

## RECOP : MONITORING NETWORK FOR CORALLIGENOUS ASSEMBLAGES

(<http://www.observatoire-mer.fr/en>)

### Coralligenous habitat, what is it?

In Mediterranean sea, deep coastal systems are colonized by coralligenous assemblages between - 12/-50 m and -40/-120 meters depending on the water transparency (Ballesteros, 2006). The coralligenous habitat consists of blocks of organic concretions, mainly calcareous algae (Laborel 1961; Laubier, 1966; Sartoretto et al, 1996; Ballesteros, 2006) and animal builders such as bryozoans, serpulids, cnidarians, mollusks, sponges, crustaceans and foraminifera (Hong, 1980; Ros et al, 1985). These reefs are a great substrate for the attachment and growth of other organisms such as red coral colonies or gorgonians. The coralligenous assemblages are a complex patchwork of micro- habitats and species. Their species richness, biomass and productivity are equivalent to those of tropical reef assemblages (Bianchi, 2001). Coralligenous habitat is, after the *Posidonia* seagrass beds, the second key benthic ecosystem of the Mediterranean in terms of biodiversity (Boudouresque, 2004).



Coralligenous habitats are reefs composed on organic concretions. These are an excellent substrate for the fixation and growth of other organisms like gorgonians or sponges.

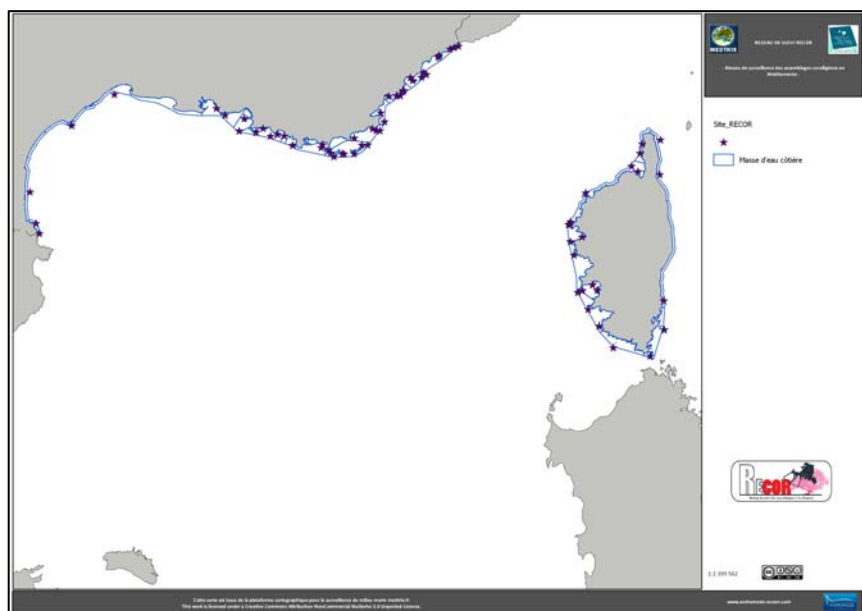
### RECOP, a monitoring network for coralligenous assemblages

Despite its high ecological and economic value, spatio-temporal surveys focusing on coralligenous habitats are rare. Supported by the Water Agency Rhône Mediterranean and Corsica, the **RECOP network** covers the entire French Mediterranean coast bordered by the three regions Corsica, Provence-Alpes-Côte d'Azur (PACA) and Languedoc-Roussillon (LR). RECOP's objectives are to collect **data describing the state and functioning of the coralligenous habitat** according to an adapted and standardized methodology and follow their **changes in time and space**. All of these data aim to complete data obtained otherwise in order to evaluate *in fine* the environmental quality of coastal water bodies as requested by the Water Framework Directive (WFD). Each water body comprises at least one RECOP site.



### Localization of the sites

RECOP includes **70 sites**, some of which are sampled at different depths (= station). The network started in June 2010 in the PACA region with 42 stations. It was completed in 2011 by 53 stations around Corsica in 2012 and 25 stations in the LR area. These **120 stations are distributed between 17 and 90 meters deep** and are monitored every three years at the end of spring (May-June).



Localization of the RECOP sites

## Materials and methods

The method chosen for the monitoring of coralligenous assemblages is non-destructive, objective, fast, and provides detailed and quantitative data. It takes into account three types of measures: a **general description of the site** and the measure of abiotic factors, the **cover percentages** of non-living (sludge, sand, debris, etc...) and living (fixed and visible macro-species) structures at each station, and **demographic data concerning erected species** (gorgonians especially).

### a) General description of the site

At each site, GPS coordinates are collected from the boat. They correspond to the location of a steel spike (50 cm long) set within the coralligenous reef. This stake marked with a label also indicates the beginning of the transect for photographic quadrats.

The diver notes:

- the typology of the coralligenous habitat (bank, rim);
- the presence of particular structures;
- the porosity, complexity and crevices within the concretions;
- the presence, nature and heights of the different strata;
- the geographical orientation and the orientation relative to the current;
- the coralligenous bathymetric extent, bathymetric extent of gorgonians;
- the seabed slope, the water temperature and visibility;
- the observation of species with particular interest (invasive species, protected species, species with legacy interest...);
- anthropogenic impacts.



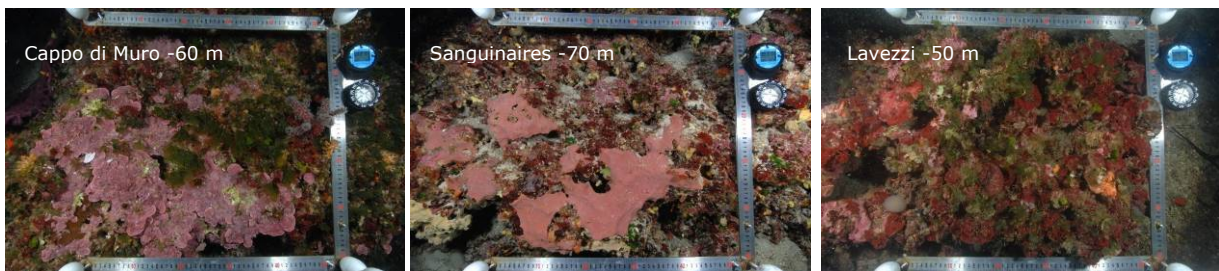
Stainless steel stake with a small buoy and label

### b) Realization of photographic quadrats at each station

40 photographic quadrats of 50x50 cm are realized at each station (same depth) along a 20-meter long transect.



The photographic quadrat and apparatus used for RECOR



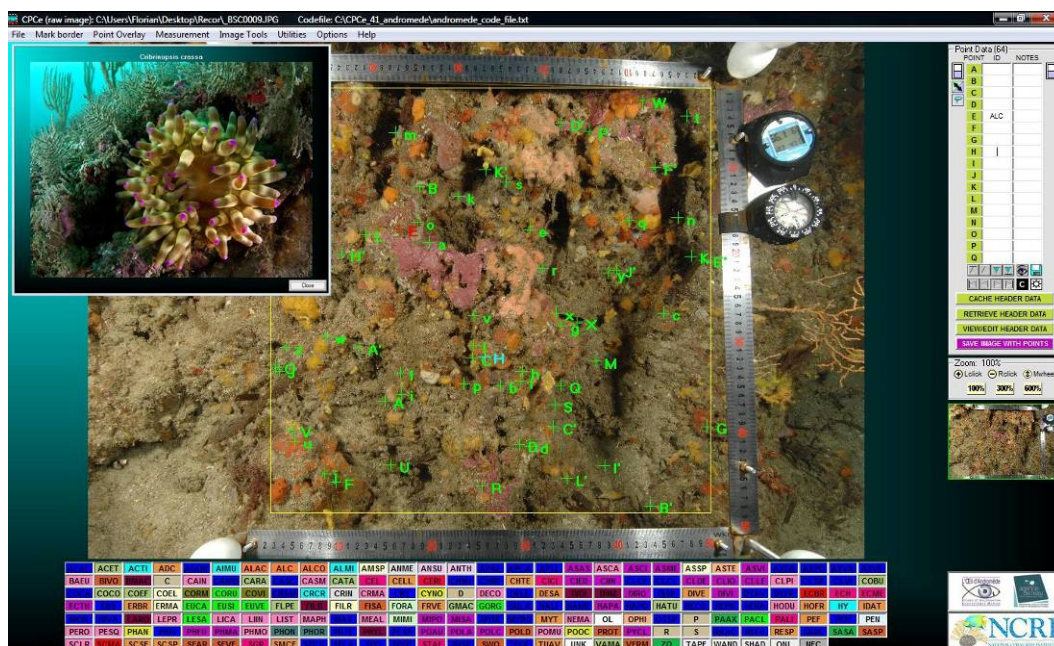
Examples of photographic quadrats taken in Corsica

Among these pictures, 30 are randomly drawn and analyzed with the software CPCE 4.1 "coralligenous assemblages version" (freely downloadable at <http://www.observatoire-mer.fr/en/cpce.html>). This version of Coral Point Count with Excel ® extension (CPCE, Kohler and Gill, 2006) software was designed in 2011 under RECOR, in partnership with the National Coral Reef Institute (USA).





The software distributes **64 random points on each of the 30 photographic quadrats**, representing 1920 points per station. The features underlying the points are user-identified (by a unique observer). Under each photo quadrat being analyzed appears the list of species likely to be identified. A picture available for each species may help for the identification.



Photographic quadrat being analyzed with 64 random points

Hundred **quantitative variables** are extracted from these analyzes such as:

- Cover percentage for non-living (sludge, crevice, biological debris) substrate and relative abundance of living structures: actinarians, alcyonarians, ascidians, asterids, brown algae, green algae, red algae, crinoids, echinoderms, erect bryozoans, encrusting bryozoans, large foraminifera, gorgonians, hydroids, scleractinians, sedentary worms, Zoantharians.

- Relative abundance for particularly important taxa: *Mesophyllum* sp, *Lithophyllum* sp and encrustin and erect *Peyssonnelia* sp (building), red coral *Corallium rubrum* (protection and commercial use), *Axinella* sp (protection of *Axinella polypoides* and fragile because of the erect bearing), algae *Caulerpa taxifolia* or *C. racemosa* (invasive), the sponge *Cliona* sp and the urchin *Echinus melo* (eroder), the ascidia *Halocynthia papillosa* (indicator of diving pressure, Sala *et al.* 1996), filamentous algae, worms *Filograna* sp / *Salmacina* sp (indicator of degradation, Ballesteros, comm. pers.).

- Relative abundance for fonctionnal groups of taxa : major builders (algae *Mesophyllum* sp., *Lithophyllum* sp. and *Peyssonnelia* sp., yellow solitary corals *Leptopsammia pruvoti*, madreporian *Caryophyllia inornata*, Foraminifera *Miniacina miniacina*), eroders (sponges *Cliona* sp., the urchins *Echinus melo*, and *Sphaerechinus granularis*), erect taxa (gorgonians such as *Paramuricea clavata*, *Eunicella cavolinii*, *Eunicella singularis*, red coral *Corallium rubrum*, high erect bryozoans and sponges *Axinella* sp), invasive algae (*Caulerpa* sp., *Womersleyella setacea*), taxa with legacy interest (*Spongia officinalis*, *Axinella polypoides*, *Savalia savaglia*, *Astroides calycularis*, *Paracentrotus lividus*, *Centrostephanus longispinus*, *Ophidiaster ophidianus*, etc.).





1. Melon urchin *Echinus melo* ; 2. Yellow solitary coral *Leptosammia pruvoti* ; 3. *Axinella polypoides*.

### c) Demographic data concerning erect species at each site (principally gorgonians)

Erect species are known for being fragile. At each site, we evaluate their density, size and structure in size. **These data allow monitoring population health condition.**



Diver counting the number of gorgonians and measuring the colonies.

**Density** and **size** of colonies are measured at a same depth within a **2 m<sup>2</sup> quadrat** (8 quadrats of 50x50 cm). For the size, a measure of height and width is done with a graduated ruler (5-cm accuracy) (Sartoretto 2003).

The **necrosis rate** of erect species (mortality of one part or of the entire colony) is measured in **30 random quadrats of 50 x 50 cm** (at a same depth) according five classes:

- 1: 0% necrosis, the colony is entirely healthy;
- 2: <0 to 10 % of surface with necrosis;
- 3: 10 to 50 % of surface with necrosis;
- 4: < 50 % of surface with necrosis;
- 5: 100 % of necrosis, the colony is entirely dead.



*Paramuricea clavata*

These necroses are also dated (by colonization) and their distribution is estimated (localized or diffuse). This technique gives good results (Perez, 2002; Harmelin and Marinopoulos, 1994) and was envisaged during the project creation "Gorgonian monitoring network" (Sartoretto, 2003).

These measurements allow to extract variables for each species of gorgonian: the number of colonies and density per m<sup>2</sup>, the number of small (<15 cm) and large colonies (> 50 cm), the average height and width of colonies, the maximum height, number and percentage of colonies with necrosis according to 5 classes, the total number colonies with necrosis, the number and percentage of colonies with recent necrosis, average and maximal date and rate of necrosis or each species, the average size of the species, the number and proportion of individuals of each species showing necrosis little or highly colonized (recent or old necrosis).



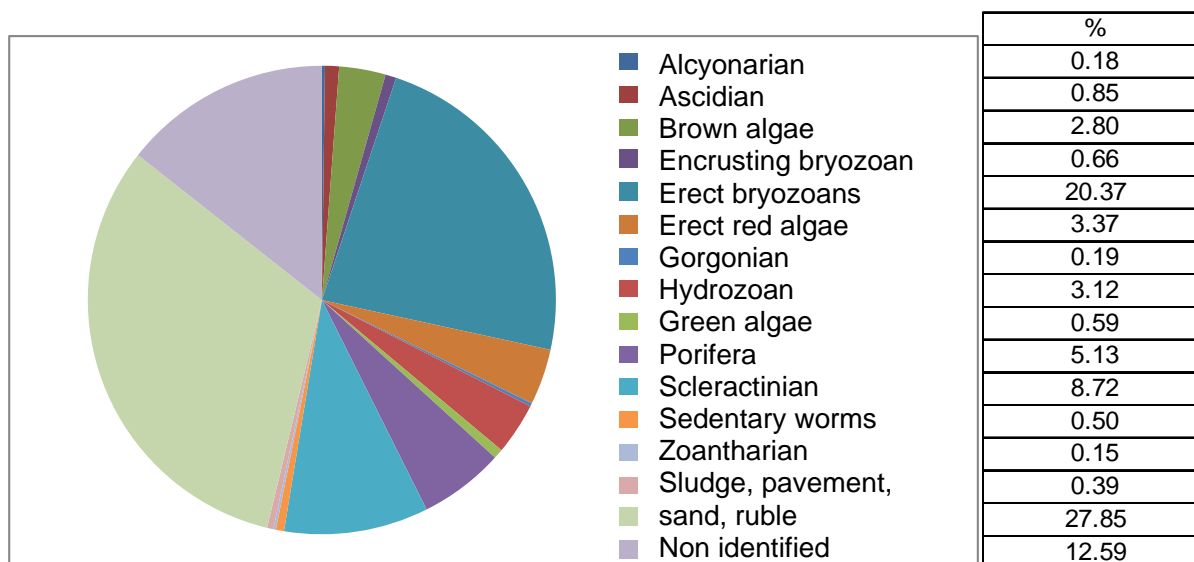
*P. macrospina*



## Results

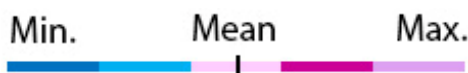
The analysis of the variables extracted from the photographic quadrats informs us about the conservation status of coralligenous communities. The 1920 points identified at each station are used to calculate the cover percentages of different taxa (number of points identified for the taxon / total number of points) \* 100) as well as siltation, crevice and diversity indices.

Distribution diagrams for the different identified taxa are available for each site sampled.



Example of distribution diagram for the different groups identified on photographic quadrats (total of 1920 points) for a station in Corsica. Cover percentages are presented on the right.

For a given parameter, **the cover percentage may be associated with a cursor** repositioning the observed value within the regional context (minimum, maximum and average values observed in a region (Corsica, PACA, LR) at all sites sampled in this region).



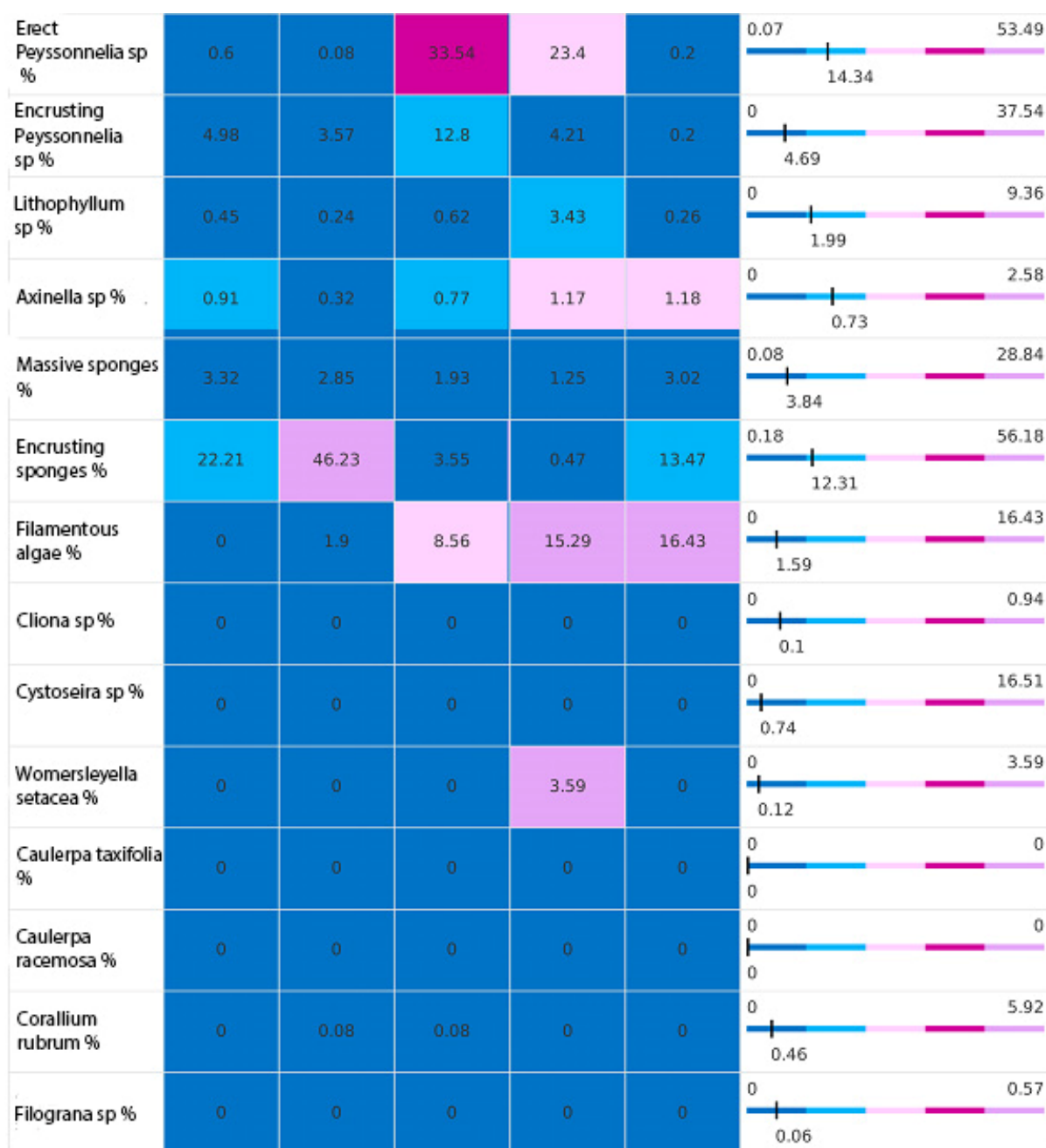
Legend of the imaged cursor associated with each detailed parameter. Are shown the mean and the maximum and minimum values observed for the parameter at all sites sampled in a region. Each color corresponds to one fifth of the extent of the observed values for the parameter concerned.

### Note: Clarification concerning the percentages presented on MEDTRIX

On the website [www.medtrix.fr](http://www.medtrix.fr), the results are presented in percentages. Nevertheless the percentages concerning the taxa are similar to relative abundances as they are calculated considering only living points (non-living points are not considered). Sedimentation is treated with the non-living structures. The tables always indicate in first variables the percentage of living and non-living structures in order to clarify on what proportion the analyses are based.

Example of cover percentages obtained for a site in Corsica in 2011 (Site Tabernacle within the golfe of Ajaccio), sampled at different depths between -40m and -90m.

Region	Corsica	Corsica	Corsica	Corsica	Corsica	Comparison scale Corsica Region Legend
Water body	FREC04b	FREC04b	FREC04b	FREC04b	FREC04b	
Site name	Tabernacle	Tabernacle	Tabernacle	Tabernacle	Tabernacle	
Depth (m)	90	70	60	50	40	
Year	2011	2011	2011	2011	2011	
Living %	35.19	67.58	68.99	68.34	81.17	35.19 81.17 60.48
Non-living %	64.81	32.42	31.01	31.66	18.83	18.83 64.81 39.52
Sludge %	36.36	22.99	11.49	10.82	4.11	2.87 42.18 19.15
Biological remains %	3.88	1.02	4.79	5.22	0	0 5.22 1.16
Crevise %	13.29	8.2	11.97	15.3	14.61	7.11 34.21 16.62
Necrosis rate	15.95	26.8	31.91	26.65	0	0 216.22 51.46
Disturbance index (%)	0	1.9	8.56	18.88	16.43	0 18.88 1.72
CAI	0.38	0.5	0.36	0.58	0.32	0.27 0.68 0.47
Main builders %	40.63	20.78	62.37	42.36	9.2	5.62 77.25 37.73
Simpson index	0.82	0.84	0.84	0.88	0.87	0.67 0.92 0.85
Shannon index	2.09	2.26	2.35	2.56	2.51	1.67 2.99 2.45
Echinids %	0	0.32	0	0.08	0	0 2.48 0.27
Bryozoan %	0.91	0.08	0.08	0.16	0.07	0 6.81 1.01
Gorgonian %	0	0.08	0.08	0	27.71	0 27.71 4.79
Mesophllum sp %	19.64	5.55	5.86	2.96	1.31	0.36 37.99 10.09



The variables obtained from the analyzes of photographic quadrats allow to calculate a **disturbance index** (sum of invasive species cover percentages) and the **CAI (Coralligenous Assemblages Index)**, Deter et al., 2012a) assessing the ecological status of the station. We are working on an improved CAI (defined in PACA) in order to integrate data from Corsica and LR. Consequently, in Corsica CAI should only be considered as an indication.

The CAI includes the following variables: the **sludge** cover percentage, **builder** cover percentage and **bryozoans** cover percentage (= bryo). More the ecological quality ratio (EQR) of a site combining these three variables compared to their respective references (EQR ' ) is close to 1 and more the ecological status is considered as high. The EQR is the ratio of the observed value and the reference value.

CAI, whose value is between 0 and 1, is used to classify each station of PACA and LR in one of the **five WFD classes (bad, poor, moderate, good, high)** and so for the long-term monitoring of coastal water bodies quality.

$$\text{EQR}' \text{ bryo} = \% \text{ bryozoans} / 7,423$$

If the station < -45 m :

$$\text{EQR}' \text{ sludge} = (100 - \% \text{ sludge}) / (100 - 26,920)$$

$$\text{EQR}' \text{ builders} = \% \text{ builders} / 32,326$$

**Or**

If the station > -45 m :

$$\text{EQR}' \text{ sludge} = (100 - \% \text{ sludge}) / (100 - 12,093)$$

$$\text{EQR}' \text{ builders} = \% \text{ builders} / 29,039$$

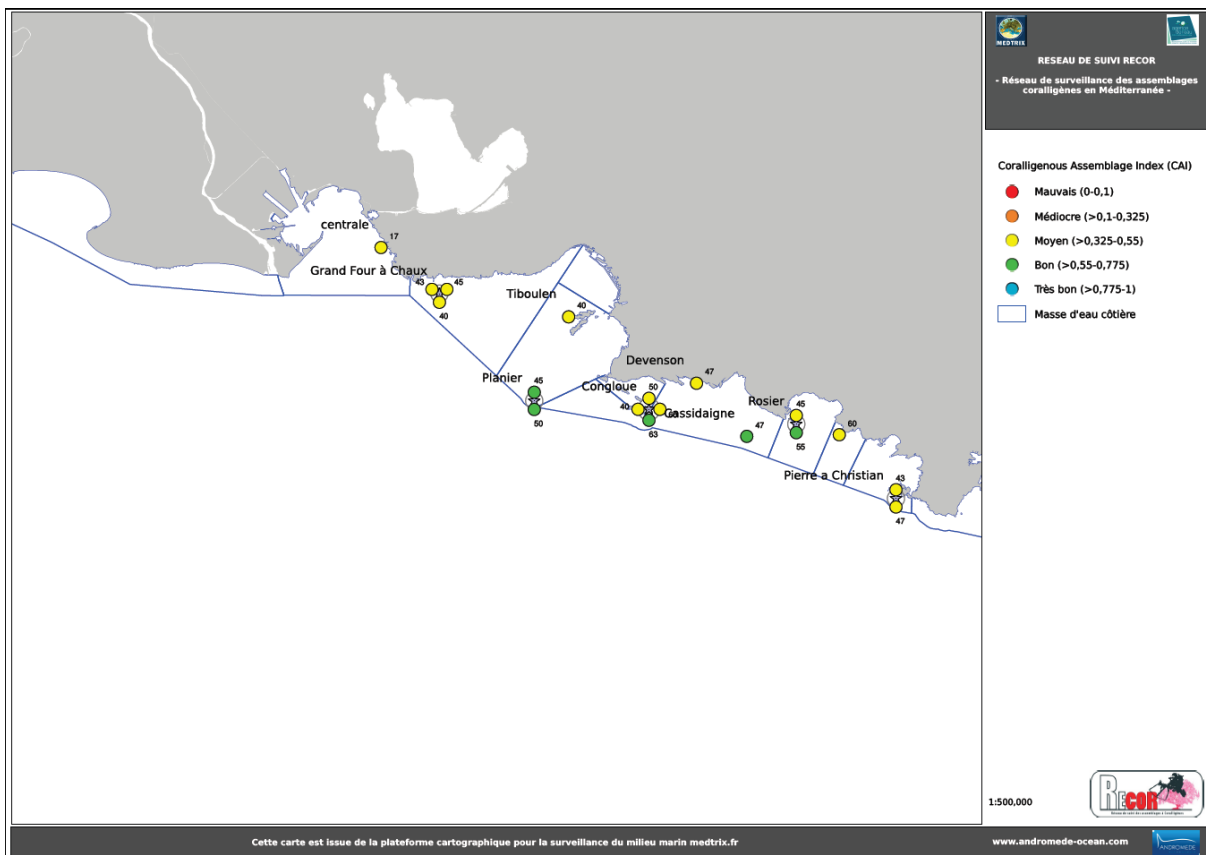
$$\text{EQR} = (\text{EQR}' \text{ sludge} + \text{EQR}' \text{ bryo} + \text{EQR}' \text{ builders}) / 3$$

With EQR = Ecological quality ratio. The EQR value is used to classify each station in one of the five WFD classes for the ecological status.

Ecological status (WFD)	EQR
High	>0,775-1
Good	>0,55-0,775
Moderate	>0,325-0,55
Poor	>0,1-0,325
Bad	0-0,1

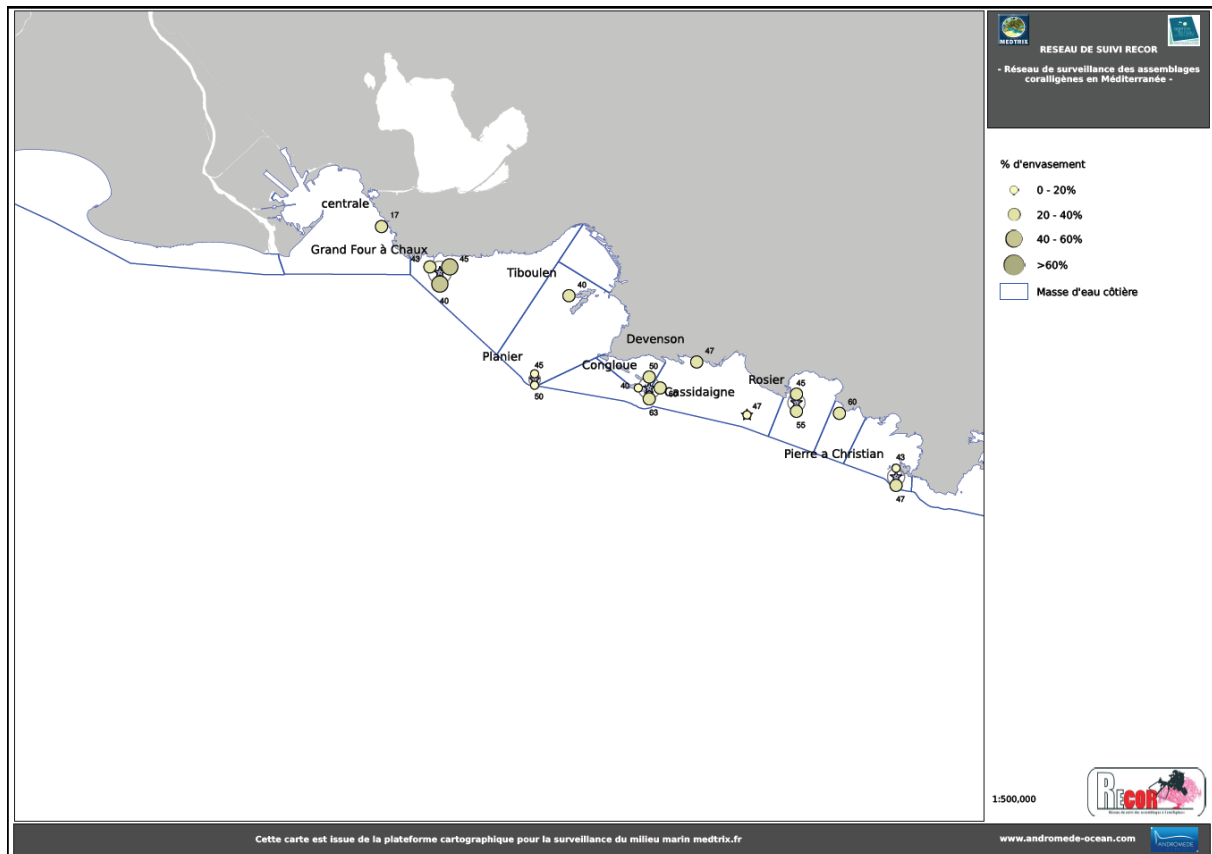
The CAI integrates 3 variables: sludge, bryozoans and builders. The detailed calculation of EQR and EQR' is presented here opposite. The reference values used for the CAI calculation in PACA and LR can not apply in Corsica where reference values seem to be totally different. The Analyses that will validate the CAI in Corsica and test the relevance of other parameters for this index are currently in progress.

**Maps** presenting the CAI value for each station, the **sludge** cover percent, **main builders** cover percent and the **disturbance index** may be realized on the cartographic platform medtrix ([www.medtrix.fr](http://www.medtrix.fr)).

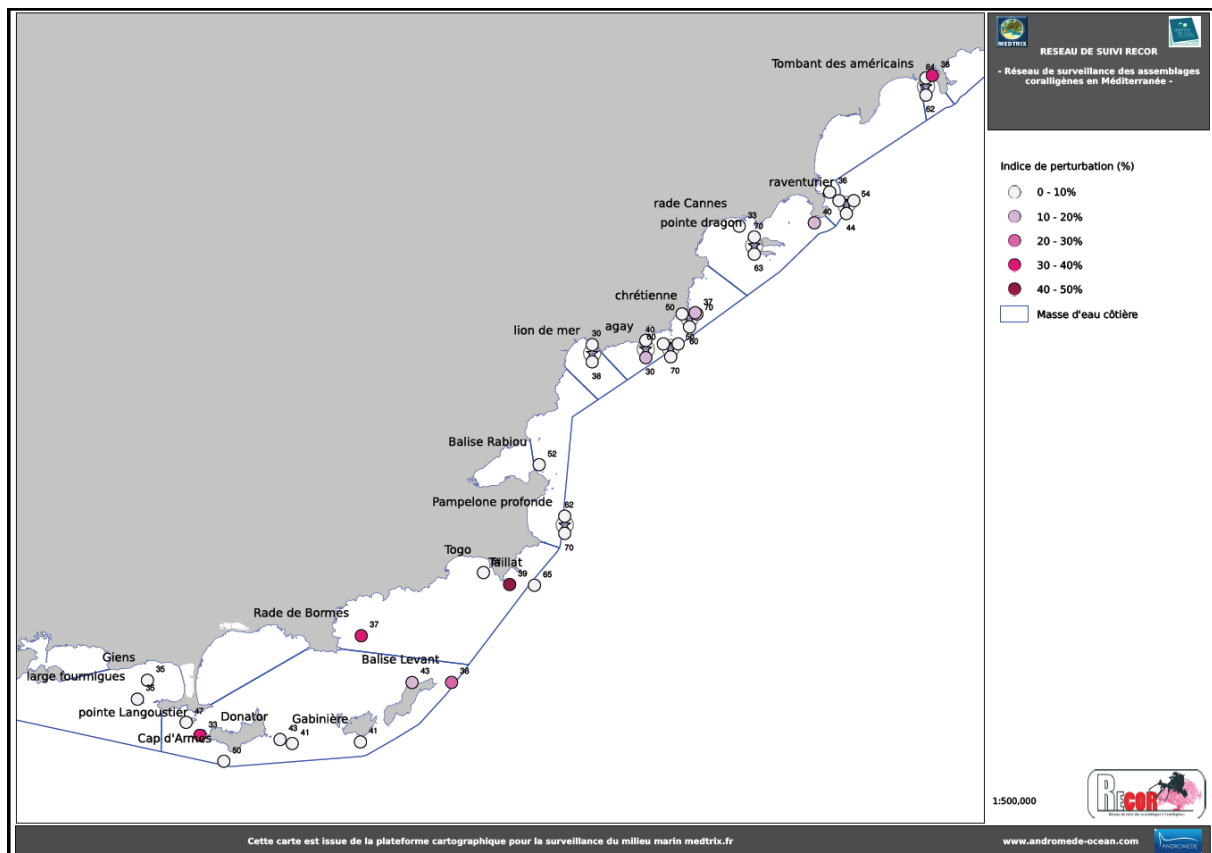


Map realized on the cartographic platform medtrix.fr and presenting the CAI values for several RECOP stations.

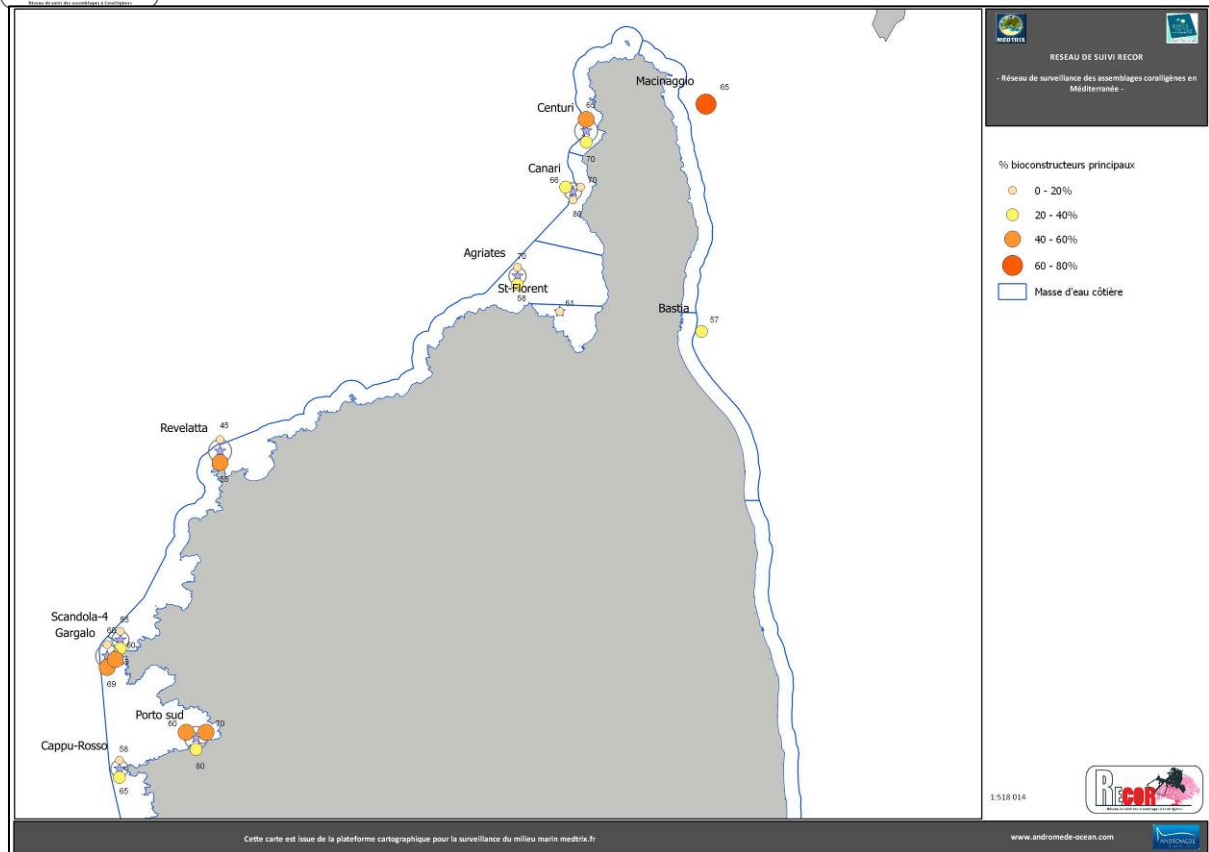




Map realized on the cartographic platform medtrix.fr and presenting the sludge percent covers for several RECOR stations.

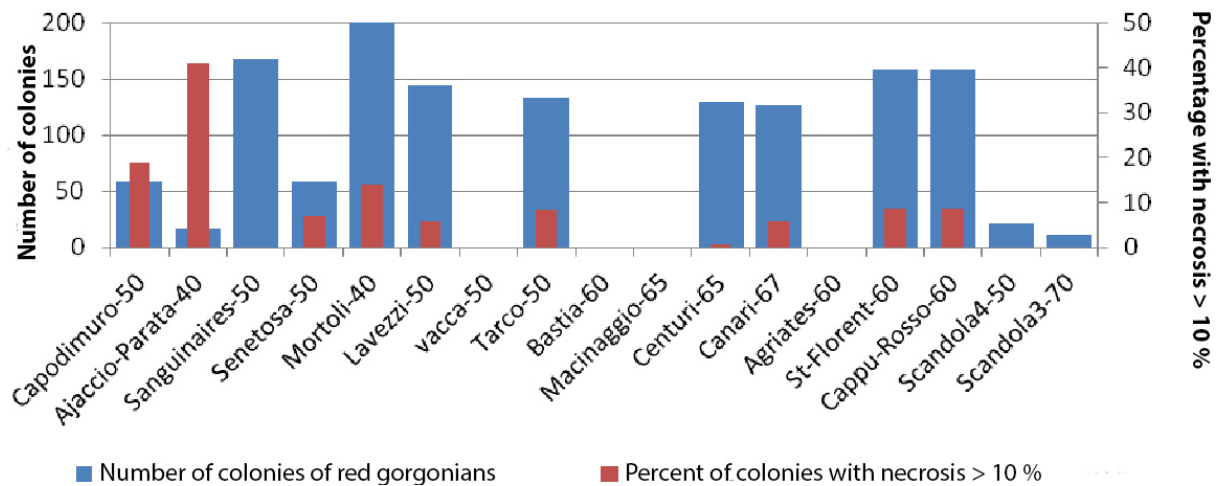


Map realized with the cartographic platform medtrix.fr and presenting the disturbance index for several RECOR stations.



Map realized with the cartographic platform medtrix.fr and presenting builders cover percents for several RECOP stations.

Concerning the erect species, **descriptive tables**, **graphs** and **standardized cards** are created in link with Excel®.



Examples of graph realized for erect species. See the number of colonies and the proportion of colonies with necrosis > 10 % in several stations of Corsica in 2011.

### PhD thesis linked to RECOR

A PhD thesis is in progress (Florian Holon, Grantv Labex CeMED/Andromède océanologie, 2013-2016) in link with ISEM (<http://www.isem.univ-montp2.fr/>) at the university of Montpellier 2 (<http://www.isem.univ-montp2.fr/>) and Andromède Océanologie at Carnon (France). The title of the thesis is "Diversity of coralligenous assemblages along the French Mediterranean coast: study of the distribution mechanisms and applications for the monitoring of the conservation status and the quality of coastal water bodies". On the basis of RECOR data, several questions are raised: importance the coralligenous habitat at the scale of the Mediterranean coast (surface, volume, biomass), diversity (taxonomic, functional or phylogenetic) distribution of the coralligenous assemblages in function of environmental and anthropogenic pressures.

### Network carriers

#### a) French Water Agency RMC

Created by the Water Act in 1964, the Water Agency is a public institution of the State under the supervision of the Ministry in charge of sustainable development. Its mission is to contribute to improving water management, fighting against pollution and protecting aquatic environments. The Water Agency focuses on three main areas:

- the fight against pollution;
- the conservation and management of water resources;
- the support for the improvement of knowledge and cooperation between stakeholders in the water sector.

Since the early 1990s the Agency has led specific actions on Mediterranean coastal and offshore waters.

Website: <http://www.eaurmc.fr>

#### b) Andromède Océanologie

Andromède océanologie is a French independent company, highly experienced, able to conduct any type of project linked to the study and valuation of the marine environment.

Andromède océanologie activities are organized into three divisions:

- Consulting: Andromède is doing bathymetry, habitats cartography, species inventories, but also ecological engineering and management plans.
- R&D: it focuses on the production of scientific knowledge, mainly on the two richest ecosystems in terms of biodiversity in the Mediterranean Sea: *Posidonia* seagrass and the coralline. This division is also responsible for improving the monitoring of coastal waters by evaluating the ecological status of these ecosystems through TEMPO, RECOR and SURFSTAT networks.
- Valuation. Its main missions consist in the valuation and exploration of the underwater environment and the dissemination of knowledge to the general public through the management of Laurent Ballesta's image bank. Andromède also makes documentaries, exhibitions, books, articles and illustrations in the mainstream press.

To better educate the public about the beauty and fragility of the underwater world, our office in Carnon (34) consists of an image gallery, a specialized library, a retail space dedicated to the marine environment as well as a diving center (Andromède Plongée Bio).

Website: [www.andromede-ocean.com](http://www.andromede-ocean.com)

### Partners

#### 1. OSU-OREME

The Science of the Universe Observatory – Mediterranean Research Observatory of Environment (OSU OREME) is an observatory of the risk and of the global and anthropogenic change. The main task of OREME is to collect, put together and share physical, chemical and biological data coming from observation in order to assess the effect of global and/or anthropogenic change and to understand the mechanisms (hazard, vulnerability) involved in their environmental effects. Its objective are: fundamental science, education and especially long term continuous observation of the natural environment.

Web site: <http://www.oreme.univ-montp2.fr/>



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