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# Distribution of soft-bottom benthic molluscs in the Gulf of Oran (Western Algeria)

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## ABSTRACT

A total of 46 samples were taken in the softbottom of the Gulf of Oran, in order to study the nature of the sediments and the spatial distribution of the mollusc communities. As a result of sampling in the study area, at depth range (30 m -106 m), a total of 29 species were identified, included in two classes: Gastropoda and Bivalvia. The use of multivariate statistical analyzes, as well as particle size analysis, made it possible to identify the main mollusc communities. Six mollusc communities were defined from faunistic and sedimentologic affinities. The malacological fauna of the Gulf of Oran is dominated by *Saccella commutata* (33.33%), *Limatula subauriculata* (20.83%) and *Nucula sulcata* (20.83%). The main ecological stocks are mixicole and coastal detritus species. The malacofauna of the Gulf of Oran is scarce and less diversified due to the nature of the soft bottoms (sand and gravel) and the absence of terrigenous inputs.

**Keywords:** Molluscs, Gastropoda, Bivalvia, softbottom, Gulf of Oran, Western Algeria

## Introduction

As the majority of the other emerged coasts all around the Mediterranean Sea, the northern extremity of the African continent is prolonged under the sea by a very tight submarine bordure (Leclaire, 1972). The gulf is subject to strong human pressure: harbours activities, urban and industrial wastewater discharges (Remili and Kerfouf, 2013; Benali et al., 2017; Rouabhi, 2020). The gulf of Oran is supplied by waters originated from the Atlantic Ocean and the circulation seems to be very turbulent along the African continent. These turbulences favour the dispersion of eventual pollution sources and permit a so relative important food chain development (Millot, 1999).

The objective of the study was related to the spatial distribution of mollusc communities in the Gulf of Oran. The majority of research on marine mollusc diversity and spatial distribution are incomprehensive and focuses only on a small geographical area. Nevertheless, this region was considered poor in terms of species (Pallary, 1900; Llabadore, 1935; Vaissière et al., 1963; Amar, 1998; Kerfouf et al., 2007). On the Algerian coast, few synthesis works has been carried out regarding the marine macrobenthic fauna (Dautzenberg, 1895; Meziane and Kerfouf, 2018; Bakalem, 1979). Molluscs communities structure analysis is a good method in the study of environmental modifications caused both by natural and anthropic perturbations (Palaz, 2005). In fact, some results show the response of the molluscs communities to different disturbance sources in a simple way.

## Material and Methods

### *Sampling*

The Gulf of Oran, on the Algerian Mediterranean coast, is located between the industrial Gulf of Arzew in the east (Cap Carbon), and cap Falcon in the west, mainly represented by two important harbours Oran and Mers El Kebir. According to the bathymetry of this zone, 23 stations have been prospected. The nearest coast station was at 30 m depth and the most far was at 106 m depth (Figure 1). Aberdeen benne (Smith McIntyre) has been used for the sediments and benthos sampling operations. All fauna and sediment were fixed in 10% formalin.

### *Data analysis*

The first segregation of the samplings was made according to the great zoological groups. Then the molluscs species were identified by using several references (Hinton, 1972; Springsteen and Leobrera, 1986; Poppe, 2008; Wong, 2011). The frequency of each inventoried species was noted, in order to establish species abundance and dominance calculations.

The sediments were analyzed in order to determine the nature and the texture of the substrate (Caulet, 1972). The method used consists of passing the dried sediment (100 g) through a column of 16 superimposed sieves (AFNOR, 1996). The granulometric analysis allows the size and the distribution evaluations of the particles constituting the sediment (Table 1).

Several classical and synthetic methods were used in order to evaluate the distribution and faunal structure such as abundance, and species richness.

As a first step, the results were processed using the multi-variable analysis method HCA (hierarchical ascendant classification), and also the sedimentary analysis permitted, to highlight the structure of the main malacofauna communities of the Gulf of Oran.

In a second step, a matrix correlation analysis was applied, in order to calculate a checkerboard score ("C-score"), which is a quantitative index of occurrence that measures the extent to which species coexist less frequently than predicted by luck (Gotelli, 2000). A community is structured by competition when the C-score is significantly larger than expected by chance (Tondoh, 2006; Tiho and Josens, 2007). It compared the co-occurrence patterns with null expectations. Gotelli and Ellison (2013) suggest using the statistical null model Fixed-Fixed, as in this model, when the row and column sums of the matrix are preserved. The null model analyses were likewise performed using the R software (R Development Core Team, 2009) and the EcosimR package (Gotelli and Graves, 1996; Gotelli and Ellison, 2013; De los Ríos-Escalante et al., 2020).

**Table 1.** Geographical coordinates and physical characteristics of the studied sites

| Site | Coordinates N | Coordinates E | Depth (m) | Median (mm) | Gravel (%) | Sands (%) | Muddy (%) |
|---|---|---|---|---|---|---|---|
| 1.7 | 35°45’45’’ | 00°42’65’’ | 70 | 0.386 | 58.86 | 35.71 | 5.43 |
| 1.9 | 35°47’23’’ | 00°41’55’’ | 90 | 0.286 | 48.86 | 49.71 | 1.43 |
| 2.4 | 35°46’70’’ | 00°40’60’’ | 82 | 0.346 | 12.43 | 74.03 | 13.54 |
| 3.1 | 35°44’38’’ | 00°40’25’’ | 61 | 0.372 | 59.71 | 30.14 | 10.14 |
| 4.2 | 35°43’05’’ | 00°39’00’’ | 66 | 0.215 | 31.57 | 51.71 | 16.71 |
| 4.3 | 35°44’05’’ | 00°39’00’’ | 74 | 0.343 | 15.57 | 75.00 | 9.43 |
| 4.4 | 35°44’09’’ | 00°38’09’’ | 77 | 0.209 | 54.14 | 42.71 | 3.14 |
| 4.6 | 35°47’03’’ | 00°78’01’’ | 82 | 0.328 | 48.86 | 46.70 | 4.44 |
| 5.6 | 35°43’08’’ | 00°37’05’’ | 60 | - | - | - | - |
| 5.7 | 35°45’00’’ | 00°37’00’’ | 70 | - | - | - | - |
| 5.9 | 35°48’06’’ | 00°36’05’’ | 94 | 0.316 | 10.43 | 76.03 | 13.54 |
| 5.10 | 35°48’04’’ | 00°36’08’’ | 106 | 0.364 | 12.13 | 77.13 | 10.54 |
| 6.4 | 35°44’68’’ | 00°35’67’’ | 39 | 0.305 | 6.00 | 93.57 | 0.43 |
| 6.5 | 35°45’42’’ | 00°35’70’’ | 55 | 0.186 | 48.86 | 45.71 | 5.43 |
| 7.4 | 35°47’10’’ | 00°34’60’’ | 60 | 0.339 | 73.14 | 26.43 | 0.43 |
| 7.5 | 35°46’77’’ | 00°34’45’’ | 70 | 0.624 | 48.29 | 49.00 | 2.71 |
| 7.7 | 35°47’10’’ | 00°34’60’’ | 60 | 0.496 | 77.29 | 22.70 | 0.01 |
| 7.8 | 35°48’15’’ | 00°35’20’’ | 70 | rocky | rocky | rocky | rocky |
| 7.9 | 35°48’50’’ | 00°35’50’’ | 80 | 0.365 | 4.00 | 95.57 | 2.43 |
| 8.3 | 35°47’10’’ | 00°33’30’’ | 32 | 0.514 | 19.43 | 80.29 | 0.29 |
| 8.4 | 35°47’40’’ | 00°33’50’’ | 41 | 0.186 | 48.86 | 45.71 | 5.43 |
| 8.5 | 35°47’60’’ | 00°33’65’’ | 49 | 0.551 | 80.00 | 19.14 | 0.86 |
| 8.10 | 35°49’78’’ | 00°34’95’’ | 95 | 0. 462 | 72.86 | 25.86 | 1.29 |

## Results and Discussion

### *Data Collection and Analysis*

A total of 46 samples of all macrobenthic fauna were collected at 23 sites of the continental shelf of the Gulf of Oran at a depth of between 30 m and 106 m. A total of 116 individuals and 29 species belonging to two classes were identified in this area (WORMS, 2022). Each species has an ecological status from a bibliographic synthesis based on the following works (Picard, 1965; Falconetti, 1980; Stora, 1982; Glemarec and Grall, 2000; Costa et al., 2010). This status corresponds to its affinity concerning the substrate (the nature of the sediment fraction) and the quality of the environment (Table 2).

### *Population’s Characterization*

Using Ascending Hierarchical Classification (CHA) for the stations made it possible to regroup stations according to the faunal composition and the substrate nature. The communities identified in the Oran's Gulf (and in most studies concerning the Mediterranean Sea), organized following the classification of biocoenoses proposed by Pérès and Picard (1964). The grain size analysis made it possible to associate each station a sedimentary type. The ascending hierarchical classification (AHC/species/stations), showing six great groups G1, G2, G3, G4, G5 and G6 (Figure 2).

**Table 2.** Faunistic list and ecological significance

| Class | Order | Families | Genus | Species |
|---|---|---|---|---|
| | Mytiloida | Mytilidae | Lioberus | *Lioberus agglutinans* (Cantraine, 1835) Sspr |
| | | | Modiolula | *Modiolula phaseolina* (Philippi, 1844) Sspr |
| | Pectinoida | Pectinidae | Pseudamussium | *Pseudamussium clavatum* (Poli, 1795) Sspr |
| | Limoida | Limidae | Limatula | *Limatula subauriculata (*Montagu, 1808) *Sspr* |
| | Carditoida | Carditidae | Centrocardita | *Centrocardita aculeata* (Poli, 1795) Mix |
| | | | Cardites | *Cardites antiquatus* (Linnaeus, 1758) Sspr |
| | | Astartidae | Gonilia | Gonilia calliglypta (Dall, 1903) Sspr |
| | Myoida, | Corbulidae | Varicorbula | *Varicorbula gibba* (Olivi, 1792) LRE/IMO |
| | Euheterodonta | Hiatellidae | Hiatella | *Hiatella arctica* (Linnaeus, 1767) LRE |
| | Lucinoida | Lucinidae | Loripes | *Loripes orbiculatus* (Poli, 1795) Sspr |
| **Bivalvia** | Anomalodesma- | Lyonsiidae | Lyonsia | *Lyonsia norwegica* (Gmelin, 1791) Mix |
| | taVeneroida, | Cardiidae | Papillicardium | *Papillicardium papillosum* (Poli, 1791) G |
| | | | | *Parvicardium scabrum* (Philippi, 1844) Sspr |
| | | Veneridae | Hysteroconcha | *Hysteroconcha dione* (Linnaeus, 1758) LRE/ DC |
| | | | | *Timoclea ovata* (Pennant, 1777) Mix |
| | | | Timoclea | *Moerella donacina* (Linnaeus, 1758) DC |
| | | Tellinidae | Moerella | *Moerella distorta* (Poli, 1791) DC |
| | | | Moerella | *Gari costulata* (Turton, 1822) Sspr |
| | Nuculanoida | Psammobiidae | Gari | *Saccella commutata* (Philippi, 1848) Mix |
| | Nuculida | Nuculanidae | Saccella | *Nucula turgida* (Gould, 1846) IP |
| | | Nuculidae | Nucula | *Nucula sulcata* (Bronn, 1831*)* V |
| | | | | *Nucula nucleus* (Linnaeus, 1758) Mix |
| | *Cardiida* | *Tellinidae* | Gastrana | *Gastrana fragilis* (Linnaeus, 1758 ) Sspr |
| **Gasteropoda** | Neogastropoda | Nassariidae | Tritia | *Tritia lima* (Dillwyn,1817) Sspr |
| | | | | *Tritia reticulata* (Linnaeus, 1758) Sspr |
| | | Fasciolariidae | Gracilipurpura | *Gracilipurpura rostrata* (Olivi, 1792) Mix |
| | | Buccinidae | Euthria | *Euthria cornea* (Linnaeus, 1758) Sspr |
| | | Naticidae | Notocochlis | *Notocochlis dillwynii (*Payraudeau, 1826) Sspr |
| **Total** | 13 | 20 | 24 | 29 |

***G**: gravel, **DC**: coastal detritic, **IP**: indicator of pollution, **IMO**: organic matter indicator, **LRE**: species with wide ecological distribution, **Mix**: mixicole, **S**: sandy species, **Sspr**: species with no specified ecological significance, **V**: muddy species.*

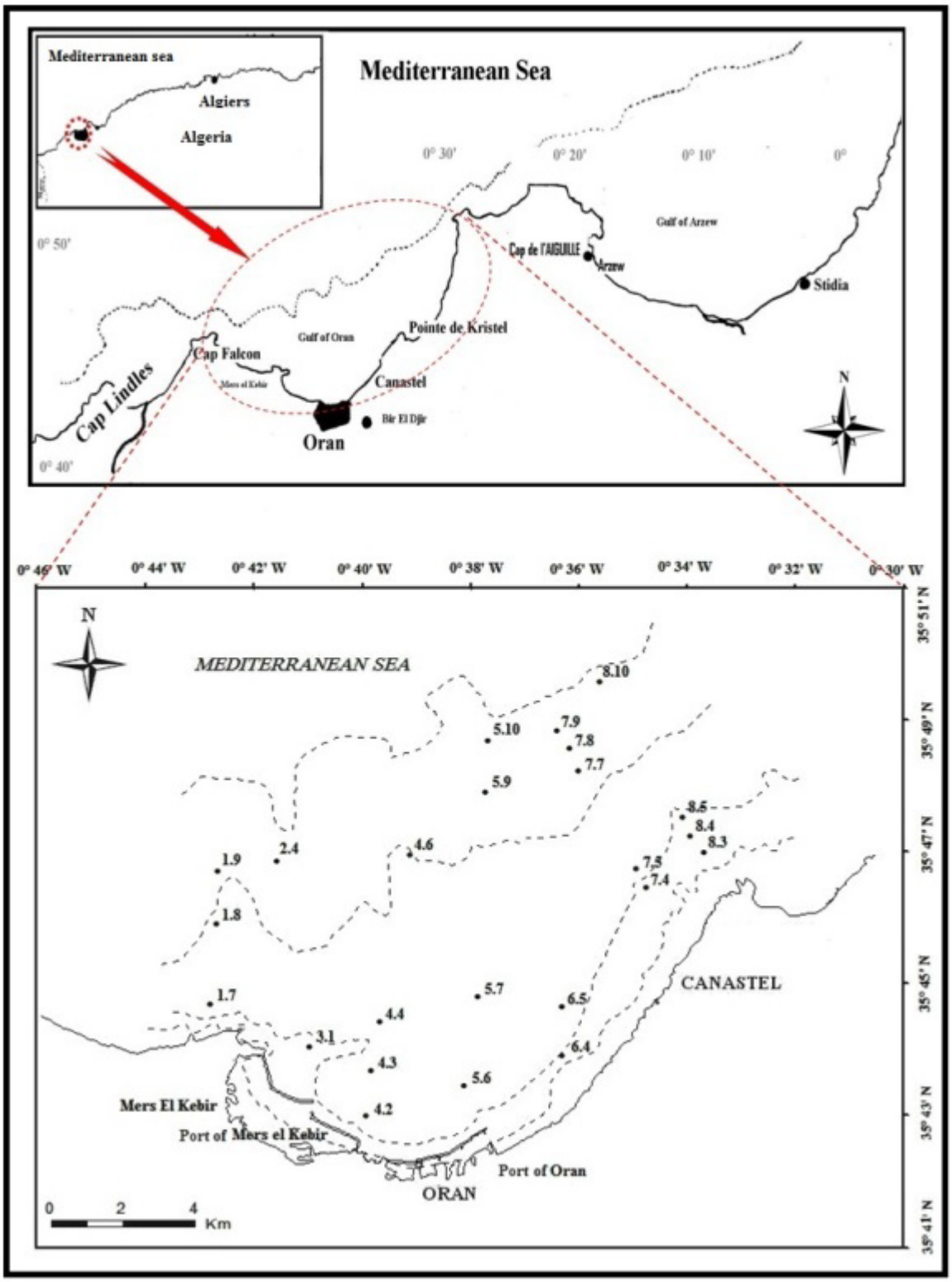


**Figure 1.** The locations of the sampling sites.

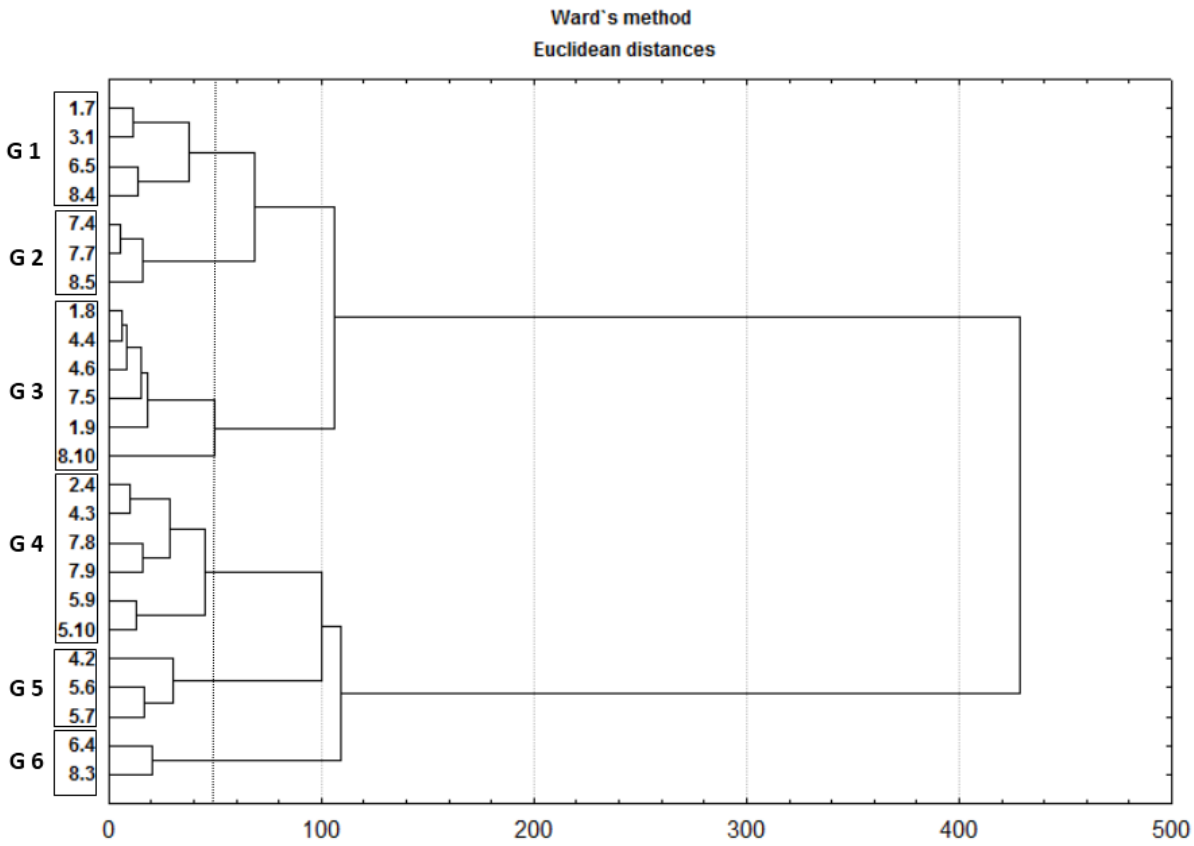


**Figure 2.** Ascending hierarchical analysis (AHC)

Six mollusc communities were defined from faunistic and sedimentologic affinities (figure 3).

The G1 group is made of 4 stations (1.7, 3.1, 6.5, and 8.4). The G2 group is composed of 3 stations (7.4, 7.7, and 8.5). G3 group and G4 are comprised of 6 stations (1.8, 1.9, 4.4, 4.6, 7.5, 8.10), and (2.4, 4.3, 5.9, 5.10, 7.8, and 7.9), respectively. The G5 and G6 groups are formed of 3 stations (4.2, 5.6, and 5.7) and 2 stations (6.4, 8.3).

The main communities are represented by the groups of stations: G3 and G4. They are each represented by 6 stations. G3 represents the community of *Nuculana commutata* (27.27%) and *Papillicardium papillosum* (18.18%) with mixed sediments (gravel 50%, sands 47%, muddy 3%), and G4 represents the community of *Nucula turgida* (23.80%) and *Nuculana commutata* (23.80) located on a sandy substrate (sands 80%, muddy 10%, gravel 10%). Both communities are far from the coast at a depth of 80m. The diversity of sedimentary habitats provides this community with good conditions for development. The characteristic species of Group G3 are *Nuculana commutata, Papillicardium papillosum, Amygdalum phaseolinum, Limatula subauriculata, Nassa limata, Nucula nucleus, Nucula turgida* and *Timoclea ovata.* For group G4, the pool of characteristic species is made up of *Nucula turgida, Nuculana commutate, Hiatella arctica, Cardita aculeta, Varicorbula gibba, Gracilipurpura rostrata, Limatula subauriculata, Nassa limata, Nucula nucleus, Nucula sulcata, Parvicardium scabrum,* and *Hysteroconcha dione.*

The G1 group is formed of 4 stations representing the community of *Nuculana commutata* (63.15%). This community is located at a depth between – 40m and -70 m, and on a

mixed soft-bottom (sands 40%, gravel 55%, muddy 5%). The malacological composition of this community is represented by *Nuculana commutata, Collochiton larvis, Euthria cornea, Limatula subauriculata, Lyonsia norwegica, Nucula sulcate, Tellina donacina, and Timoclea ovata.*

Groups G2 and G5 are each made up of 3 stations, and represent respectively the community of *Nucula sulcata* (53.84%) and the community of *Parvicardium scabrum* (22.22%) and *Notocochlis dillwynii* (22.22%). These two communities are located in the central area of the gulf, at a depth between - 55m and - 65m. The two species *Nucula sulcata* and *Tellina donacina* are present in both communities.

Finally, the community of *Nucula turgida* (27.27%) and *Venericardia antiquate* (18.18%), constitutes the G6 group. This group is located almost along the coast of the gulf (depth < -40m), and sand is the dominant sediment (>80%). The specific composition of this malacological community is represented by *Nucula turgida, Cardites antiquatus, Varicorbula gibba, Gari costulata, Tritia reticulata*, *Limatula subauriculata, Loripes orbiculatus, Peplum clavatum.*

In general, the malacological fauna of the Gulf of Oran is dominated by *Nuculana commutata* (33.33%), *Limatula subauriculata* (20.83%) and *Nucula sulcata* (20.83%). The large ecological stocks are mixicole species and coastal detritus species. The malacofauna of the Gulf of Oran is scarce and less diversified (29 species) due to the nature of the soft bottoms (sand and gravel) and the absence of terrigenous inputs.

The results of the null model analysis revealed that species associations are structured; this means that these are not random (observed index > mean index, and "p" value lower than 0.05). Whereas the niche sharing revealed that species share ecological niche, and in consequence, there are interspecific competition (see observed index > mean index; and "p" value lower than 0.05) (Table 3).

The distribution of macrobenthic species depends on the nature of the substrate and the quality of the water due to hydrodynamics and anthropic activities.

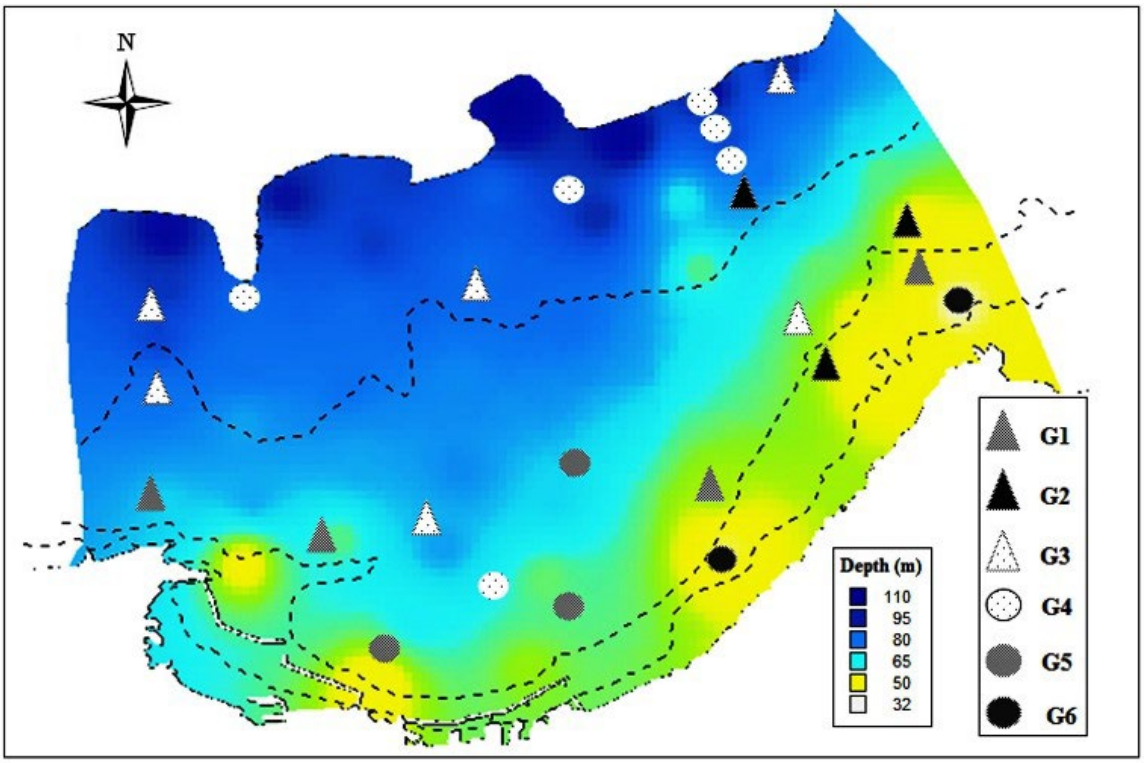


**Figure 3.** Mollusc communities in the Gulf of Oran

**Table 3.** Results of null model analysis in the present study

| | Mean index | Observed index | Variance | Standard effect size | P |
|---|---|---|---|---|---|
| **Species co-occurence** | 3.0924 | 3.2037 | 0.0017 | 2.6982 | < 0.001 |
| **Niche sharing** | 0.1076 | 0.1419 | 0.0001 | 10.8170 | <0.001 |

The present study indicates that the malacological fauna is less diverse than previously reported in other studied areas of the Algerian coast (Hassam, 1991; Oulmi, 1991). Data analysis such as zoological composition, nature of the sediments and the depth of the Molluscs of the Gulf of Oran has shown the six main communities. The results of the null model analysis revealed that species associations are structured. The results confirm that the malacological fauna of the Gulf of Oran is relatively poor from a specific point of view, both qualitatively and quantitatively, compared to what is known along the Algerian coast (Rebzani-Zahaf, 1992; Amar, 1998; Meziane et al., 2020; Bakalem et al., 2020) because only 29 species were observed. The conclusions also provide insight into the impact of the sedimentary compartment and the quality of the environment on the biogeography of the mollusc group. The knowledge of the mollusc assemblage in an area is a key requirement for the design of conservation measures (Lodeiros, 2011). Thus, surveys of benthic invertebrate assemblages in marine habitats, such as the anthropogenic region studied, are of fundamental importance to biomonitoring and the development of conservation strategies (Lima, 2017).

## Conclusion

As a conclusion, a total of 29 species of benthic molluscs were identified. This study on the benthic malacofauna sampled on the Gulf of Oran constitutes an inventory of the coastal ecosystem and complements the database because bionomic research is rarely studied and fragmented. This study also provides a clear description of the main characteristics of six mollusc communities.

**Compliance with Ethical Standard**

**Conflict of interests:** The authors declare that for this article they have no actual, potential, or perceived conflict of interests.

**Ethics committee approval:** Ethics committee approval is not required.

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