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Vertical Phytoplankton Community Distribution under Seasonal Fluctuations of Hydrological Parameters (Cap Juby, Moroccan Atlantic sea, 2009)

Hariss Ikram [1,2,*], TAZI Ouadiaa[1], Somoue Laila[2], Elarraj Leila [1], Agouzouk Aziz [2], Charib Said [2], Idrissi Mohamed [2], Hilmi Karim [2], Makaoui Ahmed[2] and ettahiri Omar[2]

[1]Laboratory of Aquatic Ecology and Environment, Faculty of science Ain Chock Hassan II University, B.P 5366 Maarif 20100, Casablanca, Morocco.

[2]National Institute for Fisheries Research. Route Sidi Abderrahmane Club équestre Ould Jmel – Casablanca, Morocco.

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ABSTRACT

The vertical distribution of phytoplankton in stratified water columns (upper 150 m), was studied at five stations around the cap Juby area, Moroccan Atlantic sea, during four periods in 2009. Five depth levels were sampled: 5, 25, 50m for coastal stations and up to 90, 150m for offshore stations. The vertical variability of the physical parameters was analyzed to assess the impact of hydrological fluctuations on phytoplankton vertical distribution. The maximal densities are noted at the surface in April and June, where the upwelling activity reaches its maximum, manifested by cold-water temperature, low salinities and an intense intake of nutrients. These observations are confirmed by the vertical distribution of dominant species, such as *Thalassiosira spp*, *Leptocylindrus danicus*, *Leptocylindrus minimus*, *Nitzschia spp and Alexandrium spp*. Indeed, these five common and frequently occurring phytoplankton species showed maximal proliferation, on the upper layers, in upwelling periods. In February and October, a considerable stratification of all parameters is noticed, leading to an unremarkable vertical variability in phytoplankton distribution.

Introduction

The knowledge on factors governing phytoplankton population's structure may give insights for understanding the pathways of marine production from wind-forced upwelling through the lower trophic levels, which is crucial to estimate the interannual, decadal and longer-term fluctuations and trends in coastal production, and in implementing improved management of those resources (1).

Turbulence and advection along the water column are known to affect the composition and distribution of marine phytoplankton communities. In systems with short-duration mixing events, such as upwelling zones, the phytoplankton communities are more structured with chain-forming diatoms, which are characterized by a fast and explosive growth, that are replaced by small sized fractions of phytoplankton or solitary diatoms in more stable stratified waters (2).

In upwelling zones, the major axis of spatial distribution for phytoplankton is the vertical dimension. Therefore, it is necessary to examine the interaction between the vertical variability of hydrological factors and the phytoplankton abundance and composition.

In view of the scarcity of reports from cape Juby concerning vertical distribution phytoplankton community, the present study aims to examine seasonal patterns of phytoplankton abundance at different depths. Also, to evaluate the impact of vertical fluctuations of the hydrological parameters (temperature, salinity, nutrients contents) on phytoplankton community's distribution.

Tele:

E-mail address: harissikram@gmail.com

Material and methods

Study site

Sampling concerned the Cap Juby zone (28 ° N) and the upwelling filament associated.

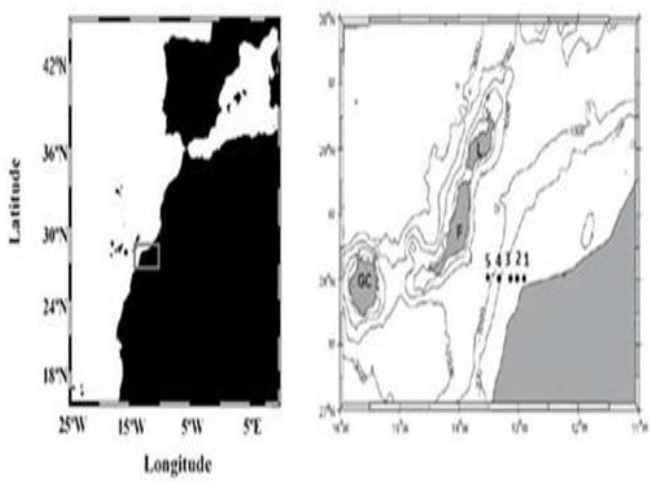

Figure-1. Study area and sampling stations, Cape Juby area (28°N, Moroccan AtlanticSea).

Four cruises were conducted on board the R/V Amir MoulayAbdellah (AMA). During those four cruises, five stations transect, sampled and oriented East-West (Fig. 1). Water samples were collected during day time at standard depths of 5, 25, 50, 90 and 150 m depending on the depth of the water column.

Hydrographic samples were collected using a CTD Sea Bird SBE 9-11. Seawater samples were collected with Niskin Bottles for the analysis of phytoplankton species. Phytoplankton samples were immediately preserved with an acid Lugols solution (2% final concentration), according to the Utermöhl method (3). For the taxonomic identification, the following guides were used (4, 5, and 6). The cruises were conducted in 2009 (Tab. 1) to assess the seasonal variability of different parameters.

Table 1. Sampling stations (Geographic coordinates, maximal depths and distance from coast); Cruises calendar (February, April, June, October 2009) near cape Juby area (28°N, Moroccan Atlantic Sea).

Stations	Latitude	Longitude	Maximal Depth (m)	Distance fromcoast (Km)
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

Results and discussion

Upwelling seasonality

The studies concerning the upwelling fluctuations in cape Juby area showed a clear upwelling seasonality in our study year (*7, 8*). Indeed, authors noticed an absence of deep water masses during the winter period (February 2009) with dominance of one homogeneous water masses with a density about 26.85Kg/m^3. In other seasons, cold and less salted deep waters resurgences occurred at the coast, marking a coast-offshore gradient, pronounced in April and June. In October, we noticed a significant stratification associated to warmer water masses *(7). Others* concluded that the upwelling in cape Juby coast appears most in April and June, manifested by low temperature and salinities in sub-surface layers (8).

Vertical distribution of biological and hydrological parameters

The distribution of phytoplankton and physical constituents are shown in Fig.2. In February, significant phytoplankton densities (1281.10² cell.l-1), are noted near the surface waters, around 5m depth, where low temperatures (15.9°C) and salinities (36.4 psu) are recorded. A remarkable drop in phytoplankton densities is recorded towards deep waters. These phytoplankton densities, not exceeding 80.10² cell.l^{-1},are noted at 150m depth.Temperature and salinity values varies in a small range and don't seem to be governed by the depth parameter.The vertical distribution of nutrients was recorded in a wide range, [0.3-1µmol/l] for phosphorus and [0.8-6.2µmol/l] for nitrogen.The relatively high surface phytoplankton densities in this period, despite the absence of upwelling,could be explained by the fact that in oceanic waters of the Canaries area, the annual plankton production cycle is affected by almost permanent seasonal thermocline that disappears during the winter as a result of decreasing surface water temperatures, supporting phytoplankton proliferation.Therefore, it is only during the short mixing period (winter) following deep convection, that phytoplankton grow rapidly *(9)*.

In April, maximal densities (547.10² cell.l-1) are observed near the surface at 5m depth corresponding to a minimum temperature of 15.2°C and low salinities of 36.1 psu; due to the resurgence activity deep waters to the upper layers.At this level, the nutrients are minimal, phosphates (0.2 µmol/l)and nitrogen (0.7 µmol /l), which can be explained by a high nutrient intake leading to the observed phytoplankton proliferation.

A considerable drop in phytoplankton abundance is recorded between 20 and 25 m depth, corresponding to a fluctuation of hydrological conditions at this level, since a variation in temperature, salinity and nutrientis observed between these two depths.The same pattern is observed in June where intense phytoplanktonic proliferations are observed at surface waters corresponding to low salinities and a drop in nutrient levels. Below 50m depth, we noticed a clear decline in phytoplankton densities, while nutrients availability increases.

In October, lower phytoplankton densities are notedaccompanied by a small variation in distributions along the water column,whichcan be described as a vertical stratification. Temperatures and salinities as well as nutrients vary within a very narrow range and do not seem to be governed by the depth parameter.

The vertical distribution of common and frequently occurring phytoplankton species (Cf. Hariss et al., 2015) during our study are shown in Fig3.

Thalassiosira spp shows maximum densities near the water surface (5m) during all the periods of sampling, except in February where the maximum is reached at 50m (43.10² Cell.l-1).The genus Thalassiosira was often cited as accompanying upwelling events (11, 12, 13), explained by injection of nutrients in the upper layers. The two species Leptocylindrus danicus and Leptocylindrus minimus were more abundant near the surface at the all periods and showed maximum densities in October beyond 90m depth. Many authors reported these two species as indicators and accompanying upwelling activities (14, 15, 16). Leptocylindrus danicus was reported as the most dominant specie in the algal assemblage in central Chile (27-18 ° S), characterized by a seasonal upwelling activity (17). The diatom Nitzschia spp was abundant in the upper layers at February and April, between 40 and 60 m depthin February and at deeper waters (150m) in October. Maximal densities of the dinoflagellate Alexandrium spp, were recorded from the surface layers up to 25m depth. This species also was reported as abundant during the upwelling of the Cantabrian coast (16) and near the coast of A.Coruña (18) in the northwest of Spain.

Conclusion

The study area is part of the Canary Current system, which is characterized by a constant upwelling between Cap Juby (28 ° N) and Cap Blanc (21 ° N) (Aristegui et al., 2006). Our study shows a clear vertical seasonality of upwelling activity in cape Juby area manifested by resurgence events that occurs most in April and June, with low temperatures and salinities in sub-surface layers. Maximal phytoplankton densities are recorded at these periods. This finding was supported by the analysis of vertical distribution of most common phytoplankton species which allowed us to highlight a remarkable variability in upwelling indicators species vertical distribution mainly governed by upwelling activity.

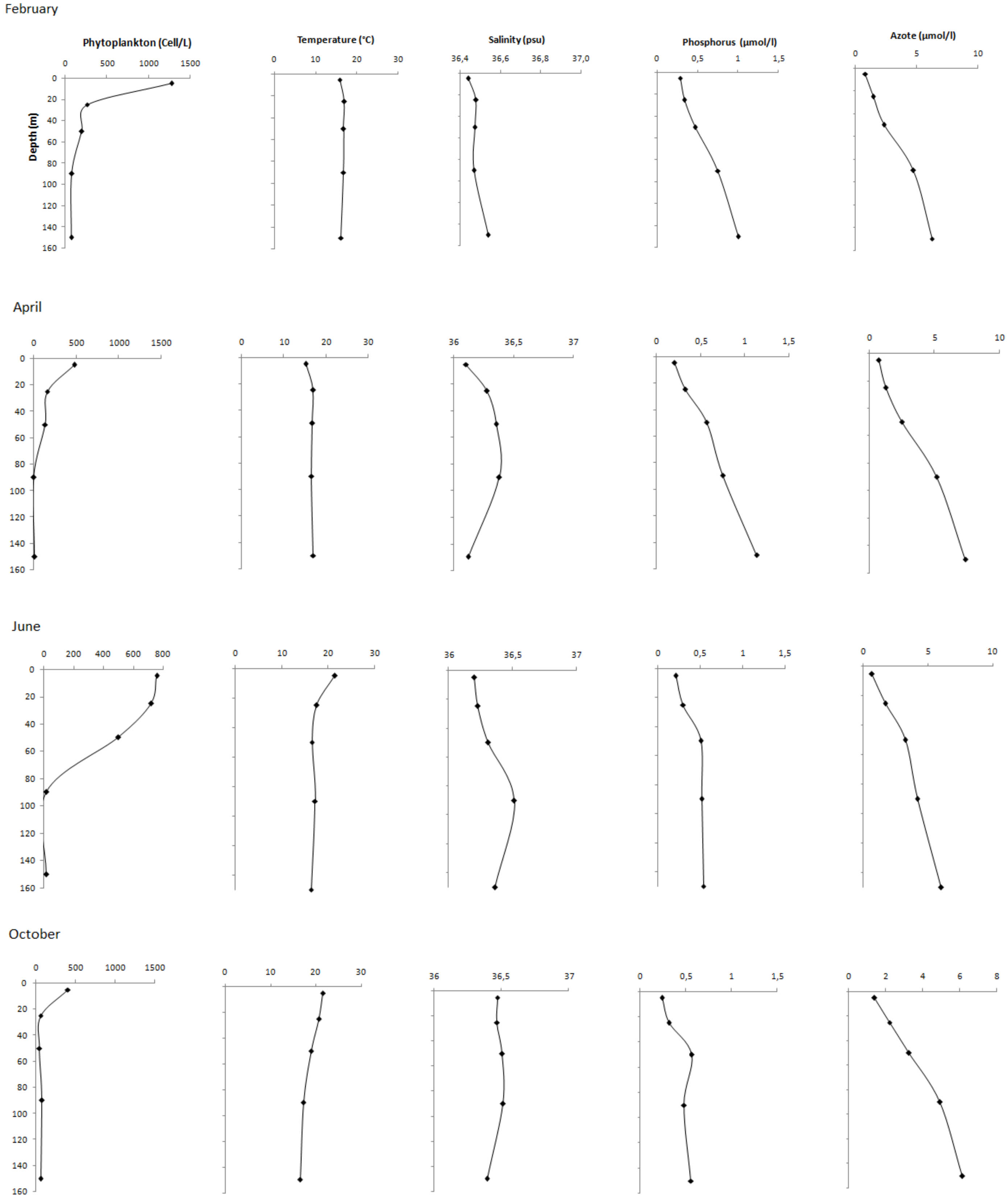

Figure 2. Vertical distribution of phytoplankton densities and hydrographic characteristics during the four sampling periods *near cape Juby area (28°N, Morocco, Atlantic)*.

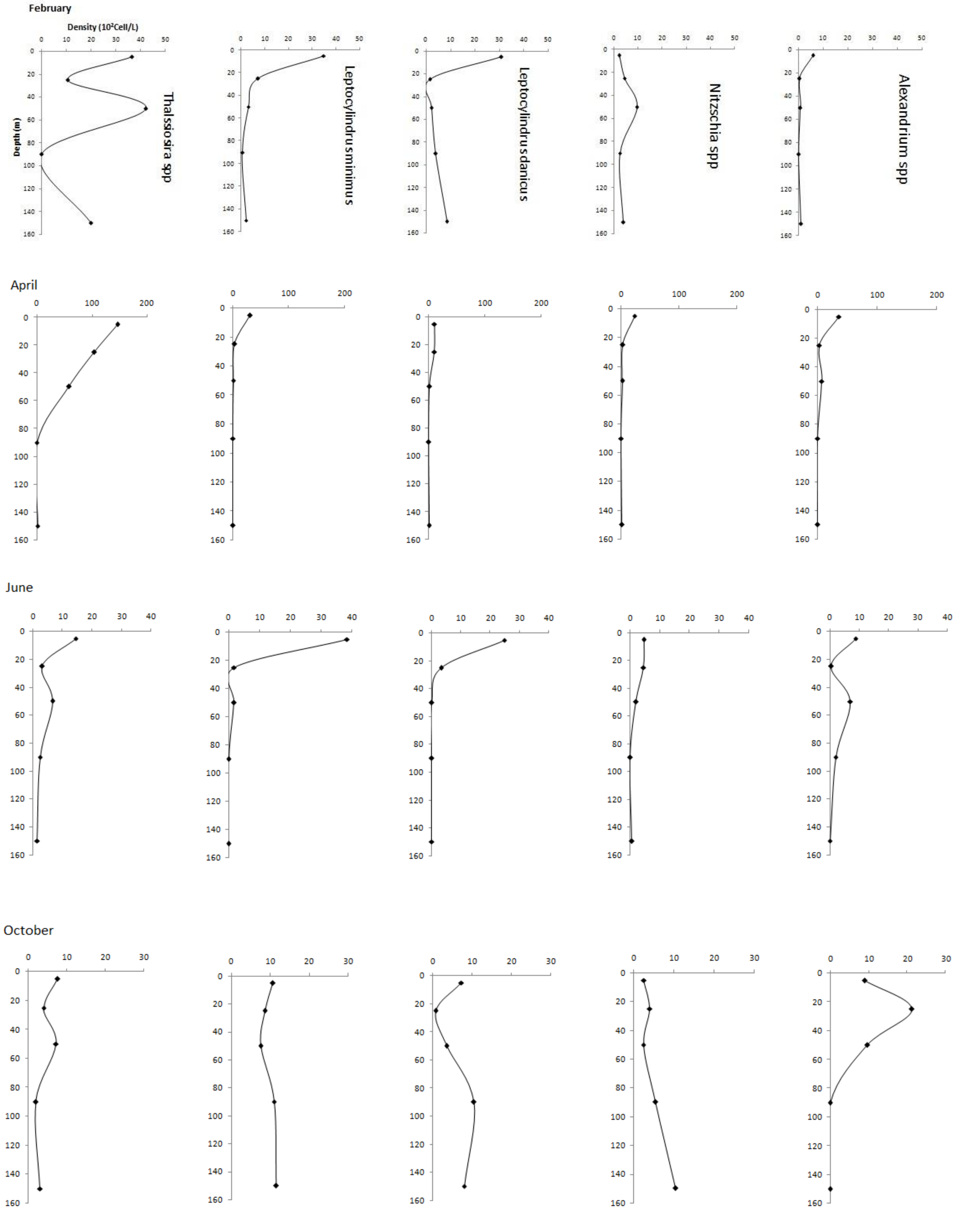

Figure 3. Vertical distribution of dominant species during the four sampling periods *near cape Juby area (28°N, Morocco, Atlantic).*

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