Biodiversity Journal, 2019, 10 (4): 343–352 https://doi.org/10.31396/Biodiv.Jour.2019.10.4.343.352

The benthic stands of the soft and rocky substrates of the Paloma Island, Algeria

Aouicha Haddou-Dekhir*, Yacine Boutiba, Sihem Abid-Kachour, Fatima Zohra Khelil-Radji & Mohamed Bouderbala

Environmental Monitoring Network, Department of Biology, Faculty of Natural and Life Sciences, University of Oran 1, Algeria
*Corresponding author, email: haddou.auicha@yahoo.fr

ABSTRACT The Oran coastal zone (Algeria) is distinguished by a remarkable wealth of habitat and species (*Posidonia* meadow, coralligenous groupers, and endemic seaweed). This work has allowed us to inventory and identify one hundred (100) macrobenthic species of soft substrates and 65 macrobenthic species of rocky substrates. The contents of the different grain size fractions show a homogeneity between the four stations with a trimodal sand dominated by coarse sand (diameter = 0.08–10 mm). The distribution of these species was mapped using the System of Geographic Information (GIS). Finally, the computation of the Shannon-Wiener (H) and Simpson (Si) indices of the rocky and soft substrates of this study area reveal an average ecological richness with a high biological diversity. It is necessary to undertake annual monitoring of macrobenthos through a wider investigation of several sites and stations in a longitudinal and vertical distribution. The "overall biological quality" index will be calculated and refined in order to rank the different sites by establishing specific indices for each site.

KEY WORDS Granulometry; indice; macrobenthos; mapping; Paloma Island; rocky substrates; soft substrates.

Received 13.07.2019; accepted 25.10.2019; published online 11.12.2019

INTRODUCTION

The Convention on Biological Diversity (https://www.cbd.int/) defines biological diversity or biodiversity as "*the variability of living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part, this includes diversity within and between species and ecosystems. In other words, biodiversity is the variety of life on earth at all levels, from genes to global populations of the same species, from species communities sharing the same small habitat area to global ecosystems*".

This biodiversity is not only a condition for the healthy and natural development of species and ecosystems, but also a natural legacy we leave to future generations. As such, our company has an ethical and moral responsibility.

Marine biodiversity research is timely and fundamental for many reasons. Marine biodiversity plays a key role in the supply and regulation of ecosystem services, provides economic wealth with resources for active substances in pharmacology and the medical field, for fisheries and aquaculture products, but also in the field of cultural well-being, or as a source of relevant models in basic and applied research.

Overall, there is a real lack of synthetic data on national marine biodiversity. When this data is advanced (Algeria, Tunisia for some taxa), it is certainly largely underestimated because resulting from some local studies. In North Africa, entire portions of coastlines and habitats known to harbor high biodiversity have not been explored at all (5ème Rapport National de l'Algérie, 2014).

Without a minimum knowledge of the distribution of characteristic habitats of the Mediterranean Sea, and at least of species with special status (species of interest for conservation), it seems at least complicated to provide tools for assessing the impact of change. There is no real device for continuous observation and biodiversity inventories are often very punctual in space and time (Unep, 2011).

In Algeria, the first observation made is that of a lack of knowledge of a certain component of marine biodiversity. Many taxonomic groups or some benthic communities have not been studied. This action is recommended for all "Environmental quality monitoring networks", in order to have a long-term follow-up and to evaluate the consequences of natural modifications and anthropogenic changes in the environment.

MATERIAL AND METHODS

Study area

The study area on the Plane or Paloma Island (Fig. 1) is located about 7 km from the beach of Bousfer, in the bay of Andalusia, at 35°46.281'N and 0°54.115'W, between Cape Falcon and Lindless cape. The island covers an area of 300 meters long and 100 meters wide. It is uninhabited (except for a gull colony) and has a small dock for small boats. The island has an unoccupied lighthouse in operation. Concretely our sampling area on Paloma Island covers four stations corresponding to the four GPS points whose coordinates are shown in figure 1.

Sampling and treatments of soft and rocky substrates

The sampling of soft sediments was carried in

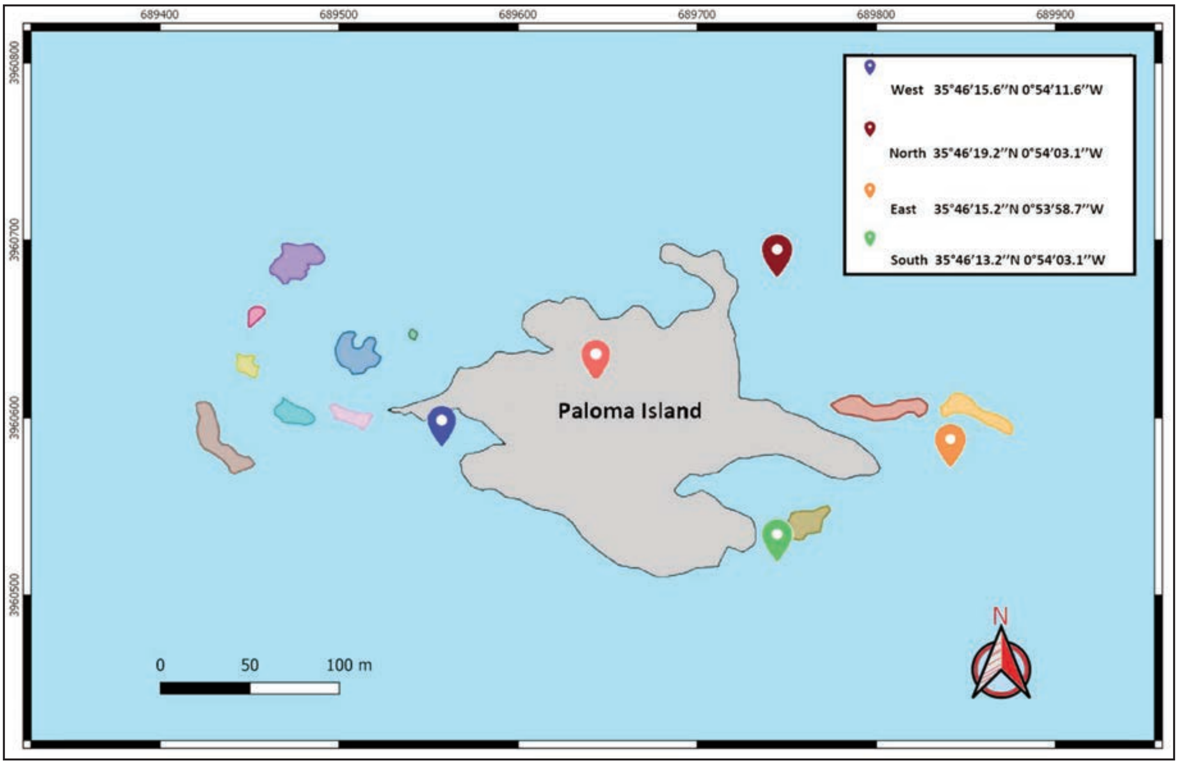


Figure 1. Sampling stations of Paloma Island, Algeria.

December 2018 with a manual grab. The grab shots are replicated four times to account for the distribution of species at a given point and the dispersal of larger species. Following the standard protocol, an extra bucket per station should be collected to analyze the sediments associated with the organisms (granulometric study). The same protocol is performed at the four stations. For rocky substrates a non-destructive sampling was performed. In the laboratory, samples stored in a cooler will be pretreated to remove debris and waste. Depending on their sedimentary nature, the samples are sieved on a 1 mm sieve (round mesh) for fine or silted sediments or 2 mm for coarse sediments. Sieve rejects fixed with diluted formalin (5%) will be subject to biological sorting and identification.

Granulometric study

The study of the soft sediments of the four stations (North, South, East, West) of Paloma Island will be the subject of a granulometric study according to the Norms (NFP 94 056 and 94 057).

Identification of benthos

To be taken into account, specimens must have enough intact parts for correct taxonomic identification, especially having their head (to avoid counting the head and body of the same individual as two animals). It is recommended to use optical equipment (binocular loupe, optical microscope). Larval exuvia or empty shells (e.g., gastropods and bivalves), empty sheaths (e.g., phryganes) are not counted. Subsamples have been sorted until all benthos have been removed. The sorted specimens are subsequently photographed and then re-stored in formalin. Genus and species identification will be done later using identification keys (http://www.marinespecies.org).

RESULTS AND DISCUSSION

Granulometry

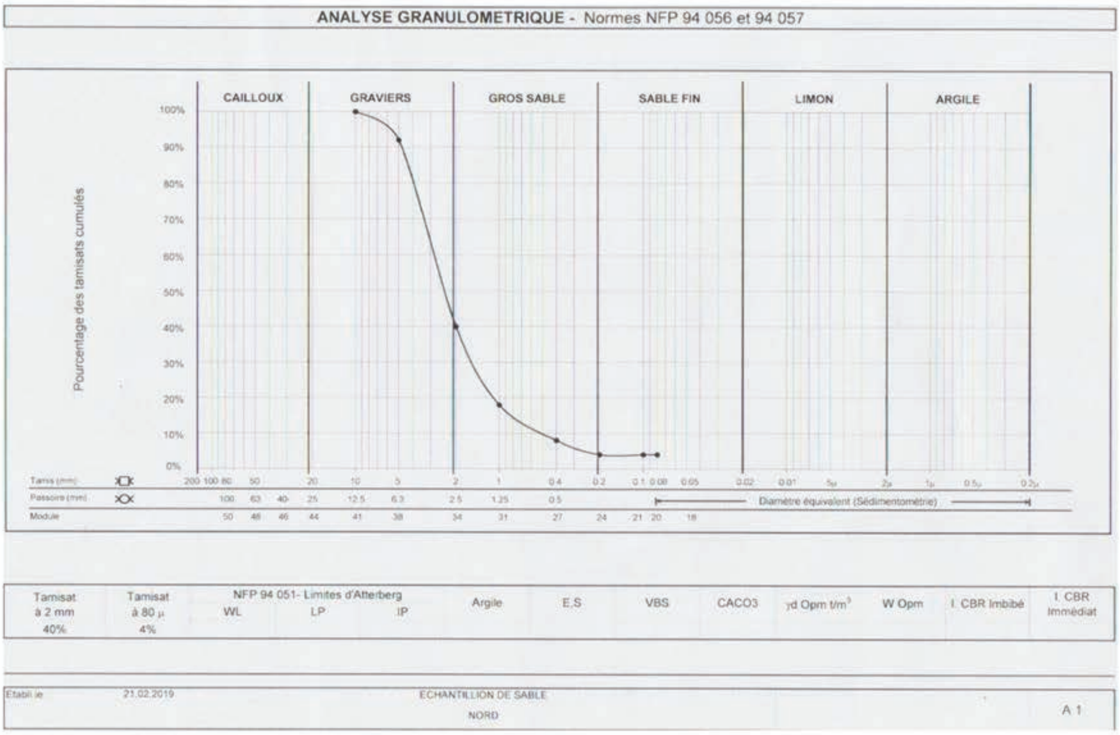
The study of soft substrats of Paloma Island has, on the one hand, characterized the sediment cover within the sampling site and, on the other hand, established the spatial variations of these characters between the four stations of the studied site. The contents of the various size fractions show a notable homogeneity. For all the stations (Figs. 2–5) a trimodal sand dominated by coarse sand with main modes of 0.08 mm to 10 mm was found. The general appearance of the all cumulative grain size curves of the analyzed samples is rectified, which reflects the homogeneity of the sediments belonging to the four sampling stations. On the whole, the curves are relatively sloping, which underlines the good classification of the sediments. The presence of coarse sands can be explained by the nature of the study area which is a rocky island. Fine sands are usually found in shallow or coastal areas.

Identification of benthos

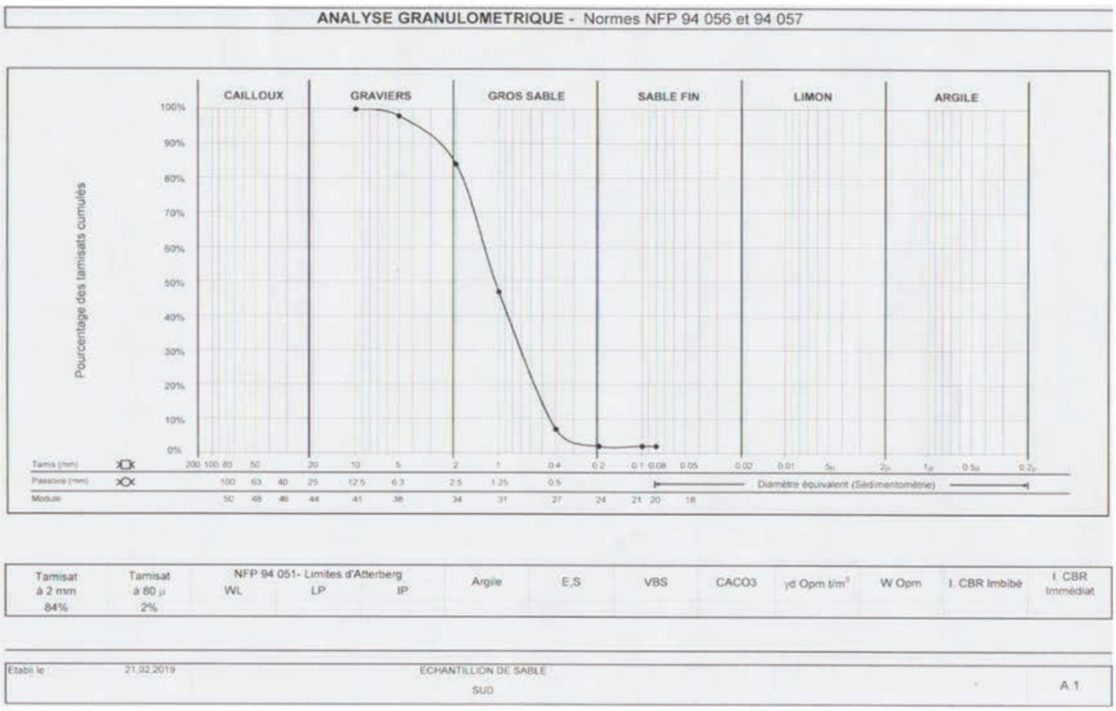
The results obtained are only partial and therefore not really representative of the benthic richness of the site. These results show the presence of at least a global number of 100 species collected on soft substrates (Fig. 6), divided into seven groups namely: gastropods, bivalves, echinoderms, crustaceans, polychaete annelids, cnidarians, marine plants and 65 species harvested from rocky substrates (Fig. 7) divided into ten groups namely: gastropods, bivalves, echinoderms, crustaceans, polychaete annelids, polyplacophores, cnidarians, algae, sponges, marine plants.

Classification of species according to their pollution sensitivity

Accidental or recurrent release of a disturbing agent into the marine environment immediately results in physical and chemical changes in water properties as well as short, medium and long-term effects on biota. To obtain information on this type of effect on marine organisms, plankton is not the most useful marine biota compartment at the local level because it is composed mainly of small organisms whose life cycle is short, floating passively in the current (it does not stay in the affected area) and has a high ability to rebuild populations (high reproductive capacity). Necton is composed of organisms (mainly fish) that are very mobile, allowing them to flee and move in search of better conditions. The benthos is the marine biota compartment that offers the most interesting

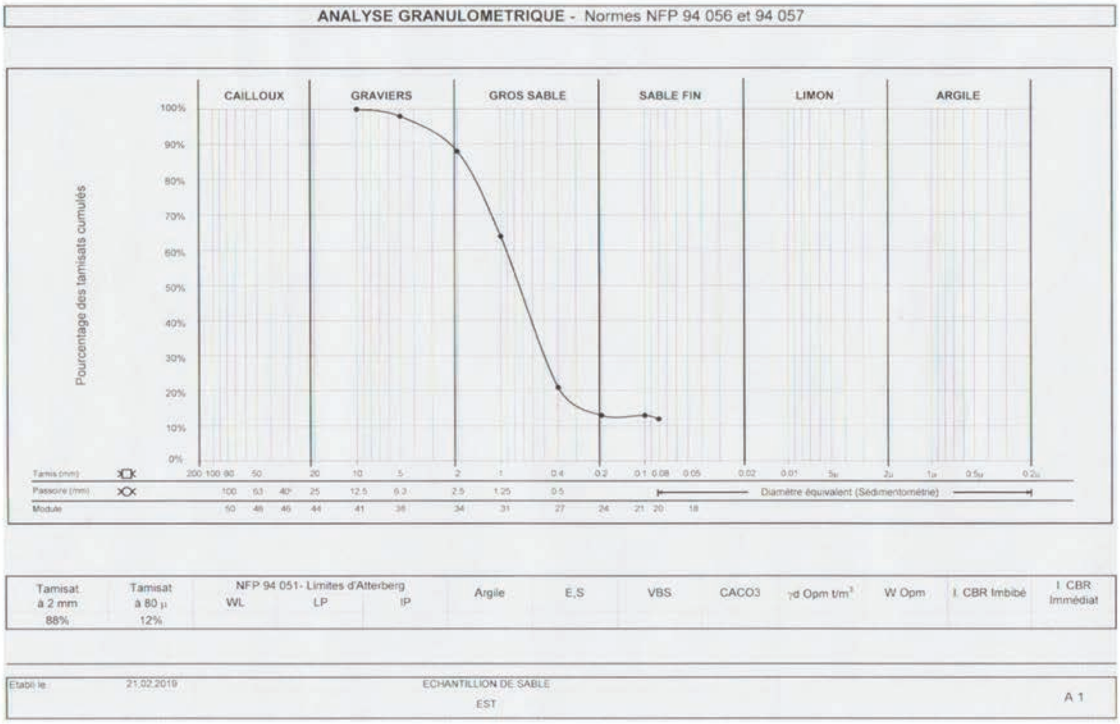


2

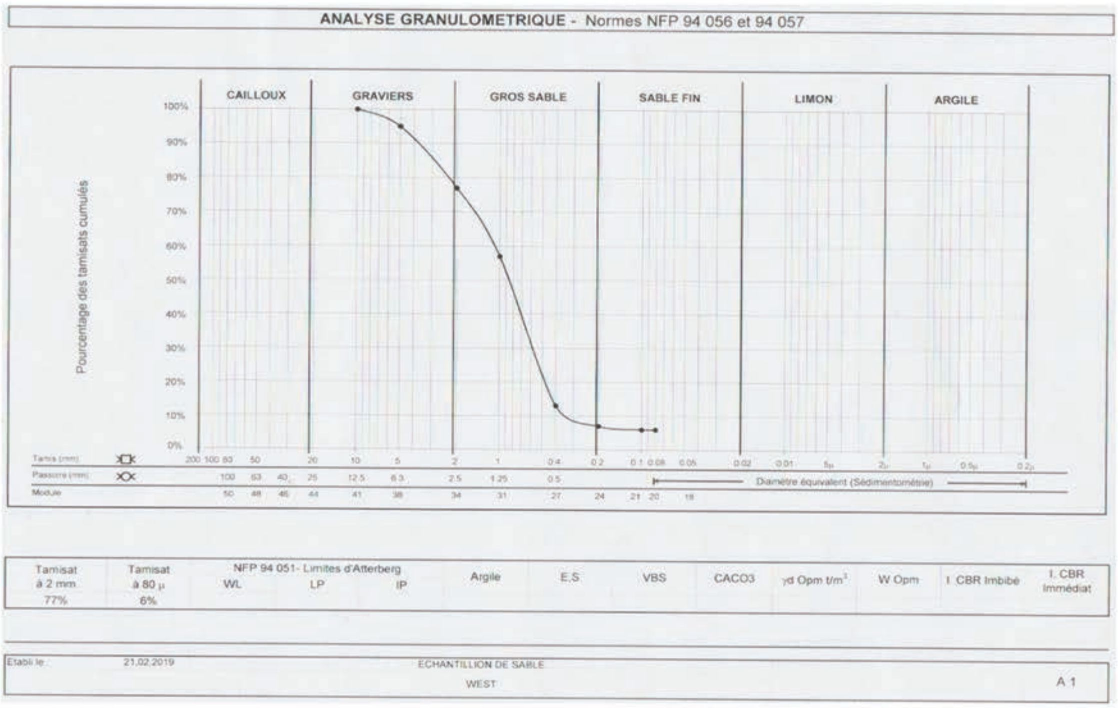


3

Figure 2. Grain size curve of Paloma Island, Algeria: North station (2019).
Figure 3. Grain size curve of Paloma Island, Algeria: South station (2019).



4



5

Figure 4. Grain size curve of Paloma Island, Algeria: East station (2019).
Figure 5. Grain size curve of Paloma Island, Algeria: West station (2019).

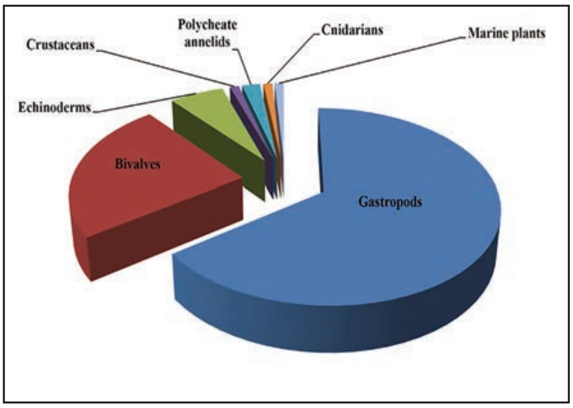


Figure 6. Benthic groups of soft substrates of Paloma Island, Algeria.

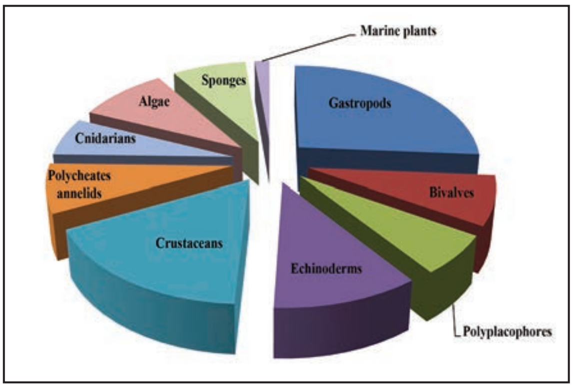


Figure 7. Benthic groups of rocky substrates of Paloma Island, Algeria.

information, mostly sedentary, the benthic organisms remain in the affected area and are unable to avoid the environmental changes likely to occur in their habitat. Therefore, either they survive these changes perfectly or they survive with obvious signs of stress and downsizing or they completely disappear from the system. They can therefore be used as bioindicators (sublethal and lethal effects), as permanent or periodic "sentinels" for the level of quality of the waters in which they live, and contribute greatly to the environmental monitoring of coastal waters (Garcias-Gomez, 2015).

Soft bottoms, more unstable and uniform than rocky bottoms, offer less epibenthic diversity. However, it is on these sea bottoms that seagrass meadows are established, which must be preserved as it plays a major ecological role on our coasts. Especially *Posidonia oceanica* (L.) Delile and *Cymodocea nodosa* (Ucria) Asch. (1870) perfectly visible, localizable and, in general, sensitive to disturbances and pollution. We can observe several types of response to different environmental disturbances. Some of them disappear or decrease massively (sensitive species), others manage to survive normally without showing any external sign of degradation (tolerant species), others still do not decrease but show morphological abnormalities (decay, weak growth, diseases due to microorganisms, etc.) (Garcias-Gomez, 2015).

Several indifferent species for the pollution of soft and rocky substrates have been inventoried (gastropods, bivalves, crustaceans and annelids). Their environmental tolerance gives them a broad ecological valence (Becerro et al., 1994; García-Gómez, 2007). If found in clear waters and rich biodiversity in excellent conservation status, they also support situations of high environmental stress, high turbidity, high sedimentation and moderate levels of suspended organic matter. The great adaptability of these organisms does not make them good indicators of clean and limpid water, as the information provided is very limited. They are a perfect example of species not to be selected for monitoring the evolution of well-preserved funds that may be subject to environmental monitoring through sensitive bioindicators (Carballo & Naranjo, 2002).

Among the species sensitive to the pollution of soft and rocky substrates there are the *Patella* Linnaeus, 1758 (Gastropoda Patellidae), particularly *P. ferruginea* Gmelin, 1791. This species can not be considered strictly sessile because it is vagile at high tide, it then moves actively around its substratum where it returns to settle at the rock at low tide. In addition, it is not a FBI species (Fixed Biological Indicator) and according to the design of Rovere et al. (2015), it can not be considered as such at low tide. Endemic species of the western Mediterranean it is in marked decline since the beginning of the 20th century. It has almost disappeared from continental European coasts where it is now reduced to small subpopulations in Corsica, Sardinia and the island of Pantelleria. On the African coast, its presence is restricted to Morocco, Habibas Islands in Algeria, Zembra island and Cap Bon in Tunisia. In Spain, there are some colonies in Andalusia and in the region of Murcia, the main ones being in Ceuta, Melilla and in the Chafarinas Islands. The *Patella* are species traditionally associated with limpid and well oxygenated waters. They are sensitive to pollution, turbidity and oxygen depletion in water (Espinosa, 2005). In several studies, they have been proposed as species indicative of good environmental conditions (Espinosa et al., 2007).

The emblematic species of the Mediterranean Sea widely used in the biomonitoring of soft and rocky substrates is *Posidonia oceanica*.

According to the clarity of the water, it is found from the surface up to 40 meters deep. This Mediterranean endemic species is indicative of clean, unpolluted and well-oxygenated waters (García-Gómez 2007, Montefalcone 2009, López & Royo et al., 2011). It is particularly sensitive to the progressive increase in turbidity, especially if it is associated with an organic load (Cancemi et al., 2003) and a high sedimentation rate (Ruiz & Romero, 2003, Sánchez-Lizaso, 2004). This species is one of the most emblematic of the Mediterranean Sea for monitoring and environmental monitoring, due to the sensitivity of seagrasses to anthropogenic disturbances. Figures for protection Inscribed in Council Directive 92/43/EEC (Annex I: Types of natural habitats of Community interest whose conservation requires special conservation areas) Listed in the Spanish and Andalusian Lists of Wild Species special protection scheme (LESRPE, Royal Decree 139-2011 and LAESRPE, Decree 23/2012).

Statistical descriptors

They are the basis for calculating many other

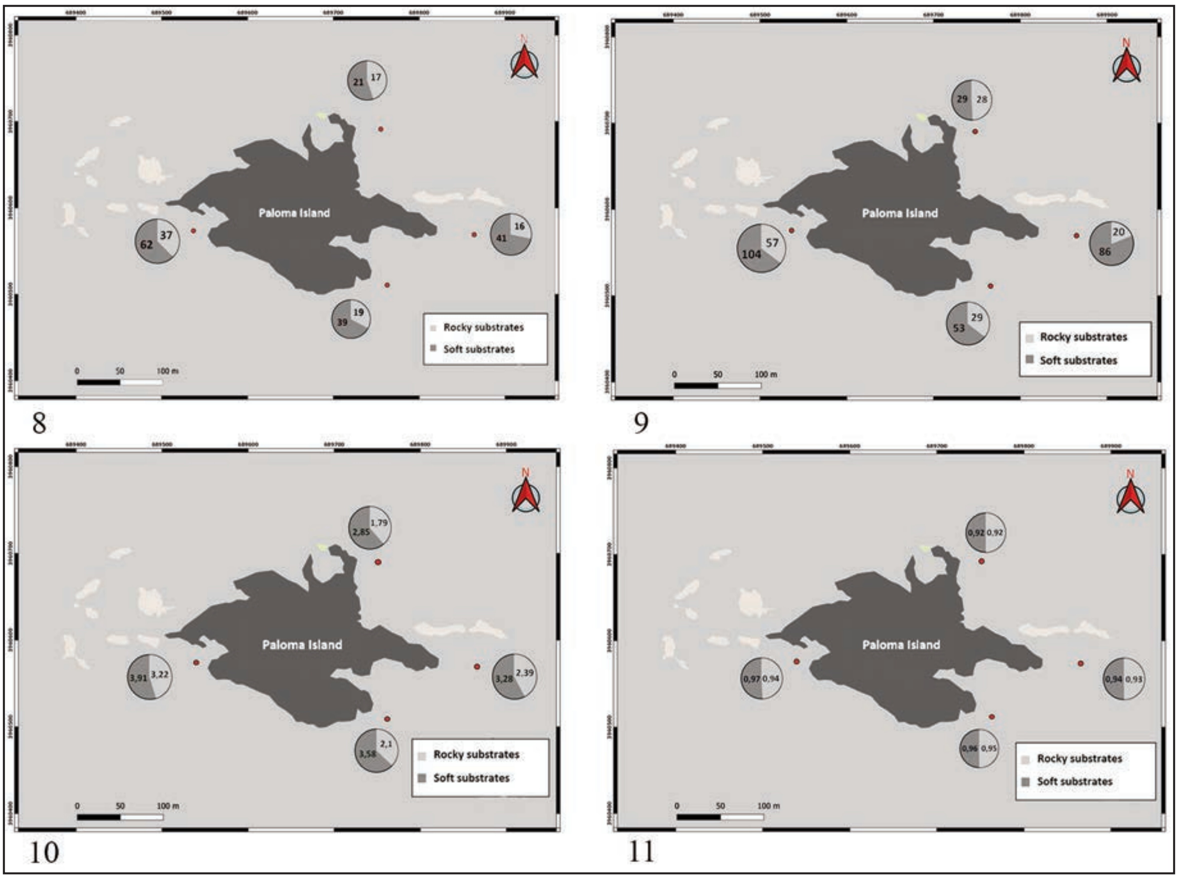


Figure 8. Specific wealth of soft and rocky substrates of Paloma Island (Algeria). Figure 9. Abundance of soft and rocky substrates of the four Paloma Island stations (Algeria). Figure 10. Shannon-Wiener index of the soft and rocky substrates of the four Paloma Island stations (Algeria). Figure 11. Simpson's index of soft and rocky substrates at the four Paloma Island stations (Algeria).

more complex indices. However, they are often influenced by the sampling method, sample size, and identification procedures: the site can not be sampled in its entirety, the number of species present in the samples do not generally reflect the absolute diversity but the apparent diversity. In addition, these methods do not take into account the relative abundance of each species, which contributes to the diversity of the site. The validity of these descriptors on communities growing on hard substrates is questionable because of the difficulty in counting colonial organisms, or the difficulty of sampling. Thus, the values of these indices can only be compared when the sampling protocol has been the same. In addition, these indices are highly dependent on habitat type, and the determination of average values representative of a state of environmental quality requires the determination of threshold values for each habitat type (Grall & Coïc, 2005).

Specific wealth

This map represents the specific richness of the soft and rocky substrates of the four Paloma Island sampling stations, on a scale of 1/50 m. The specific richness of soft substrates is greater than that of rocky substrates (Fig. 8). The spatial variation of this same index shows that the western sector represents the most important specific richness, it is supposed that this is due to the presence of several islets which offer a multitude of habitats and refuges to the benthic species. The species richness index has the drawback of being strongly dependent on the size of the samples (the number of species sampled increasing with the sampled surface) and the type of habitat (the specific richness varies according to the type of substrate, depth, salinity, etc.). It remains difficult to make a descriptor of the state of a medium. Simboura & Zenetos (2002), however, suggest assigning threshold values for different types of ecological groups and for different habitats.

Abundance

In the face of pollution, species will follow three types of reaction according to their sensitivity:

-Disappear, for the most sensitive.

-To maintain oneself, for the indifferent ones.

-Take advantage of the new conditions put in place and develop, for the tolerant and opportunistic.

These different responses will translate into the abundance of species. Abundance profiles over time are therefore widely used as indicators of the effects of pollutants in sediments, as well as biomass and species richness curves (Grall & Coïc, 2005).

This map represents the abundance of soft and rocky substrates at the four sampling sites on Paloma Island. Abundance of soft substrates is shown to be greater than the abundance of rocky substrates (Fig. 9). Similarly, the species richness of the benthic species is greater at the western station. The softer substrates, which are easier to sample with four-fold replica grab, have made the number of species more important, although it is known that it is rather the rocky substrates that offer many habitats and shelters to them. In addition, plant species are difficult to translate in terms of numbers, and their biomass can not be quantified.

Shannon-Wiener (H) index

The Shannon-Wiene index (H) is calculated just for fauna.

We have considered for comparison the scale proposed by Simboura & Zenetos (2002), for sandy/muddy habitats:

The index H':> 4 is very balanced; 2.5-4 balanced; 1.5-2.5 unbalanced and <1.5 very unbalanced.

This map represents the Shannon-Wiener index of soft and rocky substrates at the four sampling sites on Paloma Island (Fig. 10). According to the stand classification thresholds from the Shannon H index. The ecological state is average (balanced), and the classification of the pollution is moderately polluted for the rocky substrates. Even though the island is classified marine protected area, it should be noted that the levels of protection of these marine areas is derisory. The marine environment in general, and the Algerian coast in particular, constitute a rich sea sheltering ecosystems, which, in recent years, have been markedly degraded, mainly due to pollution and human impact, including shoreline developments, overfishing, trawling, the introduction of exotic species that can lead in the near future to a trivialization of stands and ecosystems.

Simpson index (Si)

The Simpson index (H) is calculated just for fauna.

Simpson's index of soft and rocky substrates tends to 1, reflecting a high diversity (Fig. 11). The homogeneity of this index between the two types of substrates depends on the fact that these species share the same distribution areas, and therefore even if the workforce is not very important because of the Mediterranean is a poor enough sea, in terms of nutrients, it offers a very important diversity, particularly related to the Messinian crisis.

CONCLUSIONS

The objective of this study is to demonstrate the value of an ecosystem approach to assess the quality of the marine environment. The proposed approach is therefore global, based on the study of Benthos quality of soft and rocky substrates. The ecosystem approach proves to be highly sensitive, as it differs from the ecotoxicological approach and is non-discriminatory with respect to pollutants that require costly measures and thus allows harmonization of interpretations. It also makes it possible to compare the sites with each other in terms of benthic richness and to provide elements for classifying areas or reviewing the status of certain species or inventories of new invasive species.

REFERENCES

Becerro M.A., Uriz J.M. & Turón X., 1994. Trends in space occupation by the encrusting sponge Crambe crambe: variation in shape as a function of size and environment. Marine Biology, 121: 301–307.

Cancemi G., De Falco G. & Pergent G., 2003. Effects of organic matter input from a fish farming facility on a *Posidonia oceanica* meadow. Estuarine Coastal, and Shelf Science, 56: 961–968. https://doi.org/10.1016/S0272-7714(02)00295-0

Carballo J.L. & Naranjo S., 2002. Environmental assessment of a large industrial marine complex based on a community pg benthic filter-feeders. Marine Pollution Bulletin, 44: 605–610. https://doi.org/10.1016/S0025-326X(01)00295-8

Espinosa F., 2005. Caracterization biologica del molusco protegido *Patella ferruginea* Gmelin, 1791 (Gastropoda; Patellidae): bases para su gestion y condervation. Thèse. Laboratorio de Biologia Marina Universidad de Sevilla, 329 pp.

Espinosa F., Guerra-García J.M. & García-Gómez J.C., 2007. Sewage pollution and extinction risk: an endangered limpet as a bioindicator. Biodiversity and Conservation, 16: 377–397. https://doi.org/10.1007/s 10531-005-3014-3

García-Gómez, J.C., 2007. Biota littoral y Vigilancia Ambiental en Las Areas Marinas Protegidas, Junta de Andalucía, Consejería de Medio Ambiente, 193 pp.

García Gómez J.C., 2015. Guide de suivi environnemental des fonds rocheux dans les aires Laboratoire de Biologie Marine, Faculté de Biologie, Université de Séville Département de Recherche Biologique R+D+I, Aquarium de Séville. 482 pp.

Grall J. & Coïc N., 2005. Synthèse des méthodes d'évaluation de la qualité du benthos en milieu côtier. 90 pp.

Lopez y Royo C., Pergent G., Alcoverro T., Buia M.C., Casazza G., Martínez-Crego B., Pérez M., Silvestre F. & Romero J., 2011. The seagrass *Posidonia oceanica* as indicator of coastal water quality: Experimental intercalibration of classification systemes. Ecological Indicators, 11: 557–563. https://doi.org/10.1016/j.ecolind. 2010.07.012

Montefalcone M., 2009. Ecosystem health assessment using the Mediterranean seagrass *Posidonia oceanica*: A review. Ecological indicators, 9: 595–604. https: //doi.org/10.1016/j.ecolind. 2008.09.013

5ème Rapport National de l'Algérie, 2014. Sur la mise en œuvre de la convention sur la diversité biologique au niveau national.

Rovere A., Antonioli F. & Bianchi C.N., 2015. Fixed biological indicators. In: Shennan I., Long A.J. & Horton B.P. (Eds.), Handbook of Sea Level Research, pp. 268–280. John Wiley & Sons, Ltd, Chichester, UK.

Ruiz J.M. & Romero J., 2003. Effects of disturbances caused by coastal constructions on spatial structure, growth dynamics and photosynthesis of the seagrass *Posidonia oceanica*. Marine Pollution Bulletin, 46: 1523–1533. https://doi.org/10.1016/j.marpolbul. 2003.08.021

Sánchez-Lizaso J.L., 2004. Impactos sobre las praderas de *Posidonia oceanica*. In: Luque A.A. & Templado J. (Eds.), Praderas y bosques marinos de Andalucía, pp. 127–132. Consejería de Medio Ambiente, Junta de Andalucía, Sevilla, 336 pp.

Simboura N. & Zenetos A., 2002. Benthic indicators to use in ecological quality classification of Mediter-

ranean soft bottom marine ecosystems, including a new biotic index. Mediterranean Marine Science, 3: 77–111.
Unep, 2011. Synthèse sub-régionale "Méditerranée Occidentale" des documents nationaux d'identification des propriétés majeures des écosystèmes et d'évaluation de l'état ecologique et des pressions sur la biodiversité marine et côtièreCAR/ASP. Tunis, 55 pp.