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RESEARCH ARTICLE

The structure of phytoplankton communities off Cape Juby (28°N) in the Canary Current System (Northwest Africa)

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Abstract

Phytoplankton community in the upwelling area of cape Juby was studied in two years 2009 and 2010. Diversity, abundance and taxonomic composition were characterized at 5 stations for each period. A total of 107 species have been recorded. Diatoms constituted the majority group represented by a total of 54 taxa, followed by dinoflagellates with 45 taxa, and 8 taxa belonging to other groups. The highest phytoplankton densities were recorded in February and June 2009, and the lowest at august 2010. The maximum number of species (87) was recorded during February 2009 while the minimum (22) was noted during August 2010. Shannon diversity index (H') values varied in a range of 1,48 and 3,35 bits, generally in parallel with the species number (SR) and the eveness (J) variations. 34 taxa dominated the phytoplankton community but only 5 species were dominant commonly during the seven sampled periods. An overall high similarity on the species number (Sorensen Index q, Hierarchical clustering and NMDS analysis) was observed between the coast and the open ocean during all the sampling periods.

INTRODUCTION

The combined effect of the wind stress and the rotation of the earth produce a net offshore transport of water in the upper layer of the ocean that must be replaced by a vertical motion of colder subsurface water near the coast – upwelling (Smith, 1968). Upwelling has a key role in the nutrients enrichment of the upper layers supporting oceans productivity (Barton et al., 2013)
The Moroccan Atlantic coast extending over 3000 km between latitudes 36°N (Cape Spartel) and 21°N (Cape Blanc) is characterized by the presence of several resurgences sites of cold deep waters to the surface (upwelling). This feature combined with a strategic location in relation to the Canary Current gives the Moroccan Atlantic coast the advantage of being one of the richest coasts in exploitable biological resources (Makaoui et al., 2005).
However, through the Canary current system, the regional variability in plankton community is almost unknown, with a few well-documented local exceptions (Aristegui et al., 2009)
The area of Cape Juby, have been identified by Marcello and al., 2011 as one of the three main upwelling zones of Moroccan Atlantic coast with a marked upwelling seasonality (Salah et al., 2012).
Several authors have been interested in studying the transport of organic matter, zooplankton or fish community structure in front of cape Juby through a filament that would be in a close interaction with the generated currents

near the Canary Islands (Salah et al., 2013, Pelegri et al., 2005; Garcia-Munoz et al., 2004; Rodriguez et al., 2004). But few studies have affected the phytoplankton population's structure and their taxonomic composition in the upwelling area of cape Juby.
The structure of phytoplankton communities is thought to influence total productivity, food webs and the export of carbon below the mixed layers (Crispin et al., 2013). It is indeed relevant to study phytoplankton community structure in order to understand the functioning of an ecosystem.
In view of the scarcity of reports from cape Juby concerning phytoplankton communities structure and species composition, our study aims to i) investigate the structure (diversity, dominant species) and composition (Taxonomy, richness and species abundances) of phytoplankton communities, and ii) assess the seasonal spatial variability of their species distribution in this upwelling area (species transfer and dispersion).

Material and methods

Study site

Sampling concerned the Cap Juby zone (28 ° N) and the upwelling filament associated. Seven cruises were conducted on board the R/V Amir Moulay Abdellah (AMA). During the seven cruises, a 5 stations transect, east-west oriented was sampled (Fig 1). Hydrographic Samples were collected using a CTD Sea Bird SBE 9-11. Seawater samples were collected with Niskin Bottles for the analyses of phytoplankton species. Phytoplankton samples were immediately preserved with an acid Lugols solution (2% final concentration), according to the Utermöhl method. For the taxonomic identification, the following guides were used: Tomas C.R., 1996; 1957; Ricard M., 1987; Drebes G., Elbrachter M., 1976.
The cruises were conducted in two years 2009 and 2010 (Tab 1) to assess the seasonal variability of different parameters.

Structural and Statistical analysis

Different indexes, quantitative and qualitative, were used to describe phytoplankton seasonal composition, abundance and structure (Diversity and Distribution):

- Species richness (SR) is the total species number in each sample
- Shannon-Weaver Index (H) reflects the species diversity (bits/individual) that composes the phytoplankton community. It establishes the link between the number of species and number of individuals of the same ecosystem or a community. (Shannon and Weaver, 1948)
- Pielou's Index (J) (Pielou, 1975), measures the eveness (or equidistribution) of species in the community compared to a theoretical distribution that is equal for all species. It measures how close in numbers each species in an environment are.
- Dominance Index (Y) calculated for each species *(Zhao & Zhou, 1984),* using a threshold value $Y \geq 0{,}02$ the dominant species and thus the rare ones *(Chen et al., 1994 ; Xu & Li, 2005 ; Guo et al., 2011).*
- Sorensen Similarity index (q) *(Dajoz, 1985)* was used to appreciate the similarity of species composition between the coastal stations (Maximal Depth < 100m) and Oceanic stations (Maximal Depth > 100m).

A hierarchical classification method and an ordination method (Non-Metric Multidimensional Scaling [NMDS]) were used to analyze similarities among sampling sites in terms of species number and also to assess affinities among different species groups. This method aggregates the variables according to 'Bray Curtis' Similarity coefficient (Bray and Curtis, 1957). The principle of this method is to give the same weight to all objects in the calculation of the association.
The NMDS, developed by Shepard (1962), then by Kruskal (1964), is highly recommended in ecology (Field et al., 1982; Hosie et al., 1994) This analyze is an ordination method that minimizes coefficient stress which vary between 0 and 1, the value 1 indicate a perfect illustration.
The two analyses were performed using the software PRIMER 5 (Plymouth Routines In Multivariate Ecological Research 5).

Results

Phytoplankton community composition

A total of 107 species have been recorded. Diatoms constitute the majority group represented by a total of 54 taxa, followed by dinoflagellates with 46 taxa, Silicoflagellates, coccolithophorids and raphidophyte are poorly represented with a total of 7 taxa (Tab 3).

Diatoms represented the majority group in all seasons, with a percentage up to 97% in February 2009. Diatoms densities reaches its maximum during February (8657.10² Cell.L^{-1}), April (3686.10² Cell.L^{-1}) and June (4001.10² Cell.L^{-1}) 2009. The lowest densities were recorded in August 2010 (552. 10² Cell.L^{-1}) and June 2010. Dinoflagellates, represented in February (230.10² Cell.L^{-1}) and April (122.10² Cell.L^{-1}), less than 5% of the phytoplankton population, while in June, their contribution to the community rises to 53% with 1145.10² Cell.L^{-1} and 1061.10² Cell.L^{-1} respectively during June 2009 and June 2010 (Fig 2A).

A remarkable opposite variability was noted in the spatial variability between the two phytoplankton groups (Diatoms and Dinoflagellates). In fact, when diatoms density increases for instance in station 2 (1725.10² Cell.L^{-1}) during October 2009, dinoflagellates density decreases at same station (35.10² Cell.L^{-1}) then it increases in station 3 (155.10² Cell.L^{-1}) while diatoms became rare (90.10² Cell.L^{-1}). Une nette diminution des densités est observée pour les deux groupes à la station 5 (Fig 2A).

Phytoplankton density

The highest densities were recorded in February and June 2009, and the lowest at august 2010.

Phytoplankton mean abundance was higher at station 3 (3292.10² Cell.L^{-1}) during February 2009 and lower at the same station (40.10² Cell.L^{-1}) during August 2010. A well marked variation was observed in station 3 during all sampling periods, with a density decrease at this station during October 2009, April, June and August 2010. While a marked peak can be observed during February, April and June 2009 at same station. In fact, at station 3 which can be considered as an intermediate station, remarkable and sudden variations were observed during all the periods. An overall density decrease can be observed in station 5 during all the periods. (Fig 2A)

Structure variation: Species richness and diversity

The maximum number of species (87) was recorded in stations 4 and 5 during February 2009 while the minimum was noted is station 3 (22) during August 2010.

Shannon diversity index (H') values varied in a range of 1,48 and 3,35 bits generally in parallel with the species number (SR) and the eveness (J). The highest diversity (3,35 bits) was noted in station 1 during April 2010 and the minimum diversity (1,48 bits) in June 2010 at same station. The Eveness (J) variations follow the same pattern (Fig 2B).

Dominant species

Dominance index calculated for all the taxa encountered during all the sampling periods at different bathymetric levels from the surface up to 150 m, revealed a dominance of 34 taxa, including five species that were dominant commonly during the seven sampled periods: *Thalassiosira spp (Y=0,72), Leptocylindrus danicus (Y=0,17), leptocylindrus minimus (Y=0,23), Nitzshia spp (Y=0,38) and Alexandrium sp (0,70) (Tab 2).*

Similarity Sorensen index

A remarkable similarity is observed between coastal stations and oceanic stations during all the sampling periods especially in February, June and October 2009 (q >70%). Less similarity [64%-67%] can be reported in other periods between coastal and oceanic stations reflecting average species dispersion from coast to the open ocean (Tab 4)

Statistical analysis

The study of similarity shows the existence of 3 groups of species. Cluster 2 includes species generally neritic, found at coastal stations, with medium to high densities, taxa of this group dominate the phytoplankton population during all or many periods of our study (according to the dominance index results). Cluster 3, includes rare species occurring during a season or two at low densities. Cluster 1 is constituted by species with medium densities but abundant in a particular season (Fig 3A).

The non-metric multidimensional scaling (NMDS) clearly highlights 3 separate stations groups. A first group A1, bringing together the stations of February 2009 and both April 2009, 2010. A second group A2 grouping stations of October and June 2009. Finally, a third group A3 collecting stations of June and August 2010 (Fig 3B).

Figure-1: ***(a) Diagram showing the Cap Juby filament associated with Cap Boujdor filament interacting with cyclonic and Anticyclonic eddies (Barton et al., 2004), (b) 5 sampled stations radial***

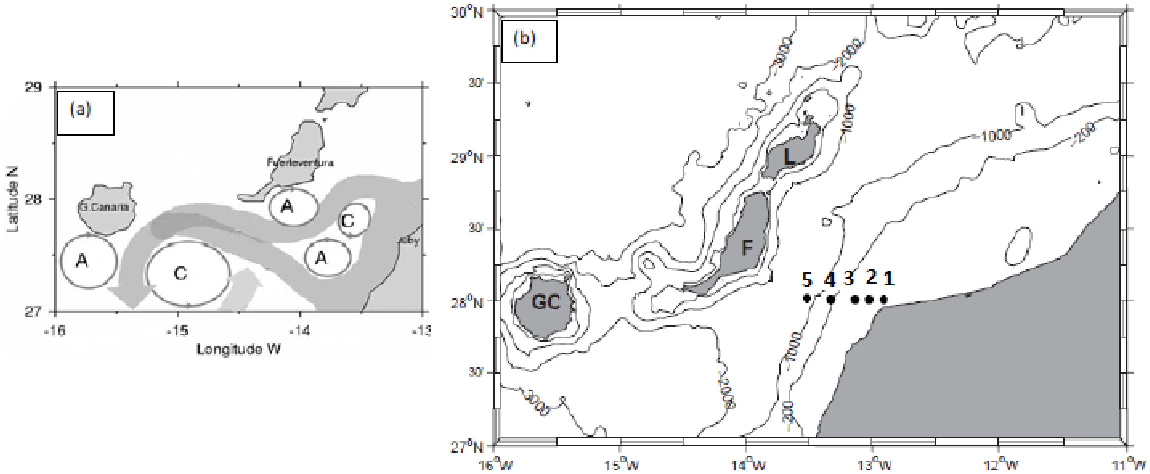


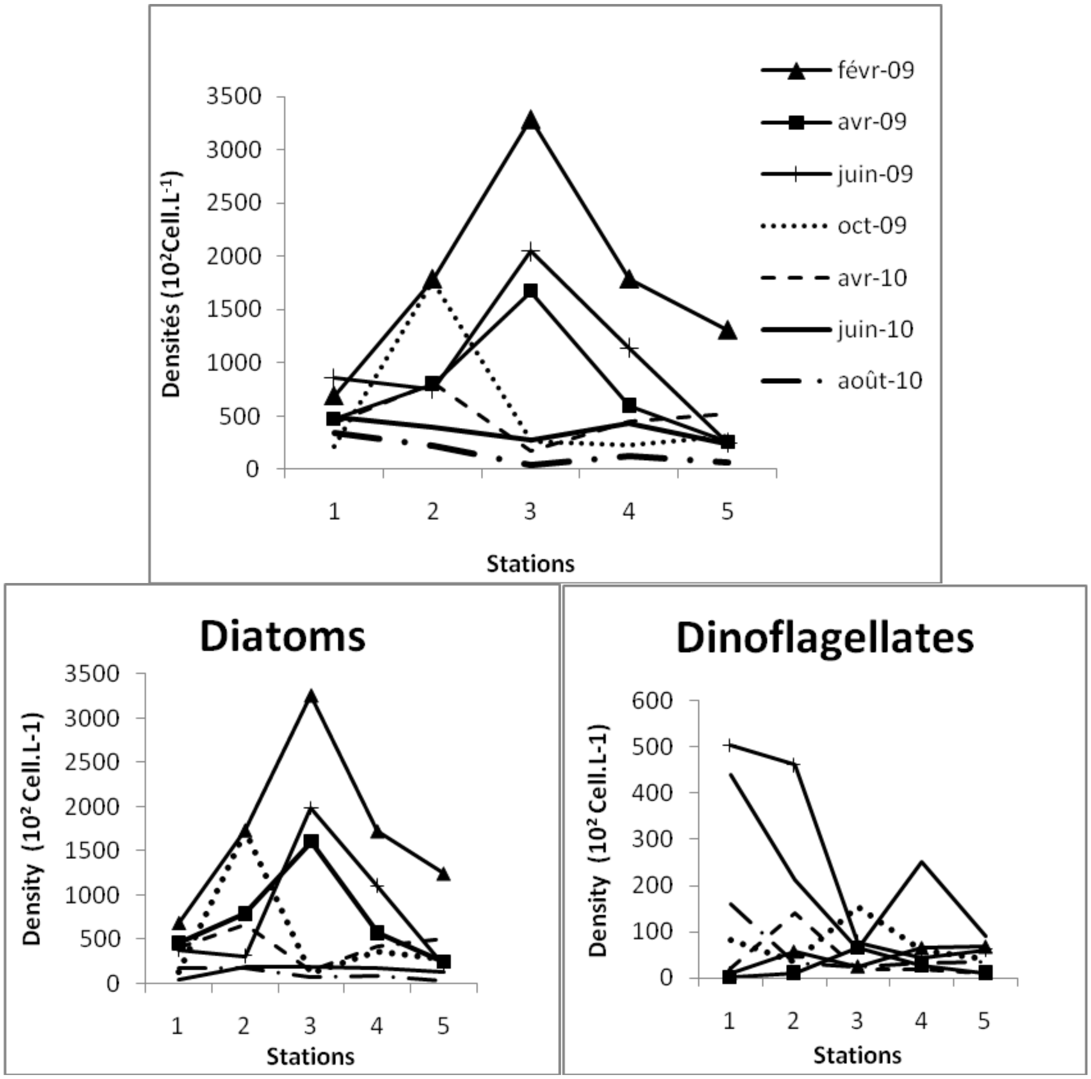
Table-1: sampling stations (Geographic coordinates, maximal depths and distance from coast); Cruises calendar (*February, April, June, October 2009 and April, June, August 2010) near cape Juby area (28°N, Morocco, Atlantic)*

	Stations	Latitude	Longitude	Depth (m)	Distance from coast (Km)
Cap Juby	1	28°00,14	12°45,51	28	8
	2	27°59,73	12°56,78	40	26,3
	3	28°00,20	13°08,85	68	46,6
	4	28°00,00	13°20,29	396	64,6
	5	28°00,10	13°31,67	1185	83,5

Cruises calendar
24/02/2009
22/04/2009
16/06/2009
27/10/2009
15-17/04/2010
25-26/06/2010
30/08/2010

Figure 2: Spatial Variations in (A) phytoplankton densities, Diatoms and dinoflagellates densities, (B) species number, Diversity index and Eveness during the seven sampling periods (February, April, June, October 2009 and April, June, August 2010) near cape Juby area (28°N, Morocco, Atlantic)

(A)


févr-09
avr-09
juin-09
oct-09
avr-10
juin-10
août-10
Densités (10²Cell.L⁻¹)
Stations
Diatoms
Density (10² Cell.L-1)
Stations
Dinoflagellates
Density (10² Cell.L-1)
Stations

(B)

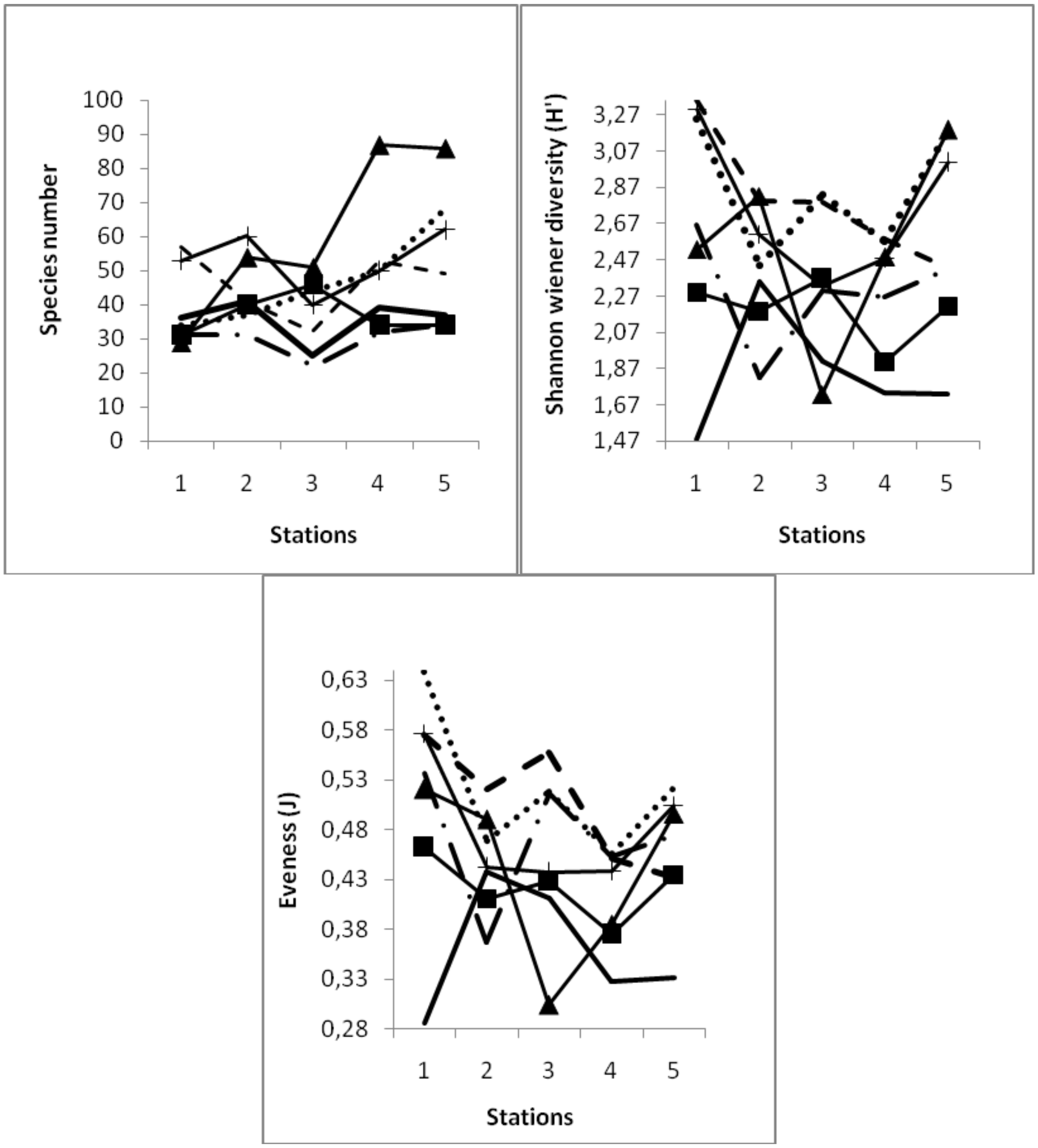


Table 2: Dominant species at each sampling period
*** Species that commonly dominate during the 7 periods**

Febr-09	Apr-09	Jun-09	Oct-09	Apr-10	Jun-10	Aug-10
Ps.de	T spp*	Rh.se	Sk.co	G.st	Gym sp	Nit spp*
L.ann	L.ann	Gym.ca	Mel sp	Le.min*	Nit spp*	Pr.mic
Ps.se	Ps.se	Ps.se	Alx*	Le.dan*	Le.min*	T spp*
Chae	Ps.de	Le.min*	Ps.de	Mel sp	Le.dan*	Sc sp

T spp*	Chae	Alx*	T spp*	Nit spp*	Pr.mic	Gym sp
Le.min*	Le.min*	Mel sp	L.ann	T spp*	T spp*	Le.min*
Le.med	Le.dan*	Le.dan*	Le.dan*	Alx*	Gon	Le.dan*
Le.dan*	Mel sp	Ps.de	Ps.se	Chae	G.st	G.st
C.clo	G.st	T spp*	Nit spp*	A.gla	Chae	Pr.al
Mel sp	Alx*	L.ann	Le.min*	L.ann	Dip.sp	Dip.sp
Sk.co	Nit spp*	Chae	Ox sp	Od	Alx*	Alx*
Pr.al	Dy.br	St.pa	Nav sp	Gym sp		Gyr.fu
Nit spp*	Gym sp	Nav sp	C.clo	C.fur		Ps.de
Nav sp	Pr.al	Nit spp*	Gym sp	Pr.al		Coc
Alx*	Nav sp	Ox sp	Pr.al			Nav sp
		Gym sp	Gyr.fu			
		Pro.de	Sc sp			
		T.nit	Chae			
		Sc sp	Gyr			

Table-3. A check list of phytoplankton species encountered during the study (*February, April, June, October 2009 and April, June, August 2010) near cape Juby area (28°N, Morocco, Atlantic)*

-A-	F09	A09	J09	O09	A10	J10	At10
Baccilariophyta							
Division:Chromophyta							
Class-Baccillaryophyceae							
Centrics							
Order-Lithodesmiales							
Family-Lithodesmiaceae							
Dytilum brightwellii (T.West) Grunow, 1885		+					
Helicotheca tamesis (Shrubsole) M.Ricard, 1987					+		
Order-Hemiaulales							
Family-Hemiaulaceae							
Hemiaulus proteus Heiberg 1863	+			+	+		
Climacodium Grunow 1868							+
Order-Licmophorales							
Family-Licmophoraceae							
Licmophora Kützing, 1844	+	+	+	+			+
Order-Rhopalodiales							
Family-Rhopalodiacea							
Epithemia Kützing, 1844	+	+					
Order-Bidulphiales							
Sub-order-Biddulphianeae							
Family-Triceratiaceae							
Odontella C.Agardh, 1832	+			+	+	+	

Family-Bellerocheaceae							
Bellerochea Van Heurck, 1885	+	+					
Sub-order-Coscinodiscanea							
Family-Paraliales							
Paralia sulcata (Ehrenberg) Cleve, 1873	+	+					+
Family- Coscinodiscineae							
Coscinodiscus spp. Ehrenberg, 1839	+	+	+	+	+	+	+
Family-Hemidiscacea							
Actinocyclus sp Ehrenberg, 1837							+
Proteus Hemidiscus	+			+	+		
Family-Fragilariaceae							
Fragilaria Lyngbye, 1819	+		+				+
Asterionollopsis glacialis (Castracane) Round, 1990	+				+		
Family-Leptocylindraceae							
Leptocylindrus danicus Cleve, 1889	+	+	+	+	+	+	+
Leptocylindrus minimus Gran, 1915	+	+	+	+	+	+	+
Leptocylindrus mediterraneus (H.Peragallo) Hasle 1975	+						
Family-Melosiraceae							
Melosira sp C.A.Agardh, 1824	+	+	+	+	+		
Family-Stephanopyxidaceae							
Stephanopyxis palmeriana (Greville) Grunow, 1884		+	+				
Family-Skeletonemaceae							
Skeletonema costatum (Greville) Cleve, 1873	+	+		+			
Family-Surirellaceae							
Surirella Turpin 1828	+		+				
Family-Thalassiosiraceae							
Detonula sp Schutt ex De Toni, 1894			+	+	+		
Lauderia annulata Cleve, 1873	+	+	+	+	+	+	
Thalassiosira sp (Ehrenberg) Cleve, 1903	+	+	+	+	+	+	+
Family-Rhizosoleniaceae							
Dactyliosolen fragilissimus, (Bergon) Hasle, 1996					+		
Rhizosolenia styliformis Brightwell, 1858	+	+					+
Rhizosolenia spp Brightwell, 1858		+	+	+	+	+	+
Rhizosolenia robusta G.Norman in Pritchard 1961	+		+	+			
Rhizosolenia hebetata f. semispina Hensen, 1887			+				
Rhizosolenia imbricata Brightwell, 1858	+		+				
Rhizosolenia setigera f. pungens (Cleve-Euler) Brunel, 1962	+						
Rhizosolenia setigera Brightwell 1858	+		+		+	+	
Proboscia alata (Brightwell) Sundström, 1986	+	+	+	+	+	+	+
Guinardia flaccida (Castracane) H.Peragallo, 1892	+				+		+
Guinardia striata (Stolterfoth) Hasle, 1996	+	+	+		+	+	+

Guinardia delicatula (Cleve) Hasle, 1997		+					
Pseudosolenia B.G.Sundström, 1986							+
Family-Cheatoceraceae							
Chaetoceros sp. Ehrenberg, 1844	+	+	+	+	+	+	
Family-Naviculaceae							
Navicula spp Bory de Saint-Vincent, 1822	+	+	+	+	+	+	+
Plagiotropis sp Pfitzer, 1871	+		+				
Pleurosigma spp Wm. Smith, 1852	+	+		+	+		
Gyrosigma spp Hassall, 1845	+	+			+	+	
Family-Diploneidaceae							
Diploneis bombus (Ehrenberg) Ehrenberg, 1853	+	+	+	+	+		
Diploneis crabro (Ehrenberg) Ehrenberg, 1854	+		+				
Diploneis sp					+	+	+
Family-Cymbellaceae							
Amphora sp.	+						
Family-Baccillariaceae							
Ceratoneis closterium Ehrenberg, 1839	+	+	+	+	+		
Nitzschia spp Hassall, 1845	+	+	+	+	+	+	+
Pseudo-nitzschia delicatissima (Cleve) Heiden, 1928	+	+	+	+	+	+	+
Pseudo-nitzschia seriata (Cleve) H.Peragallo, 1899	+	+	+	+	+		
Order-Striatellales							
Family-Striatellaceae							
Striatella spp C.A .Agardh, 1832	+						
Family-Thalassionemataceae							
Thalassionema nitzschioides (Grunow) Mereschkowsky, 1902	+	+	+	+			
Sub-order-Bacillariineae							
Family-Achnantaceae							
Cocconeis sp.					+	+	
Diatomées centriques hemidiscacea	+	+	+	+			
-B-							
Dinoflagellates							
Division:Chromophyta							
Class:Dinophyceae							
Order:Peridiniales							
Family-Ceratiaceae							
Neoceratium fusus (Ehrenberg) F.Gomez, D.Moreira & P.Lopez-Garcia, 2010	+	+	+	+	+	+	+
N.furca (Ehrenberg) F.Gomez, D.Moreira & P.Lopez-Garcia, 2010	+	+	+	+	+	+	+
N.candelabrum (Ehrenberg) F.Gomez, D.Moreira & P.Lopez-Garcia, 2010			+				
N.paradoxides (Ehrenberg) F.Gomez, D.Moreira & P.Lopez-Garcia, 2010						+	
N.lineatum (Ehrenberg) F.Gomez, D.Moreira & P.Lopez-Garcia, 2010	+	+	+	+			
N.trichoceros (Ehrenberg) F.Gomez, D.Moreira & P.Lopez-Garcia, 2010	+	+					

N.tripos (O.F.Müller) F.Gomez, D.Moreira & P.Lopez-Garcia, 2010					+	+	+
N.symmetricum (Pavillard) F.Gomez, D.Moreira & P.Lopez-Garcia, 2010	+				+	+	
N.macroceros (Ehrenberg) F.Gomez, D.Moreira & P.Lopez-Garcia, 2010			+			+	
N.declinatum (Karsten) F.Gomez, D.Moreira & P.Lopez-Garcia, 2010			+				
N.horridum (Gran) F.Gomez, D.Moreira & P.Lopez-Garcia, 2010			+				
Family-Peridiniida incertae sedis							
Heterocapsa Stein, 1883	+			+			+
Pentapharsodinium Indelicato & Loeblich III, 1986						+	
Podolampas Stein, 1883						+	
Family-Oxytoxaceae							
Oxytoxum Stein, 1883	+		+	+	+		+
Family-Peridinniaceae							
Peridinium quinquecorne (Abé) Balech, 1974	+	+	+	+	+	+	+
Family-Protoperidiniaceae							
Protoperidinium pentagonum (Gran) Balech, 1974		+					
Protoperidinium diabolus (Cleve) Balech, 1974	+	+			+	+	
Protoperidiniumdepressum (Bailey) Balech, 1974	+	+	+	+	+		+
Protoperidinium conicum (Gran) Balech, 1974		+		+			
Protoperidinium spp Bergh, 1882					+	+	+
Family-Calciodinellaceae							
Scripsiellasp.Balech ex Loeblich, 1965	+	+	+	+	+	+	+
Family-Kolkwitziellaceae							
Diplopsalissp.	+	+	+	+	+	+	+
Order-Prorocentrales							
Family-Prorocentraceae							
Prorocentrum micans Ehrenberg, 1833	+		+	+	+	+	+
Prorocentrum treistinium Schiller, 1918				+			
Prorocentrum sp Ehrenberg, 1834	+			+	+	+	
Order-Gymnodiniales							
Family-Gymnodiniaceae							
Amphidinium sp Claperède & Lachmann, 1859						+	
Cochlodinium Schütt, 1896						+	+
Gymnodinium spp Stein, 1878	+	+	+	+	+	+	+
Gymnodinium catenatum Graham, 1943	+	+	+	+			
Gyrodinium fusus (Meunier) Akselman, 1985	+	+	+	+	+	+	+
Gyrodinium spirale (Bergh) Kofoid & Swezy, 1921	+	+	+	+		+	+
Family-Dinophysiaceae							
Dinophysis Odosia (Pavillard) Tai & Skogsberg, 1934	+						
Dinophysis caudata Saville-Kent , 1881	+		+	+			
Dinophysis acuta Eherenberg, 1839	+		+				
Dinophysis acuminata Claparéde et Lachman, 1859			+		+	+	

Dinophysis sp Ehrenberg, 1839			+		+	+	+
Dinophysis rudgei (Murray &Whitting) Abé, 1967	+		+				
Family-Noctilucales							
Pronoctiluca spp Fabr-Domergue, 1889	+			+	+	+	+
Noctiluca scintillans (Macartney) Kofoid&Swezy, 1921				+		+	
Family-Gonyaulacaceae							
Alexandrium sp Halim, 1960	+	+	+	+	+	+	+
Pyrophacus Stein, 1883	+	+	+		+	+	+
Gonyaulax Diesing, 1866	+	+	+			+	+
Family-Pyrocystaceae							
Pyrocystis lunula (J.Schütt) J.Schütt, 1896	+		+				
Family-Ostreopsidaceae							
Ostreopsis sp Schmidt, 1901				+			+
-C-							
Class-Raphydophyceae							
Order-Chattonellales							
Family-Chattonellaceae							
Chattonella spp B.Biecheler, 1936	+		+	+	+		
Fibrocapsa sp S.Toriumi&H.Takano, 1973			+				
Family-Euglenaceae							
Euglena sp Ehrenberg, 1830	+	+	+	+			
Family-Dictyochaceae							
Octactis octonaria (Ehrenberg) Hovasse, 1946	+	+	+	+		+	+
Dictyocha fibula Ehrenberg, 1839		+	+	+			
Coccolithophoridés	+	+	+	+	+	+	+
Silicoflagellés							+
Cyanobactéries					+		

Table-4: ***Sorensen's similarity index (q, %) across sampling sites***

Sampled period	Coastal Stations Vs oceanic Stations
February-09	71,02803738
April-09	64,1025641
June-09	78,43137255
October-09	72,72727273
April-10	66,66666667
June-10	67,6056338
August-10	65,57377049

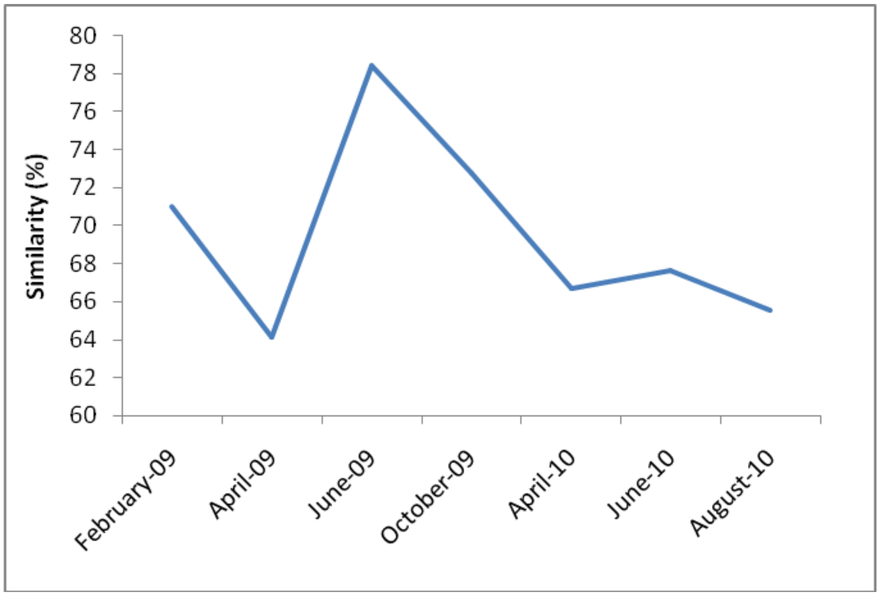
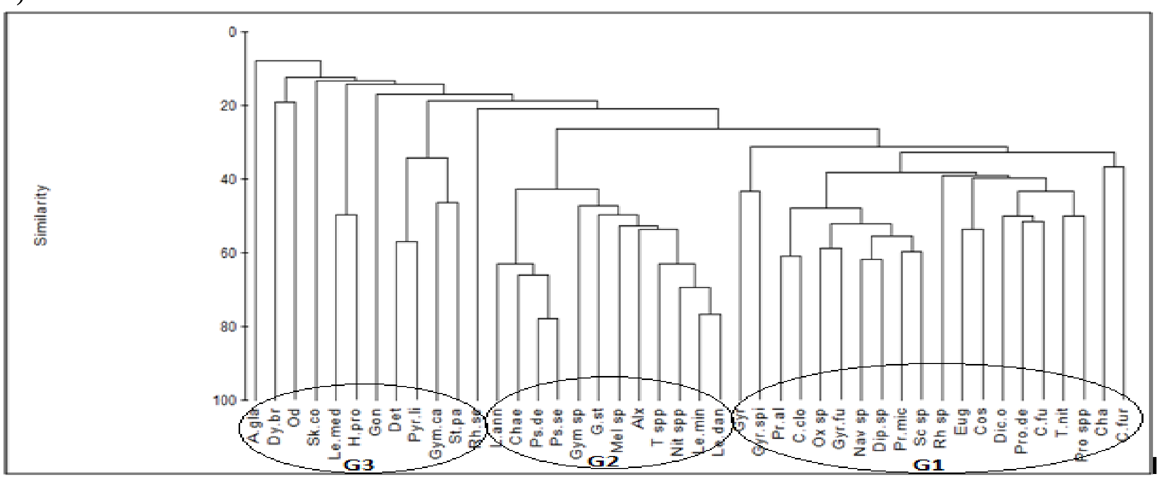
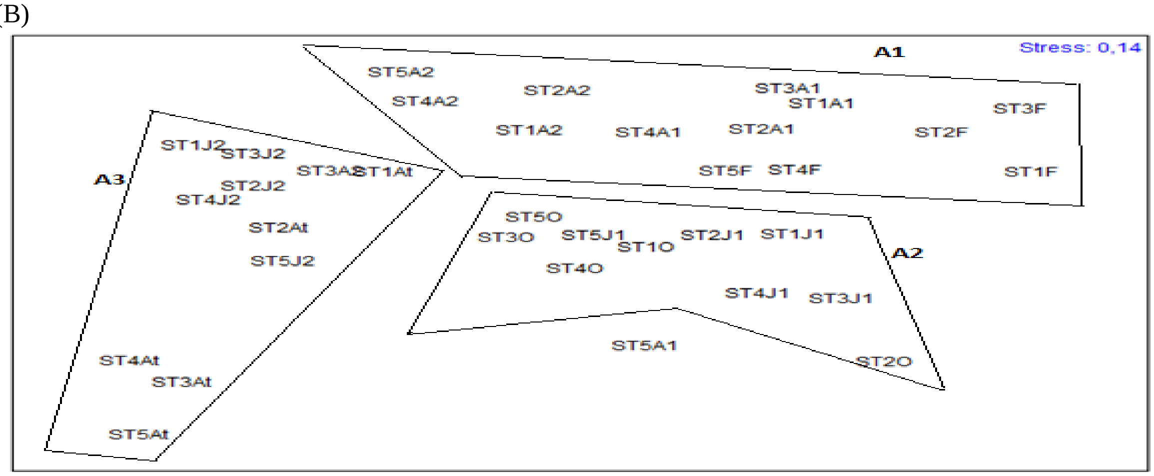


Figure 3: (A) Dendrogram resulting from cluster analysis of the most-abundant taxa and (B) NMDS Ordination plot using Bray-Curtis Similarity of sampled stations

(A)



(B)



Discussion

In our periods, phytoplankton communities was represented by 107 Taxa, including 54 Diatoms, 45 Dinoflagellates and 8 other groups: Silicoflagellates, raphidophyceaes and coccolithophorids…

Our study shows the existence of a clear seasonality in phytoplankton composition, structure and distribution, with a dominance of diatoms during winter and early spring while dinoflagellates densities increase in summer. A negative spatial (coast-offshore) correlation between diatoms and dinoflagellates biomasses was observed in our periods. A similar coastal–offshore pattern of distribution was observed by Arístegui et al. (2004) along a complex filament developed near Cape Juby: large phytoplankton cells (mainly diatoms) with high densities were replaced by smaller cells with lower biomass. These differences are caused by the recirculation of organic material towards the shelf favoured by mesoscale features, leading to enhanced community respiration (Arístegui et al., 2004).

he quantitative dominance of diatoms at the upwelling ecosystems enriched in nutrients have been reported by several authors (*Tilstone et al., 2000; Joint et al, 2001; Lassiter, 2003 ; Somoue et al., 2003; Elghrib et al., 2012*). Indeed, in systems characterized by short mixing events (few days) as in upwelling areas, phytoplankton communities appear to be composed by diatom species with a rapid and explosive growth *(Tilstone et al, 2000 et Laghrib et al., 2012)*.

However, competitive interactions between diatoms and dinoflagellates in natural assemblages are not well understood nor heavily studied, perhaps because dinoflagellates populations generally follow diatom blooms. It is in fact, generally known that dinoflagellates, in regions of mixing events, starts growing once nutrients availability limit growth of diatoms, which would otherwise outcompete dinoflagellates (Gettings et al., 2014)

Dominance index results showed a temporal succession of 35 dominant taxa, including 5 species that are dominant through our seven periods sampled, Thalassiosira spp (Y=0,72), Leptocylindrus danicus (Y=0,17), leptocylindrus minimus (Y=0,23), Nitzshia spp (Y=0,38) and Alexandrium sp (0,70). These taxa are known as indicators and accompanying upwelling activities. The species of the genus Thalassiosira were often cited as accompanying upwelling events *(Kobayashi and Takahashi, 2002; Loureiro et al, 2005; Lassiter, 2006), explained by injection of nutrients in the upper layers. Also Leptocylindrus minimus (Horner, 2002 ; Crespo et al., 2006 et Prego et al., 2012). Leptocylindrus danicus* was reported as the most dominant species in the algal assemblage in central Chile (27-18 ° S), characterized by a seasonal upwelling activity *(Avaria and Munoz, 1987).* This species was also reported as abundant during the upwelling of the Cantabrian coast (Prego et al., 2012) and near the coast of A.Coruña (Casas et al., 1999) in the northwest of Spain.

The hierarchical classification applied to species which relative abundance is equal to or greater than 0.1%, helped distinguish three assemblages of taxa with similar ecological affinities, reflecting a remarkable seasonal variability. Cluster 1 is constituted by species with medium densities but abundant in a particular season: Grodynium spp, Navicula sp, Rhizosolenia sp, Coscinodiscus sp, Thalassionema nitzschoides, Prorocentrum micans…., Cluster 2 includes species whose densities are medium to high and abound in almost all sampled periods and are known as indicators and accompanying the activity of deep water upwelling: Lauderia annulata, Pseudonitzschia seriata, Thalassiosira sp, Alexandrium... Cluster 3 includes rare or accidental species that appear in a particular period:

In accordance to this, stations ordination with the NMDS analysis also showed a considerable seasonality in the stations groups concerning species composition; A1 was represented by winter and early spring stations. A2 consisted on autumn and early summer sites, and A3 includes summer stations.

This similarity among stations joins the “Similarity Sorensen” index results which showed high similarities between coastal and oceanic stations sampled at the same season. This remarkable similarity can be explained by a great exchange of waters between the coast and the open ocean. The dispersion of biological material from the coast to open sea, through the filament upwelling at Cape Juby has been demonstrated by several authors, including Aristegui et al *(2004; 2009)* and *Salah et al (2013). Brochier et al. (2008 ; 2011)* explain that the filaments and eddies observed in the continental shelf of the Cap Draa - Cap Juby region, are largely responsible of the transportation of sardine and anchovy larvae to the Canary Islands.

Ultimately, we can conclude that a further study including hydrological parameters especially nutrients inputs should be conducted for a synoptic view.

Bibliography article 2015

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