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First Study on Coralligenous Habitats in the Marine Protected Area of Mount Edough National Park in Annaba, Northeastern Algeria

Said Belbacha[1], Amina Tania Dahel[1, 2*], Abdallah Borhan Djebar[1], Amine Bey Djebar[1], Kaouther Lebdjiri[1], Rafik Kebbab[1]

[1] Laboratory of Ecobiology of Marine and Coastal Environments, Department of Marine Science, University Badji Mokhtar, Annaba (23000), Algeria
[2]Laboratory of Biodiversity and Pollution of Ecosystems, Department of Marine Science, Faculty of Natural Sciences, Chadli Bendjedid University, El Tarf (36000), Algeria

[*]**Corresponding Author: dahel-amina@univ-eltarf.dz/ dahelzanat@yahoo.fr**

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ABSTRACT

This study is the first to advance knowledge of the coralligenous ecosystem within the Monts Edough Marine Protected Area (MPA), officially established in September 2023. Situated on the western outskirts of Annaba in eastern Algeria, the MPA was created as part of a partnership with the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ). The initial survey revealed both pre-coralligenous and coralligenous formations, although their distribution within the MPA is uneven. These habitats cover extensive areas, colonizing vertical walls and the outer zones of sea caves, and forming cord-like structures at depths ranging from –4 to –61m. A total of 296 species were recorded, 86 of which play a direct role in the formation of coralligenous habitats. The ecological condition of the observed communities appears satisfactory, with no evidence of significant anthropogenic impacts such as urban or industrial discharges. The only human activity currently identified is low-intensity artisanal fishing. However, numerous tourism development projects planned for the region represent a potential threat to this sensitive ecosystem. This study underscored the urgent need for strengthened protection measures and sustainable management of the Monts Edough MPA to safeguard its biological richness against increasing human pressures. It highlights the importance of a proactive conservation strategy to ensure the long-term resilience of this fragile environment.

INTRODUCTION

Coral reefs are a typical Mediterranean benthic habitat, composed of the biogenesis of calcareous crustaceous algae, particularly rhodophytes, and calcareous skeleton organisms such as sponges, sand tubes, and bryozoans **(Ballesteros, 2006)**. These

formations develop into complex structures, with vertical walls or horizontal plateaus, generally between 30 and 120 meters in depth **(Sara, 1969)**. Thanks to their structural heterogeneity, native corals are home to remarkable biodiversity, with over 17,000 species recorded, including a wide range of sessile invertebrates and fish, as well as emblematic species such as gorgonians and corals. After the Posidonia oceanica meadows, this is the second hotspot of biodiversity in the Mediterranean **(Boudouresque, 2004; Coll *et al*., 2010; Lebedjeri *et al*., 2024)**.

Although the number of MPAs in the Mediterranean is increasing, their geographical distribution remains uneven between the northern and southern shores, to the detriment of the southern countries of the basin in particular. Recognizing the strategic importance of its marine ecosystems, Algeria has made the conservation of coastal and marine biodiversity an environmental priority. This was reflected in the enactment of Law 11-02 of 2011 on protected areas, which sets out the legal framework for the creation, management, and protection of protected areas. As part of this protection initiative, and in line with the Action Plan for the Conservation of Coralligenous and Other Calcareous Bioconcretions in the Mediterranean **(UNEP-MAP-RAC/SPA, 2008; 2011)**, our study focuses on the ecological enhancement of the *Aire Marine Protégée du Parc Naturel des Monts de l'Edough à Annaba* in northeastern Algeria, officially classified by decision no. 2261 of September 4, 2023. This recently recognized site is receiving particular attention due to its rich benthic habitats.

This study is the first contribution to the state of knowledge on the coralligenous ecosystem of the Edough Mountains MPA, located in the eastern part of the Algerian coastline. It addresses several major challenges, notably the conservation of marine biodiversity, the sustainability of artisanal fishing, the development of sustainable tourism, and the enhancement of local socio-economic uses. With this in mind, the present work aimed to characterize the composition and spatial distribution of coralligenous communities using a transect approach. Two specific objectives were pursued: (1) to carry out a qualitative inventory of the species associated with this habitat and (2) to analyze their geographical distribution. This is the first detailed ecological inventory of coralligenous communities in the eastern part of the Monts Edough MPA. Consequently, this work provides the first scientific data on a marine habitat of high heritage value, offering an essential reference base for the implementation of sustainable management of this ecosystem targeting decision-makers, managers, and conservation stakeholders.

MATERIALS AND METHODS

1. Study area

The Monts de l'Edough Marine Protected Area (MPA) is located in northeastern Algeria, southwest of the Mediterranean basin. It extends west of the city of Annaba

along a 60km stretch of coastline, bounded by Cap de Garde to the east and Sidi Akacha to the west (Fig. 1). Geomorphologically, the area is highly diverse in both structure and landscape. It includes a variety of coastal formations, such as sandy beaches (Jenen El Bey, Sables d'Or 1, 2, and 3), rocky coasts (Deux Frères site), several coastal wadis (Bagratte, Semhoute, El Gueb), as well as coastal caves (Pain de Sucre), calanques (Chetaïbi), islands and islets (Île Sainte-Piastre, îlot de l'Espion), and prominent bays and capes (Cap de Garde and Sidi Akacha). This geomorphological richness makes the MPA an area of exceptional ecological and landscape value.

The eastern portion of the Monts de l'Edough MPA—spanning a 37km stretch between Cap de Garde (7° 47′ E) and Axcine Rock (7° 30′ E)—served as the study site. To achieve comprehensive coverage, 25 stations were surveyed by diving at depths ranging from –18 to –55m, while 13 transects were conducted between –4 and –61m across 8 distinct sectors. Each sector comprised 2 to 4 stations examined by spot dive, with 1 to 2 transects per zone (Fig. 1).

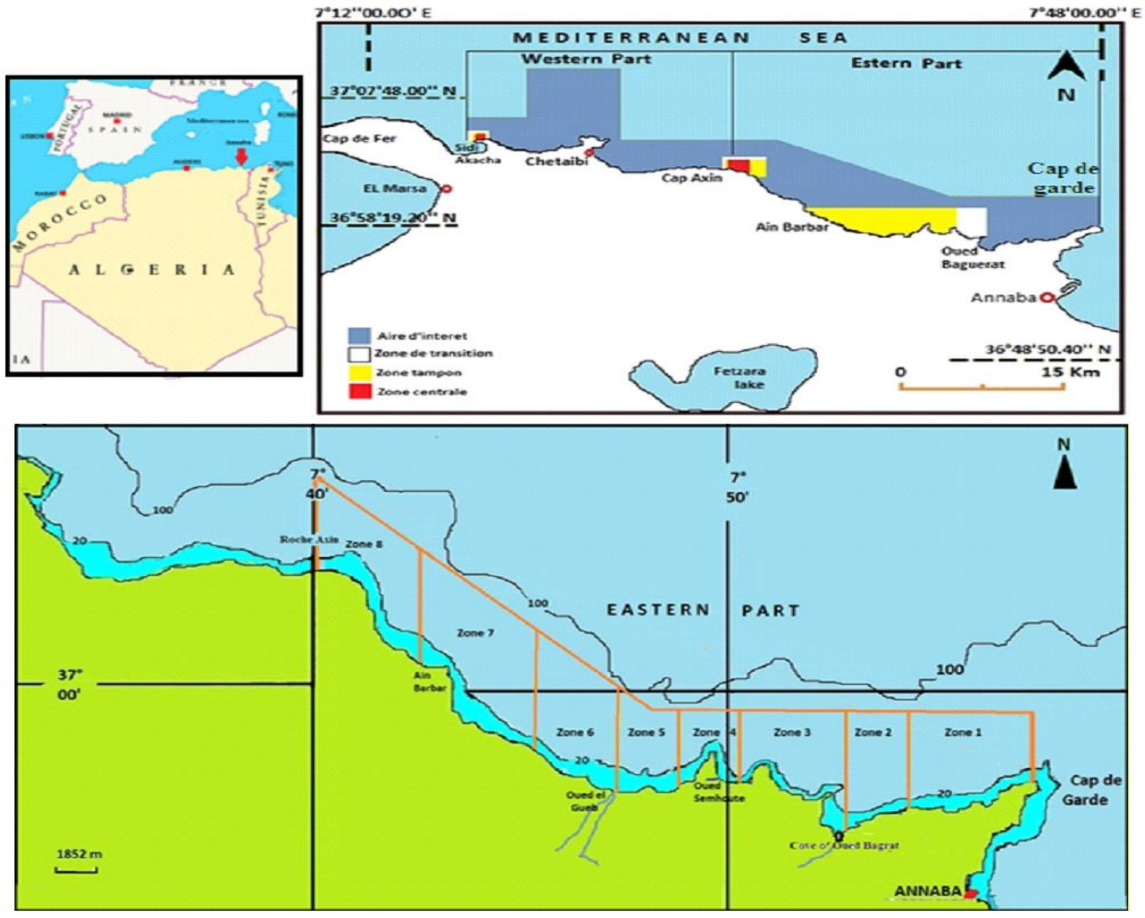

Fig. 1. Geographical location, administrative zoning and subdivision into 8 zones of the eastern part of the Edough Mountains MPA

2. Methodology

The study area encompasses the eastern portion of the Edough Mountains MPA, covering 37km of the total 60km coastal length. It extends from Cap de Garde (7°47′ E) to Axcine Rock (7°30′ E). To ensure full coverage, 25 stations were surveyed by diving at depths ranging from –18 to –55 m, while 13 transects, located between –4 and –61m, were carried out across 8 distinct sectors. Each sector included 2 to 4 stations examined by spot dives, with 1 to 2 transects per zone.

In total, six scuba diving campaigns were conducted between September 2023 and February 2024. The survey protocols were based on census techniques combining direct observation, photography, targeted taxon sampling, and field surveys. Data collection relied on four complementary methods, applied according to the scale of analysis and the required level of precision:

- Hydroplane-assisted diving towed by boat, following **UNEP-MAP-RAC/SPA (2012)** guidelines, to locate large habitats in general, identify coralligenous formations, and assess bathymetric distribution with a precision of ~10 m (Fig. 2).
- Spot dives along transects to characterize benthic assemblages, with meter-level accuracy.
- Underwater photography and macrobenthos sampling, following the protocols of **Kollmann and Stachowitsch (2001)**, achieving <1 m accuracy.
- Direct species identification carried out in the laboratory.

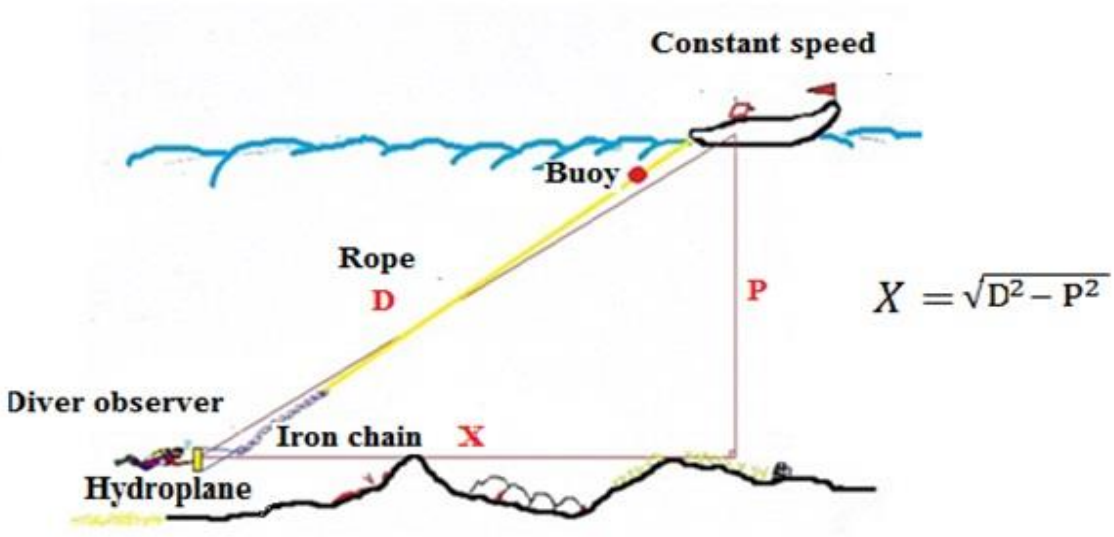

Fig. 2. Method of mapping marine transects via hydroplane according to **UNEP-MAP-RAC/SPA (2012)**, modified. P: Depth, D: Length of traction device, X: Length of transect

RESULTS

1. Location and geomorphological characteristics of dive sites in the MPA

Analysis of the 25 dive sites in the Monts Edough MPA revealed four main substrate types: sand (10 sites, 32– 38m), rock (9 sites, 21– 48m), coralligenous formations (5 stations, 42– 55m), and *Posidonia oceanica* seagrass beds (1 station, 18m) (Table 1). Sandy substrates were the most widespread, while rocky substrates were particularly well represented in the northern and southern parts of the study area. Coralligenous substrates occurred exclusively in deep, localized zones (Table 1).

The spatial distribution of substrates highlighted notable geomorphological heterogeneity across the eight zones:

- Zones 1–3: marked diversity, with alternating sand, rock, and coralligenous substrates (Fig. 3).
- Zone 4: gradual transition from sand to coralligenous (Fig. 3).
- Zone 5: dominated by homogeneous sandy substrate (Fig. 4).
- Zone 6: ecological mosaic composed of sand, *Posidonia*, and coralligenous formations (Fig. 4).
- Zone 7: loose substrates followed by rocky outcrops.
- Zone 8: predominantly rocky, with structured relief (Fig. 4).

Bathymetric zoning followed a pattern typical of the Mediterranean: *Posidonia* in shallow waters (< 20m), sand and rock in intermediate depths (25– 40m), and coralligenous assemblages restricted to deep slopes and drop-offs (42– 55m) (Table 1).

Table 1. Location and geomorphological characteristics of the 25 dive sites

Zone	Station	Location	Depth (m)	Nature of the seabed
1	P1	N 36. 9721 E 7.7834	-55	Coralligenous
	P2	N 36. 9698 E 7.7805	-27	Rock
	P3	N 36. 9693 E 7.7736	-39	Sand
	P4	N 36. 9676 E 7.7689	-32	Sand
2	P5	N 36. 9617 E 7.7285	-32	Rock
	P6	N 36. 9627 E 7.7171	-38	Rock
3	P7	N 36. 9606 E 7.7061	-22	Rock
	P8	N 36. 9822 E 7.6846	-34	Sand
	P9	N 36. 9781 E 7.6704	-42	Coralligenous
4	P10	N 36. 9740 E 7.6478	-29	Sand
	P11	N 36. 9795 E 7.6169	-51	Coralligenous
5	P12	N 36. 9757 E 7.6187	-33	Sand
	P13	N 36. 9790 E 7.6032	-34	Sand

6	P14	N 36. 9915 E 7.5711	-32	Sand
	P15	N 36. 9923 E 7.5627	-18	Posidonia meadow
	P16	N 36. 9999 E 7.5619	-55	Coralligenous
	P17	N 36. 9997 E 7.5597	-47	Coralligenous
7	P18	N 37. 0051 E 7.5609	-34	Sand
	P19	N 37. 0126 E 7.5471	-37	Sand
	P20	N 37. 0250 E 7.5411	-48	Rock
	P21	N 37. 0229 E 7.5340	-21	Rock
8	P22	N 37. 0272 E 7.5286	-36	Rock
	P23	N 37. 0353 E 7.5260	-28	Rock
	P24	N 37. 0434 E 7.5200	-44	Rock
	P25	N 37. 0514 E 7.5103	-32	Rock

2. Habitat diversity by transect

Analysis of the 13 transects conducted in the Edough Mountains Marine Protected Area (MPA) revealed a high degree of heterogeneity in benthic substrates. Sand was the most common, occurring in 10 transects, while rock and *Posidonia oceanica* were also strongly represented, each recorded in 11 transects (Figs. 3, 4). Coralligenous formations, observed in five transects, were restricted to deeper habitats between 47 and 61m, indicating structurally complex environments that support high biodiversity. Less common substrates, including mud, gravel, and rubble, occurred only sporadically (Table 2).

Table 2. Location and geomorphological characteristics of the transects explored in the Edough Mountains MPA

Zone	Transect/ length/ Orientation	Dive point	Nature of the seabed	Depth	Exit point	Depth of Exit
1	T1 1468 m 180°	N 36°58.36’ E 07°45.51’	Sand (Entrance depth)	- 42m	N36°57.517’ E 07°45.425’	-08m
			Rock	- 38m		
			Posidonia tuft	-15m		
			Rock	-13m		
2	T2 1045 m 180°	N 36°58.057’ E 07°44.254’	Coralligenous (Entrance depth)	-47m	N36°57.491’ E 07°44.253’	-11m
			Rock	- 29m		
			Sand	-15m		
3	T3 1337 m 175°	N 36°58.917’ E 07°40.360’	Coralligenous (Entrance depth)	-53m	N36°58.031’ E07°41.069’	-12m
			Rock	-34m		
			Sand	-28m		
			Rock	-17m		
	T4	N 36°58.398’	Coralligenous (Entrance	-55m	N36°58.503	-17m

	880 m 225°	E 07°44.895’	depth)		E07°40.214’	
			Sand	- 40m		
			Rock	- 21m		
4	T5 1202 m 140°	N 36°58.629’ E 07°38.607’	Sand (Entrance depth)	-35m	N 36°58.098’ E 07°38.897’	-16m
			Posidonia litter	- 30m		
			Rock	-18m		
	T6 1066 m 180°	N 36°58.620’ E 07°37.713’	Sand (Entrance depth)	-48m	N 36°57.939’ E 07°37.721’	-12m
			Posidonia beds / Rock	-15m		
5	T7 1316 m 190°	N 36°58.812’ E 07°36.686’	Sand (Entrance depth)	-47m	N 36°58.092’ E 07°36.656’	-09m
			Rock	- 20m		
			Posidonia beds	- 15m		
	T8 1107 m 180°	N 36°59.008’ E 07°35.696’	Sand (Entrance depth)	-40m	N 36°58.395’ E 07°35.657’	-15m
			Posidonia	- 21m		
			Rock	- 17m		
6	T9 997 m 180°	N 36°59.070’ E 07°35.816’	Sand (Entrance depth)	-38m	N 36°58.647’ E 07°35.382’	-7m
			Rocks	- 20m		
			Posidonia	- 9m		
	T10 1445 m 240°	N 36°59.894’ E 07°34.470’	Coralligenous (Entrance depth)	-61m	N 36°59.502’ E 07°.33.700’	-5m
			Sand	- 31m		
			Posidonia	-23m		
			Rock	- 15m		
7	T11 1419 m 245°	N 37°00.572’ E 07°34.154’	Mud (Entrance depth)	- 42m	N 37°00.240’ E 07°33.337’	-13m
			Sand	- 40m		
			Rock	- 23m		
			Posidonia	- 15m		
	T12 1132 m 230°	N 37°01.254’ E 07°32.893’	Gravel (Entrance depth)	-54m	N 37°00.815’ E 07°32.350’	-4 m
			Sand	- 35m		
			Posidonia	- 18m		
8	T13 865 m 220°	N 37°02.539’ E 07°30.920’	Coralligenous (Entrance depth)	- 52m	N 37°02.539’ E 07°30.920’	-8 m
			Rock	- 30m		
			Rubble	- 21m		
			Posidonia	-16m		

All transects followed a bathymetric gradient that decreased toward the coast, ranging from deep areas (down to 61m) to shallow zones (4– 15m), reflecting a regular topographic transition. The spatial distribution revealed a concentration of coralligenous formations in the central–western part of the eastern MPA boundary, a well-developed vertical extension of *Posidonia* seagrass beds across most sectors, and extensive mixed areas of sand, rock, and *Posidonia*. Together, these patterns highlight the high ecological complexity of the site (Table 2 & Figs. 3, 4).

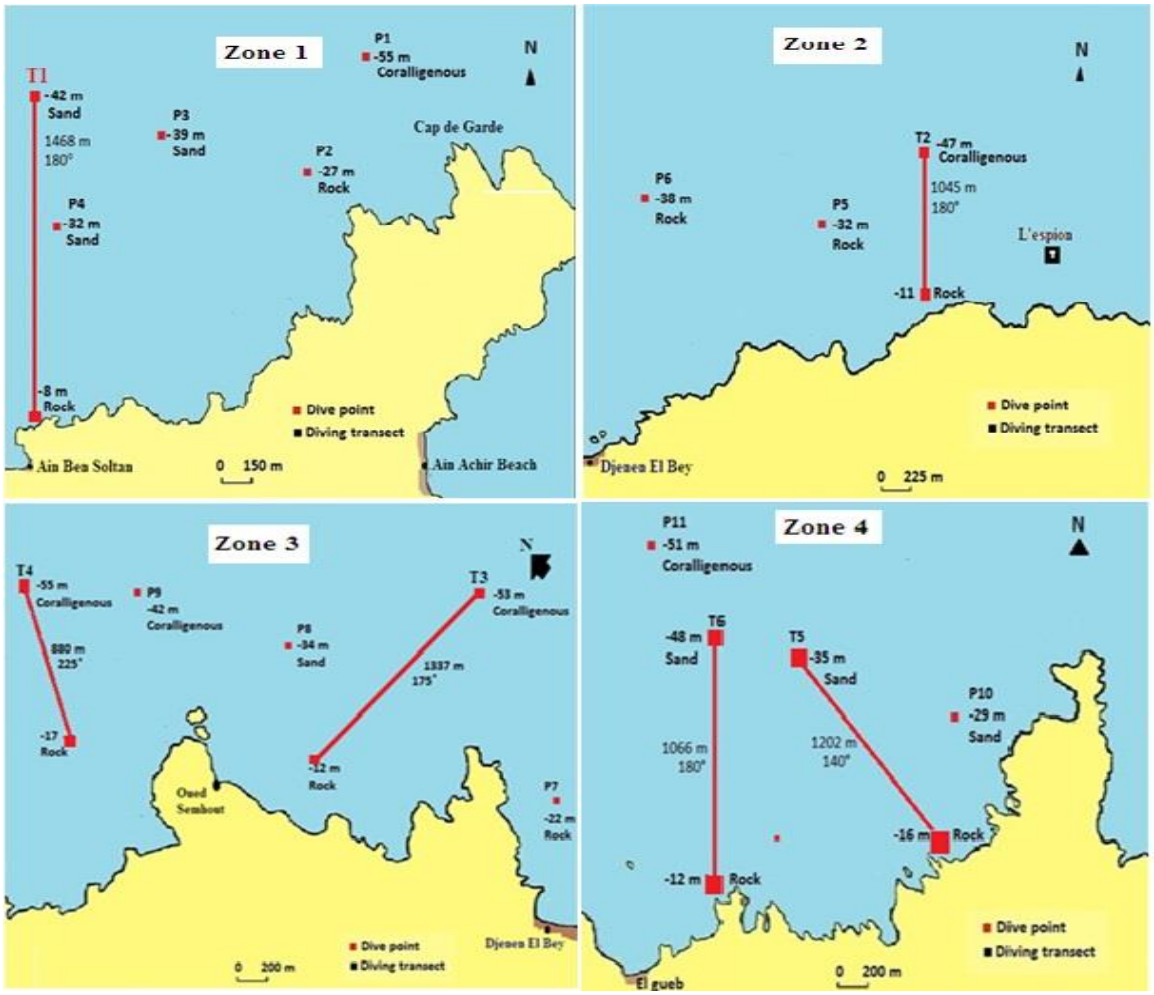

Fig. 3. Positions of dives (P1- P4) of transect T1 in zone 1, (P5 - P6) of transect T2 in zone 2, (P7 - P9) of transects T3 -T4 in zone 3 and (P10 - P11) of transects T5 -T6 explored in zone 4

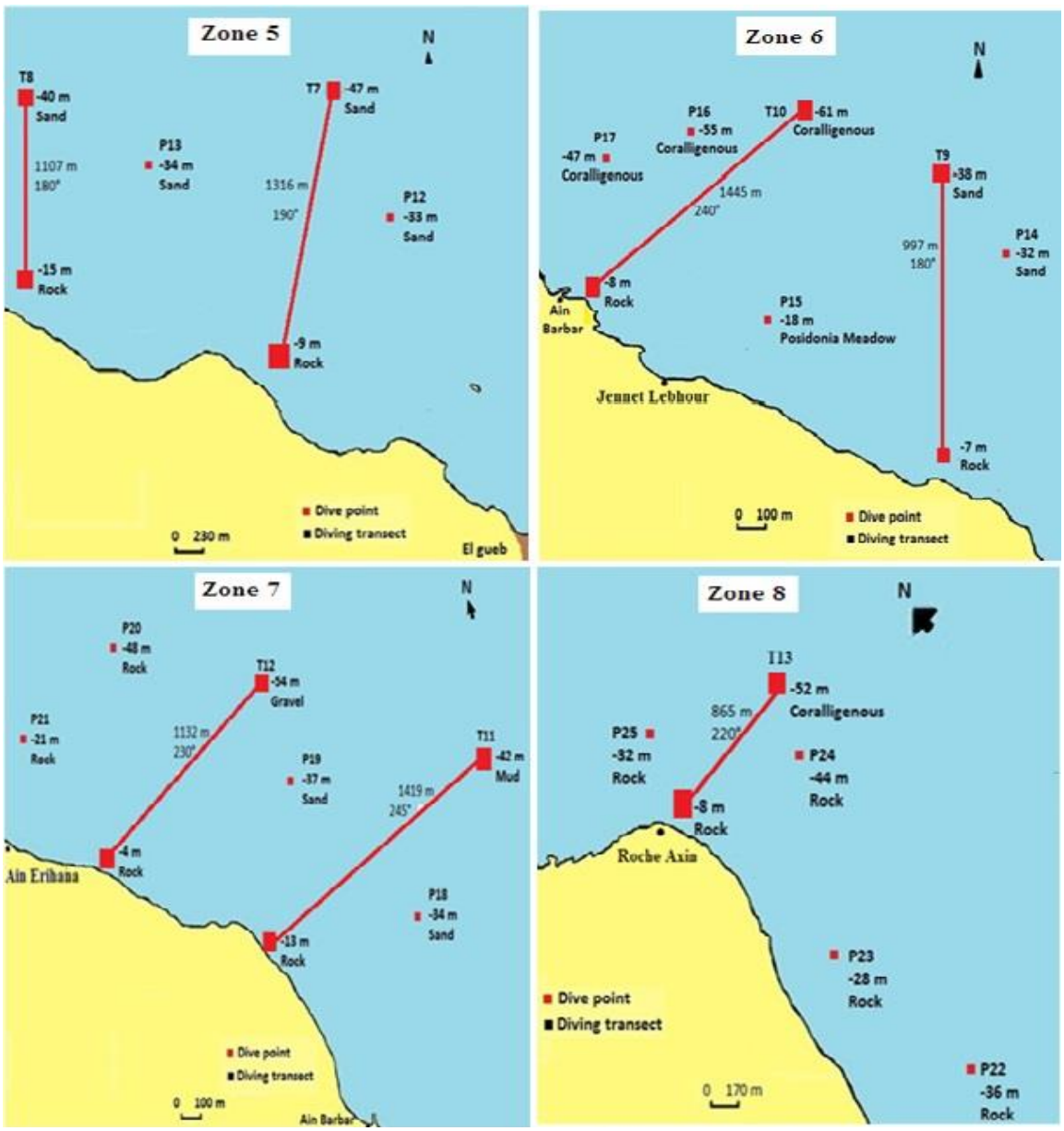

Fig. 4. Positions of dives (P12 - P13) and transects T7 - T8 explored in zone 5, (P14 - P17) of transects T9 - T10 in zone 6, (P18 - P21) of transects T11 - T12 in zone 7 and (P22 - P25) and transect T13 explored in zone 8

3. Coralligenous taxa in the Edough Mountains MPA

3.1. Animalia taxa

The Monts Edough Marine Protected Area (MPA) hosts remarkable benthic and nectobenthic biodiversity, typical of the Mediterranean seabed. This richness spans several zoological phyla (Table 3), reflecting both ecological diversity and the variety of benthic habitats (rock, sand, coralligenous) (Table 3 & Fig. 5a).

Chordates (14 species) were the most represented group, accounting for 29% of all taxa recorded. This group included demersal fish such as *Epinephelus marginatus* and *Sciaena umbra*, both indicators of good ecological quality and undisturbed habitats, as well as tunicates such as *Aplidium conicum*. Their high representation suggests a significant dominance of marine vertebrates in the ecosystem.

Cnidarians (8 species) and bryozoans (9 species), each representing 22% of the fauna, also played key ecological roles. Structuring cnidarians such as *Paramuricea clavata* and *Corallium rubrum* are characteristic of well-developed coralligenous habitats. Bryozoans such as *Pentapora fascialis* and *Myriapora truncata* highlighted the high structural complexity of the substrate, which favors colonization by numerous species.

Porifera (7%), represented by 3 species including *Agelas oroides* and *Spongia officinalis*, reflected stable, well-oxygenated habitats. Molluscs (3 species) and arthropods (7%) included emblematic taxa such as octopus, *Palinurus elephas*, and several bivalves and crustaceans (Table 3 & Fig. 5a). In contrast, annelids (1 species) and echinoderms (3%) were poorly represented, possibly due to substrate type or methodological limitations.

Overall, this faunal composition illustrates a rich and structured coralligenous ecosystem, characteristic of Mediterranean rocky habitats. These results confirm the ecological importance of the Monts Edough MPA and reinforce the need for its long-term conservation.

3.2. Plantae taxa

In the waters of the Edough Mountains MPA, three major groups of macroalgae were identified: Rhodophyta (red algae), Chromophyta (brown algae), and Chlorophyta (green algae). The assemblage was dominated by Rhodophyta, consistent with deep, stable, and undisturbed coralligenous environments characteristic of well-structured Mediterranean habitats (Table 3 & Fig. 5b).

Rhodophyta (red algae) accounted for 64% of identified species. Abundant in deep rocky or poorly lit areas, they use phycobilin pigments adapted to low-light conditions. Their high representation reflects coralligenous and semi-dark habitats that favor their development. The group was highly diverse, with 21 encrusting species (e.g., *Lithophyllum stictaeforme*, *Peyssonnelia* spp.) as well as leafy forms (e.g., *Plocamium cartilagineum*, *Sphaerococcus coronopifolius*). Their dominance indicates conditions conducive to algal bioconstructions typical of Mediterranean coralligenous zones (Table 3 & Fig. 5b).

Chromophyta (brown algae) represented 27% of species, mainly Phaeophyceae (*Dictyota*, *Halopteris*, *Ericaria*). These 9 species colonized hard, light-exposed substrates characteristic of rocky littoral zones. Their distribution suggests an ecological transition between mediolittoral and infralittoral stages, reflecting good light availability and favorable substrates.

Chlorophyta (green algae) were the least represented, accounting for only 9% of species. As a pioneering group typically associated with unstable or well-lit environments (e.g., intertidal zones or loose substrates), their low presence reflects the depth and stability of the study site. Among the three species recorded were *Flabellia petiolata* and *Valonia macrophysa*, both associated with clear, unpolluted waters, confirming the good ecological condition of the area (Table 3 & Fig. 5b).

Overall, algal diversity in the Edough MPA reflects a structured and stable coralligenous ecosystem in good ecological condition. The dominance of Rhodophyta, the structural role of Chromophyta, and the selective presence of Chlorophyta highlight the ecological integrity of this Mediterranean biodiversity hotspot.

Table 3. Coralligenous Animalia and Plantae taxa in the Edough Mountains MPA

Taxons Animalia		Taxons Plantae	
Porifera	*Agelas oroides*	**Chlorophyta**	*Flabellia petiolata*
	Spongia (Spongia) officinalis		*Thon Halimeda*
	Axinella polypoides		*Valonia macrophysa*
Cnidaires	*Alcyonium acaule*	**Chromophyta**	*Zanardynia typus*
	Corallium rubrum		*Dictyopteris polypodioides*
	Epizoanthus arenaceus		*Dictyota dichotoma*
	Eunicella cavolini		*Dictyota dichotoma var. implexa*
	Eunicella singularis		*Spatoglossum soulieri*
	Leptogorgia sarmentosa		*Zonaria tournefortii*
	Paramuricea clavata		*Halopteris filicina*
	Parazoanthus axinellae		*Halopteris scoparia*
	Astroides calycularis		*Ericaria zosteroides*
Annelida	*Bonelia viridis*	**Rhodophyta**	*Osmundea pinnatifida*
Arthropodes	*Pagurus anachoretus*		*Polysiphonia sertularioides*
	Palinurus elephas		*Polysiphonia sp.*
	Scyllarides latus		*Lithophyllum stictaeforme*
Mollusques	*Arca noae*		*Mesophyllum alternans*
	Loligo vulgaris		*Mesophyllum expansum*
	Poulpe vulgaire		*Mesophyllum lichenoide*
Bryozoaires	*Adeonella calvetti*		*Neogoniolithon mamillosum*
	Myriapora truncata		*Phyllophora crispa*
	Pentapora fascialis		*Kallymenia sp.*
	Reteporella grimaldii		*Sphaerococcus coronopifolius*
	Schizobrachiella sanguinea		*Halymenia floresii*
	Schizomavella (Schizomavella) linearis		*Peyssonnelia polymorpha*
	Schizomavella mamillata		*Peyssonnelia rosa-marina*
	Smittina cervicornis		*Peyssonnelia rubra*
	Hornera frondiculata		*Peyssonnelia sp*
Echinodermes	*Centrostephanus longispinus*		*Peyssonnelia squamaria*
	Aplidium conicum		*Plocamium cartilagineum*
	Clavelina dellavallei		*Rhodymenia adissonei*

Chordées	*Pycnoclavella nana*		*Rhodymenia pseudopalmata*
	Phycis phycis		*Sebdenia* sp.
	Anthias anthias		
	Apogon imberbis		
	Chromis chromis *Coris julis*		
	Dentex dentex		
	Diplodus vulgaris		
	Epinephelus marginatus		
	Sciaena umbra		
	Symphodus tinca		
	Scorpaena scrofa		

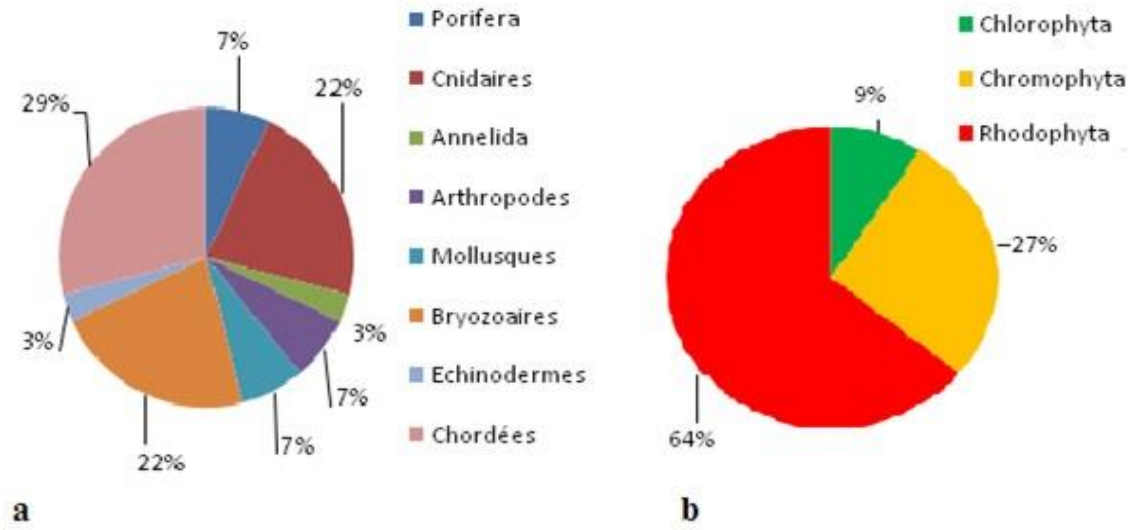

Fig. 5. Specific composition of the various coralligenous zoological (a) and Plantae taxa (b) identified in the Edough Mountains MPA

DISCUSSION

The present study highlights the ecological importance of coralligenous assemblages within the Monts Edough Marine Protected Area (MPA), established on September 4, 2023 (Decision no. 2261), along the western coast of Annaba in eastern Algeria. Surveys showed that these biogenic structures mainly colonize vertical rock faces and cave entrances between 11 and 50m in depth, with a smaller coralligenous plateau identified beyond 40m.

A total of 296 taxa were recorded, including 77 dominant species associated with coralligenous habitats, distributed across 11 phyla (43 animal and 34 plant species).

These results confirm the biological richness of this habitat, consistent with the observations of **Ballesteros (2006)** on Mediterranean coralligenous assemblages **(PNUE/PAM/CAR/ASP, 2003)**.

Animal taxa included:

- **Porifera** (*Agelas oroides*, *Spongia officinalis*), indicators of stable, oxygenated habitats.
- **Cnidarians** (e.g., *Paramuricea clavata*, *Corallium rubrum*), key structuring species typical of mature coralligenous environments.
- **Bryozoans** (e.g., *Pentapora fascialis*, *Myriapora truncata*), reflecting high substrate complexity.
- **Chordates**, including tunicates (*Aplidium conicum*) and demersal fish (*Epinephelus marginatus*, *Sciaena umbra*), bioindicators of good ecological status.

Plant taxa were dominated by calcareous algae, particularly Rhodophyta (*Mesophyllum alternans*, *Lithophyllum*, *Peyssonnelia*), which are the principal builders of coralligenous structures **(UNEP-MAP-RAC/SPA, 2021)**. Notably, the Taza marine area (Jijel) is richer in rhodophytes than the Edough MPA **(Belbacha *et al*., 2011)**. The dominance of these calcareous algae reflects stable environmental conditions and favorable substrates.

The ecological status of the coralligenous in the Edough Mountains MPA is considered satisfactory, based on six key indicators:

1. Abundance of calcareous algae forming three-dimensional structures;
2. Presence of *Cystoseira* spp.;
3. High density of gorgonians of all size classes, with no visible necrosis;
4. Presence of large bryozoans;
5. Clean substrates with little sedimentation;
6. Abundant heritage fauna, including grouper (*Epinephelus marginatus*), slipper lobster (*Scyllarides latus*), spiny lobster (*Palinurus elephas*), red coral (*Corallium rubrum*), and the diadem sea urchin (*Centrostephanus longispinus*).

Two main morphological forms of coralligenous were observed:

- **Shelf coralligenous**: cavernous structures several meters thick, located at 47–61 m depth (transects T2, T3, T4, T10, T13), with porosity comparable to "Gruyère cheese" **(PNUE/PAM/CAR/ASP, 2003)**.
- **Wall coralligenous**: formations colonizing vertical walls or caves at 42–55 m depth (zones 1, 3, 4, 6; points P1, P9, P11, P16, P17), with thicknesses ranging from 20 cm to over 2 m. Their distribution depends strongly on local topography, light availability, sedimentation, and hydrodynamics **(PNUE/PAM–CAR/ASP, 2006)**.

The wall coralligenous of the Monts Edough MPA showed a spatial distribution of *Corallium rubrum* similar to that described in the Gulf of Annaba, with colonies

concentrated on west-facing drop-offs exposed to prevailing currents, and highest densities occurring on steep vertical slopes **(Belbacha *et al.*, 2002)**. These assemblages also showed affinities with those documented in Ceuta, Morocco **(Ocaña *et al.*, 2009)**, and the Chafarinas Islands, Spain **(Sánchez-Tocino *et al.*, 2009)**, where species such as *Eunicella*, *Paramuricea*, *Ellisella* spp., and *Astroides calycularis* predominate. In contrast, notable differences were observed with communities in northern Tunisia **(Ramos *et al.*, 2001a, b; Ben Mustapha *et al.*, 2004)** and the El Kala region of Algeria **(Belbacha *et al.*, 2007, 2009)**, where characteristic species such as *Parerythropodium coralloides* and *Paramuricea clavata* are absent.

A broader comparison between the coralligenous of the Edough MPA (Algeria), Al Hoceima (Morocco) **(Dakki, 2004; SPA/RAC-NTZ/MPA, 2021)**, and La Ciotat (France) **(Bonhomme *et al.*, 2021)** revealed strong similarities in algal composition, particularly the dominance of calcareous coralline algae (*Mesophyllum*, *Lithophyllum*, *Peyssonnelia*), and high overall biodiversity across all three sites (Table 4). However, marked differences were observed in structural morphology—vertical walls in France, plateau benches in Morocco, and mixed structures in Algeria—as well as in depth distribution and hydrodynamic regimes, reflecting regional oceanographic and geomorphological contexts **(Dakki, 2004; PNUE/PAM-CAR/ASP, 2013; ; Michez & Sartoretto, 2017; OFB, 2021; SPA/RAC-NTZ/MPA, 2021)**.

Table 4. Specific comparisons between coralligenous species in Algeria, Morocco and France

Criteria	**Algeria (Edough MPA) Our results**	**Morocco (Al Hoceima)**	**France (La Ciotat)**
Dominant algae	Mesophyllum, Lithophyllum, Peyssonnelia	Similar, with local variations (plateaus and slopes)	Dominance of calcareous coralline algae on rocky substrates
Morphology	Walls and plateaus, variable thickness, cavernous structure	Banks on continental shelf	Vertical walls, thickness up to several meters.
Biodiversity	Rich in sponges, gorgonians, endofauna	Highly diversified thanks to climatic and geological gradients	Abundant upright benthic fauna
Depth	10 - 90 m, circalittoral stage with variation according to site	0-100 m plus continental slope	Up to 66 m complex topography of the bay
Hydrodynamics	Average influence of the western Mediterranean Sea	Influence of the Rifaine Sea and Mediterranean currents	Local currents, moderate hydrodynamics

Currently, the coralligenous of the Edough MPA is not subject to major anthropogenic pressures (trawling, dumping). However, the development of coastal tourism in the region represents an emerging threat. It is therefore essential to accelerate the implementation of sustainable management measures, including strengthening legal protection, monitoring sensitive species, preventing overfishing and protecting breeding habitats.

CONCLUSION

Our study confirms that the coralligenous habitat within the Marine Protected Area (MPA) of the Edough mountains constitutes a healthy and complex Mediterranean ecosystem, rich in biodiversity, including several protected species. The observations made by diving in the MPA of the Edough Mountains reveal a high degree of substrate heterogeneity (e.g., coralligenous, sand, rock) as well as a marked vertical zonation, favoring a large benthic diversity. The presence of deep coralligenous formations suggests stable conditions, while the rarity of *Posidonia oceanica* could reflect localized anthropogenic pressure. This mosaic of interconnected habitats justifies the implementation of differentiated and targeted management strategies tailored to the ecological sensitivity of each zone. The overall favorable ecological status is attested by six key indicators, such as the abundance of calcareous algae, the presence of *Cystoseira* spp. and a well-represented heritage fauna. This quality is due in particular to the current low anthropogenic pressure. This work provides the first ecological baseline data on coralligenous habitat of this MPA, and contributes to national and regional initiatives in integrated coastal zone management. However, despite its ecological value, the MPA remains modest in size at the Mediterranean scale, highlighting the urgency of implementing a strengthened management plan and more extensive ecological monitoring.

REFERENCES

Ballesteros, E. (2006). Mediterranean coralligenous assemblages: A synthesis of present knowledge. Oceanography and Marine Biology: An Annual Review., 44: 123–195.

Belbacha, S.; Khelifi-Touhami, M. and Ounissi, M. (2002). Statut de la ressource en corail rouge (*Corallium rubrum* (Linnaeus, 1778)) dans la région d'Annaba (Algérie). Actes du 5e CILO, Paris, 9–12 septembre 2002. Journal de Recherche Océanographique, numéro spécial., 28(1): 1–5.

Belbacha, S., Semroud, R.; Dupuy de la Grandrive, R.; Foulquié, M. and Seridi, M. (2007). Données préliminaires sur la biodiversité phytobenthique du littoral d'El Kala (Est Algérien). In C. Pergent-Martini, S. El Asmi, and C. Le Ravallec (Éds.),

Proceedings of the Third Mediterranean Symposium on Marine Vegetation (Marseille, 27–29 March 2007, pp. 236–238). Tunis: CAR/ASP, UNEP-MAP-RAC/SPA.

Belbacha, S.; Semroud, R.; Dupuy de la Grandrive, R. and Foulquié, M. (2009). Données préliminaires sur la répartition et la composition de la biocénose du coralligène du littoral d'El Kala (Algérie). In Proceedings of the 1st Mediterranean Symposium on the Conservation of the Coralligenous and Other Calcareous Bio-concretions (Tabarka, Tunisia, 15–16 January 2009, pp. 157–159).

Belbacha, S.; Semroud, R. and Ramos-Esplá, A.A. (2011). Inventaire des peuplements de coralligène de l'aire marine de Taza (wilaya de Jijel, Algérie). Rapport Technique. Programme « MedPAN Sud », WWF Europe / Parc National de Taza, 67pp.

Ben Mustapha, K.; Bouajina, A.; Guellouz, S.; Ramos-Esplá, A. A. and Sánchez-Jérez, P. (2004). Rapport global des travaux de prospection marine: Bionomie benthique. Dans Élaboration du plan de gestion de la partie marine du Parc National de Zembra et Zembretta (Projet MedMPA, activité MP3, pp. 11–24). CE/RAC-SPA / Université d'Alicante.

Bonhomme, P.; Boudouresque, C.F.; Bernard, G.; Verlaque, M.; Charbonnel, E. and Cadiou, G. (2001). Espèces, peuplements et paysages marins remarquables de la Ciotat, de l'Île Verte à la calanque du Capucin (Bouches du Rhône, France). Contrat RAMOGE & GIS Posidonie, Gis Posidonie publ., 1-132.

Boudouresque, C.F. (2004). Marine biodiversity in the Mediterranean: status of species, populations and communities. Sci. Rep. Port-Cros Natl. Park., 20: 97-146.

Coll, M.; Piroddi, C.; Steenbeek, J.; Kaschner, K.; Ben Rais Lasram, F. *et al*. (2010). The Biodiversity of the Mediterranean Sea: Estimates, Patterns, and Threats. PLOS ONE., 5(8): e11842. https://doi.org/10.1371/journal.pone.0011842

Dakki, M. (2004), Programme d'Aménagement Côtier en Méditerranée marocaine: étude de faisabilité. Royaume du Maroc Ministère de l'Aménagement du Territoire, de l'Eau et de l'Environnement, Département de l'Environnement, 113 pages. http://www.papthecoastcentre.org/pdfs/PAC_Maroc_Rapport_Final.pdf

Décision de wilaya d'Annaba. (2023). Décision no. 2261 du 4 septembre 2023 portant création d'une aire protégée. Annaba, Algérie.

Directive Habitats. (1992) ; Directive 92/43/CEE du 21 mai 1992.

Kollmann, H. and Stachowitsch, M. (2001). Long-term changes in the benthos of the Northern Adriatic Sea: A phototransect approach. Marine Ecology., 22(1–2): 135–154. https://doi.org/10.1046/j.1439-0485.2001.00753.x

Lebdjiri, K.; Dahel A. T.; Belbacha S.; Djebar A. B.; Kebbab R. and Djebar A. B. (2024). Seabed Status, Mapping and Assessing *Posidonia oceanica* in the Edough Mountains MPA, Annaba (Northeastern Algeria): A Baseline for Spatio-Temporal Monitoring. Egyptian Journal of Aquatic Biology and Fisheries., 28(6):2261-2278. https://doi.org/10.21608/ejabf.2024.400590

Michez, N. and Sartoretto, S. (2017). IV.3.1. Biocénose coralligène (C). In Typologie nationale des biocénoses benthiques de Méditerranée (NatHab-Med). UMS PatriNat. https://inpn.mnhn.fr/habitat/cd_hab/977/tab/description

OFB. (2021). Office français de la biodiversité. Document d'objectifs site Natura 2000 FR 9301998 « Baie de la Ciotat » - Tome 2- Programme d'actions- Préconisations et financements du programme de mesures 137 pages. https://www.bouches-du-rhone.gouv.fr/contenu/telechargement/45867/261575/file/DOCOB_tome2_vf.pdf

Ocaña, O.; Ramos-Esplá, A. A. and Templado, J. (2009). Los paisajes sumergidos de la Región de Ceuta y su biodiversidad. Fundación Museo del Mar de Ceuta. España, 254 pp.

PNUE-PAM-CAR/ASP. (2003). Programme d'Action Stratégique pour la Conservation de la Diversité Biologique (PAS BIO) en région Méditerranéenne. Tunis, CAR/ASP.

PNUE/PAM–CAR/ASP. (2006). Classification des biocénoses benthiques de la Méditerranée. CAR/ASP, Tunis, 13 p.

PNUE-PAM-CAR/ASP. (2013). Communautés biologiques marines du Cap des Trois Fourches (Mediterranée, Maroc): caracterisation, cartographie et orientations de gestion. Par Bazairi H. Limam A., Benhoussa A., Navarro-Barrancoa C., González A.R., Maestre M., Perez-Alcantara J.P., Espinosa F. Ed. CAR/ASP-Projet MedMPAnet, Tunis: 88 pp + Annexes.

Ramos-Esplá, A.A. and Azzouma, A. (2001a). Biodiversité Marine de l'Archipel de la Galite. Conservation et Réhabilitation d'Ecosystèmes Insulaires Fragiles. 3ème. Rapport Projet LIFE (TCY 97/TN/055): 18-37.

Ramos-Esplá, A.A.; Azzouna, A. and El Hili, H. (2001b). Evolution de l'environnement marin à Zembra depuis le travail de Boudouresque et al. (1986). Conservation et Réhabilitation d'Ecosystèmes Insulaires Fragiles. 3ème. Rapport Projet LIFE (TCY 97/TN/055): 7-20.

Sánchez-Tocino, L.; Maldonado, M.; Navarro, C. and González-Velasco, C. (2009). Informe de la campaña realizada en el Refugio Nacional de Caza de las Islas Chafarinas. Universidad de Granada-CEAB Blanes, 18pp.

Sará, M. (1969). Research on coralligenous formation: problems and perspectivas. Pubbl. Staz. Zool. Napoli., 37: 124-134.

SPA/RAC_NTZ/MPA. (2021). Élaboration de Plan de Gestion intégrée pour le Parc National d'Al Hoceima, Maroc (2021-2026). https://www.racspa.org/sites/default/files/consultancies/dao_al_hoceima_plan_gest_ntz.pdf

UNEP-MAP-RAC/SPA. (2008). Action plan for the conservation of the coralligenous and othercalcareous bio-concretions in the Mediterranean Sea. Ed. RAC/SPA,Tunis: 1-21.

UNEP/MAP-RAC/SPA. (2011). Draft Lists of coralligenous/ maërl populations and of main species to be considered by the inventory and monitoring. Expert Meeting to propose standard methodologies for the inventory and monitoring of coralligenous/maërl communities and their main species. Rome, Italy, 7-8 April 2011, 11 pp.

UNEP-MAP-RAC/SPA. (2012). Synthesis report of the ecological characterization of the marine areas of Enfeh peninsula, Ras Chekaa and Raoucheh cave in Lebanon. By Ramos-Esplá A.A., Bitar G., El-Shaer H., Forcada A., Limam A., Ocaña O, Sghaier Y.R., Khalaf G., Fakhri M., Tarek E. and Valle C. RAC/SPA-MedMPAnet Project, Tunis: 30 pages + annexes.

UNEP-MAP-RAC/SPA. (2021). Les assemblages coralligènes méditerranéens: Une synthèse des connaissances actuelles par Enric Ballesteros, Ed. SPA/RAC, Tunis: 155 pp.