PHYTOPLANKTON ASSEMBLAGE CHARACTERIZATION ALONG THE MEDITERRANEAN COAST OF MOROCCO DURING AUTUMN

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Abstract – The present study aimed to assess the composition, abundance and diversity of phytoplankton assemblage along the Moroccan Mediterranean coast. Phytoplankton samples were collected in October 2018 at 48 stations from M'diq bay in the West to Saïdia in the East, using Niskin bottles in the surface. Its identification and enumeration were carried out using the Utermöhl method. 92 taxa have been inventoried along the study area belonging to five groups. Diatoms dominate qualitatively and quantitatively (85.5 %) the total microalgal population during this period. It is mainly represented by Leptocylindrus danicus, Pseudo-nitzschia spp. and Chaetoceros spp., followed by dinoflagellates (12 %) where Gymnodinium spp., Katodinium spp., Diplopsalis spp. and Amphisolenia spp. were the most abundant species. The other groups (euglenophyceae, raphidophyceae and coccolithophorideae) were poorly represented.

The phytoplankton abundance varied from 8×10^2 cells L^{-1} to 598×10^2 cells L^{-1}. Shannon and evenness indices showed respectively (broadly H>3 bits and J> 0.8). High values of phytoplankton abundance and diversity were located in the western part of Moroccan Mediterranean Sea, especially (from Jebha to M'diq) because of the influence of the Atlantic flow.

Introduction

In the Mediterranean coast of Morocco, fishing is considered as one of the main social and economical activities mainly small pelagic species in terms of biomass and commercial interest [1-2]. However, anthropogenic disturbances increased by human activities and warming waters caused by climate change are having a major impact on the biological components and has obviously an impact on fisheries resources occurring in a very complex and vulnerable ecosystem [3-4-5-6]. The latter is limited by the strait of Gibraltar where the Atlantic Jet enters and feeds two anticyclonic Alboran gyres (Est-West) [7], giving specific properties [8]. These properties make indeed changes on phytoplankton composition.

Because it is considered as a basic component, changes on its composition could be influenced by their surrounding environment [9] and affected directly the energy source and ecological stability for zooplankton, ichthyoplankton and the other links of the food web [10-11].

Until now, phytoplankton studies in this ecosystem still scarce [12-13]. The present investigation will allow to acquire a scientific knowledge (composition, abundance and

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diversity) of this first link of the marine food web, which have a major impact on biodiversity and local fisheries resources as well as on the world climate through its contribution to ocean carbon sequestration [14].

Materials and methods

An oceanographic survey was conducted in October 2018 along the Mediterranean coast of Morocco and a total of 48 stations were sampled in surface (Figure 1). These were located from Saïdia to M'diq. Phytoplankton was made from 100 ml of sea water collected with Niskin bottles and fixed using lugol. The identification and enumeration of phytoplankton was performed according to Utermöhl method [15] under a Nikon inverted microscopy. The phytoplankton densities were expressed in cells L^{-1}.

The occurrence (F) was calculated [16], to classify the identified species into three groups: i-) constant species ($F \geq 50\%$); ii-) accessory species ($25\ \% \leq F < 50\ \%$) and iii-) incidental species ($F < 25\ \%$).

For ecological indices, the species richness (Rs) is the number of species present in each station, the species diversity was investigated according to Shannon (H) and Pielou (J) [17-18]. The Community dominance index (CDI) [19] was estimated to determine the percentage of abundance contributed to a community by two most abundant species. H ranges from 0 to infinity. J ranges from near 0 (which indicates low evenness or high single-species

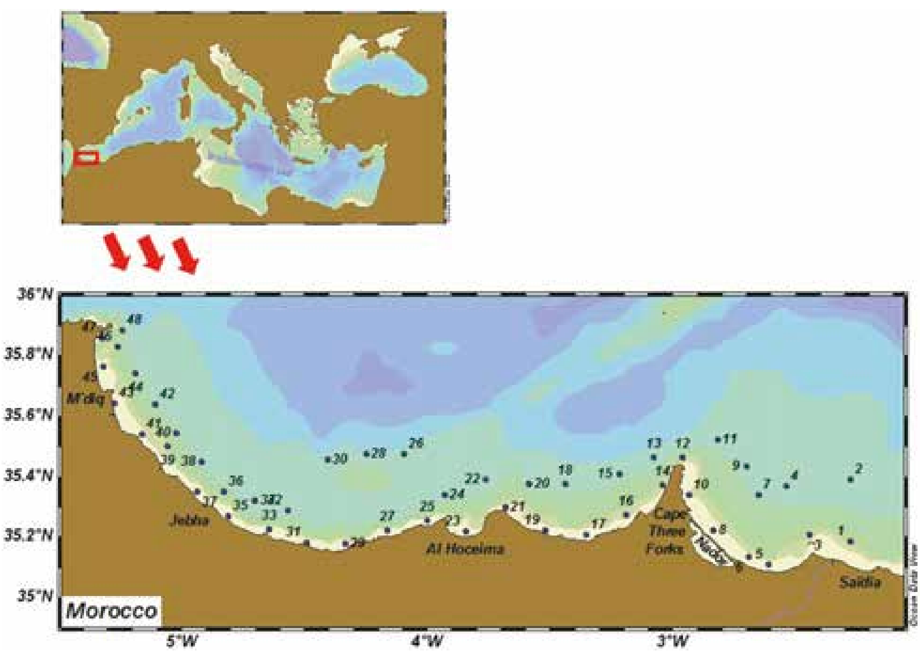

Figure 1 - The investigated areas with sampling sites located in the Moroccan Mediterranean coast.

dominance), to 1 (which indicates equal abundance of all species or maximum evenness). CDI values range between 0 and 100.

For statistical analyses, MDS (Multi Dimensional Scaling) analyses were performed to evaluate association between stations, based on the total phytoplankton abundance using PRIMER (version. V) Software, with a Bray-Curtis similarity index [20].

Results

In October 2018, the phytoplankton in the study area is composed of 92 taxa, belonging to five groups (Table I). Diatoms represented by 42 species, dinoflagellates (46 species) and 1 species for each other group (euglenophyceae, raphidophyceae, silicoflagellates and coccolithophorideae).

Table 1 - The list of phytoplankton species along the Moroccan Mediterranean coast during October 2018.

Group	Genera	Species
Diatoms	Achnanthes	*Achnanthes* spp.
	Actinocyclus	*Actinocyclus octonarius*
	Amphora	*Amphora* spp.
	Asterolampra	*Asterolampra* spp.
	Asterionellopsis	*Asterionellopsis glacialis*
	Baccillaria	*Baccillaria* spp.
	Bacteriastrum	*Bacteriastrum* spp.
	Chaetoceros	*Chaetoceros* spp.
	Cocconeis	*Cocconeis* spp.
	Corethron	*Corethron* spp.
	Cylindrotheca	*Cylindrotheca closterium*
	Cymatopleura	*Cymatopleura* spp.
	Dactyliosolen	*Dactyliosolen fragilissimus*
	Diploneis	*Diploneis* spp.
	Eucampia	*Eucampia* spp.
	Fragilaria	*Fragilaria* spp.
	Hemiaulus	*Hemiaulus* spp.
	Guinardia	*Guinardia delicatula* *Guinardia flaccida* *Guinardia phuketensis* *Guinardia striata*
	Lauderia	*Lauderia annulata*
	Leptocylindrus	*Leptocylindrus danicus* *Leptocylindrus minimus*
	Licmophora	*Licmophora* spp.
	Melosira	*Melosira* spp.
	Meuniera	*Meuniera* spp.
	Navicula	*Navicula* spp.
	Nitzschia	*Nitzschia* spp.
		Nitzschia longissima
	Paralia	*Paralia* spp.
	Planktoniella	*Planktoniella* spp.

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	Proboscia	*Proboscia alata*
	Pseudo-nitzschia	*Pseudo-nitzschia* spp.
	Rhizosolenia	*Rhizosolenia bergoni* *Rhizosolenia setigera*
	Tabellaria	*Tabellaria* spp.
	Thalassionema	*Thalassionema nitzschoides*
	Thalassiosira	*Thalassiosira* spp.
	Synedra	*Synedra* spp.
Dinoflagellates	Actiniscus	*Actiniscus pentasterias*
	Alexandrium	*Alexandrium* spp. *Alexandrium tamarense*
	Amphidinium	*Amphidinium* spp.
	Amphisolenia	*Amphisolenia* spp.
	Cochlodinium	*Cochlodinium* spp.
	Dinophysis	*Dinophysis caudata* *Dinophysis acuminata*
	Phalacroma	*Phalacroma rotundatum*
	Diplopsalis	*Diplopsalis* spp.
	Fibrocapsa	*Fibrocapsa japonica*
	Gonyaulax	*Gonyaulax* spp.
	Gymnodinium	*Gymnodinium catenatum* *Gymnodinium sanguineum*
	Gyrodinium	*Gyrodinium fusus* *Gyrodinium spirale*
	Heterocapsa	*Heterocapsa* spp.
	Karenia	*Karenia* spp.
	karlodinium	*Karlodinium veneficum*
	Katodinium	*Katodinium* spp.
	Metaphalacroma	*Metaphalacroma* spp.
	Noctulica	*Noctulica* spp. *Noctulica scintillans*
	Ostreopsis	*Ostreopsis* spp.
	Oxyphysis	*Oxyphysis* spp.
	Oxytoxum	*Oxytoxum* spp.
	Pronoctulica	*Pronoctulica* spp.
	Prorocentrum	*Prorocentrum balticum* *Prorocentrum gracile* *Prorocentrum lima* *Prorocentrum micans* *Prorocentrum minimum* *Prorocentrum rostratum*
	Protoperidinium	*Protoperidinium depressum* *Protoperidinium diabolus* *Protoperidinium quinquecorne* *Protoperidinium steinii*
	Pyrophacus	*Pyrophacus* spp.
	Scrippsiella	*Scrippsiella* spp.
	Torodinium	*Torodinium* spp.
	Tripos	*Tripos candelabrum* *Tripos furca* *Tripos fusus* *Tripos muelleri*
Euglenophyceae	Eutreptiella Euglena	*Eutreptiella* spp. *Euglena* spp.
Coccolithophorideae	Coccolithus	*Coccolithus* spp.
Raphidophyceae	Chattonella	*Chattonella* spp.

The species Occurrence showed that 4 taxa among the 92 identified were constant in the area (F≥50 %). These include *Nitzschia* spp., *Tabellaria* spp., *Pseudo-nitzschia* spp. and *Cylindrotheca closterium.* 15 species were accessory (25≤F<50) such as *Gymnodinium* spp., *Leptocylindrus minimus*, *Katodinium* spp., *Chaetoceros* spp., *Scrippsiella* spp., *Amphisolenia* spp., *Heterocapsa* spp., *Euglena* spp.. The rest of the taxa were accidental (F<25 %).

Diatoms dominate qualitatively and quantitatively (85.5 %) the microalgal Mediterranean population during this period. It is mainly represented by *Leptocylindrus danicus*, *Pseudonitzschia* spp. and *Chaetoceros* spp., followed by dinoflagellates (12 %) where *Gymnodinium* spp., *Katodinium* spp., *Diplopsalis* spp. and *Amphisolenia* spp. were the most abundant species. The other groups (euglenophyceae, raphidophyceae and coccolithophorideae) were poorly represented.

Total densities of phytoplankton varied from 8×10² cells L^{-1} to 598×10² cells L^{-1}. The high values were founded in the Western Mediterranean coast of Morocco, especially (between Jebha and M'diq) (Figure 2).

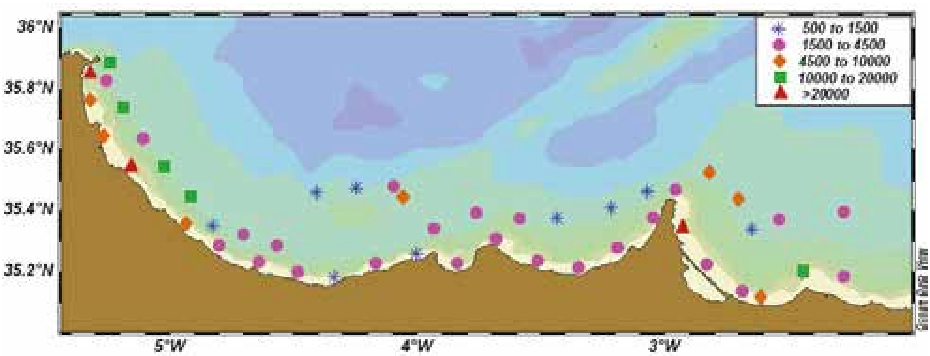

Figure 2 - Distribution of phytoplankton density in sampled stations (cells L^{-1}) collected during October 2018 along Moroccan Mediterranean coast.

Ecological indices (Figure 3) based on species richness and diversity were used to describe community structure and change. Species richness was generally (>15 taxa) with high values (27 species) recorded in the west region (particularly between Jebha and M'Diq) (Figure 3A). The diversity indices (Shannon index (H) and Evenness index (J)), showed a high diversity along the studied ecosystem (generally: H > 3 bits and J > 0.8) (Figure 3B and C). A maximum of H and J were respectively 4bits and 0.98 located from Hoceima to M'diq Bay. Stations where less diversity reveals high values of community dominance index (CDI), proving the dominance of some taxa to the detriment of others (Figure 3C).

Based on the distribution of total microalgal abundance, the MDS analysis plot (Figure 4) showed two groups of stations corresponded to two geographical areas. Group I included 33 stations located generally in the Western area (Three Forks cape – M'diq), characterized by high to medium densities. Group II included 15 stations, corresponding to the Eastern area (Saïdia-Three Forks cape), characterized by low population.

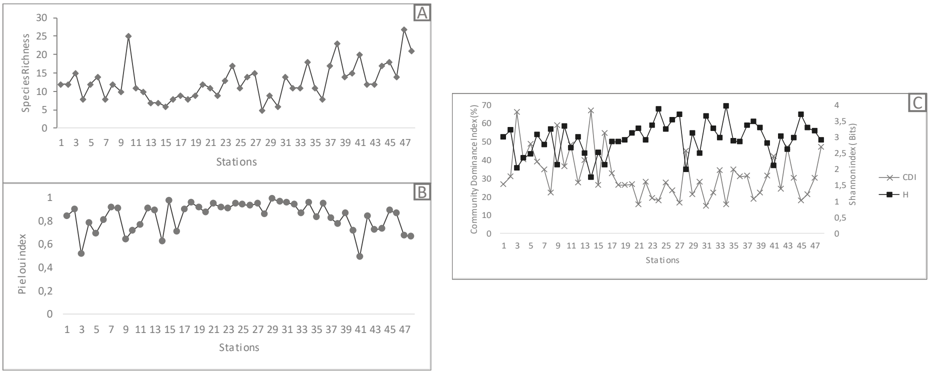

Figure 3 - Comparing ecological indices (A: Species richness, B: Pielou and C: Shannon - Community Dominance Index) in sampling stations (St1-48: Saïdia- M'diq).

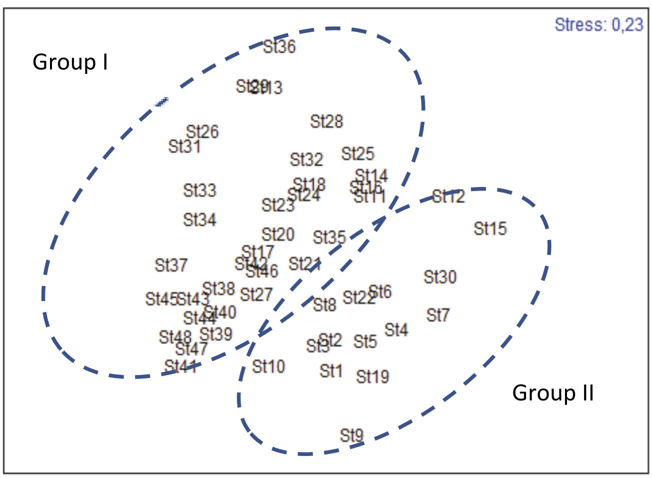

Figure 4 - Stations grouping obtained by performing a MDS analysis based on total phytoplankton abundance.

Discussion

The Mediterranean coast of Morocco is more productive because of water exchange between Atlantic and Mediterranean through strait of Gibraltar [21].

The inflow of Atlantic Jet (AJ) may explain this productivity [7] which is in accordance with the fact that the highest phytoplankton abundance was mostly recorded at coastal and neritic stations (Figure 2), especially in the West region (between Jebha and M'diq).

According to the autumn season, 92 species of microphytoplankton were identified along the Mediterranean coast of Morocco with the dominance of diatoms followed by dinoflagellates. This finding is in agreement with previous studies in the Mediterranean [22-23-24] and Atlantic ecosystem [25-26-27-28]. Reference [29] reported that this statement of diatoms was maintained in turbulent water masses whereas dinoflagellates need relatively well stratified waters for their optimal growth. *Leptocylindrus danicus*, *Pseudo-nitzschia* spp., *Chaetoceros* spp., *Tabellaria* spp., *Leptocylindrus minimus, Nitzschia* spp., *Cylindrotheca closterium*, *Guinardia striata, Gymnodinium* spp., *Katodinium* spp., *Diplopsalis* spp. and *Amphisolenia* spp. were the most abundant phytoplankton species. It is considered that *Leptocylindrus danicus*, *Chaetoceros* spp., *Leptocylindrus minimus*, *Guinardia striata* and *Katodinium* spp. were endemic to the Atlantic Ocean [28] while the other species were widespread except *Amphisolenia* spp. found particularly in the western area. This latter proliferates mainly in tropical waters [30]. Its abundance could be explained by the increase in temperature during this season. Shannon index determines not only diversity but also pollution status of water body [31]. This index ranges 1.74-3.97 bits, it is clear that the studied area shows moderate pollution level and the higher values indicated greater species diversity that proves these smallest differences in abundance between communities.

The ecological indices highlighted that the spatial distribution of phytoplankton community is clearly visible, diversified and equitable mainly in the west region (from Cape Three Forks to M'diq). In the Moroccan Mediterranean Sea, phytoplankton diversity and abundance were very pronounced in the western part because of the influence of the Atlantic flow. A confrontation of the hydrological variables will be established in order to identify the impact of environmental factors determining the phytoplankton variability in the study area and subsequently the biological resource.

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