora. If the influence of Atlantic water does not appear to be strong in this area, on the contrary the effect of the Suez Canal is very important on the biogeographical distribution and biodiversity of the marine plants. Furthermore, the influence of the Nile on the entire hydrology of the Levantine Basin is very important. Previous to the Aswan High Dam 1965, the huge amount of fresh water outflowing during the flood of the Nile reduced the surface salinity in the Levantine coasts down to 37‰. After the damming of the Nile, this flood disappeared and some changes occurred on the hydrology of the area. A slight, but continuous increase of the salinity is recorded, the salinity now registers the highest values of the entire Mediterranean (39.75‰). As consequences to these hydrological conditions, certain ecological changes in the marine environment appeared, particularely on the benthic communities affecting the biodiversity, the composition and the biological cycles of many species.

**Table 3**
**Common species between Lebanese coast, Syrian coast and Red Sea**

| Taxa | Lebanon | Syria | Red Sea |
|---|---|---|---|
| *Cyanophyceaea* | 25 | 13 | 3 |
| *Chlorophyceaea* | 59 | 29 | 18 |
| *Rhodophyceaea* | 126 | 77 | 34 |
| *Pheophyceaea* | 29 | 22 | 24 |

The major introduced Indo-Pacific and/or Eritrean species into the Mediterranean are:

***Ulvophyceae***: *Acetabularia parvula, A. moebii, Caulerpa racemosa, C. scalpelliformis, Derbesia boergesenii*

***Fucophyceaea***: *Stypopodium shimperi*

***Rhodophyceaea***: *Acanthophora delilei, Aspa-ragopsis taxiformi, Hypnea hamulosa, Liagora farinosa, Lophocladia lallemandii*

***Phanerogams***: *Halophila stipulacea*

## Conclusions

The results indicate that the algal communities of the Lebanese coast are characteristics of the Levantine Basin marine flora;

found also on the Syrian, Palestinian and Egyptian Mediterranean coasts. The theory of bathymetric distribution of benthic communities elaborated by MOLINIER (1960) and PERES (1967) and adopted by most of marine ecologists (BOUDOURESQUE & FRESI, 1976), can not be applied without changes to the Eastern Mediterranean ecosystems, because of the different ecological conditions from those prevailing in the Western Mediterranean. Biological and ecological concepts, should be taken in consideration to classify benthic communities according to the littoral levels. The results of our study permited to define assemblages that characterize the supra, medio and infralittoral levels on the Lebanese coastline. This classification is similar to that used by ecologists in the western Mediterranean, with, however, certain differences in the species composition and abundance.

Different types of pollution produce significant changes in community structure of benthic macroalgae along the coast of Lebanon. There are big changes in taxonomic diversity, biomass and species composition between the different sites.The greatest concentration of urban pollution from Beirut affects probably the north side of the city and in Jounieh Bay which acts as an epicenter from which pollutants spread northward by the northern direction current. These results agree with BASSON *et al.* (1976) who found a negative correlation between the species diversity of macroalgae and proximity to pollution sources (sewage). The reduction in the number of *Phaeophyta* appears as the result of the effect of pollution. At station No 5, the reduction of brown algae species is due to thermic pollution and at station 6 due to the sewage nutrient enrichment. The effects of power plants on algal communities may result not only from heated water but also from chlorine or other toxic chemical substances added to the cooling water (HAMILTON *et al.*, 1970).

Phosphates appears to be the important nutrient pollutant affecting the macroalgal community; nitrates is of less importance. Relatively high concentrations of $NO_3$ and $PO_4$ at station 6 (sewage) have significant effects on reducing taxonomic diversity; whereas a comparable level of $NO_3$ at station 1,with only low $PO_4$, upon diversity. At station 2, the highest phosphate concentration and low nitrates create a very low diversity (0.83), less than 34% of control station 4. At the same station 2 where $PO_4$ is the highest, brown algae represent only 20% of the control station 4. These results confirm the findings of BASSON *et al.* (1976) who also found that brown algae and secondarely red algae were sensitive and cannot survive in polluted areas, whereas the *Chlorophyta*, particularely of the genera *Enteromorpha* and *Ulva,* thrived in sewage polluted waters. A high dominance of these green algae seems to be a reliable indicator of pollution. On rocky platforms surrounding major sewage oufalls around Beirut, practically the entire biomass is formed by *Enteromorpha* spp. and *Ulva* spp. RUENESS (1973) noted the disappearance of the brown alga Ascophyllum nodosum from the inner Oslofjord of Norway in response to increased sewage pollution.

The marine flora of the Lebanese coast need to be more explored. Further studies are under consideration in the near future.

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