

General structure of Nereids of the East Coast of Algeria

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Abstract. The study of biodiversity of nereids at three sites (El-Kala, Annaba and Skikda) of the Algerian east coast for the year of 2018 has allowed us to identify 8 species belonging to the family of Nereididae: *Perinereis cultrifera*, *Perinereis floridana*, *Perinereis oliveirae*, *Perinereis macropus*, *Perinereis marionii*, *Platynereis dumerilli* and *Nereis falsa*. The aim of this study was to carry out the analysis of the specific richness and the abundance of annelids in order to determine their biodiversity where the structure and functioning of these communities were analyzed. Moreover, the analysis of the ecological indices shows a less rich biodiversity at the two sites (Annaba and Skikda). Physico-chemical parameter data show significant differences between the three sites especially for dissolved oxygen.

Key Words: abundance, Algerian Eastern Coast, biodiversity, Nereididae.

Introduction. Pollutants affect the abundance and composition of marine species (Wildsmith et al 2011). The presence of these compounds in environmental media, biota and food today represents a serious threat to human health and environmental integrity (Bouzahouane et al 2018).

Surveys and monitoring programs of the marine environment often use benthic communities (Pearson & Rosenberg 1978; Dauer et al 1993; Gray & Elliott 2009; Josefson et al 2009; Snani et al 2015). Polychaetaannelids represent a significant percentage of the total benthic population (Papageorgiou et al 2006; Garcia-Alonso et al 2008; Gozler et al 2009; Ramdani et al 2020). In the Mediterranean, more than 1172 species of polychaetes have been described (Coll et al 2010).

Several factors influence the distribution and abundance of polychaetes: the structure of the sediment, the amount of organic matter contained in the sediment, depth, salinity, temperature, and others (Hutchings 1998). Labrune et al (2007) studied polychaetes from the Gulf of Lyon (North-West of the Mediterranean) in relationship with soft bottom sediments and the main environmental parameters, establishing very significant relationships.

The family of Nereididae from Polychaeta worms represents the most usual and typical species of estuarine macrobenthos (Scaps 2002) and are recognized as biological models of choice for revealing disturbances affecting coastal ecosystems (Rouhi et al 2016). In fact, the benthic invertebrate community is considered to be a tool reflecting the conditions of the seabed and is, therefore, a way of assessing marine environmental health. Our study consists of sampling three populations of polychaete annelids belonging to the Nereididae family on the East-Algerian coast in the Mediterranean from three sites represented by: the beach of La Montagne (El-Kala) considered as a reference site, Rezgui Rachid beach (Annaba) and Bikini beach (Skikda) considered as sites affected by industrial and urban pollution. Our work took place in 2018. In addition, the objective of our study was to determine the general structure of the Nereidae population of the

eastern Algerian coast using an ecological approach by analyzing biodiversity as a function of time and of site.

Material and Method

Description of the study sites. The collection of specimens took place in the northeastern part of the Algeria. Three sites were chosen. The first site was located at El-Kala (La Montagne station), which is a municipality in the Wilaya of El-Tarf near to the Algero-Tunisian border. It is located at latitude $36^{\circ}53'53.33''\text{N}$ and longitude $08^{\circ}27'3.28''\text{W}$. The second site was located at Annaba (Rezgui Rachid ex Saint Cloud station). It was located at latitude $36^{\circ}91'67.70''\text{N}$ and longitude $07^{\circ}76'81.70''\text{W}$. The third site was located at Skikda (Bikini Beach), at latitude $36^{\circ}52'18.86''\text{N}$ and $06^{\circ}54'3.28''\text{W}$ (Figure 1).

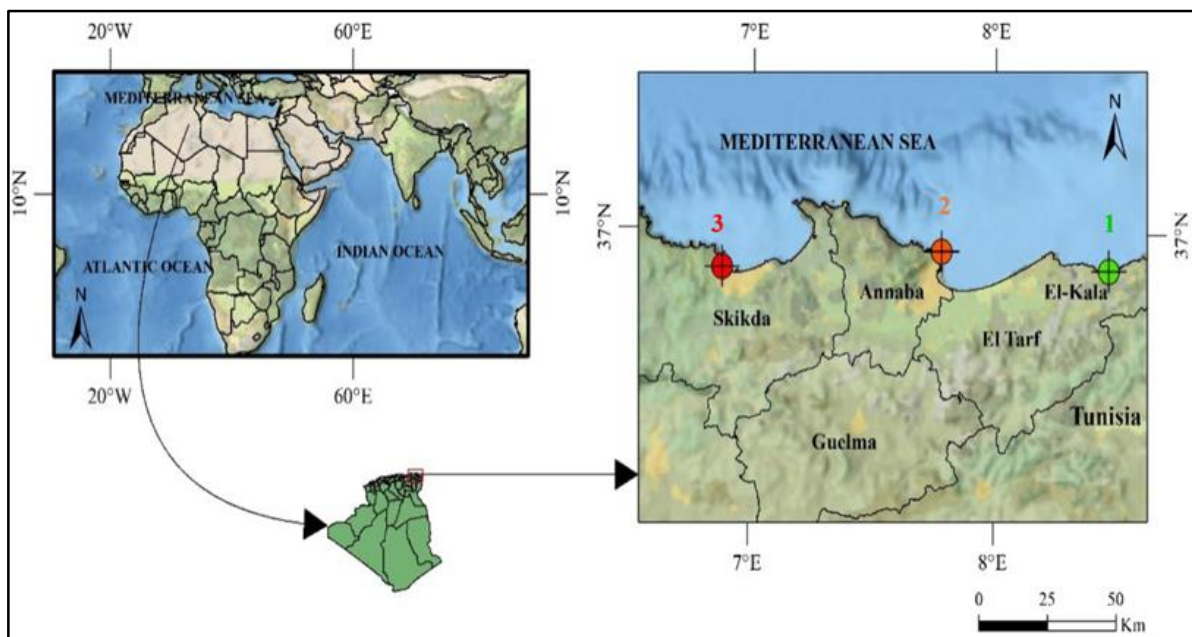


Figure 1. Location of the sampling area.

Sampling procedure. Monthly withdrawals were made during the year 2018. Sampling was carried out in rocky and sandy substrates covered with algae. At each site, three replicates of sampling were performed each month by using a 25×25 cm quadrat at a 0.5 m depth by using a scraper. In the laboratory, the polychaetes were fixed in the field with a 4% formaldehyde formalin solution, and then preserved in 70% ethanol. Then, the polychaetes were identified based on the shape and distribution of the paragnaths of the proboscis, as well as the identification of the setae in the different parapodia especially posterior ones, key elements in the description of the species of Nereids (Fauvel 1923; Day 1967). The Polychaetes were observed using a specialized microscope linked to a "Leica suite lazerleica dm500" computer, which allowed studying the parapodia. To determine the general structure of the communities of the polychaetes (Nereididae), the following descriptive parameters were determined: the specific richness (S), abundance (A) or the total number of individuals per unit area (ind m^{-2}), relative frequency (F), dominance (P_i), Shannon-Weaver diversity index (H') and Piélou's equitability index (J').

Abiotic parameters. In order to better interpret our results, it was essential to take into consideration the natural environmental factors that could influence the dynamics of the species studied. The physico-chemical parameters of seawater represented by temperature ($^{\circ}\text{C}$), salinity (mg L^{-1}), dissolved oxygen (mg L^{-1}) and pH were recorded using a "Thermo" multi-parameter scientific Orient 5-star portable multi-parameter.

Statistical analysis. Data was expressed as mean (\pm standard deviation). Significant differences were assessed by one-way or two-way analysis of variance (ANOVA) followed by the Tukey test; significance of differences was defined at $p < 0.05$. The principal component analysis (PCA) was used to establish the abiotic typology of the sampling sites on the basis of the set of environmental parameters measured at each station throughout the study. All the statistical analyses were performed using MINITAB® software and XLSTAT.

Results and Discussion

Abiotic parameters. The physico-chemical parameters were measured throughout the duration of the study at the three study sites: El-Kala, Annaba and Skikda. We did not observed any significant differences between the study sites for seawater temperature, pH and salinity (Figure 2). For dissolved O₂, a very highly significant effect was recorded at El-Kala site.

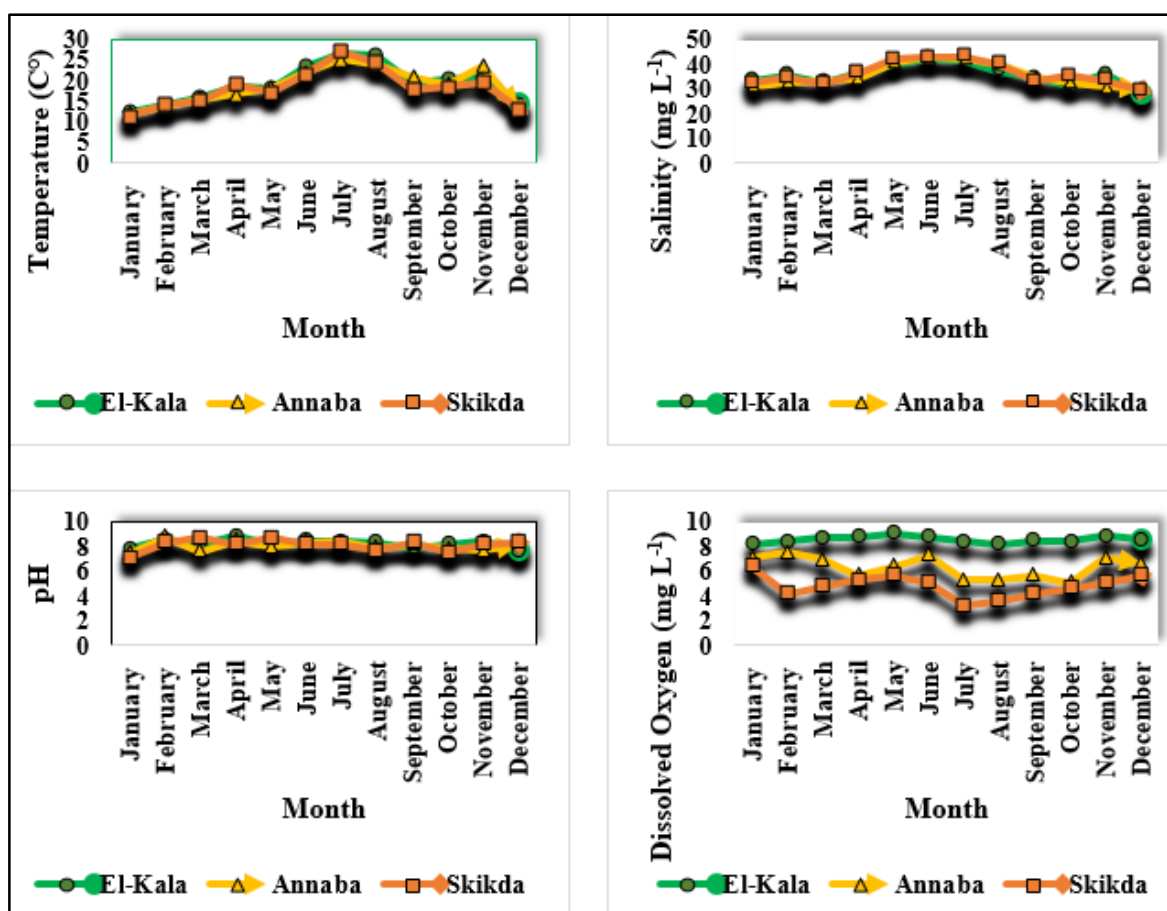


Figure 2. Monthly variations of the mean physico-chemical parameters of seawater in El-Kala, Annaba and Skikda from January to December 2018. Each data point represents mean \pm standard deviation ($n=3$).

The ANOVA single controlled factor variance analysis indicates that there are significant differences only between the dissolved oxygen in the three study site ($p < 0.05$) (Table 1).

Table 1

Statistical analysis of monthly variations in physicochemical parameters seawater measured at the three study sites (El-Kala, Annaba and Skikda) from January to December 2018

	Temperature (C°)	Salinity (mg L ⁻¹)	Dissolved O ₂ (mg L ⁻¹)	pH
El-Kala	19.30±3.55	35.77±3.16	8.4±0.31	8.24±0.27
Annaba	18.80±3.74	35.48±3.96	6.3±0.8	8.05±0.32
Skikda	18.35±3.48	36.26±3.84	4.80±0.72	8.09±0.32
p	0.876 NS	0.911 NS	0.000***	0.511 NS

Note: NS - not significant (p>0.05); * - very significant (p<0.05); ** - highly significant (p<0.01); *** - very highly significant (p<0.001).

Annelids composition and community structure. The number of individuals of different species is very variable. The species found in large numbers at all sites is *Perinereis cultrifera* (Annelid, Polychete) throughout the study period. In addition, we noticed the presence of several species at the El-Kala site compared with other sites. The species listed at this site are *Perinereis cultrifera*, *Perinereis floridana*, *Perinereis oliveirae*, *Perinereis macropus*, *Perinereis marionii*, *Platynereis dumerilli* and *Nereis falsa* (Table 2).

Table 2

Number of individuals (ni) of the different species of nereids recorded at three study sites during 2018

	El-Kala	Annaba	Skikda
<i>N. falsa</i>	78	82	49
<i>P. cultrifera</i>	483	397	386
<i>P. floridana</i>	102	0	0
<i>P. macropus</i>	38	0	0
<i>P. marionii</i>	29	0	0
<i>P. oliveirae</i>	4	0	0
<i>P. dumerilii</i>	6	0	0

Dominance of Nereids present at the three sites. At La Montagne beach (El-Kala: site1), we collected 740 individuals belonging to the Nereidae family, with unequal dominance. The results obtained revealed an important abundance of *P. cultrifera*, with a percentage of 65.27%, followed by *P. floridana* and *N. falsa* with 13.78% and 10.54%, respectively. Finally, *P. oliveirae*, *P. macropus*, *P. marionii* and *P. dumerilii* were represented in very low percentages (Figure 3).

At the Rezgui Rachid beach (Annaba: site2), we have identified 482 individuals belonging to the Nereidae family, with a dominance of *P. cultrifera* reaching 82.88%, followed by *N. falsa* (17.11%) and a total absence of *P. floridana*, *P. oliveirae*, *P. macropus*, *P. marionii*, and *P. dumerilii* throughout the study period (Figure 3).

At Bikini beach (Skikda: site 3), we have inventoried 435 individuals belonging to the Nereidae family. We noted the presence and abundance of *P. cultrifera* (88.73%) compared to *N. falsa* (11.26%), and a total absence of *P. floridana*, *P. oliveirae*, *P. macropus*, *P. marionii* and *P. dumerilii* throughout the study period (Figure 3).

Shannon-Weaver Index (H') and Pielou's equitability index (J'). The diversity (H') of the annelids at the three sites on the eastern Algerian coast varied from 1.63 at site 1, 0.66 at site 2 and 0.61 at site 3.

Pielou's equitability index (J') varied from a maximum in site 1 of 0.54 to a minimum of 0.20 in site 3 (Table 3).

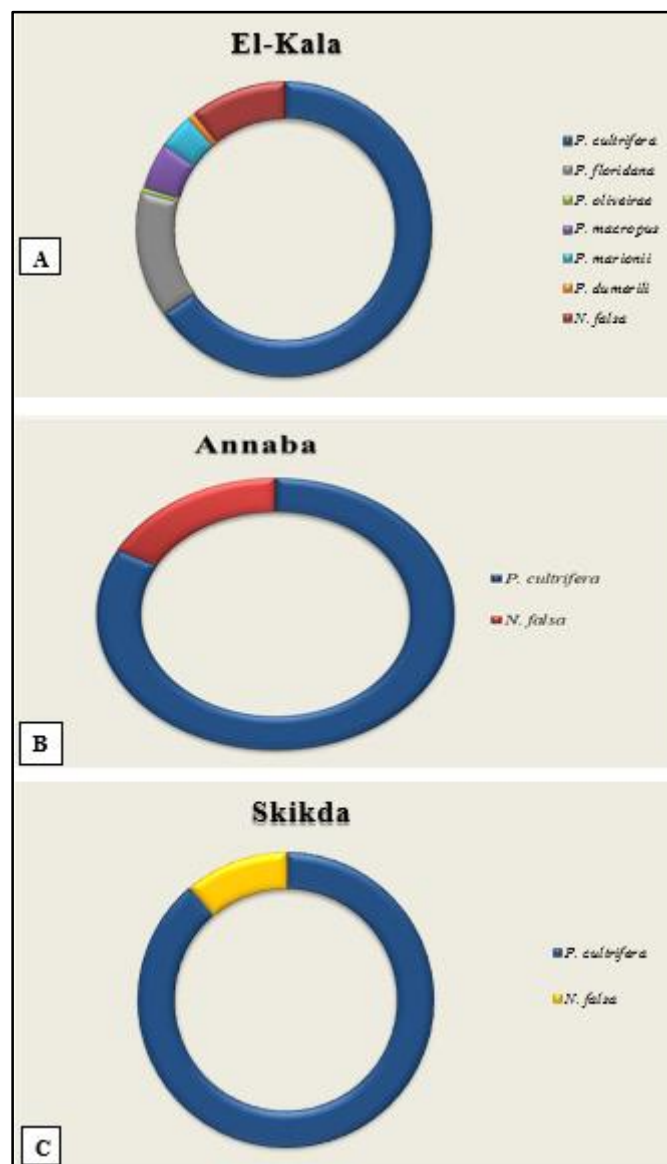


Figure 3. Dominance of Nereids present at the three sites during 2018.

Table 3
Abundance (N), Shannon-Weaver Index (H') and Pielou's equitability index (J') of Nereids in the three study sites during 2018

	N (Ind m^{-2})	H'	J'
Site 1	740	1.63	0.54
Site 2	479	0.66	0.22
Site 3	435	0.61	0.20

Identification characteristics. Fauvel (1923) reports that species belonging to Nereididae are recognized by their many segmented body and by the presence of four eyes, two palps ending in a small palpostyle, two antennas and two pairs of tentacular cirri. On their everted pharynx there are two jaws and paragnaths divided into 8 groups on 2 rings (oral and maxillary) (Table 4), bi-ramed parapods (except at Lycastis), excepting the first 2 pairs, which are uni-ramed. This description agree with the characters of our Nereididae.

Table 4

Number and shape of paragnaths on AVI and AV on everted pharynx; A - Area; HoS - *Homogomph spiniger*; HeS - *Heterogomph spiniger*; HoF - *Homogomph falciger*; HeF - *Heterogomph falciger*

<i>Nereids</i>	AVI	AV	HoS	HeS	HoF	HeF	Observations
<i>P. cultrifera</i> Grube (1840)	1 transverse bar	3	+	+	-	+	Fauvel (1923)
<i>P. floridana</i> Ehlers (1868)	1 transverse bar	1-2	+	+	-	+	De Leon Gonzalez & Goethel (2013); De León-González & Solís-Weiss (1998); Park & Kim(2017)
<i>P. oliveirae</i> Horst (1889)	1 ridge shaped tooth	1	+	+	-	+	Fauvel (1923)
<i>P. macropus</i> (Claparède, 1870)	1-2transverse bars	10	+	+	+	+	Claparède R. É. (1832-1871)
<i>P. marionii</i> (Audouin and Milne, Edwards, 1833)	1 paragnath	1	+	+	-	+	Fauvel (1923)
<i>P. dumerilii</i> (Audouin and Milne Edwards, 1833)	2 transverse bars	0	-	+	+	+	Day (1967)
<i>N. falsa</i> Quatrefages (1866)	4 paragnaths	0	+	-	+	+	Day (1967)

Principal Component Analysis (PCA) was performed to determine the relationships between ecological indices and physicochemical parameters. The analyzed matrix is a table of 10 columns corresponding to the environmental parameters and the biotic parameters taken into account and 3 lines representing the 3 sampling stations during the 12 months of study. Most of the total variance is provided on the first two factorial axes F1 (83.26%) and F2 (16.74%), which accumulate 100% of the total inertia (Figure 4). The PCA results obtained a split of the biotic and abiotic parameters into two groups. The first group (1) reveals a correlation between salinity and the Skikda site. The second group (2) reveals positive correlations between ecological indices namely: Pielou fairness index (J), Shannon-Weaver index (H'), frequency of occurrence (OF), specific richness (S) and abundance (N) and physicochemical parameters represented by temperature (T°) and dissolved oxygen. These characteristics can be seen at the El-Kala site.

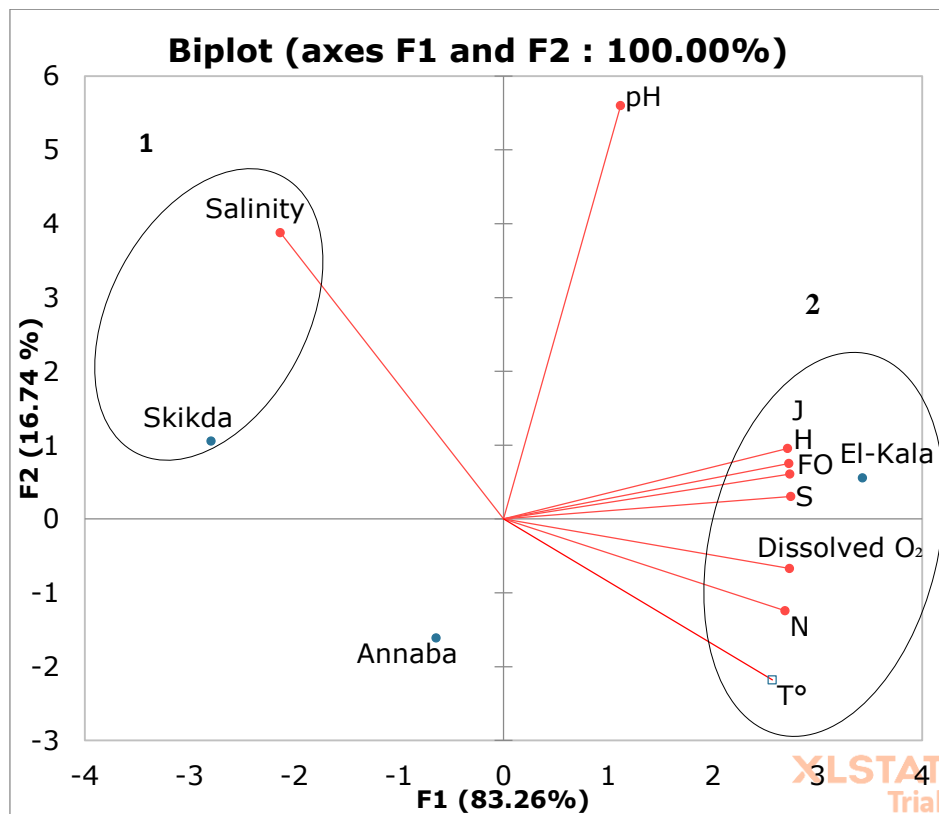


Figure 4. Results of the Principal Component Analysis (PCA) carried out on the environmental variables measured in the different sites during the study period represented by a biplot showing the distribution of the stations relative to their abiotic and ecological characteristics in the factorial plane F1 X F2.

An ecosystem indicates an environment in which the physicochemical conditions are fairly homogeneous, allowing the development of a set of living organisms. In an environment, climatic, geological and hydrological conditions define a biotope, which indicate a place of life allowing the development of certain plant, animal and fungal species or a community or association of living beings coexisting and form a biocenosis (Dajoz 2006). Monitoring programs that assess changes in environmental quality over time are generally based on the evaluation of biological indicators using morphological taxonomy (Aylagas et al 2018). Global warming and the modification of landscapes could be partially a result of the overexploitation of natural resources and agricultural and industrial waste. Environmental pollution has become one of the major problems leading to physicochemical alterations of the seawater temperature, salinity, dissolved oxygen and pH, which are important to overall seawater quality (Mackie & Schloesser 1996). The distribution patterns of macro-benthos and other organisms are determined, among others, by temperature and its interaction with other abiotic factors, such as water speed, oxygen rate, etc. (Ekau et al 2010). Temperature is an important physical property of the environment, which measures the movement and kinetic energy of molecules (Gillooly et al 2001). It controls oxygen supply, metabolism and other associated thermal adaptation mechanisms in invertebrates (Ekau et al 2010). The increase in temperature favors, with other factors, primary productivity and therefore an increase in food for aquatic fauna (Bremond & Vuichard 1973). In the three study sites, water thermal values did not indicate variations. However, they divulged the existence of a commonly Mediterranean seasonal cycle.

Salinity largely determines biological processes, but also chemical processes in water. It is also known for its influence on metal bioavailability (Durou et al 2006). It determines the distribution and dynamics of species (Llanso et al 2002; Teske & Wooldridge 2003).

Our results showed differences between study periods, with a low value recorded during the winter period conceivably due to the incursion of rainwater, opposed to its high value recorded during summer due to the increase in temperature. This work is in agreement with the work carried out on the Oran coast by Rouane-Hacene (2013).

Hydrogen potential (pH) influences many chemical or biological processes (Hinga 2002). A low pH could allow toxic elements to become more available for absorption by aquatic biota producing conditions that are toxic to aquatic life (Faragallah et al 2009). The data collected does not show a significant variation between the three sites, and presents generally similar values. The alkalinity of the different study sites indicates a good quality of the environment for biodiversity of aquatic fauna and flora. Alkalinity was observed at the Skikda site in a previous study (Bordjiba et al 2009). These results are in agreement with those of Kaimoussi et al (2001). Fluctuations in pH can be affected by processes such as: mixing with fresh water, accumulation of organic matter of continental origin and contamination by agricultural, urban or industrial discharges (Aminot & K erouel 2004).

Dissolved oxygen is one of the most important abiotic factors for marine life. The content of dissolved oxygen defines the living conditions of aquatic organisms requiring oxygen. Ekau et al (2010) reported that changes in species composition were a common response to changing oxygen conditions, the strength of which depends on the duration and amplitude of hypoxic events. Oxygen depletion is exacerbated in situations where water bodies are highly stratified or isolated from oxygenated water bodies (Levin et al 2009).

The fluctuation of oxygen of the seawater at station 1 revealed high mean values compared to the two other sites. These fluctuations are linked to seasonal variations in temperature, which directly affect the solubility process of oxygen in water. This hypothesis is confirmed by the study by Tarsila et al (2006) and Ramdani et al (2020), who point out that the oxygen solubility in the water is higher in lower temperatures. However, according to Rodier (1996), the cause of any variation in dissolved oxygen levels may be a function of the presence of plants, oxidizable materials, organisms and aerobic germs. Low oxygen values were recorded at Annaba (Saint-Cloud) and Skikda (Bikini) sites, characterized by the presence of organic pollutants due to industrial discharges from the petrochemical platform.

Concerning species representative of the Nereididae family, Meghlaoui et al (2015) reported the association of four species (*P. cultrifera*, *P. macropus*, *N. falsa*, and *P. dumerellii*) on the east coast of Algeria. Grimes (2004) describes the presence of 54 hard-bottomed Polychaeta annelides species, including those of the genus *Perinereis* (*P. cultrifera*, *P. macropus*, *P. marionii*, and *P. oliveirae*), those of the genus *Nereis* (*N. falsa*, *N. fucata*, *N. pelagica* and *N. zonata*) and a single species of the genus *Platynereis* (*P. dumerellii*). Other studies have indicated the presence of other annelid species in soft bottoms (the bay of Algiers, Annaba), among which 5 species of Nereididae belong to the genera *Perinereis* and *Nereis* (Younsi et al 2010; Madani et al 2011).

The examination of the inventory carried out on the three populations of Nereids during the study period allowed us to identify 7 species belonging to the Nereidae, based on the morphological keys of each species. In addition, this study allowed us, on the one hand, to determine the qualitative composition represented by a list of species and their presence in the sampling sites, and, on the other hand, to analyze the quantitative structure using various ecological indices.

El-Kala (Site 1) was the most diverse and richest in individuals and species (an average of 740 individuals and 7 species), while the lowest values of species richness and abundance were recorded at Skikda (site 3) (435 individuals and 2 species). This was indicated by the persistence of disturbances in this area, preventing the population from progressing to a more mature stage. This difference in species and specimen richness, which in turn increases diversity, can be explained, at least in part, by the different sampling procedures.

The purpose of calculating the most widely used ecological indices of diversity, namely the Shannon-Weaver (H') and Pielou's equitability index (J'), was to estimate the balance of the Nereids population structure.

The four (4) following classes are considered by Grimes (2010) in interpreting the H' index: $H' < 1.5$ - very unbalanced; H' between 1.5-2.5 - unbalanced; H' between 2.5-4 - balanced; $H' > 4$ - very balanced. Thus, the structure is unbalanced at El-Kala and very unbalanced at Annaba and Skikda. These results are linked to pollution and Guemouda et al (2014) confirm that individuals from Skikda and Annaba have been submitted to a highly polluted environment. The structure index is higher at site 1 compared to other sites throughout the study period, classifying it as a site rich in biodiversity. Mirza & Gray (1981) found a decrease in species diversity along a gradient from relatively clean areas to areas heavily affected by organic pollution. Our results show a higher H' at El-Kala (site 1) compared to Annaba (site 2) and Skikda (site 3), in correlation with the dominance of the different species present at each site.

As for the data relating to the Pielou index, Grimes (2010) also proposed a scale of 4 classes to estimate the balance of the population structure: $J' < 0.4$ - very unbalanced; J' between 0.4 and 0.6 - unbalanced; J' from 0.6 to 0.8 - subnormal; and J' between 0.8 and 1 - normal. Therefore, El-Kala site presents an unbalanced distribution, compared to Annaba and Skikda, which are very unbalanced.

Conclusions. The ecological study allowing the analysis of the physico-chemical parameters of seawater at the three sites, La Montagne (El-Kala), Rezgui Rachid (Annaba) and Bikini (Skikda), showed that there is no significant difference in temperature, pH and salinity. However, a very highly significant difference was recorded for dissolved oxygen. We identified eight species of Nereids: *P. cultrifera*, *P. oliveirae*, *P. macropus*, *P. marionii*, *P. dumerillii* and *N. falsa*. At site 1, the richness and abundance are the highest compared to those of the other two sites (2 and 3), and according to the Shannon-Weaver index, El-Kala is a site rich in biodiversity.

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Conflict of Interest. The authors declare that there is no conflict of interest.

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