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Faunal composition, distribution and richness of the Oran's intertidal coastal zone (Mediterranean Sea, Algeria)

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Abstract

This study is based on the inventory of coastal benthic faunal at the level of 13 coastal sites through Oran's coast from Sidi Medjdoub (Mostaganem) to Sebiate (Ain Témouchent). The differences that are determined on basis of the habitat / biodiversity shows a variation between the systems (natural, artificial, polluted, visited, and inhabited). The difference is visible on the coastal system, which remains distant from anthropogenic pressure with an important diversity of populations (Ain Defla, Madagh II), compared to the artificial coastal system of Oran's harbour dyke, or inhabited like Bousfer. This official report clearly explains the influence of hydrodynamic functioning and the importance of human impact at different levels.

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Introduction

Oran is located in South East of Alboran Sea (Eastern Mediterranean) (fig 1). The coast of Oran with its 2 million inhabitants is characterized by a strong expansion, but unfortunately it is developing in the coastal side (Bouras and Boutiba, 2006). The consequence of this expansion is the pollution whose origin is domestic waste and industrial development (Boutiba *et al.*, 2003) with a lack of sewage treatment (Seridi *et al.*, 2007).

The studied zone has a colossal natural reserve with more than 800 marine species (Daauvin *et al.*, 2013) made up of a big and important potential heritage that needs to be safeguarded (Bouras and Boutiba, 2004; Bouras, 2007; Bouras, 2012). On the other hand, there are not enough data on biodiversity in this region.

The composition and abundance of benthic macro-invertebrate fauna is one of the elements proposed for benthic quality assessment and for determining ecological status (Texeira *et al.*, 2009) to study the environmental modifications caused by natural or anthropogenic perturbations in the region (Bakalem *et al.*, 2009; Grimes *et al.*, 2010).

The diversity of species in a particular area does not depend only on the number of species found, but also in their density. Ecologists call the number of species in an area its richness, and the relative abundance of species its evenness (Camargo, 1995). Ecological indicators are employed with the aim of supplying synoptic information about the state of ecosystems (Salas *et al.*, 2006). This work is the first one about biodiversity of the intertidal rocky shore population in the region of Oran.

The work's aim is to establish the organization and structure of benthic communities, in different areas, visited during an annual cycle. The results have impacts on ecological threatened sites. They will reveal medium-term changes in population densities of coastal species in the intertidal zone and will help to understand future modifications and the effect of climate changes (Bianchi and Morrià, 2000; Helmuth *et al.*, 2006) on the intertidal zone in the event of elevation of sea level in the long-term changes. In this study, we sampled the intertidal rocky shore fringe macrofauna communities of Oran region (Algeria), using strictly the same methods as in the above-mentioned studies, at sites assumed to correspond to pollution level, natural or artificial, high or low hydrodynamic.

Materials and methods

Geographic location

Oran is located on the east side of Algerian coast and in the South West of Alboran Sea (South East Mediterranean). It is the starting point of the Algerian current. The sampling zone is 13 sites extented over 160km (fig 1; table 1).

Table 1. GPS localization and characteristic of the studied sites.

Location	GPS Positions	Specifications
Sebiate Island, Ain Temouchent (SI)	35.553191N, 1.200327W	Remote area
Madagh II, Ain Temouchent (MII)	35.632936N, 1.071474W	Remote area
Bousfer, Oran west (BOU)	35.733432N, 0.843256W	Inhabited area
Pain Sucre, Oran West (PS)	35.766916N, 0.818892W	Remote area
Cap Falcon, Oran West (CF)	35.773258N, 0.792181W	Remote area
Port of Oran (digue) (OP)	35. 42811 N, 0.393591W	Artificial area
Ain Defla (Kristel) exposed, Oran Est (ADE)	35.877224N, 0.296423W	Remote area
Ain Defla (Kristel) abrité, Oran Est (ADA)	35.840142N, 0.484806W	Remote area
Cap Carbon Est (Arzew West), Oran (ECC)	35.901231N, 0.339445W	Inhabited area
Port Arzew West, Oran (WPA)	35.877224N, 0.296423W	Weakly Inhabited area

Mersa Hadjadj (Arzew Est), Oran (MH)	35.799916N, 0.166857W	Inhabited area
Mersa Hadjadj Vermet (Arzew), Oran (MHV)	35.800244N, 0.163559W	Weakly Inhabited area
Sidi Mejdoub, Mostaganem (SM)	35.968316N, 0.092179E	Inhabited area

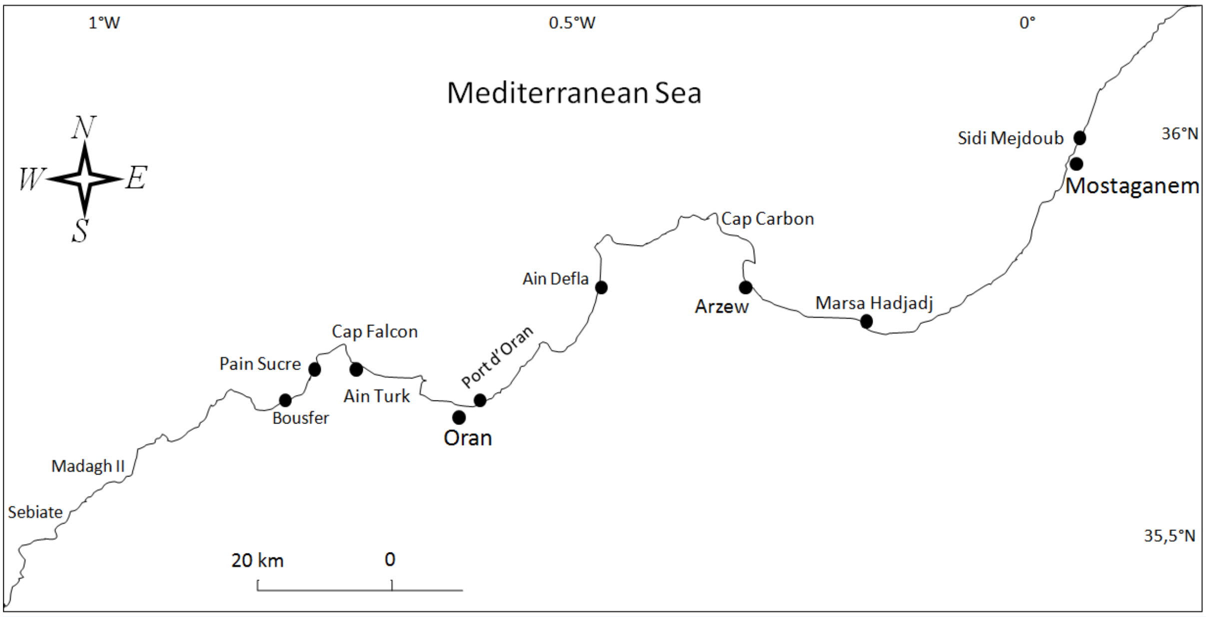

Fig. 1. Geographical localization of the studied zone.

Fieldwork and sampling

About thirty sampling missions in sea were carried out on several sectors, 13 sites have been visited twice: in winter and in summer. The sampling was performed according to a non-destructive method. From this perspective, a 10 m transect was drawn on the foreshore of each site (the same method of counting limpets of Guerra-García *et al.* 2004 ; Espinoza, 2009, and fauna being at the level of the studied transect coastal sectors was shot *in situ* then identified in laboratory, in order to list the different benthic intertidal communities, which characterizes the habitats of the targeted coastal sectors. The identification of fauna is principally based on FAO index of species identification for the needs of fishing of 1987 (Fischer *et al.*, 1987).

Only J' and H' results failed on Oran's Port Site because the dike became now a military zone.

Diversity and specific richness

The general structure of the population was assessed across specific richness index S (total number of species listed on the zone of study) (Fig 3; 4; 5 and 6). This index combines at the same time richness and regularity and allows therefore the appreciation of the benthic population diversity present on the whole zone of study (Trigui *et al.*, 2007).

Then through the Shannon indices H'. The importance of Shannon's indices is to provide important information about rarity and commonness of species in a community (fig 3; 4 and 5). The ability to quantify diversity in this way is an important tool for biologists trying to understand community structure (Grall and Hily, 2003). The results will be strengthened and confirmed or disproved due to lack of accuracy of the biodiversity richness S. Shannon's indices is useful when one need comparison between different locations (Bajpai *et al.*, 2012).

The Shannon index is accompanied by the Pielou equitability index J'. The equitability index measures the distribution of individuals within species, regardless of species richness S (Grall and Coïc, 2006). In other words, it represents an evenness index of species; mathematically it is defined as a measure of biodiversity which quantifies how equal the community is numerically (Mulder *et al.*, 2004).

This approach will allow us to determine the difference of biodiversity between the following coastal sectors: Sidi Medjboud, Marsa El Hadjadj (platforms in vermets and rocky coast), Arzew, Cap Carbon, Ain Defla-Kristel (facing waves and sheltered), Harbour of Oran, Cap Falcon, Pain Sucre, Bousfer, Madagh II, Sébiate Island) and to find the responsible biotic and abiotic factors.

Shannon's index: $H' = - \Sigma ((Pi) \times \log_2 (Pi))$

Pi = Proportion of *S* made up of the *i*th species **Pi = ni / N**

ni = Number of entities of the species

N= total number of entities of the dataset.

Equitability index: $J' = H'/H'max$

$H'max = \ln S$ (S= Specific richness)

Results and discussion

Identification, inventory and species distribution

The identified species are shown in Table 2. The Fig. 2 shows the dominance of each group at each site of our study.

Ain Defla is the richest site in terms of biodiversity because of low human pressure exerted, and sea currents bringing full of nutriments from west which feeds the fauna (macro and microalga) which represents the first link of food chain.

Table 2. Density of intertidal species in Oran coastal zone.

Groupe	Taxons	SI	MII	BOU	PS	CF	OP	ADE	ADA	ECC	WPA	MH	MHV	SM
SPONGES	*Crambe crambe* (Schmidt, 1862)	-	-	-	+-	-	+	-	-	-	-	-	-	-
	Haliclona cratera (Schmidt, 1862)	-	+-	-	-	-	-	-	-	-	-	-	-	-
CNIDERIA	*Anemonia viridis* (Forsskål, 1775)	-	-	-	+	-	-	++	-	-	+-	-	-	+
	Actinia equina (Linnaeus, 1758)	-	+	+-	+	+-	+	+-	-	-	+	-	-	+-
ECHINODERMS	*Paracentrotus lividus* Lamarck, 1816	-	+	-	+-	-	+	++	-	-	-	-	-	+
	Starfish sp.	-	-	-	-	-	+-	-	-	-	-	-	-	-
BIVALVIA	*Mytilus galloprovincialis* Lamarck, 1819	-	-	-	-	-	++	++	-	-	-	-	++	++
POLYPLACOPHORA	*Chiton olivaceus* Spengler, 1797	-	-	+	-	-	+	++	+-	-	-	++	++	-
GASTEROPODA	*Patella caerulea* Linnaeus, 1758	++	++	++	++	++	-	++	++	++	++	++	++	-
	Patella rustica Linnaeus, 1758	++	-	+	+	-	-	+	-	+-	++	++	+	++
	Patella ferruginea Gmelin, 1791	+	+	+	+	++	++	++	+-	+	+	+-	+	-
	Patella vulgata Linnaeus, 1758	-	-	-	-	-	-	-	-	+	-	-	-	-
	Siphonaria pectinata Linnaeus, 1758	+	-	+	++	-	-	+-	++	+-	+	++	++	++
	Stramonita haemastoma (Linnaeus, 1767)	-	-	-	+-	+-	+-	+	-	-	-	+-	-	++
	Osilinus turbinatus (Born, 1780)	++	++	+	+	+	+	++	+	+	+	-	+	++
	Melarhaphe neritoides (Linnaeus, 1758)	++	-	-	-	++	++	-	++	-	++	++	++	++
	Dendropoma cristatus (Biondi, 1857)	++	-	-	-	-	++	++	-	-	-	-	++	-
CRUSTACEANS	*Chthamalus stellatus* (Poli, 1791)	++	++	-	-	++	++	++	-	-	++	++	-	++
	Ligia italica Fabricius, 1798	++	++	-	-	++	++	++	-	-	-	++	-	-
	Pachygrapsus marmoratus (Fabricius, 1787)	-	-	+-	+-	+-	+-	+-	-	+-	+-	+	-	-
	Carcinus maenas (Linnaeus, 1758)	-	+-	-	-	+-	-	+-	-	-	-	-	-	-

	Pollicipes pollicipes (Gmelin, 1789)	-	+-	-	-	-	+	+-	-	-	-	-	-	-

- Absent (0) +- Rare (<5) + moderately abundant (5-30) ++ abundant (>31)

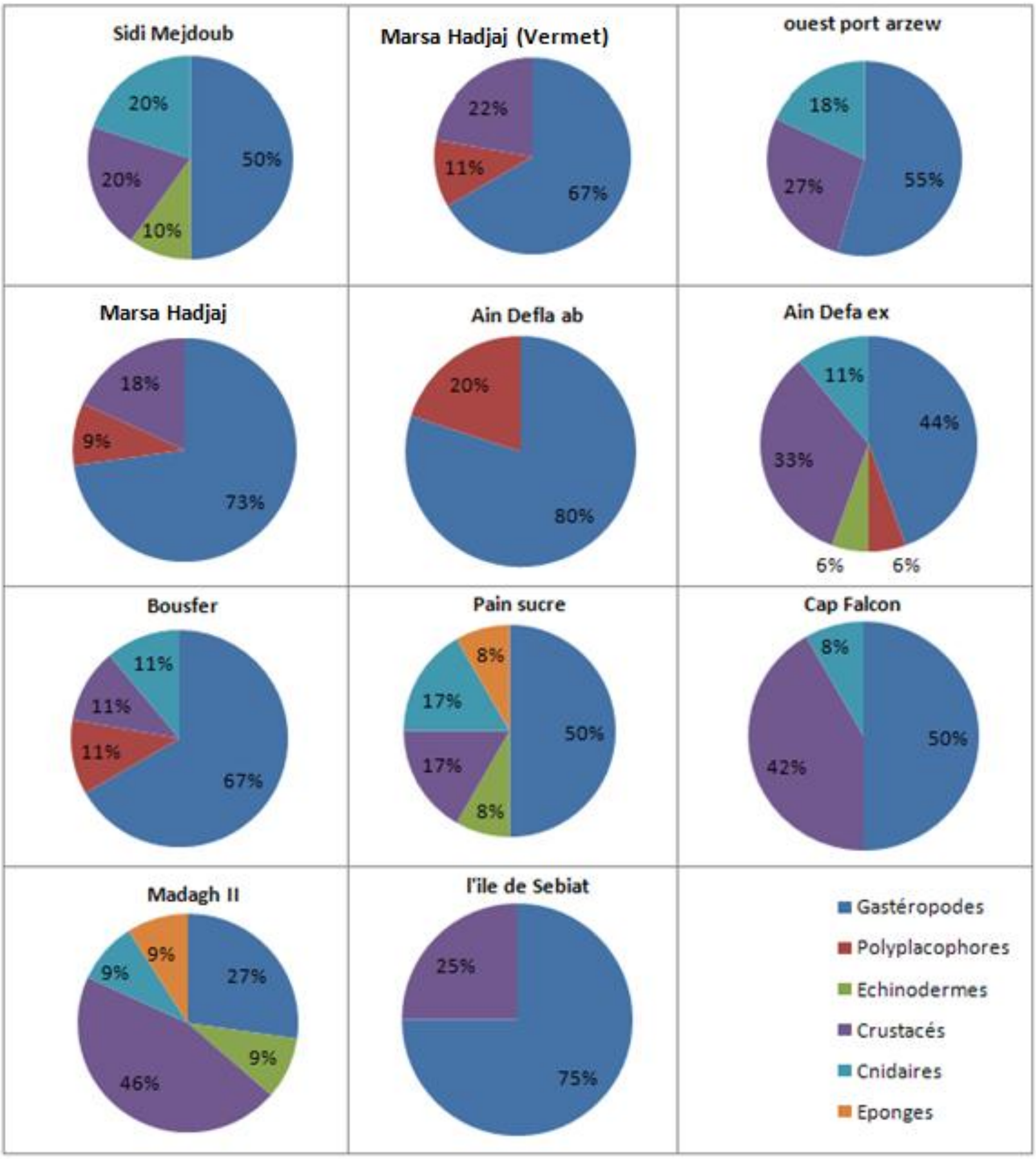

Fig. 2. The distribution of the principal groups of fauna in Oran intertidal zone.

An important dominance of the group of Molluscs Gastropoda is noted, compared to other zoological groups listed at the level of Ain Defla-Kristel. Indeed, half of intertidal benthic biological diversity is represented by 9 species of Gastropoda on a specified faunistic richness equal to 18. All kinds of Mediterranean limpets are present: *Patella caerulea, Patella ferruginea, Patella rustica* and the false limpet *Siphonaria pectinata*. In some zones, difficult to access the biggest individuals to be found are found

Patella caerulea as well as *Stramonita haemastoma* (about 8 cm in length).

Let us note the presence of the Mollusc Gasteropoda *Dendropoma petraeum*, responsible for the formation of vermetid platforms in pavements (Boudouresque, 2004).
The Crustaceans are represented by 4 species: two species of crabs, a big density of Balanomorpha or Chtamales *Chthamalus stellatus* and the tiny Crustaceans *Ligia italica*.

Cnidaria is represented by the beadlet anemone *Actina equina*, and the sea anemone *Anemonia viridis*. They are carnivore species nourishing on small fishes and crustaceans which they capture by paralyzing them with their tentacles. When the sea leaves, certain anemones retract and leave behind only gelatinous bowls.

An important population of Echinoderms is represented by a single species: the common sea urchin *Paracentrotus lividus*, which size varies from 4 to 12 cm in diameter. The smallest ones were observed at the level of platforms on the lower intertidal part while the biggest ones were observed on the infratidal floor.

At the level of platforms in vermets, an important number of the common mussel *Mytilus galloprovincialis* is found.

Molluscs Polyplacophora (a multi plate shell**)** are represented by the *Chiton olivaceus*. The latter looks like what could be Mollusc. It can, therefore, be considered very archaic (Brugneaux and Peres, 2002).

On the same site of Ain Defla-Kristel, at the level of sites safe from waves that can erupt on the coast, richness decrease to 9. This result is explained by the weak oxygenation and dryness due to the feeble hydrodynamic movements.

Another natural site, Sebiate Island is marked by a very weak richness S due to vermetid terraces and a type of substratum (sandy rock) that cannot welcome a strong benthic population.

The biological diversity (fauna and the flora), on the side of the pier of Oran's harbor, is less important than that of Ain Defla-Kristel, where the specific richness is 15. However, some populations are very present at the level of the site; case of *Patella rustica* in Oran's harbor dyke. Some faunistic and floristic populations decrease when moving east (fig 6).

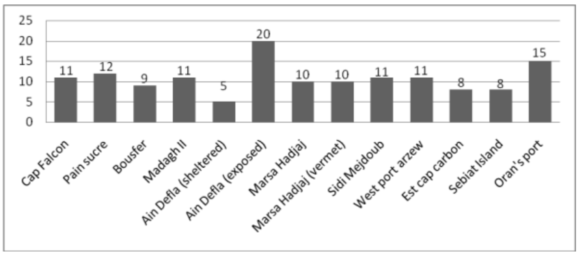

Fig. 3. Distribution of the biodiversity richness S in Oran's coast.

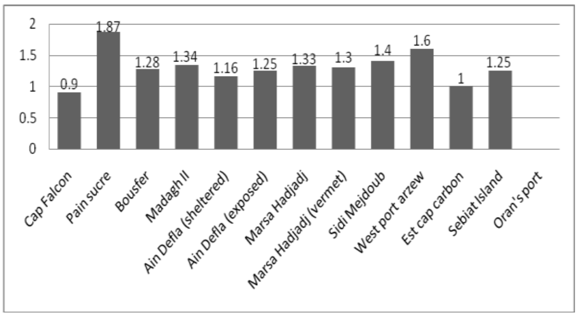

Fig. 4. Distribution of the Shannon's index H' in Oran's coast.

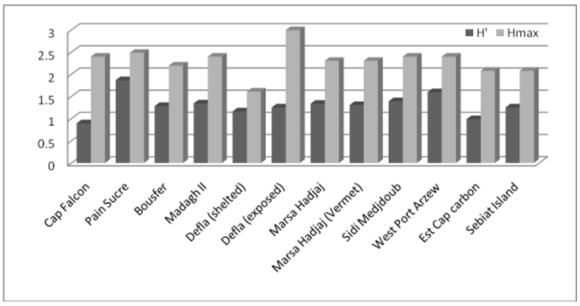

Fig. 5. Graphic of H' and Hmax in Oran's coast.

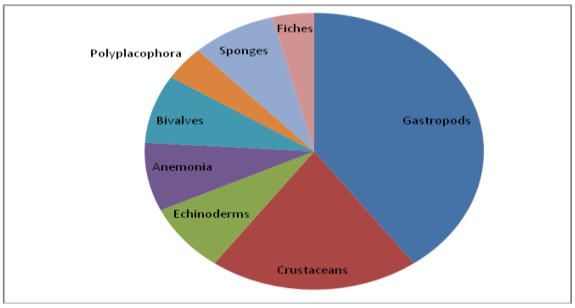

Fig. 6. General distribution of the specific richness on Oran intertidal zone.

Specific richness

Furthermore, many forms of biodiversity fit to ecological requirements of the artificial substrate of Oran's dyke. Thus by taking into account species which face up to the pollution generated by the emissary ejection of Fort Lamoun, different anthropogenic attacks and important hydrodynamic action of this coastal sector [18]. Although the biodiversity value is inferior compared to Ain Defla-Kristel, the number of Gasteropoda species remains predominant compared to other groups, with nearly 1/3 of the intertidal benthic population of the dyke. Indeed, 6 species of Gastropoda S=16 of intertidal fauna with an abundance of limpets of high important density throughout the dyke (Kallouche *et al.*, 2012). Inspite of the presence of only three species of limpets: *Patella caerulea*, *Patella ferruginea* include an abundance of two subspecies (*lamarcki* and *rouxi*) and the false limpet *Siphonaria pectinata*.

The giant limpet *Patella ferruginea* develops better on coasts exposed to hydrodynamic and escapes sheltered coasts (Rais *et al.*, 2002). This observation is applicable on the population of *Patella rustica* at the level of the pier of Oran's harbour dyke. Indeed, a clear abundance of the latter kind was recorded on this coastal portion where waves are extremely strong. The giant limpet *Patella ferruginea*, is an endemic species of the Western Mediterranean. It is a protected species, whether on the international level (Convention of Barcelona, 1996), or on the national level (Official Gazette of the Republic of Algeria 22/11/2006), this kind of limpet is more frequent with a density that reaches up till 20 individuals / m². Yet, the population of the same kind is not as frequent in Ain Defla-Kristel. This species which used to be very abundant, now seems to be confined on the Mediterranean insular zones and north of Africa, it is an endangered species of the North side of the Mediterranean Western basin (Guallart *et al.*, 2012).

The big Gasteropoda *Stramonita haemastoma*, the Trochidae *Osilinus turbinatus* and tiny *Melarhaphe neritoides* presence is noted, According to Cabral-Oliveira *et al.* (2009) *Melarhaphe neritoides* population density was higher at the impacted area.

Regarding the group of the Crustaceans, the existence of *Chthamalus stellatus* is noted, the liege of shores *Ligia italica* which moves on intertidal and Supratidal floors, the crab *Pachygrapsus marmoratus* and *Pollicipes pollicipes* which is a species living rather in a strong hydrodynamic habitat (Pergent *et al.*, 2007).

Regarding the population of Echinoderms, besides the common sea urchin *Paracentrotus lividus*, we note the presence of a kind of a starfish in the upper infratidal zone. The common mussel *Mytilus galloprovincialis,* a very resistant to pollution species, is widely present with a very frequent population, with individuals of big sizes (exceeding 5 cm), on both sides of the dyke (external nad internal sides of the harbour).

Let us also note the presence of Cnidaria *Actina equina*, and the absence of sea anemone on the external side of the dyke. Conversely, of the internal side of the same dyke, the anemone presents a very important density making a sort of tentacles carpet. As for sponges, we find the sponge *Crambe crambe*, the distinguishes itself with its lively orange color, is found on rocks sheltered from light as well as calcareous sponge *Haliclona cratera* of pale orange color turning to pink as in our present study. The group of Polyplacophora is represented by the *Chiton olivaceus*.

The sites that are exposed to the hydrodynamic force are richer than sheltered zones. Indeed, we observe in Ain Defla a huge difference between sheltered areas and areas exposed to the hydrodynamic force in term of specific wealth (fig 1).

Regarding Artificialised inhabited Site, Bousfer is edged by houses built at the boundary of the coastal fringe, and this site remains much polluted. The inhabitants of houses edging this coast generally pour their wastewaters directly into the sea by means of simple PVC channels.

Concrete cubes are stored on the external side of the dyke, so that water enters at the level of the interspaces which separate them, to absorb the frontal shock of waves. These cubes constitute an extension of intertidal zone inside the dyke, so the density of the population of *Patella caerulea*, of *Patella ferruginea* and other intertidal populations are present with a very important density. Besides, the flat, broad surfaces tipped up by concrete cubes, constitute a continuity of intertidal floor (about more than three meters wide), and offer new biotopes, very favorable to the fixing of the benthos.

Vermitid Platforms (Ain Defla-Kristel) are generally located on the intertidal floor, above the high tide level; however, it is present at a lower level, often with a slope towards the sea. These platforms are a biological construction built by the close association of two species: a vermited gastropod *Dendropoma petaeum* and uncrusting coralline alga *Neogoniolithon brassica-florida*. Swept by waves, the pavement is covered with a fine film of water, of some centimeter in thickness, allowing survival and institution of various populations of Invertebrates and alga which are going to fit to this milieu. This state explains the presence of some animal or plant species in the intertidal floor, while they usually visit the infratidal floor (especially the algale population), contributing to the importance of the remarkable biodiversity determined in Ain Defla-Kristel (table 3).

Table 3. Different indices of intertidal biodiversity.

	S	H'	Hmax	J'=H'/Hmax
Cap Falcon	11	0,9	2,4	0,37366749
Pain Sucre	12	1,86	2,5	0,7521433
Bousfer	9	1,3	2,2	0,5846714
Madagh II	11	1,34	2,4	0,56042579
Defla (shelted)	5	1,16	1,6	0,72400014
Defla (exposed)	20	1,25	3	0,41797514
Marsa Hadjadj	10	1,33	2,3	0,5802522
Marsa Hadjadj (Vermet)	10	1,3	2,3	0,56769084
Sidi Medjdoub	11	1,4	2,4	0,58023568
West Port Arzew	11	1,6	2,4	0,66561939
Est Cap carbon	8	1	2	0,47592938
Sebiat Island	8	1,25	2	0,60217588

We note that some species are not very widespread on Oran's coast in general and on the intertidal floor especially as it is the case of *Pagurus bernhardus*, the sponges (*Crambe crambe, Haliclona cratera*) which are infratidal species, or foreign species as is the case of the common limpet of the Atlantic *Patella vulgata* which presence is insignificant compared to other limpets (Arzew and Cape Carbon).

Index of Shannon

The using of Shannon's indices is significant when different locations are studied. Our study reveals that Pain Sucre is the more homogeneous. The site Pain Sucre is characterized by the biggest index of Shannon (H'=1.87), it means that all the different communities are represented with an important density , which means that this studied site is healthy, probably because Pain Sucre is a wild uninhabited area.

when comparing the same site with different parameter of hydrodynamics we find out that the exposed area of Ain Defla-Kristel (H'=1.25) is better than the sheltered site (H'=1.16). The landscapes of Ain Defla (exposed) and Sebiate Island are similar with the same condition (hydrodynamics, limited anthropogenic effects and vermitid platforms), this later explains their equal Shannon's Index (H'=1.25). The only different parameter among these three sites is the nature of the substratum. Unlike the sedimentary rock of Sebiate and Kristel, a volcanic rock is found in Pain sucre (table 3).

Although Bousfer and Marsa Haddjadj are inhabitant zones, their Shannon equals respectively 1.28 and 1.4. Overall, the discharge from the sewage treatment plant increases the nutriment concentration in the seawater at the impacted area. The presence of higher amounts of nutriments may have led to better development of phytobenthos, on which deposivors feeds, on the rocky surfaces compared to the unimpacted site (Kallouche *et al.*, 2012). The smallest fig. of H' is in Cap Falcon and Cap Carbon (H'=1).

Evenness (Pielou J') is between 0 and 1, and it is good when it is near 1, J'=0.75 in Pain Sucre. It represents the best value of J' in the region, so that means the abundance of species is the more equitable compared the other sites. The bad J' is also like the bad H' found in Cap Falcon and Cap Carbon.

According to the general distribution of species on our studied area, there is a clear dominance of deposit feeders, deposivors, case of Gastropods as limpets, which by scraping the bedrock through their radula, feed on microalgae deposited on the surface, followed by crustaceans and echinoderms which are suspension feeders, suspensivors.

To sum up we can say that the species richness S is linked with environmental biodiversity only, conversely, that of Shannon binds both biodiversity on one side and stand density on the other side. Data collected gives more value to the results of biodiversity (distribution, health and balance of biocenosis) (table 3).

Conclusion

Oran's coast is characterized by many phenomena of various origins, with strong ecological prints. It is an environment on which balance depends on biotic factors (Mediterranean biodiversity), abiotic (hydrodynamics and climatic changes) and especially anthropogenic (population growth, plague of coastal region, urban and industrial rejections).

The organization and the biodiversity aspect of the benthic community show that the evolution between both studied coastal systems is of a remarkable difference: The system of Pain Sucre, Sebiate and Ain Defla-Kristel, which is autochthonous, undergoes a little bit the influence of the external factors and seems to be even independent and which pioneer stages are long. While widely-visited polluted and artificial systems (Oran's harbour dyke) or edged by small houses (Bousfer, Marsa Hadjadj) develop under the influence of external factors (hydrodynamism, pollution, anthropogenic pressure).

From this perspective, the benthic coastal biodiversity inventory studied, reveals very promising results, as it is the first study dealing with the intertidal macrofauna density in western Algeria, it is a stepping stone towards national or Mediterranean level, to enlarge data base for future monitoring especially with the challenge of climate change.

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