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RESEARCH ARTICLE

A preliminary inventory of biodiversity and benthic habitats of "Plane" Island (Paloma) in Oran Bay, north western Algeria (western Mediterranean)

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Abstract

This study aimed to create an inventory of the prominent species in "Plane" Island on the Algerian coast of the Mediterranean Sea for the conservation interest and to classify rocky benthic habitats. The study was carried out at eight stations by 27 dives between the surface and 34 m depth from 2014 to 2015. In total, 201 taxa were listed, of which 30% consists of macroalgae, 1% phanerogams, 52% macroinvertebrates and 17% fish. The biotope was characterized by the presence of 6 biocenosis of hard rock (19 associations and 9 facies). The bioconcretions were represented by red and yellow gorgonians and other sessile macrofauna that embellishes the coralligenous habitat. The macrobenthos were marked by the presence of several species. Exotic and sometimes invasive species were also present, such as *Caulerpa racemosa* var. *cylindracea*, *Codium fragile*, *Asparagopsis armata*, *Asparagopsis taxiformis* and *Oculina patagonica*. "Plane" Island represents a space with multiple stakes and uses, which requires a thorough study, valorization and a rational and durable exploitation in order to preserve its major assets. The study will provide support for the management of coastal ecosystems, such as those in "Plane" Island, aiming to create a marine protected area and the strengthening of fisheries regulations, as a veritable hot spot of biodiversity along the Algerian coasts.

Keywords: Biodiversity, biocenosis, fauna, flora, coastline, Plane Island, Oran, Algeria, western Mediterranean

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Introduction

"Paloma" or "Plane" Island, a component of the insular environment of the Oran's coastline, has a great potential in terms of specific biodiversity and underwater habitats, favorable to the development of a diversified marine population. Due to the proximity to the Strait of Gibraltar, it benefits from

continuous supply of currents rich in nutrients and oceanic plankton (Millot 1999; Hussein 2015). A significant circulation of horizontal and vertical currents sweeps the region, called "Oran current" between Almeria and Algeria (Millot and Taupier-Letage 2005). The topography of the area is characterized by the presence of Alidade seamounts (30 miles long) that generated the insular formations of the region and a very narrow continental margin with a tight continental shelf from where an important "upwelling" enriches the area (Hussein and Bouras 2014). The potentialities offered are under-exploited due to the lack of harmony and integration of the management of this coastal zone (Hussein 2015). The absence of scientific work on the environment and marine organisms of “Plane” Island gives to the study its originality with important results that can provide support for the management of coastal ecosystems and could help designing a new marine protected area (MPA).

This initial biodiversity data obtained can inform us about populations quality through the species richness "S" of the macrobenthos, which is represented either in number of species or in biomass value, all referred to a surface unit which is a criterion to characterize a population or a habitat, according to its rarity (e.g. rossworms reefs), its structural interest (e.g. coralligenous) or because it serves as a feeding or recruitment zone for other species (e.g. seagrass meadows). Populations characterization is an essential tool for understanding and monitoring the coastal and marine environment under the influence of the various human activities that discharge liquid and solid waste into the sea (Bellan-Santini 1969, 1994; Boudouresque 1970, Eleftheriou *et al*. 1984; Bensahla Talet *et al*. 2015). Detailed inventories of species and habitats are necessary in order to identify future losses that might result from anthropogenic impacts. Such biodiversity databases are available for the NW Mediterranean where biodiversity is monitored over decades. It is important to set an initial inventory of the local biodiversity and follow its evolution through time to evaluate potential biodiversity losses induced mainly by global climate change that highly impact local biodiversity in the Mediterranean (Cramer *et al*. 2018).

An inventorial scientific study on “Paloma” or “Plane” Island, part of the island complex of western Algeria, offers an opportunity to relaunch a global conservation dynamic of the relevant marine sites of Algeria and could, with the promulgation of decrees on the classification of insular sites as Rachgoun Island and Habibas Islands (already classified as MPAs), constitute a pole of nature conservation in the southwestern sector of the western Mediterranean. Therefore, the present work aims to constitute a preliminary database resulting from investigations carried out *in situ* on the characterization of the biodiversity and the benthic habitats of the island, with the objective to provide an initial diagnosis and necessary arguments to start a classification process of the island's as a MPA in the Wilaya (District) of Oran.

Material and Methods

Study area

"Plane" Island or "Paloma" is located approximately 7 km off Bousfer beach in "Les Andalouses" Bay, at 35°46.281'N and 0°54.115'W, between Cape Falcon and Cape Lindless (Figure 1). This island is located in the South-West of the Algerian basin, which is part of the island complex of Western Algeria.

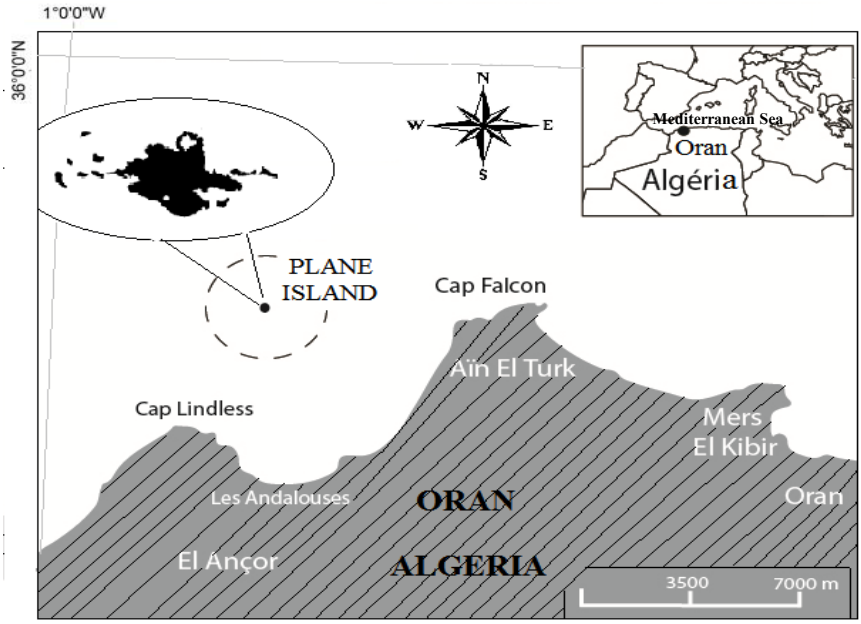

Figure 1. Study area in Oran, Algeria, Mediterranean Sea

Methodology

The *in situ* study was carried out between 2014 and 2015 on eight random band transects corresponding to eight stations (Figure 2) by 27 dives in total (Snorkeling for shallow waters; scuba dives for the infralittoral zone): 16 dives (2 replicates for visual identification and counting of species) and 11 additional dives for benthic typology realized from the surface to a maximum of 34 m depth, depending on stations (Table 1).

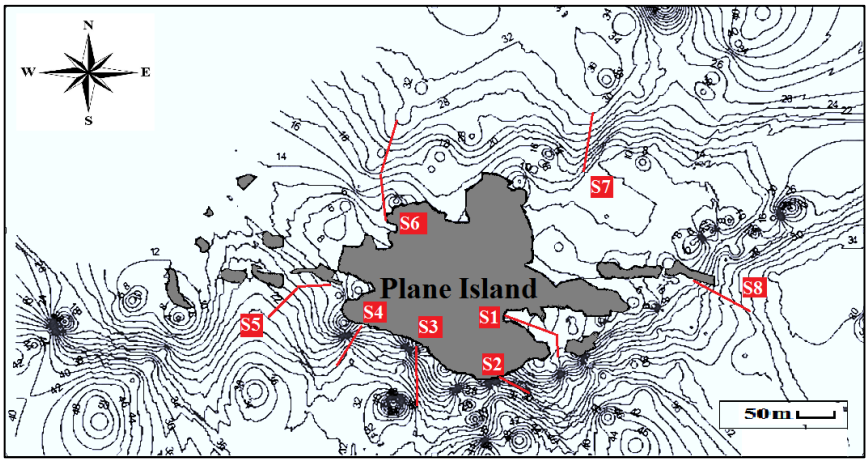

Figure 2. Eight transects investigated around Plane Island

A tentative inventory based on *in situ* observations was used to cross-monitor the sector on a vertical profile from the deepest point to the surface, so the dominant and remarkable species of different habitats were visually identified. A description of the topography and the submarine landscape (Table 1) was also noted (Bajjouk *et al*. 2010; Besnard and Salles 2010) to determine substrate typology. Then, a transect (the length of which varied according to the underwater topography of each station (Table 1) was monitored by visual census (UVC) according to the method applied in the Mediterranean Sea (Harmelin-Vivien and Harmelin 1975; Harmelin-Vivien *et al*. 1985). For each station (S1 to S8) two divers performed the study, the first diver counted the mobile species and the second one the fixed species. As stated previously, 11 supplementary dives were realized to describe the ecological aspects and benthic habitats. The selected parameters for the flora and fauna were as follows: absent: 0, present: + and strong presence: ++ (Lenfant *et al.* 2011). The biodiversity aspects and benthic habitats were supported by underwater images (videos and photographs) of band transects according to the REBENT MED protocols (Kantin *et al*. 2006).

The identification and classification of species was made through FAO species identification sheets (Fischer *et al*.1987), as well as other scientific documents (Boudouresque 2005, Pergent *et al.* 2007). For the characterization of communities, Pérès and Picard (1964) and UNEP-MAP (1998) protocols were used. For species and habitats of conservation interest, we used Annexes II and III of the Protocol on Specially Protected Areas and Biological Diversity in the Mediterranean of Barcelona Convention (1976) and Bern Convention (1979).

Results and Discussion

Benthic biodiversity of the mediolittoral zone
The bionomic study of the macrobenthos in the upper medio littoral levels revealed a richness of 55 species: of which 36 species were distributed as:
-7 Chlorophyceae (green algae) *Ulva rigida, Ulva lactuca, Catheomorpha aerea, Caulerpa racemosa, Enteromorpha compressa, Flabellia petiolata, Valonia macrophysa*,
-17 Rhodophyceae (red alguae) *Amphiroa rigida, Bonnemaisonnia asparagoides, Ceramium ciliatum, Ceramium codii, Chylocladia verticillata, Corallina elongata, Corallina officinalis, Hypnea musciformis, Jania rubens, Laurencia* sp*., Laurencia papillosa, Lithophyllum incrustans, Lithothamnion valens, Nemalion helmintoides, Peyssonnelia* spp., *Pterocladia capillacea, Sphaerococcus cornopifolius,*
-12 Phaeophyceae (brown algae) *Arthrocladia villosa, Cladostephus spongiosus, Cystoseira amentacea, Dictyopteris polypodioides, Dictyota dichotoma, Dilophus faciola, Halopteris filicina, Leathesia difformis, Padina pavonica, Ralfsia verrucosa, Sargassum vulgar, Taonia atomaria*.

Fauna was represented by 19 species:
-4 cnidarians *Actinia equina, Anemonia viridis, Astroides calycularis, Parazoanthus axinellae,*
-1 echinoderm *Paracentrotus lividus*,
-10 mollusks *Aplysia punctata, Cerithium rupestre, Dendropoma petraeum, Mitra corniculata, Patella furigenea, Patella rustica, Patella ceriola, Osilinus articulatus, Osilinus turbinatus, Stramonita haemostom,*
-4 crustaceans: *Dardanus arrosor, Eriphia verrucosa, Euraphia depressa, Pachygrapsus marmoratus.*

It appears from the study of the medio-littoral level that the photophilous algae is well developed and diversified with coexistence of a large population of the highly endangered patellid limpet *Patella ferruginea* (Rivera–Ingraham *et al.* 2011) which has been maintained around the island.

The results obtained showed the different distributions of the floristic taxa, by a dominance of the Rhodophycea (47%), Pheophycea (33%) and Chlorophycea with only 20% (Figure 3). The fauna seemed much influenced by the topographical aspect, the echinoderms were the least represented, but the distribution of certain species of this phylum like the common sea urchin *Paracentrotus lividus* was wider than the other macroinvertebrates, the beadlet anemone *Actinia equina* and the green anemone *Anemonia viridis*. The medio-littoral zone was mainly dominated by gastropods. The total of 55 species, belonging to 7 phyla, reflected a good taxonomic diversity in the area. This richness seems closely related to the hydrodynamism of the island and sediments nature. Contributions of organic matter and nutrients determining the

establishment of the biocenosis was already reported by Vaissiere and Fredj (1963).

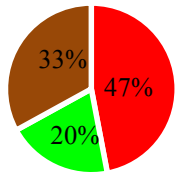

Figure 3. Proportion of floristic taxa encountered in the medio-littoral zone of "Paloma" Island

Distribution of some dominant species in the upper mediolittoral level is presented in Figure 4, where the distribution of six macroalgae and two macroinvertebrates were mapped. The analysis of the distribution map shows the existence of *Cystosiera* sp. mainly in the areas exposed to the north/north-west currents, whereas the nitrophilic species, presented by *Ulva*, was mainly present in the south/south-east part of "Plane" Island. *Jania rubens* has a high recovery rates for a long period of the year (Hussein 2015) and it appears that the mode of exposure of the terrestrial part of the island strongly influences the distribution of these species.

Benthic biodiversity of the infralittoral zone

The stations were dominated by hard substrates, mainly in the form of steep cliffs, screes and drop-offs (Table 1), favoring the installation of rich biodiversity, as is generally the case in the Northwestern Mediterranean (Bonhomme *et al*. 2009; UNEP-MAP RAC/SPA 2010). Overall, more than 195 species were recorded between 0 and 30 m depth in the Island, 60 floristic taxa and 135 faunal taxa (Tables 2 and 3), composed of 30 % macroalgae, 52 % of macroinvertebrates, 17 % of fish and 1% phanerogams (Figure 5).

Table 1. Habitat characteristics of sampling stations in "Plane" Island

Stations	**S 1**	**S 2**	**S 3**	**S 4**	**S 5**	**S 6**	**S 7**	**S 8**
Habitat	Rocky							
Depth: Min-Max (m)	0-17	0-29	1-30	0-27	0-26	0-31	7-24	0-34
Topographic profile	Gentle slope	Steep slope	Steep slope	Steep slope	Gentle slope	Irregular slope	Irregular slope	Steep slope
Transect length (m)	80	40	50	40	60	80	60	50

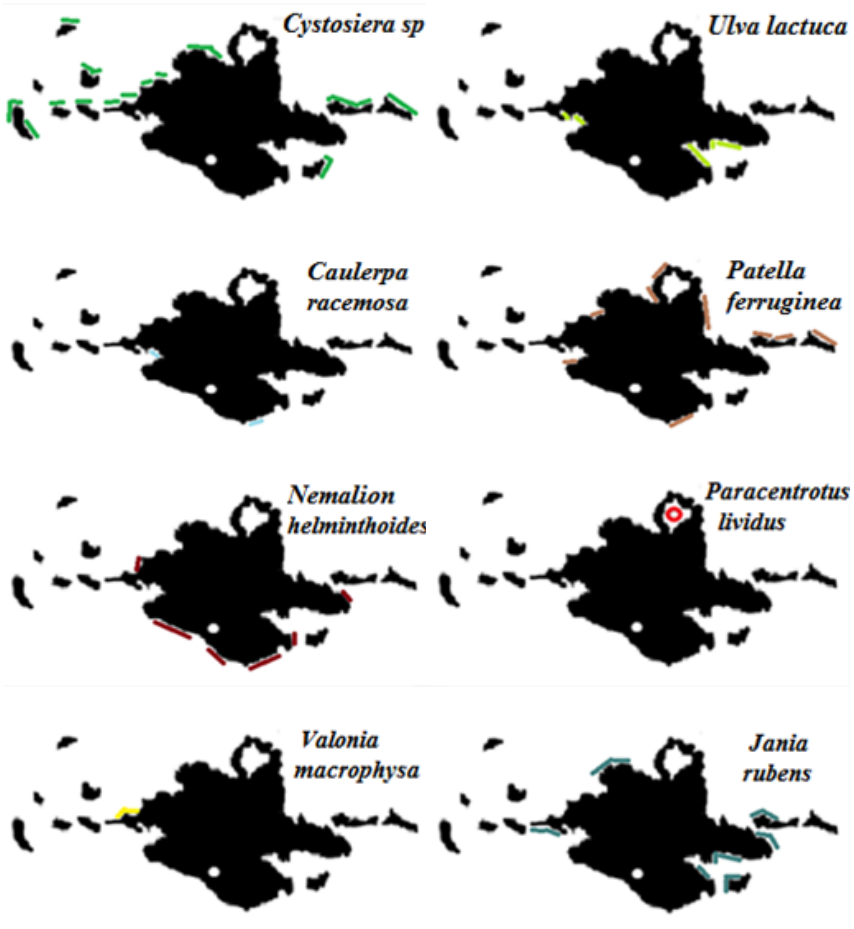

Figure 4. Distribution of the benthic flora and fauna of the medio littoral zone of "Plane" Island

The presence of three groups of algae have been recorded: Chlorophyceae (19 species), Rhodophyceae (25 species), Pheophyceae (with 15 species), the nominative listing of species is presented in Table 2.

Table 2. Benthic flora taxa found in 8 stations of "Plane" Island
S: Number of species. Species presence are marked as: absent: 0, present: + and strong presence: ++, *: endangered species, **: alien species

Stations	S1	S2	S3	S4	S5	S6	S7	S8
Flora								
Macroalgae								
A -Chlorophycae								
Acetabulria acetabulum (Linnaeus) P.C. Silva 1952	+	0	0	0	+	+	0	0
Anadyomene stellata (Wulfen) C. Agardh, 1823	+	+	0	0	++	+	0	0
Bryopsis muscosa (J.V.Lamouroux., 1809)	+	++	+	+	+	++	+	++
Chaetomorpha aerea (Dillwyn) Kützing., 1849	+++	0	0	0	++	++	0	0
*Caulerpa racemosa*** (Forsskål J.Agardh 1873)	0	0	+	0	++	0	0	0
Cladophora spp. (Kützing, 1843)	+	0	0	0	0	0	0	0
Cladophora rupestris (Linnaeus) Kützing 1843	++	+	0	+	++	+++	+	+
Codium bursa (Olivi) C.Agardh, 1817	+++	++	++	++	++	++	+	++
*Codium fragile*** (Suringar Hariot, 1889)	+	+	0	+	+	0	+	0
Codium effusum (Rafinesque) Delle Chiaje, 1829	0	+	0	0	++	+	0	+
Codium vermilara (Olivii) Delle Chiaje 1829	0	+	++	0	+	++	+	+
Dasycladus vermicularis (Scopoli) Krasser 1898	0	0	+	0	0	0	0	0
Enteromorpha compressa (Linnaeus) Nees,1820	++	0	0	0	+	+	0	0
Flabellia petiolata (Turra) Nizamuddin 1987	+	++	+	0	+	++	+	+
Halimeda tuna (J.Ellis & Solander) J.V.Lamouroux 1816	+	++	+++	++	+++	++	+++	+++
Palmophyllum crassum (Naccari) Rabenhorst 1868	0	+	+	0	++	+	0	0
Ulva rigida (C. Agardh,1823)	0	0	0	0	+	+	0	0
Ulva lactuca (Linnaeus,1753)	+++	+	0	0	+++	+	0	0
Valonia macrophysa (Kützing, 1843)	0	0	0	0	++	++	0	0
S = 19	12	11	8	5	17	15	7	7
B - Pheophyceae								
Arthrocladia villosa (Hudson) Duby, 1830	+	+	0	0	++	+	0	+
Cladostephus spongiosus (Hudson) C. Agardh,1817	+	0	0	+	0	0	0	0
Colpomenia sinuosa (Mertens ex Roth) Derbès & Solier, 1851	++	+	+	++	++	+	+	+
*Cystoseira amentacea** (C.Agardh) Bory de Saint-Vincent, 1832	0	0	0	0	++	+++	0	0
Cystoseira compressa (Esper) Gerloff & Nizamuddin 1975	+	0	0	0	+	++	+	+
Dictyopteris polypodioides (A.P.De Candolle) J.V.Lamouroux 1809	+	+	+	+	+	+	0	0

Table 2. Continued

Dictyota dichotoma (Hudson) J.V. Lamouroux 1809	+++	+	++	++	+++	+++	++	++
Dilophus fasciola (Roth) M.A.Howe, 1914	+	0	0	0	+	+	+	0
Halopteris filicina (Grateloup) Kützing, 1843	++	0	0	0	+	++	+	+
Leathesia difformis (Areschoug, 1847)	+	+	+	0	++	+	++	+
Padina pavonica (Linnaeus)Thivy, 1960	++	+	++	+	+++	+++	+++	++
Ralfsia verrucosa (Areschoug) Areschoug 1845	++	++	+	++	+	++	+	0
Sargassum acinarium (Linnaeus) Setchell, 1933	0	+	0	0	0	+	0	0
Taonia atomaria (Woodward) J.Agardh, 1848	0	0	+	+	0	+	++	0
Bugula neritina (Linnaeus,1758)	+	++	0	+	++	0	++	+
S = 15	12	9	7	8	12	13	10	8
C - Rhodophycae								
Amphiroa rigida (J.V.Lamouroux, 1816)	++	+	+	++	+++	++	+++	++
Asparagopisis armata (Harvey 1855)**	+++	++	++	++	++	++	+	++
*Asparagopsis taxiformis*** (Delile) Trevisan de Saint-Léon, 1845	+	+	+	+	0	0	+	+
Bonnemaisonia asparagoides (Woodward) C.Agardh, 1822	+++	+	+	0	+	+++	++	++
Ceramium ciliatum (J.Ellis) Ducluzeau, 1806	+	+	0	0	+	++	0	++
Chylocladia verticillata (Lightfoot) Bliding 1928	++	+	+	+	++	0	+	0
Corallina elongata (J.Ellis & Solander 1786)	++	0	+	0	+	+	0	0
Corallina officinalis (Linnaeus, 1758)	+	+	+	0	++	0	0	+
Halymenia sp.	0	+	0	+	++	+	0	+
Hypnea musciformis (Wulfen) J.V.Lamouroux, 1813	++	++	+	0	++	0	0	++
Jania corniculata (Linnaeus) J.V.Lamouroux, 1816	++	0	0	0	++	++	+	++
Jania rubens (Linnaeus) J.V.Lamouroux, 1816	+++	+	+	++	+++	+	++	+
Laurencia sp.	+	0	++	0	+	++	+	+
Laurencia papillosa (C.Agardh) Greville, 1830	+	0	0	+	+	+	0	0
Lithophyllum incrustans Philippi, 1837	++	+++	+	++	+++	+	+++	+++
Lithothamnion valens Foslie, 1909	+	+	++	+	0	+	+	0
Mesophyllum alternans (Foslie) Cabioch & M.L. Mendoza, 1998	++	+	0	+++	+	++	++	+
Nemalion elminthoides (Velley) Batters, 1902	++	+++	++	+++	++	+	0	+
Peyssonnelia spp.	+++	+	+++	+	++	++	++	+
Peyssonnelia rosa-marina Boudouresque & Denizot, 1973	+	+++	++	++	+	+++	+++	+++

Table 2. Continued

Peyssonnelia squamaria (S.G.Gmelin) Decaisne ex J.Agardh, 1842	+++	+	+	++	++	++	+++	++
Plocamium cartilagineum (Linnaeus) P.S.Dixon, 1967	0	++	+	+	++	+++	++	0
Pterocladia capillacea (S.G.Gmelin) Bornet, 1876	+	+	++	0	+	+	++	++
Schottera nicaeensis (J.V.Lamouroux ex Duby) Guiry & Hollenberg, 1975	0	0	+	+	0	+	0	0
Sphaerococcus coronopifolius Stackhouse, 1797	+	++	+	0	++	+	++	+
S = 25	22	20	20	16	22	21	17	19

The inventory of the macroinvertebrates of the infralittoral level of the studied stations showed the different distributions of the taxa by a dominance of the sponges and mollusks presented by 23 species in each taxon. Crustaceans were the least represented by 8 species (Table 3).

The rocky characteristics of the "Plane" Island showed that the macrofauna was represented by 1 phylum of vertebrates counting 33 Fish (5 orders and 14 family) and 99 invertebrate species belonging to 8 phyla (23 sponges, 23 mollusks, 22 cnidarians, 12 echinoderms, 8 crustaceans, 5 polychaetas, 4 tunicates and 2 bryozoans). However, underwater visual census method used during our survey seem to underestimate the actual marine biodiversity in Plane Island. In fact, small size species require a high taxonomic expertise and the numbers could potentially rise if visual census used during our study was coupled to laboratory taxonomic and molecular identification protocols.

Table 3. An inventory of faunal taxa in the infralittoral of 8 stations of "Plane" Island. S: Number of species. Species presence are marked as: absent: 0, present: + and strong presence: ++, *: endangered species

Stations	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**
Macroinvertebrates								
A - Porifera								
Agelas oroides (Schmidt,1864)	+	+	0	0	0	0	+	0
Anchinoe fictitius (Bowerbank,1866)	++	+	+	0	+	+	0	+
Aplysilla sulfurea (Schulze,1878)	++	++	+	0	0	+	0	+
Aplysina sp.	0	+	+	0	0	0	+	0
Axinella cannabina (Esper,1794)	0	+	+	0	0	0	0	0
*Axinella polypoides** (Schmidt,1862)	+	0	0	+	0	0	+	+
Axinella verrucosa (Esper,1794)	0	0	+	+	0	+	0	+
Cacospongia mollior (Schmidt,1862)	+	+	+	+	++	+	+	+
Chondrilla nucula (Schmidt,1862)	+	++	+	+	+	+	++	+
Chondrosia reniformis (Nardo,1847)	++	++	+	+	++	+	++	++
Clathrina coriacea (Montragu,1814)	+	+	+	0	+	+	0	+
Crambe crambe (Schmidt,1862)	+++	++	++	+	+++	++	++	+++
Dysidea avara (Schmidt,1862)	+	+	0	0	+	0	0	+
Dysidea fragilis (Montagu,1814)	+	0	0	0	+	0	+	0
Hamigera hamigera (Schmidt,1862)	+	0	0	0	+	+	+	+

Table 3. Continued

Hippospongia communis (Lamarck,1814)	0	+	0	+	+	0	+	+
Ircinia fasciculata (Pallas,1766)	+	+	+	0	++	+	+	0
Ircinia oros (Schmidt,1864)	+	0	++	+	+	+	++	+
Phorbas paupertas (sensu Boury-Esnault, 1971)	+	++	0	+	+	+	+	++
Phorbas tenacior (Topsent,1925)	+	0	0	0	+	+	0	+
Sarcotragus spinosula (Schmidt,1862)	+	+	0	0	0	+	+	+
Spirastrella cunctatrix (Schmidt,1868)	+	0	0	+	0	0	0	+
*Spongia officinalis** (Linnaeus,1759)	++	++	++	+	++	++	+++	+++
S = 23	19	16	13	11	15	15	15	18
B - Cnidaria								
Alcyonium acaule (Marion,1878)	+	++	+	+	+	+	+	+
Actinia equina (Linnaeus,1758)	+++	++	+	+	+++	++	0	+
Aglaophenia tubiformis (Marktanner Turneretscher, 1890)	+	+	0	+	+	0	+	0
Aiptasia mutabilis (Gravenhorst, 1831)	++	+	0	0	+	0	+	0
Anemonia viridis (Forsskål, 1775)	+++	++	+++	++	+++	++	+++	++
*Astroides calycularis** (Pallas, 1766)	+++	++	++	++	+++	++	++	+++
Bunodeopsis strumosa (Andrès, 1881)	+	++	0	0	+	0	0	0
Calliactis parasitica (Couch, 1842)	+++	++	++	++	+++	++	+++	++
Caryophyllia inornata (Duncan, 1878)	++	++	+++	++	+	+	+	++
Cladocora caespitosa (Linnaeus, 1767)	+	+	0	0	+	+	+	+
Cotylorhiza tuberculata (Macri,1778)	0	0	+	0	0	0	0	+
Condylactis aurantiaca (Delle Chiaje, 1825)	++	+	+	0	+	0	+	+
Eunicella singularis (Esper,1791)	++	++	+++	++	++	+++	++	++
Eunicella cavolini (Koch,1887)	++	++	++	++	+	++	+++	++
Leptogorgia sarmentosa (Esper,1789)	+++	++	+++	++	++	+++	++	++
Leptopsammia pruvoti (Lacaze Duthiers, 1897)	++	+	+++	+	+++	+	+	++
Paramuricea clavata (Risso, 1826)	++	++	+++	++	+	+	+	+++
Parazoanthus axinellae (Schmidt,1862)	+	+	+	++	++	++	0	+
Pelagia noctiluca (Forskål, 1775)	++	++	++	++	++	++	++	++
Pourtalosmilia anthophylites (Ellis &Solander, 1786)	+	++	++	0	0	0	0	++
Pteroeides griseum (Linnaeus,1767)	+	+	0	0	+	0	0	+
Bolinopsis vitrea (L. Agassiz,1860)	+	+	+	+	+	+	+	+
S = 22	21	21	16	14	19	14	15	18
C - Polychaeta								
Hermodice carunculata (Pallas,1766)	++	+	+	0	++	0	+	0
Sabella spallanzanii (Gmelin,1791)	+	0	0	0	+	+	0	+
Veretillum cynomorium (Pallas,1766)	0	0	0	0	0	0	+	0
Prostheceraeus sp.	+	0	0	0	+	0	0	0
Protula tubularia (Montagu, 1803)	+++	+	++	++	+++	+	+	++
S = 5	4	2	2	1	4	2	3	2
D - Crustacea								
Dardanus calidus (Risso,1827)	+++	++	++	+	++	+	++	++
Dromia personata (Linnaeus,1758)	++	+	++	+	+	+	+	++
Eriphia verrucosa (Forskål,1775)	+	0	0	0	+	0	0	0
Euraphia depressa (Poli,1791)	++	+	0	0	++	0	0	+
*Maja squinado** (Herbst,1788)	+	0	0	0	0	+	+	+
Scyllarides latus (Latreille,1803)	0	+	+	0	0	0	+	+
Pachygrapsus marmoratus (Fabricius, 1787)	++	+	0	0	++	+	0	0

Table 3. Continued

*Palinurus elephas** (Fabricius,1787)	0	+	0	0	0	0	+	+
S = 8	6	6	3	2	5	4	5	6
E - Mollusca								
Aplysia punctata (Cuvier,1803)	++	+	0	+	+	+	0	+
Arca noae (Linnaeus,1758)	+	0	0	0	+	+	+	0
Cancellaria cancellata (Linnaeus,1767)	+	+	+	0	+	+	+	+
Cerithium vulgatum (Bruguière,1792)	++	++	+	+	++	++	++	+
Chlamys sp.	+	0	0	0	0	0	0	+
Charonia lampas (Linnaeus,1758)	+++	++	++	+	++	++	+++	++
Cratena peregrina (Gmelin,1791)	+	+	+	0	+	0	+	0
Dendropoma petraeum (Monterosato, 1984)	+	+	0	0	+	+	0	0
Erosaria spurca (Linnaeus,1758)	+	0	0	0	+	+	+	0
Tarantinaea lignaria (Linnaeus,1758)	+	+	+	+	+	+	+	+
Hypselodoris sp.	0	0	+	0	0	0	0	0
Lima lima (Linnaeus,1758)	+	++	0	0	0	+	0	+
Lithophaga lithophaga (Linnaeus,1758)	+	+	+	+	0	0	+	+
Mitra sp.	0	+	+	+	0	0	+	0
Octopus vulgaris (Cuvier,1797)	++	0	+	0	++	0	0	0
Osilinus articulatus (Lamarck,1822)	+	+	0	0	+	0	+	+
Phorcus turbinatus (Born,1778)	+	+	+	0	+	++	0	0
Ostrea edulis (Linnaeus,1758)	+	+	+	+	+	0	+	0
*Pinna nobilis** (Linnaeus,1758)	++	+	++	+	++	+	+	++
*Pinna rudis** (Linnaeus,1758)	+	+	0	0	+	+	++	0
Semicassis granulata (Born,1778)	++	++	+	+	++	+	++	++
Sepia officinalis (Linnaeus,1758)	+	+	+	+	+	+	+	+
Stramonita haemostoma (Linnaeus,1767)	++	+	0	0	0	+	+	+
S = 23	21	18	14	10	17	15	16	13
F - Bryozoa								
Cellepora pumicosa (Pallas, 1766)	+	+	0	+	+	0	+	+
Myriapora truncata (Pallas, 1766)	++	+	+	++	+	+	++	++
S = 2	2	2	1	2	2	1	2	2
G-Echinodermata								
Arbacia lixula (Linnaeus,1758)	+	++	+	0	0	0	+	+
Astrospartus mediterraneus (Risso, 1826)	+++	++	+	0	+	0	++	0
*Centrostephanus longispinus** (Philippi,1845)	+++	++	+	++	++	+	++	+
Echinaster sepositus (Retzius,1783)	++	+	0	0	+	+	++	+
Hacelia attenuata (Gray, 1840)	+	+	+	++	+	++	+	++
Holothuria tubulosa (Gmelin,1791)	++	++	0	0	++	++	0	0
Holothuria forskali (Delle Chiaje,1823)	+++	+++	++	++	+++	++	++	++
Ophioderma longicauda (Bruzelius,1805)	++	++	0	0	++	+	0	++
Ophiura ophiura (Linnaeus,1758)	+++	++	+	0	++	++	+	+
*Ophidiaster ophidianus** (Lamarck,1816)	+++	++	+++	++	+++	++	++	++
*Paracentrotus lividus** (Lamarck,1816)	+++	+++	++	++	+++	+++	+++	+++
Sphaerechinus granularis (Lamarck,1816)	++	++	+	++	++	+++	+	++
S = 12	12	12	9	6	11	10	10	10
H - Tunicata								
Aplidium nordmanni (Milne-Edwards, 1841)	0	+	+	0	0	0	+	0
Aplidium sp.	0	+	0	+	+	0	+	+

Table 3. Continued

Botryllus spp.	+	+	+	+	+	+	+	+
Halocynthia papillosa (Linnaeus, 1767)	+	+	0	0	+	0	0	+
S = 4	2	4	2	2	3	1	3	3
Fish								
Class: **Osteichthyes**								
Ord: **Anguilliformes**								
Fam: **Muraenidae**								
Muraena helena (Linnaeus, 1758)	++	+	+	0	+	0	+	++
Fam: **Congridae**								
Conger conger (Linnaeus, 1758)	+	+	0	0	+	+	0	0
Ord: **Scorpaeniformes**								
Fam: **Scorpaenidae**								
Scorpaena porcus (Linnaeus, 1758)	+++	++	+	+	+	++	++	++
Scorpaena scrofa (Linnaeus, 1758)	++	+	0	0	+	++	+	+
Ord: **Perciformes**								
Fam: **Serranidae**								
Anthias anthias (Linnaeus, 1758)	++	++	+	0	+	+	+	+
*Epinephelus costae** (Steindachner, 1878)	0	0	+	+	0	+	+	+
*Epinephelus marginatus** (Lowe, 1834)	+	+	+	+	+	++	+	++
Serranus scriba (Linnaeus, 1758)	++	+	++	++	++	++	+	++
Serranus cabrilla (Linnaeus, 1758)	++	++	++	+	+	++	+	++
Fam: **Apogonidae**								
Apogon imberbis (Linnaeus, 1758)	++	+	++	+	++	++	+	++
Fam: **Sparidae**								
Boops boops (Linnaeus, 1758)	0	+	+	+	+	+	++	++
Dentex dentex (Linnaeus, 1758)	0	+	+	0	0	0	+	+
Diplodus annularis (Linnaeus, 1758)	+	+	+	+	+	+	+	+
Diplodus cervinus cervinus (Lowe, 1838)	+	+	0	0	0	+	+	+
Diplodus puntazzo (Walbaum, 1792)	0	+	0	+	+	+	0	0
Diplodus sargus sargus (Linnaeus, 1758)	+	+	++	+	+	++	+	+
Diplodus vulgaris (Geoffroy Saint-Hilaire, 1817)	++	+	++	++	+	+	+	+
Oblada melanura (Linnaeus, 1758)	+	++	+	+	+	+	+	++
Sarpa salpa (Linnaeus, 1758)	+	++	+	0	+	+	+	+
Fam: **Mugilidae**								
Liza aurata (Risso, 1810)	+	+	0	0	0	+	0	0
Fam: **Mullidae**								
Mullus surmuletus (Linnaeus,1758)	+	++	++	+	+	+	0	+
Fam: **Pomacentridae**								
Chromis chromis (Linnaeus,1758)	++	++	++	++	++	++	+	++
Fam: **Labridae**								
Coris julis (Linnaeus,1758)	++	+	+	0	++	+	+	+
Symphodus cinereus (Bonnaterre,1788)	+	0	+	0	+	0	+	+
Symphodus doderleini (Jordan,1890)	+	+	0	0	0	+	+	0
Symphodus roissali (Risso,1810)	+	+	+	+	+	+	0	0
Thalassoma pavo (Linnaeus,1758)	++	++	+	+	++	++	++	++
Fam: **Blenniidae**								
Parablennius zvonimiri (Kolombatovic, 1892)	+	0	0	+	+	0	+	0
Fam: **Tripterygiidae**								
Tripterygion minor (Kolombatovic,1892)	+	+	0	+	+	+	0	+
Tripterygion tripteronotum (Risso, 1810)	+	0	+	0	+	0	+	+
Tripterygion delaisi (Cadenat & Blache, 1970)	+	+	+	0	0	+	+	+

Table 3. Continued

Ord: **Pleuronectiformes**								
Fam: **Soleidae**								
Solea solea (Linnaeus,1758)	0	0	0	0	+	0	0	0
Ord: **Gadiformes**								
Fam: **Gadidae**								
Phycis phycis (Linnaeus,1766)	+	++	0	+	+	0	+	+
S = 33	28	28	23	19	27	26	26	26

The benthic fish fauna of the infralittoral zone of "Plane" Island counted 33 species, rich and diversified but threatened by human activity (pollution, fishing and illegal spearfishing). The development of actions to promote biodiversity conservation, including the establishment of a monitoring system and strict legislation towards endangered species of ecological/economic interest is essential as is the case of the dusky grouper *Epinephelus marginatus* classified as a vulnerable species giving the alarming situation of its population (decline of mature individuals) (IUCN: Pollard *et al*. 2018).

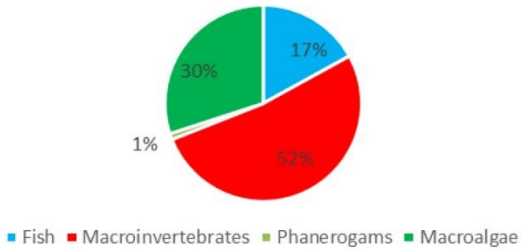

Figure 5. Percentage of phyla recorded in the infralittoral zone of "Plane" Island

We compared our floristic inventory with two islands in the western Algerian waters where 113 algal species have been recorded (MATE 2004) in the Habibas Islands (total island surface of 0.4 km^2), where 64 species of Rhodophytes, 25 Chlorophyte and 24 Pheophyte species were reported. However, around Rachgoun Island (total island surface of 0.16 km^2) a total of 80 taxa of macroflora species have been recorded (PNUE/PAM-CAR/ASP 2016) in the depths between 0 and 43 m. The most diversified group is Rhodophytes with 38 species followed by Pheophytes with 25 and Chlorophytes with 17 species. These results show that more focused taxonomic studies could possible reveal a higher biodiversity at "Plane" Island which covers a small area of only 0.04 km^2, but our preliminary study could identify 59 macroalgae species and one important species of phanerogam presented by *Posidonia oceanica*.

The results obtained at the infralittoral zone of different stations show a very clear qualitative difference between the sites subjected to the anthropogenic actions (infrastructures, overexploitations, pollution and tourism) and those

relatively distant from these actions. Given its ease of access, the stations 1, 2, 3, 4 are more exposed to anthropogenic perturbations than stations 5, 6, 7 and 8. In the southern part of the island there is a small jetty used by fishermen all year long and this also receives thousands of tourists, pleasure boats and other motorized watercrafts in summer period generating physical and chemical aggressions to that fragile ecosystem and affecting biodiversity. The most represented species around the island were the sea urchin *Paracentrotus lividus*, the beadlet anemone *Actina equina*, the green anemone *Anemonia viridis*, the sponge *Spongia officinalis* and the Mediterranean chromis *Chromis chromis.*

As stated by Fredj and Maurin (1987), the fish species encountered have an Atlanto-Mediterranean origin (Table 1), as is the case of the majority of the Mediterranean fish fauna. They have an affinity to temperate and warm waters. The listed species had a thermal preference having as origin southern Ibero-Moroccan and Saharian regions of the Mediterranean province such as *Epinephelus marginatus*, *Epinephelus costae* while endemics are represented by *Diplodus sargus sargus*.

The richness seems strongly influenced by the abiotic factors of each station, such as hydrodynamism, mode of exposure, and anthropogenic activity, Figure 6 shows an important richness in ichthyofauna, rhodophytes, sponges and cnidarians in the eight stations studied. This reflects the importance of the geographical location and the substrate nature. Generally, transects were characterized by very small shallow bottoms and many areas of scree, as a result of erosion and disruption of the rock wall resulting in a very rugged and highly complex underwater bottom.

All these elements are a major component of the island's underwater seabed, and constitute important fixation surfaces (hard substrates) for benthic organisms and allow the establishment of various biocenoses: coralligenous (red coral), ichthyological and carcinological settlements. The rocky facies is juxtaposed on the soft sedimentary facies, where it constitutes true rocky enclaves. The extensions of the cliffs and scree are appropriate substrates which are colonized in large part by macrophyte algae, hence proliferation of a strong plant dominance, such as photophilic algae at low depths. In fact, all these conditions give Paloma or “Plane” Island the characteristics of a nursing ground.

From 15 to 30 m deep the bottoms are mainly in the form of scree. Deep bedrock outcrops (25 to 34m), characterized by low illumination and many anfractuosities, resulted in sciaphilous flora and exuberant sessile fauna that make up the coralligenous ecosystem. The singular sea fan *Eunicella singularis* was one of the most remarkable species of “Plane” island bottoms marked by the presence of large fish such as *Muraena helena*, *Physis physis, Conger conger, Epinephelus costae* and *Epinephelus marginatus.*

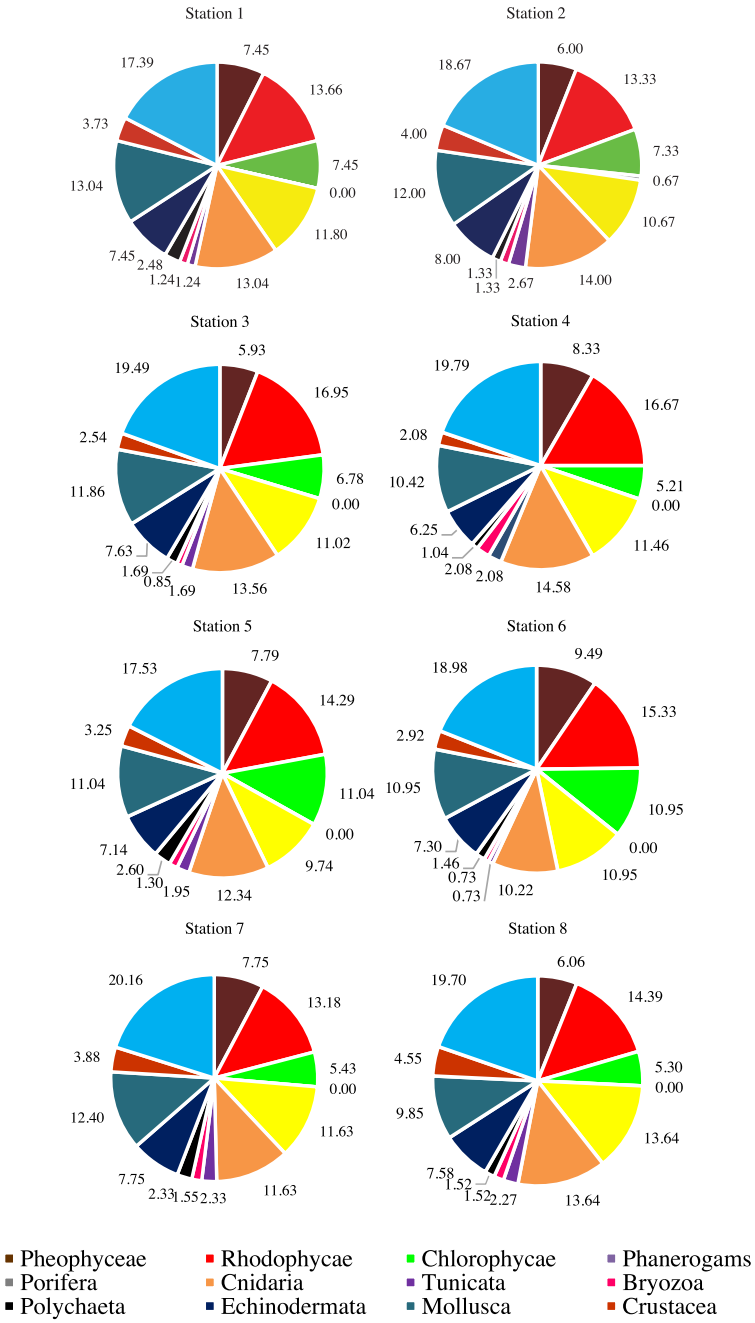

Figure 6. Specific richness (%) in the eight stations studied

Given the lack of financial means and diving personnel (only two scientific divers), our first inventory was limited to eight stations and 34m depth. Further investigations, however, will explore biodiversity beyond this limit where habitats are less exposed to the solar rays and are subject to much colder water than surface, thus an extraordinary fauna are sheltered and the famous "coralligenous reef walls" are formed.

The island contains also several underwater caves, with dark and semi-dark characteristics. Four of them were explored, having several openings, which are between 16 and 37m seen as a hot spot of biodiversity in littoral zone for a wide range of organisms which do not depend directly on the luminous energy in their life cycle like macro invertebrates that have a fixed way of life. Thus, the shape of the cave, its size, depth contribute a lot to this specific richness. The most abundant communities are the bryozoans *Myriapora truncata*, the cnidarians *Astroides calycularis, Leptopsammia pruvoti, Parazoanthus axinellae, Pourtalosmilia anthophylites*, some dominant sponges: *Agelas oroides, Clathrina clathrus, Chondrosia reniformis*. The presence of bristleworm *Protula tubularia* and ascidians *Halocynthia papillosa* should be noted. At the opening of the caves there is also a strong presence of *Apogon imberbis*, which feed on small particles displaced by marine currents. Some caves have faults and crevices in their walls where we met large specimens of *Muraena helena*, *Conger conger* and the forkbeared *Phycis phycis*.

Of the 201 species inventoried, some are protected by Algerian legislation to preserve the national biological heritage and international conventions (Barcelona and Bern Conventions) in their different annexes and also appear in the Red List of the IUCN. Status of protected species encountered in “Plane” Island are resumed in Table 4.

Unlike the fish species strongly impacted by the various fishing practices, the macrobenthic species are very diversified, marked by the presence of species with special status or subject to protective measures indicated by international conventions such as Barcelona Convention (1976) and Bern Convention (concerning marine species in 1996) such as Macrophytes (*Posidonia oceanica, Cystoseira sp, Sargassum trichocarpum, Lithophyllum byssoides*), Mollusks (*Patella ferruginea, Pinna nobilis, Pinna rudis, Charonia lampas, Lithophaga lithophaga, Dendropoma lebeche, Luria lurida*), Crustaceans (*Scyllarides latus, Scyllarus arctus Palinurus elephas Homarus gammarus, Maja squinado*), Echinoderms (*Centrostephanus longispinus, Ophidiaster ophidianus, Paracentrotus lividus*), Cnidarians (*Astroides calycularis, Savalia savaglia*) and Sponges (*Axinella polypoides, Spongia officinalis*). The immediate protection of biodiversity of this area is needed to ensure the heritage value for the Oranian shorline and for Algerian waters.

Table 4. Protection status of species encountered in "Plane Island": Algerian Protection status, Barcelona and/or Bern Convention, Red List Category of the IUCN.

	Algerian Protection status*	**Barcelona convention**	**Bern convention**	**IUCN Red List Category****
Flora				
Cystoseira amentacea	Critically Endangered	Annex II	Annex I	-
Posidonia oceanica	Endangered	Annex II	Annex I	**LC**
Fauna				
Mollusca				
Patella ferruginea	Threatened	Annex II	Annex II	-
Lithophaga lithophaga	Threatened	Annex II	Annex II	-
Pinna nobilis	Critically Endangered	Annex II		-
Pinna rudis	Threatened	Annex II	Annex II	-
Cructacea				
Palinurus elephas	Threatened	Annex III	Annex III	**VU**
Scyllarides latus	Threatened	Annex III	Annex III	**DD**
Maja squinado	Near threatened	Annex III	Annex III	-
Echinodermata				
Centrostephanus longispinus	Critically Endangered	Annex II	Annex II	-
Ophidiaster ophidianus	Near threatened	Annex II	Annex II	-
Paracentrotus lividus	Near threatened	Annex III	Annex III	-
Cnidria				
Astroides calycularis	Near threatened	Annex II	Annex II	-
Porifera				
Axinella polypoides	Near threatened	Annex II	Annex II	-
Spongia officinalis	Near threatened	Annex III	Annex III	-
Fish				
Epinephelus marginatus	Threatened	Annex III	Annex III	**VU**
Epinephelus costae	Threatened	Annex III	Annex III	**DD**

*J.O.R.A.D.P, 2006 (Presidential Decree n° 2006-405).

** LC: Least Concern; VU: Vulnerable; DD: Data Deficient

Biocenosis of the "Plane" Island

This list is based on the classification of benthic marine habitat types for the Mediterranean region elaborated by Experts on Marine Habitat Types in the Mediterranean Region (Hyères, France, 18-20 November 1998) and reviewed subsequently by experts in the 4th Meeting of National Focal Points for ASP (UNEP (OCA)/MED WG 1999).

Hard bottoms and rocks

Biocenosis of upper mediolittoral rock

Association with *Nemalion helminthoides* and *Rissoella verruculosa*

Biocenosis of the lower mediolittoral rock

Association with *Lithophyllum byssoides*

Association with *Gelidium* spp.

Association with *Ulva* spp.

Biocenosis of mediolittoral caves

Association with *Phymatolithon lenormandii* and *Hildenbrandia rubra*

Biocenosis of infralittoral algae

Association of Photophilic Algae in beaten Mode
Overgrazing Association of Encrusting Seaweeds and Urchins
Association of Hemiphotophilic Algae
Association of Photophilous Algae in beaten mode:
Overgrazing facies with encrusting seaweed and sea urchins
Association with *Cystoseira amentacea* (var *amentacea*, var *stricta*, var *spicata*)
Association with *Corallina elongata*
Association with *Sargassum vulgare*
Association with *Dictyopteris polypodioides*
Association in *Calpomenia sinuosa*
Association with *Ulva* sp.
Association with *Padina pavonica* and Dictyotales
Association with *Posidonia oceanica*
Association of Sciaphile Algae in beaten Mode:
Facies with large hydrates
Facies with *Astroides calycularis*
Sciaphile Algae Association in sheltered Mode
Association with *Peyssonnelia rubra* and *Peyssonnelia* spp.

Coralligenous biocenosis

Facies with gorgonians
Facies with *Eunicella cavolini*
Facies with *Eunicella singularis*
Facies with *Parazoanthus axinellae*
Facies and association of Coralligenous biocenosis (in enclave)

Biocenosis of semi-dark caves

Facies with *Parazoanthus axinellae*
Facies with *Astroides calycularis*

Conclusion

The examination of “Plane” Island's benthic biodiversity shows an undeniable specific richness of these seabed showing a high diversity with 55 species distributed between the supra and mid-littoral stage and 195 species to the infralittoral stage. The total number of taxa inventoried after the elimination of the species present in both parts is around 201 benthic species.

The island is characterized by the presence of six biocenosis of hard rock with 19 associations and 9 facies. The bioconcretions, the colored facies of red gorgonians (*Paramuricea clavata*), yellow gorgonians (*Eunicella cavolini*) and sessile macrofauna mark the coralligenous habitat. The presence of large and

small pelagics (sardine, bogue, Atlantic horse mackerel, tuna, swordfish…) adds interest to the area as evidenced by the large numbers of purse seiners, common dolphins (*Delphinus delphis* Linnaeus, 1758) and grey petrels *Procellaria cinerea* (Gmelin, 1789) around the island.

In addition to the ichthyofauna of the hard and soft substrates, the landings in the region reveal an important fishing potential, especially in demersal species. A population of common dolphins regularly visits the area between "Plane" and the Habibas Islands, as well as two species of turtles: leatherback (*Dermochelys coriacea* Linnaeus, 1758) and loggerhead sea turtles (*Caretta caretta* Linnaeus,1758), that are also reported around the island (Lanteri,1982; Laurent,1988,1990, Boutiba, 1992, Hussein 2015).

However, like the Oranian coast, "Plane" Island is not immune to aggressions of exotic and invasive species, such as *Caulerpa racemosa* var. *cylindracea*, *Codium brittle*, *Asparagopsis armata* and *Asparagopsis taxiformis*, bryozoan *Amathia verticillata*, scleractiniaria *Oculina patagonica*.

From a biogeographic point of view, "Plane" island is located in the transition zone between Alboran Sea and the western Mediterranean basin, rich in plankton necessary for the functioning of the benthic domain. The inventory of "Plane" Island should be used to help administrative management and decisions on protection, responding to international programs and obligations.

All of these preliminary elements aiming to evaluate biodiversity in "Plane" Island are at the same time a foundation and a real advocacy to initiate a process of classification and preservation of the terrestrial and marine heritage components of this insular ecosystem. To date, the Algerian legislation (Official Journal of the Algerian Republic 14 December 2003) has protected marine resources by prohibition of fishing activity within the 6 miles zone and around insular areas but to our point of view illegal spearfishing and ghost fishing stay as the most destructive factors resulting in biodiversity loss. Strict political decisions were taken since 2003 for the Oranian shoreline, then the protection of Habibas Island was achieved as an MPA. Recently on 1 October 2018, a second project of MPA was suggested concerning "Plane" Island.

This study aimed to inventory the prominent species in "Plane" Island, determine the presence of species of conservation interest and categorize rocky benthic habitats in order to help decision-makers and managers with the conservation plans of the island. Further studies are necessary for the taxonomic identification of small, cryptic and less flagrant species and should include depths beyond 34 m and the various caves present in the island. Investigations must include the monitoring of some pertinent species with emphasis on populations density, dynamics, and ecology. This first inventory of biodiversity

in “Plane” Island will surely help national and international MPA’s managers to fill the gaps for the threatened and vulnerable species of the Mediterranean Sea.

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