CIGESMED : Coralligenous based Indicators to evaluate and monitor the "Good Environmental Status" of the Mediterranean coastal waters

Jean-Pierre Feral, Christos Arvanitidis, Anne Chenuil, Melih Ertan Çinar, Romain David, Emilie Egea, Stéphane Sartoretto

Towards Integrated Marine Research Strategy and Programmes

CIGESMED : Coralligenous based Indicators to evaluate and monitor the "Good Environmental Status" of the Mediterranean coastal waters

French dates: 1st March2013 -29th October2016

Greek dates: 1st January2013 -31st December2015

Turkish dates: 1st February2013 –31st January2016

FINAL REPORT

Féral (J.-P.)/P.I., Arvanitidis (C.), Chenuil (A.), Çinar (M.E.), David (R.), Egea (E.), Sartoretto (S.)

INDEX

1. PROJECT CONSORTIUM. TOTAL FUNDING AND PER PARTNER

Partner number	Partner name	Funding agency (country)	Actual workload	Expensed amount (euros)
1. Coordinator	**CNRS** : Centre Nationale de la Recherche Scientifique	ANR (France)	34%	212 351€ (33% of total)
2.	**EGE** Ege University	TÜBITAK (Turkey)	22%	133 141€ (21% of total)
3.	**IFREMER** Institut Français de Recherche pour l'Exploitation de la Mer	ANR (France)	4%	41 080€ (6% of total)
4	**HCMR** Hellenic Center for Marine Research	GSRT (Greece)	25%	175 849€ (27% of total)
5	NMPZ: National Marine Park of Zakynthos	ANR (France)	14%	76 300€ (12% of total)
x	LIGAMEN	ANR (France)	x	8 984€ (1% of total)
		Total	100%	649 346€

2. EXECUTIVE SUMMARY

Coralligenous is a hard-bottom mainly biogenic habitat, produced by the agglomeration of calcareous encrusting algae growing in dim-light conditions. It is characterized by high structural complexity and spatial heterogeneity, thus supporting rich biodiversity and a variety of sessile assemblages, shaping a typical and one of the most important habitats of the Mediterranean Sea. It produces goods (e.g. food, raw material) and services in several domains (e.g. CO_2 sequestration, aesthetics and education). Pollution, smothering and abrasion from a variety of human activities may cause its degradation at a broad scale, whilst fishing and collection of organisms mainly affect target species. Its high aesthetic value may also induce frequentation by SCUBA divers, an additional cause of degradation. Coralligenous is also susceptible to invasive alien species. This habitat, which is of great ecological, socio-economic and cultural importance, is also under the pressures linked to global warming.

CIGESMED's **GOAL** was to understand links between natural and anthropogenic pressures and coralligenous habitats as well as the effects on their functioning to define the *Good Environmental Status* (GES) of the coastal Mediterranean Sea and propose solutions for maintaining good environmental conditions.

Coralligenous specific indices have been constructed and tested by scientists, marine natural parks and reserves managers, also through the implementation of a "citizen science" pilot network. The use of the newest data mining techniques and the development of visualization tools to sort, organize and illustrate very large heterogeneous sets of data constitute an original but complex approach. It permitted to mobilize, visualize and share large data collections, and to manage knowledge to study these habitats.

The **OUTCOME** consists of: i) experimentation and results of new methods to build survey at large scales (testing operating process and materials during dive, photo analyses, population genetics, phylogenetic and metabarcoding approaches) ii) tools to diffuse new methods (website, services, training and field tools for scientists and citizen science, publications) and avoid indices misun-derstanding, iii) tools, methods and prototypes to provide datamining usable for an integrative assessment of the GES within the Framework of the Marine Strategy Directive (for this part, CIGESMED members initiated a new consortium [1] using CIGESMED metadata and dataset to build graph representation, mine graphs and provide tools for environmental decision making). All the outcomes are freely accessible online on websites with open access, open source and open data.

The overall achievement was to to bring together researchers (in ecology, economics, sociology, law, etc.) and managers in order to (i) identify the needs and to better address them, (ii) to determine interdisciplinary areas of research concerning the development and management of the coralligenous that could be the subject of a new [multidisciplinary / European / Mediterranean] research project.

CIGESMED gathered scientists from France, Greece and Turkey, making it possible to assess the coralligenous habitat in a number of sites in both the northwestern Mediterranean basin and the Aegean-Levantine, under a common approach. Members of ten highly experienced marine ecology laboratories were involved.

A total of 10 stations in France (in the Gulf of Lions), Greece (in the Ionian and the Aegean Seas) and Turkey (in the Aegean and the Levantine Seas) were selected to study coralligenous assemblages across the Mediterranean Sea. Analyses of photoquadrats (50x50 cm) and *in situ* visual observations revealed 313 species, belonging to 15 higher taxa. A total of 204 species were found in Turkey, 192 species in France and 109 species in Greece. Only fifty species were common in all sites. The abundance of the taxonomic groups in coralligenous habitats vary among sites and countries. The multivariate analysis revealed five main assemblages across the Mediterra-nean Sea. A number of important threats were withnessed to have an important impact on coralligenous, with the settlement of invasive alien species (e.g. *Caulerpa cylindracea, Womersleyella setacea*), sedimentation and factors causing algal bleaching being the most important ones.

A new method and index were applied and tested in France (60 stations in Gulf of Lions and Provence) and Greece (4 stations in the Gulf of Corinth) to evaluate the health condition of coralligenous assemblages. This method (INDEX-COR), based on images analyses (60x40cm) and *in situ* observations, takes into account three metrics giving different levels of information: (i) the ratio "Sensitive-Tolerante Species", (ii) the observable taxonomic richness of the assemblages and (iii) the structural complexity. The global index combining these metrics was tested according to a global index of pressure. Reference conditions were defined in France to propose an interpretation grid to evaluate the status of coralligenous assemblages. This grid applied in Greece demonstrated the necessity to collecte multiple and complete dataset in order to define the reference conditions for the different Mediterranean sectors (e.g. Ionian Sea, Egean Sea and Cretan Sea). Finally, additional indices (CAI, COARSE and ESCA) were tested on the datasets obtained in France and Greece. The comparison of the results is still in progress. The first ones show the advantages and the limits of each index. They underline the need to achieve precisions on (i) their degree of sensitivity in the evaluation of the coralligenous assemblages and (ii) the impact of the different images analysis techniques.

Although the global set of samples is still under analysis, the metabarcoding pilot study already gave very promising results for the assessment of coralligenous community species composition: many more species were identified

[1] **IndexMed** : Interopérabilité des bases de données en écologie (http://www.indexmed.eu)

than by eye, predicting a higher resolution than traditional approaches for monitoring and comparing coralligenous assemblages.

A dedicated Citizen Science initiative was designed and launched in the course of the project, aiming to engage enthusiast divers in the study and monitoring of coralligenous assemblages through the gathering of basic information regarding spatial occurrence, assemblage structure and associated pressures and threats. The implementation platform comprises a data collection protocol and a multilingual website[2] which serve both educational and data submission purposes. Online and paper educational documentation, as well as observation protocol guidelines are essential tools developed to train volunteer divers. Underwater slates based on the princi-ples of rapid visual assessment have also been developed and distributed to all participants for data collection. Geo-referenced data reporting focuses on: (a) basic topographic and abiotic features for the preliminary description of each site, and the creation of data series for sites receiving multiple visits; (b) presence and relative abundance of typical conspicuous species, as well as, (c) existence of pressures and imminent threats, for the characterization and assessment of coralligenous assemblages. More than 100 observation sets from across the Mediterranean have been registered to date by approximately 30 divers while 75 members have registered to the website, which remain active after the conclusion of the project.

Metadata and data produced by the CIGESMED project have a high potential for use by several stakeholders involved in environmental management. Mapping this information needed to share common definitions on coralligenous components and allows starting building a micro thesaurus. The methodology is now developed and the first part of the thesaurus is online. A new consortium called IndexMed whose task is to index Mediterranean biodiversity data, makes it possible to build graphs in order to analyse the CIGESMED data and develop new solutions for coralligenous data mining.

The outreach activity of the project included participation of the Consortium to an impressive number of Conferences, Symposia and Workshops, which made it possible to achieve not only the communication of the main objectives of the project but also the development of links with other projects, targeting Marine Biodiversity [e.g. EMBOS (The European Marine Biodiversity Observa-tory), LifeWatch (ESFRI Research Infrastruc-ture), DEVOTES (DEVelopment Of innovative Tools for understanding marine biodiversity and assessing good Environmental Status), VECTORS (VECTORS of Change in European Marine Ecosystems and their Environmental and Socio-Economic Impacts) and EU BON (Building the European Biodiversity Observation Net-work)]. A flyer was developed to provide the basic information on the project. The project was also advertised during much larger events, in the premises of the participating institutes, such as open days (e.g. exhibitions for the Climate change, TEDx events). The target audience for the outreach activity consisted of researchers and scientists, students, educators, environmental managers, policy makers and stakeholders from all the economic sectors including industry. The means which were used were: (a) the project website, which until now shows a high number of visits recorded for a specialized one: 250,000 hits; (b) the production of 353 articles for the scientific audience and for the society at large. Five websites have been created from which information on the project is broadcasted.

The methods and datasets produced by CIGESMED are disseminated to the STIC community, as free tools for studies to be used for any type of data sciences (data mining, data representation ...), particularly through the means provided by IndexMed and through data qualification processes (which will need to be continuously improved to keep them relevant). This

2 http://cs.cigesmed.eu/

reusability of the data will be improved in particular by the production of data papers and future animations planned within the framework of the IndexMed consortium

The **Steering Committee** consisting of all the WP leaders and the coordinator was responsible for all practical decision making, strategic planning and implementation.

A **Committee of External Advisors** met at an annual basis, and aimed at providing advice on all aspects of the execution of the project to ensure CIGESMED to meet its objectives.

3. AIMS AND SCOPE (OBJECTIVES)

The overall objective of the CIGESMED project is to reveal the links between natural and anthropogenic pressures and ecosystem functioning and to assess and maintain the GES of the Mediterranean Sea, by comprehensively studying the typical, complex and not well known habitats built by calcareous encrusting algae, the coralligenous.

An integrated approach of the coralligenous complexity has allowed large datasets to be shared and visualized and the knowledge from the study of this ecosystem to be properly managed. Indicators, from communities down to infra-specific level (DNA), have been developed and tested collaboratively by scientists, marine natural parks and reserves, and through the implementation of a "citizen science" pilot project. The use of trees of knowledge as tools to sort, organize and illustrate very large heterogeneous sets of data has been implemented as an original approach.

The outcome is an integrative assessment of the GES within the Marine Strategy Framework Directive.

The main objectives of the project are: (1) to fulfill the key gaps in the current scientific knowledge of the coralligenous habitat that make it difficult to make recommendations for protecting them by developing barcoding to enhance reliable identification for conservation and protection purposes (invasive and cryptic species?), and by studying genetic structuring and effective dispersal potential of keystone/habitat? species (2) to enhance the knowledge on coralligenous populations by deciding on reference states and setting up a network of Mediterranean experts (long term series), (3) to monitor networks, locally managed and coordinate them on a regional scale, standardizing protocols that could be applied to the entire Mediterranean and testing indices and indicators, specific to coralligenous, (4) to test population genetic criteria as tools to monitor the GES? of the coastal Mediterranean Sea, (5) to implement a "citizen science" network and (6) to use trees of knowledge (a type of "knowledge graph" where content is mapped to an analyzable form) as tools to sort, organize and illustrate the large heterogeneous sets of produced data and as a tool of dissemination towards scientists, decision makers, environmental managers and general public, including also data users like the STIC3 community, on the side of the CIGESMED community.

By working on coralligenous, typical habitats from the Mediterranean Sea, which host a tremendous biodiversity creating a lot of ecosystems and seascapes, and of ecological, cultural and socio-economical importance, CIGESMED challenges to assess its good state and functioning, by developing operational indicators, which can capture the amount of information

[3] Sciences et Technologies de l'Information et de la Communication

needed in order to estimate the good state of the Mediterranean coastal waters and to create the infrastructure, that is physical installations, hardware and software, and human network, which will permit to continue the monitoring activity on the habitat after the end of the project.

To achieve these objectives CIGESMED is structured into 6 work packages besides the one on the Management, coordination and reporting (WP1): Coralligenous assessment and threats (WP2), Indicator development and test (WP3), Innovative monitoring tools (WP4), Citizen Science network implementation (WP5), Data management and mapping (WP6) and Outreach and dissemination (WP7).

4. RESULTS BY WORK PACKAGE

WP1: MANAGEMENT, COORDINATION & REPORTING

LEADING PARTNER: CNRS

OBJECTIVES

- To monitor, facilitate and effectively manage the project's scientific and managerial work and information flow
- To effectively coordinate all project's activities
- To ensure on time submission of the project's deliverables
- To design and apply a CIGESMED-after plan that will implement a strategy for the sufficient update and maintenance of the project's information activities after its end

SHORT PROGRESS SUMMARY OF THE RESPECTIVE WORK TASKS

TASK 1.1: MANAGERIAL STRUCTURE [M1-M36].

CONSORTIUM AGREEMENT

The Consortium Agreement (CA) was signed by all partners on 2013, June 14th.

SUBCONTRACTING

The commitment between the coordinator (CNRS-IMBE) and its subcontractor the NATIONAL MARINE PARK OF ZAKYNTHOS (NMPZ) was established by 2013, May 27th for 33 months. With this commitment and upon CNRS's request, NMPZ agreed to undertake the provision of a service entitled: "Coralligenous survey in the North-East Mediterranean" to evaluate the benthic populations of the coralligenous in Zakynthos area through visual census, image processing and quadrat methods, to investigate their basic demographic characteristics, evaluate the main threats and pressures considering both the species and the habitat as a whole, assess biotic and abiotic factors influencing coralligenous habitat, evaluate necrosis of benthic key taxa and implement a monitoring plan through recurrent photographic sampling. The NMPZ committed to test the coralligenous quality indexes/indicators, in order to develop a database for species and habitats, to produce maps, to evaluate globally and in an integrated way the coralligenous communities and to efficiently protect and manage them. Furthermore, within the citizens participative approach, the NMPZ committed to contribute to the development, at the local and national level, of a human network (citizen science or crowd sourcing), by involving the main stakeholders, in order to ensure an efficient long term protection, to increase awareness in the different user groups, which are active in the broader marine area and to resolve potential conflicts of interests between them. It contributed to all workpackages. Each year, NMPZ produced a progress activity report (**annexe D**).

STEERING COMMITTEE

The steering committee (SC) consisted of the general coordinator, the national coordinators and the work package leaders. The SC was responsible for all practical decision making, strategic planning and implementation of the CIGESMED Consortium. All SC meetings were chaired by the general coordinator.

The members are:

• Christos ARVANITIDIS; HCMR, national coordinator for Greece, WP 5 co-leader and WP 7 leader

• Anne CHENUIL; IMBE, WP 4 leader

• Melih Ertan ÇINAR ; EGE, national coordinator for Turkey, WP 2 leader

• Romain DAVID ; IMBE, WP 6 leader

• Emilie EGEA; IMBE, project manager

• Jean-Pierre FERAL ; IMBE, general coordinator (WP 1), WP 5 co-leader

• Stéphane SARTORETTO ; IFREMER, WP3 leader

• Drosos KOUTSOUBAS ; NMPZ, sub-contractor (see anual reports, annexe D)

GENERAL ASSEMBLY MEETINGS (GAMS)

The General Assembly meetings were held each year and hosted turn by turn by the three countries.

2013: The CIGESMED kick-off meeting (first GAM) was held from 17th to 19th April 2013, in Crete, at the Hellenic Centre for Marine Research. Twenty four participants, from the 5 partners, as well as the NMPZ, were present.

2014: The second general assembly was hosted by the EGE partner and held in Izmir (Turkey) from May 6th to 9th, 2014. Members of the Committee of External Advisors have also been invited to participate.

2015: The third general assembly was held in Mytilini, Lesbos Island (Greece) from 19th to 22nd May, 2015. A meeting of the Committee of External Advisers (CEA) took place on the 19th May.

Minutes of all the meeting are available on CIGESMED website (http://www.cigesmed.eu).

COMMITTEE OF EXTERNAL ADVISORS (CEA)

As many of the Consortia with a broad scope, CIGESMED needs advice in the broader field of its expertise and its geographic coverage. SeasEra call's was eligible only to three Mediterranean countries, France Greece and Turkey, yet the coralligenous habitat and concerned scientists are found in every Mediterranean country. At the earliest phase of the project, CIGESMED decided to create an advisory committee, partly standing alone, but also subcommittees and adhoc working groups to bring the additional needed experts insight the Consortium. The goal was to extend the CIGESMED circle of contacts and have access to new perspectives and ideas.

During the second year, the list of CEA members was validated. Members met twice during the project, first in Marseille, (October 2014), and next in Mytilini (May 2015).

The Committee of External Advisors consists of the following personalities:

Name	Country	Affiliation	City
Enric BALLESTEROS SEGARRA	Spain	CEAB-Centre d'Estudis Avançats	Blanes
Angel BORJA	Spain	AZTI-tecnalia	Pasaia
Denis COUVET	France	MNHN	Paris
Joaquim GARRABOU	Spain	Institut de Ciènces del Mar	Barcelona
Xavier LE ROUX	France	INRA	Villeurbane
Paula MOSCHELLA	Monaco	CIESM-The Mediterranean Science Commission	Monaco
Anna OCCHIPINTI	Italy	Università degli Studi di Pavia	Pavia
Samuel ROBERT	France	UMR ESPACE	Marseille
Georgios TSOUNIS	German	ZMT	Bremen

TASK 1.2 WORK AND INFORMATION FLOW [M1-M36]

DASHBOARD

Concise interim reports have been set up at a bi-annual frequency in order to ensure that the official reporting proceed smoothly. An excel Dashboard file was designed as a diary journal to register actions undertaken by each partner in each WP. Dissemination and training activities related to CIGESMED as well as deliverable progress are also duly registered in this document.

STAKEHOLDER ENGAGEMENT

The WP5 leader synchronized the Greek team actions in order launch WP5 action to engage stakeholders, policy makers and other potential user groups for the sustainability of the project. Meetings at which information about CIGESMED were communicated and potential activities of stakeholders that could be integrated in the project in order to engage as many interested parties as possible, were reported by all partners of the Consortium.

TRAINING

Partner engaged	Candidate	Position	WP	Starting date	Ending date	Highlights
CNRS-IMBE / Zakynthos Agean Sea University	Zinovia ERGA	Master st.	2; 4	10/2013	07/2014	Genetic Structure of *Lithophylum* species complex, bio-constructor of the coralligenous, a typical Mediterranean ecosystem. Inferences on the connectivity at different spatial scales and ecological facies influences.
	Anastasia SAPOUNA	Undergraduate student	2	2015	2016	Assessing of coralligenous communities in the National Marine Park of Zakynthos by means of photographic methods
CNRS-IMBE / IFREMER	Selmane SAKHER	PhD st.	2	10/2013	10/2016	Spatio-temporal variability of circalittoral bioconstructed ecosystems of the northern shore of Mediterranean (Algerian fellowship)
CNRS-IMBE	Romain DAVID	PhD st	6 (connected to other WPs)	01/2013	2016	DAVID R. Ecological state of some facies of the Mediterranean coralligenous / methods of implementation of a network of a multi-criteria follow-up at the scale of the French Mediterranean shore and the organization of the various systems of information collection
	Dorian GUILLEMAIN	Master st.	2; 3; 5; 7	01/2014	06/2014	Light determination and study, an essential factor influencing variability in community repartition and species association in the coralligenous habitat.
	Laure THIERRY DE VILLE D'AVRAY	Master st.	2; 3; 5; 7	01/2014	06/2014	Coralligen population study across habitat profiles via spatial variability characterization: from sample & photo analysis to results
		PhD st.	2; 3; 5; 7	10/2014	10/2017	Coralligenous habitat ecosystemic services, measurement and valuation
	Sophie DUBOIS		2; 4	01/2014	04/2014	Genetic Structure of the bryozoan *Myriapora trunctat*, bio-constructor of the coralligenous, a typical Mediterranean ecosystem. Inferences on the connectivity at different spatial scales and ecological facies influences.
	Walid ELGUERRABI	Master st.	6	04/2014	08/2014	Analyst Programmer "image databases" applied to the field of diving biology (coralligenous habitat).
	Aurélien DE JODE	PhD st.	4	10/2014	10/2017	Understanding the functioning of coralligenous habitats and building new indicators based on genetic tools to assess their Good environmental Status
	Giulia GATTI	Post-doctorate	5	02/2015	07.2015	Temporary staff: From CIGESMED to citizen science protocol(s)

HCMR	Yiannis ISSARIS	PhD st.	2;5;6	12/2013	11/2016	Marine Ecologist – Photographic sampling and visual census and mapping of coralligenous assemblages. Data analysis and dissemination.
	Emmanouella PANTERI	Technical staff	5	2014	2016	HCMR Web developer – Assignment to CIGESMED in order to develop the web infrastructure for citizen science.
	Eleftheria-Niki MANTZANI	Master st. rotation	2	04/2015	06/2015	Assessment of coralligenous assemblages with photographic methods
	Melina NALMPANTI	BSc st. summer practice	2	07/2015	08/2015	Assessment of coralligenous assemblages with photographic methods
EGE	Çağdaş ÇELIK	Master st.	2	2013	2014	Taxonomy and ecology of Anthozoa
	Özge ÖZDEN	PhD st.	2	2014	2016	Taxonomy and ecology of Crustacea
	Alper Evcen	PhD st.	2	2013	2014	Sponge species distributed in the Levantine and Aegean Seas.
	Senem Onen	PhD st.	2	2013	2014	Determination of protection efficiency of the Fethiye-Göçek Specially Protected Area by phtographic methods.
	Denize ERDOGAN	Master st.	2	04/2015	08/2015	Taxonomy and ecology of Polichaets
IFREMER	B. DE VOGUE	Professional licence	3			Data capture for Index-Cor and image analysis
	Thomas SCHOHN	Master st.	3	04/2014	08/2014	Biostatistics

SHARED CIGESMED LITTERATURE DATABASE

The partners decided to make an inventory of the litterature related corraligenous habitat and all linked ecosystem environment aspects. This database, named "public CIGESMED", is shared by all partners via the web content software, Mendeley and allows working on meta-data.

AMENDMENTS TO THE ORIGINAL WORK PLAN (IF APPLICABLE) AND ITS RATIONALE

MODIFICATION OF THE CONSORTIUM AGREEMENT

After the first year, it was pointed out that LIGAMEN had failed its engagements regarding the Consortium agreement terms, and was declared as breaching partner by the SC members (GAM in Izmir). LIGAMEN never complied with its role of WP6 leader and did not provide any information regarding the knowledge tree algorithm functioning to the partners despite their repetitive requests. The Consortium, therefore, was not able to evaluate the results and use the algorithm for the CIGESMED purposes. As a result, CNRS took the lead of WP6 and knowledge trees development was replaced by the building of a visualization prototype4 that test the ability of graphs tools (which is a larger approach than tree graphs) to collect/mine CIGESMED data objects with non-centralized data. WP6 explored new uses of data from coralligenous habitat to demonstrate the prototype functionalities and introduce new perspectives to analyse environmental and societal responses. It permitted improvement of the ability of two scientific communities (STIC [Information and Communication Sciences and Technologies] researchers and CIGESMED teams) to work together (annexe C)[5].

The decision was taken by the SC members and subsequently supported by the vast majority of the GA members.

MODIFICATION OF END DATE OF THE FRENCH PARTNERS

The WP 3 includes the development of a method and index (INDEX-COR) to assess the conservation status of the coralligenous habitat in the western basin of the Mediterranean. Testing this method was planned first in the western Mediterranean basin and at a second phase, in the eastern basin. Due to organizational and administrative difficulties, the necessary dives in Greece could not be set up before the 2015 winter and had to be postponed to the spring of 2016 (May).

In order to be able to fund this part (field operations and laboratory works), CNRS partner asked for an extensión of its contract which was endorsed by ANR until the 29th October 2016.

---

[4] In collaboration with the IndexMed community

[5] David (R.), Féral (J.-P.), Archambeau (A.-S.), .Bailly (N.), Blanpain (C.), Breton (V.), De Jode (A.), Delavaud (A.), Dias (A.), Gachet (S.), Guillemain (D.), Lecubin (J.), Romier (G.), Surace (C.), Thierry de Ville d'Avray (L.), Arvanitidis (C.), Chenuil (A.), Çinar (M.E.), Koutsoubas (D.), Sartoretto (S.), Tatoni (T.) 2016. IndexMed projects : new tools using the CIGESMED DataBase on Coralligenous for indexing, visualizing and data mining based on graphs. *In* : S. Sauvage, J.-M. Sánchez-Pérez, A. Rizzoli (Eds.) ***Proc. 8th International Congress on Environmental Modelling and Software***, Toulouse, France, 11-13 july 2016

MAIN FINAL OUTPUTS

Deliverable	**Title**	**Remarks**	**Status**
D1.1.1	CIGESMED map of competences	Final map of competences will not be finalized as initially planned due to LIGAMEN breach of duty.	✗
D1.1.2	Consortium agreement negotiation	CA Final version signed on June 2013 by all partners	✓
D1.1.3a	Annual progress reports	2 interim reports produced before final one	✓

WP2: CORALLIGEN ASSESSMENT AND THREATS

LEADING PARTNER: EGE

OBJECTIVES

Within the framework of CIGESMED, there are five objectives for WP2;

Assessing the coralligenous megabenthic assemblages (habitats) by means of observation, photographic/video surveys;

Investigating basic demographic characteristics of key erect associated species populations and disturbances and threats;

Assessing biotic (i.e. alien species) and abiotic factors affecting the coralligenous habitats;

Quantifying necrosis of gorgonians and other key benthic species,

Establishing a monitoring plan through repetitive photographic samplings.

In the framework of the project CIGESMED, sampling stations that were defined in the kick-off meeting held in Crete were frequently visited to assess the extent of coralligenous habitats, to identify prevailing coralligenous assemblages and to validate the CIGESMED protocols. At the last year of the project, it was finally decided that four stations in the Gulf of Lions (western Mediterranean), two stations in the Ionian Sea, two stations in the Aegean Sea and two stations in the Levantine Sea were most appropriate for the aims of the project in order for the respective coralligenous habitats hosted in each of then to be well-developed, continuous and extendinf over larger areas. Therefore, some stations (i.e. Crete, and two stations along the coast of Turkey), that were candidate stations at the beginning of the project were eliminated as their coralligenous habitats were too patchy. In the last period of the CIGESMED project, the final list of coralligenous species was produced based on the data gathered from the stations through several diving activities. The structures of coralligenous assemblages across the Mediterranean were determined by using the photo-quadratic method. All photographs taken from stations according to the protocol were fully analyzed for each station. The eastern Mediterranean stations were also characterized by high coverage percentages of algal thalli that were subject to bleaching and the settlement of invasive alien species (e.g. Caulerpa cylindracea). The species list and abundance/coverage data will be further used to produce new biotic indices based on coralligenous species in collaboration with WP3. For the molecular analysis of some coralligenous species that are common across the Mediterranean such as Mesophyllum alternans, Leptopsammia pruvoti and Myriapora truncata (only in Greece and France), specimens were collected at stations and sent to the laboratory of IMBE in collaboration with WP4. In addition, to perform meta-barcoding of coralligenous habitats, two stations in Turkey (TC1 and TF1) were selected and coralligenous material within four quadrates each with 10x10 cm in dimension were scraped off and, after photographed, they were directly fixed with absolute alcohol. In the benthology laboratory of Ege University, all material was sorted and the extracted specimens were identified by experts on discrete taxonomic groups. The identified specimens were then sent to the laboratory of IMBE for meta-barcoding in collaboration with WP4. The core species list that comprised species widely distributed across the Mediterranean were used to prepare the diver's under-water tablet for the citizen-science in collaboration with WP6.

SHORT PROGRESS SUMMARY OF THE RESPECTIVE WORK TASKS

TASK 2.1. CHOICE OF THE SITES AND THE SPECIES [MARCH 2013 – MAY 2013]

CONTRIBUTING PARTNERS: EGE, HCMR, NMPZ, CNRS-IMBE.

This task was re-evaluated in the last year of the project. Taking extends of coralligenous habitat at stations into account, the locations of some pre-defined CIGESMED stations were changed and some of them were eliminated. The species list was re-constructed according to several field works performed in the last year at the CIGESMED stations.

CHOICE OF THE STATIONS

In the first and second interim reports, it was mentioned that the selections of thestations for the study of coralligenous assemblages had been completed for three countries (Turkey, Greece and France) involved in the project CIGESMED. However, it was then outlined in the 2nd interim report that the suitability of the stations for the aims of CIGESMED project should be re-evaluated and validated in the countries according to the final version of the protocols.

Finally, according the topographic features and extends of the coralligenous habitats, the location and number of stations were re-evaluated in all the countries. In Turkey, the number of stations that were previously defined as 6 in Ildır and Fethiye Bays were diminished to 4, as the coralligenous habitat at one station (formerly coded as C2, Çolak Kayalıkları) in Ildır Bay was patchy and mostly confined in crevices and overhangs. In Fethiye Bay, out of three pre-defined stations, only one station (Afkule) possessed rich coralligenous assemblages, the other two (previously coded as F1 and F3), which had patchy coralligenous outcrops, were eliminated. However, interviewing with the owners of diving clubs in Fethiye, another station (Sarıyarlar) was recommended to include a “true” coralligenous habitat. Diving at stations revealed that this station had a continuous coralligenous habitat, and thus, was selected as a new CIGESMED station. Many attempts to find extended and rich coralligenous habitat were failed both in Ildır and Fethiye Bays. In Greece, 7 provisional stations (three in Crete and three in Zakynthos and one in Korinthiakos Bay) were selected for the study of coralligenous assemblages (see the first interim report). However, according to under-water visual observations, it was realized that coralligenous habitats along the coast of Crete and Zakynthos were discontinuous and mainly developed on limited surfaces of rocks. Therefore, all these stations were eliminated and a new station near the provisional station called Mavros Kavos in Zakynthos was finally selected as a new CIGEDMED station. As the coralligenous habitat was rich and covered larger areas, the pre-defined station in Korinthiakos Bay was also selected as the CIGESMED station. In France, among 7 provisional stations listed in the first interim report, only 3 stations (previously coded as M1, M2 and M4) were selected for the study of coralligenous assemblages. In addition, one new station coded as LPD was also added to stations in the Gulf of Lions. The main characterizations of CIGESMED stations are indicated in Table 1. The locations of CIGEDMED stations are shown in Figure 1.

Table 1. General characterizations of the CIGESMED stations in Turkey, Greece and France.

Area	Station	Code for stations	Coordinates		Depth (m)	Orientation	Inclination	Rugosity
			Latitude	Longitude				
				TURKEY				
Ildır Bay	Yarık Taş	TC1	38°27'23''N	26°21'39''E	25	N	Vertical	Medium-Large
Ildır Bay	Çifte Adalar	TC2	38°23'45''N	26°26'55''E	25	NW	Vertical	Medium-Large
Fethiye Bay	Afkule	TF1	36°34'34''N	29°01'47''E	25	NW	Vertical	Medium-Large
Fethiye Bay	Sarıyarlar	TF2	36°36'46''N	29°02'06''E	25	W	Vertical	Medium-Small
				GREECE				
Korinthiakos Bay	Lambiri	KOR	38°19'17"N	21°58'23"E	25	N	Vertical	Medium-Large
Zakynthos	Mavros Kavos	ZAK	37°38'52"N	20°50'46"E	38	NW	Inclined / Subvertical	Medium-Large
				FRANCE				
Gulf of Lions	Tiboulen du Frioul	FTF	43°16'49"N	5°17'10"E	28	N	vertical	Medium-Large
Gulf of Lions	Moyade	RMO	43°10'36"N	5°22'14"E	28	S	vertical	Medium-Large
Gulf of Lions	Méjean	MEJ	43°19'42"N	5°13'29"E	28	S	vertical	Medium-Large
Gulf of Lions	Pointe du defens	LPD	43°09'11"N	5°41'1"E	28	S	vertical	Medium-Large

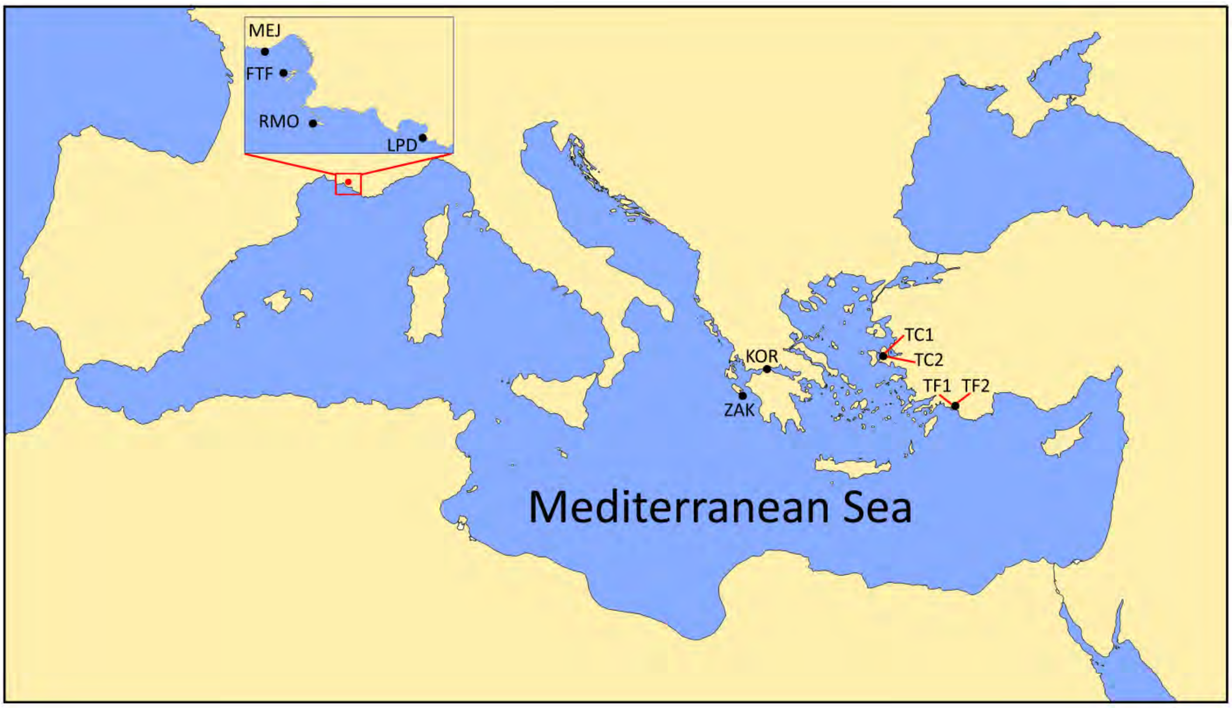
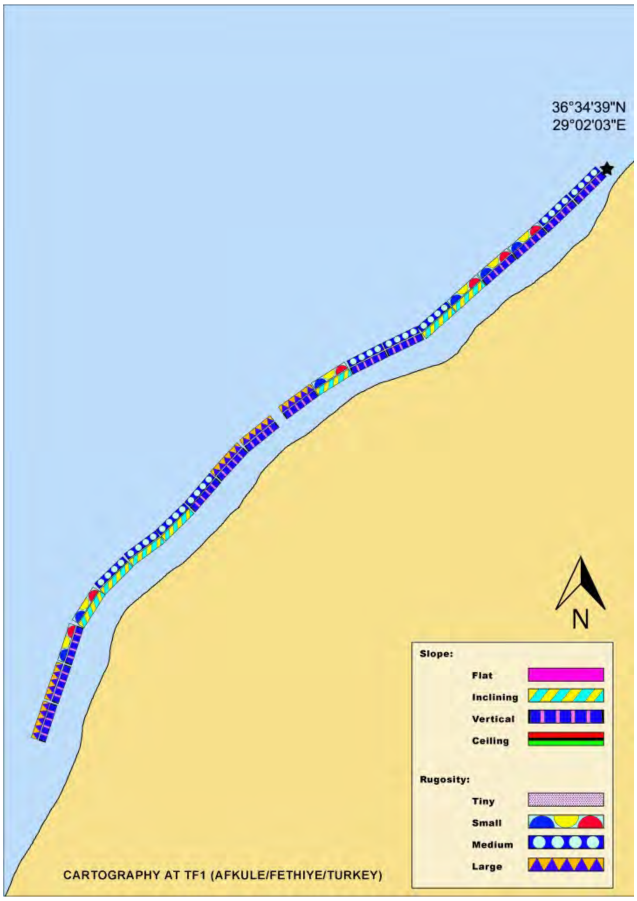


Figure 1. The location of sampling stations across the Mediterranean Sea.

According to the CIGESMED protocol, an attempt to depict the cartography of coralligenous habitat based on its rugosity and slope was carried out at stations along the coasts of Turkey. Two examples were indicated in Figure 2. At station TF1, the slope was generally vertical and the rugosity was large and medium. At station TC1, the slope was vertical and inclining, and the rugosity was medium and large (Figure 2).



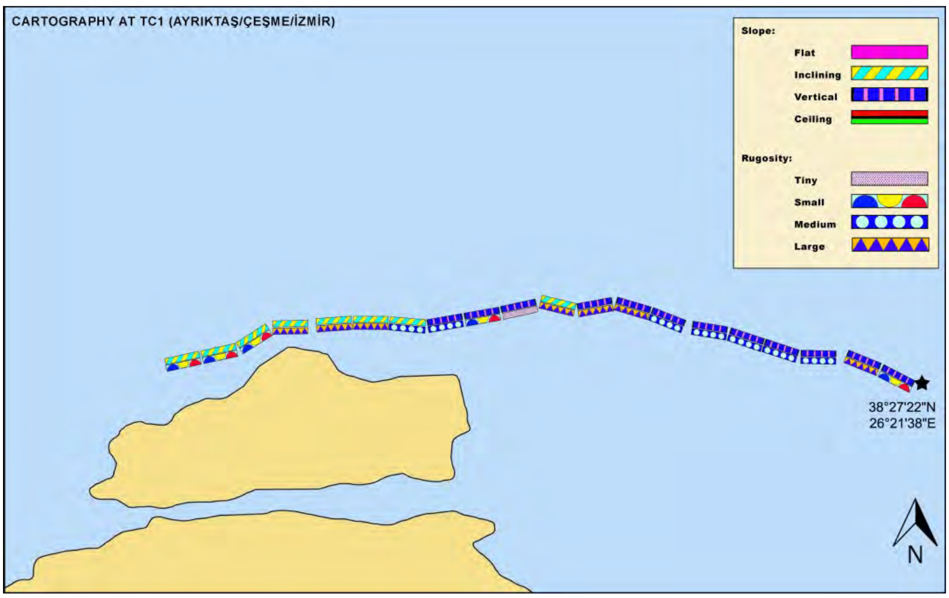


Figure 2. Cartography of coralligenous habitats at stations TF1 (above) and TC1 (below).

CHOICE OF THE SPECIES

The CIGESMED final list of coralligenous species now includes a total of 313 species belonging to 15 taxonomic groups (Chlorophyta, Phaeophycea, Rhodophyta, Foraminifera, Protozoa, Cnidaria, Platyhelminthes, Echiura, Polychaeta, Crustacea, Mollusca, Bryozoa, Echinodermata, Tunicata and Pisces). This list was also re-constructed according to the faunistic analysis of photoquadrat samples taken and under-water visual observations at the CIGESMED stations. However, some specimens could not be identified to the species level due to the difficulty in distinguishing them with naked eyes, and so they were assignated to a genus or even a higher taxon name on the list. The list is given in section 9 at the end of the present report.

Among the groups determined, the highest number of coralligenous species (>50 species) belonged to Porifera, algae and Pisces (Figure 3). Among algae, Chlorophyta, Phaeophyceae and Rhodophyta had 16, 11 and 37 species, respectively. The groups with a few number of species (<10 species) were Foraminifera, Platyhelminthes, Echiura and Crustacea.

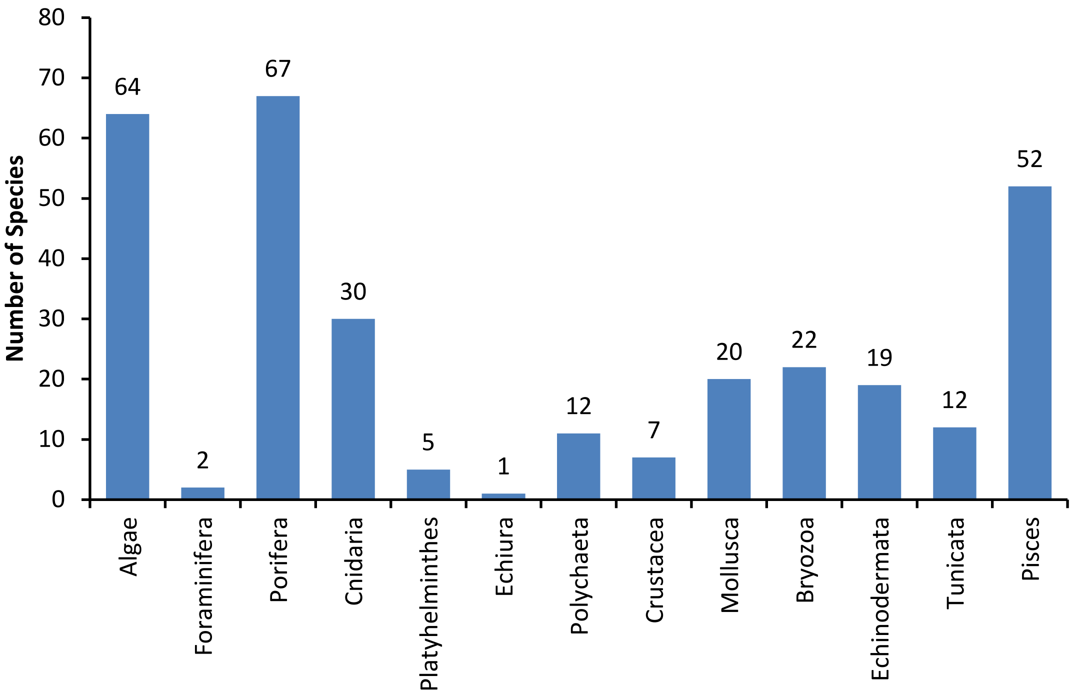


Figure 3. Distribution of total number of species to taxa.

A total of 204 coralligenous species were observed at the Turkish stations, whereas 192 and 109 species were determined at the stations in France and Greece, respectively. The number of species reported from these countries varied among taxonomic groups. The highest number of algae, sponge, polychaete, crustacean and fish species were determined at stations in Turkey, whereas Cnidaria, Platyhelminthes, Mollusca, Echinodermata and Tunicata were represented by the higher number of species at stations in France (Figure 4). The number of Cnidaria species found at the French stations was two times higher than that reported from the Greek and Turkish stations, as the coralligenous assemblages in the western Mediterranean (at least in the Gulf of Lions) were hosting large and diversified gorgonians such as Paramuricea clavata and Eunicella spp. A rich algae flora and sponge fauna were found at the Turkish stations. Although they were reported to be rare, five flat-worm species were only found at the French stations. However, apart from some groups (e.g. algae, Cnidaria, Platyhelminthes and Pisces), the number of species reported from the countries were somewhat identical.

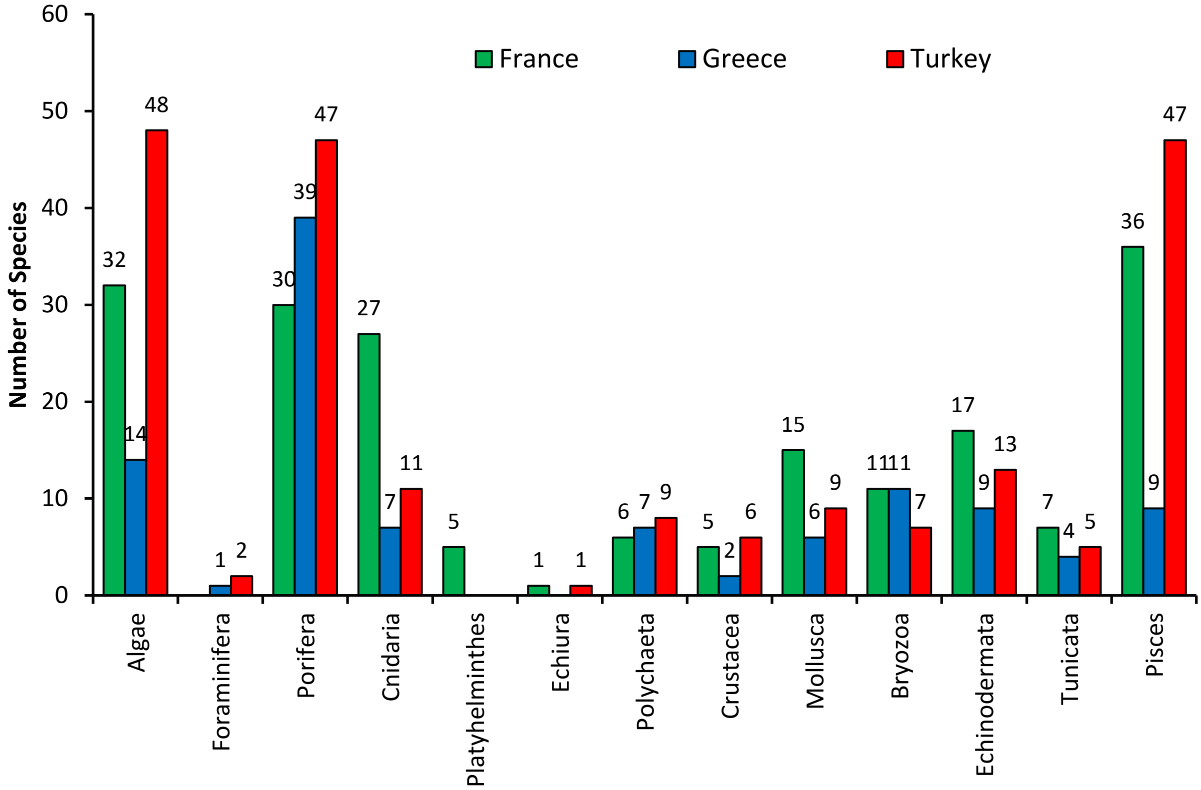


Figure 4. The species numbers found in each group per country.

The number of species solely found in the Turkish, Greek and French stations were 66, 24 and 79, respectively (Figure 5). The number of species common both in the eastern and western Mediterranean Seas were 50, comprising 16% of the total number of species (Figure 5). However, this number might increase with increasing scientific efforts to assess the species diversity of coralligenous habitats at stations, as species (59 species) common both at the French and Turkish stations might also occur at the Greek stations. Therefore, the number of common species present on coralligenous habitats in both parts of the Mediterranean could be around 100.

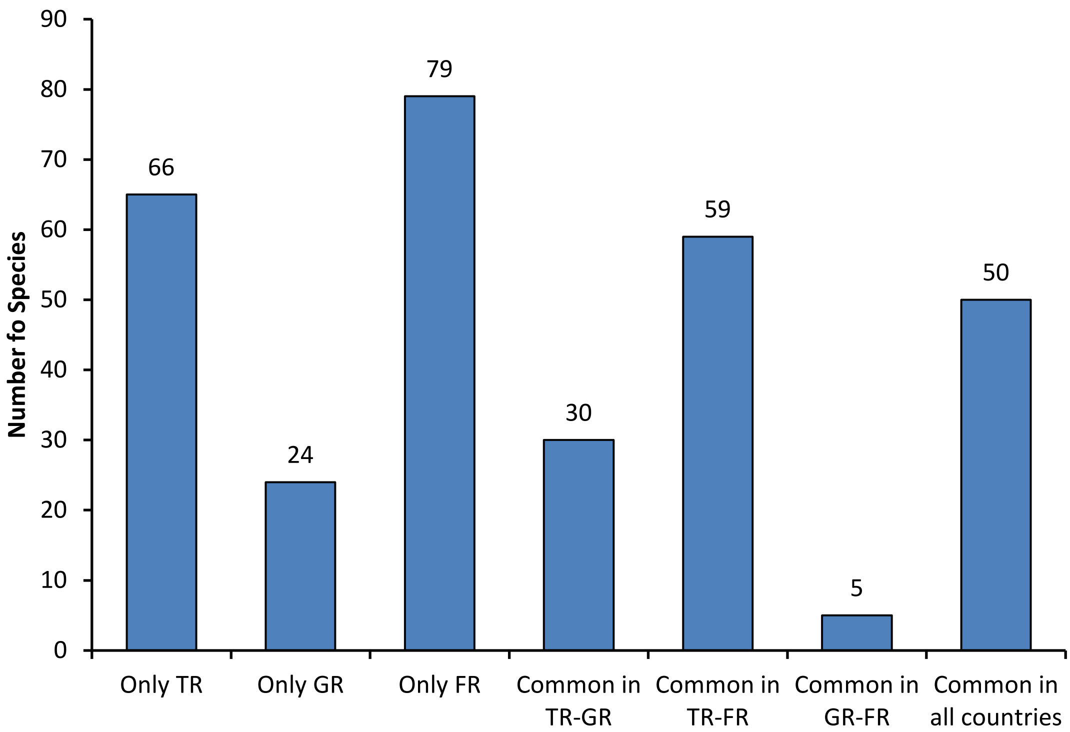


Figure 5. The coralligenous species number only found or commonly shared by the countries (TR: Turkey, GR: Greece, FR: France).

A high number of algae (26 species), sponges (15 species) and fish (14 species) were only reported from the Turkish stations (Figure 6). However, 17 out of 30 cnidarian species (57% of total number of cnidarian species), all flat worms, and the half of total number of molluscan (mainly sea-slugs) and ascidian species were specific to the French stations. The species exclusively found in the Greek stations mainly belonged to Porifera (9 species) and Bryozoa (6 species). The majority of fish species (24 species) were only observed at the French and Turkish stations. Echinodermata (42% of total number of species), Polychaeta (37%), Crustacea (29%) and Porifera (21%) had the highest number of common species for all countries.

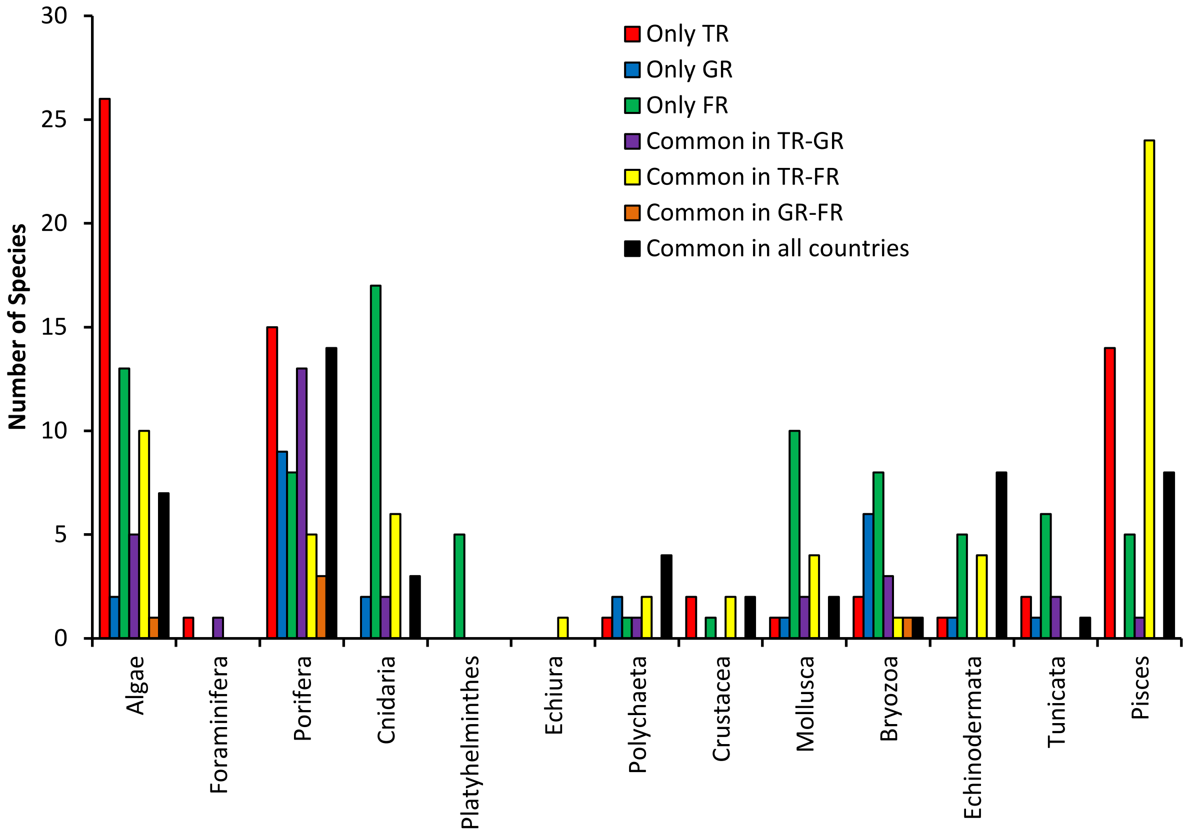


Figure 6. The coralligenous species number in groups exclusively found or commonly shared by countries (TR: Turkey, GR: Greece, FR: France).

The number of coralligenous species ranged from 45 (LPD) to 155 (FTF) at the French stations; from 60 (KOR) to 92 species at the Greek stations; and from 74 (TF2) to 134 (TC1) species at the Turkish stations (Figure 7). The average number of species was estimated as 101, 76 and 106 for the French, Greek and Turkish stations, respectively.

The coralligenous assemblages at stations were mainly constructed by three groups, namely algae, sponges and cnidarians, comprising 50-60% of the total number of species (Figure 8). The group with the highest number of species varied among stations. Algae were represented by the highest species richness at FTF, LPD and TF1; sponges at stations RMO, KOR, ZAK, TC1, TC2 and TF1; cnidarians at station MEJ. The relative abundance of cnidarians in the assemblages decreased from the west to east, and at the Greek and Turkish stations, they comprised only 3-4 % of total number of species. In contrast, cnidarians reached 25 % of total number of species observed at station MEJ. Fish were not observed at two French stations (MEJ and LPD), whereas they generally accounted for more that 15-20 % of total number of species found in coralligenous assemblages at stations. In contrast to the eastern Mediterranean stations, bryozoans possessed a relatively richer fauna in the western Mediterranean stations (French stations).

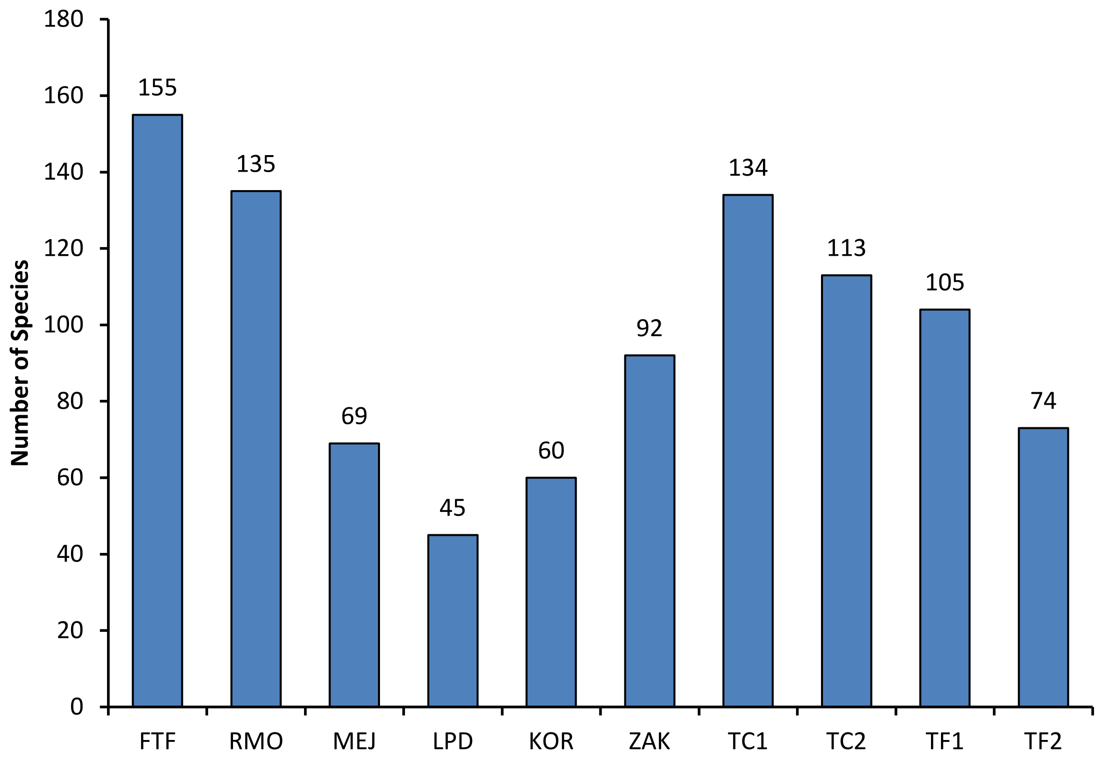


Figure 7. The coralligenous species number found at each station.

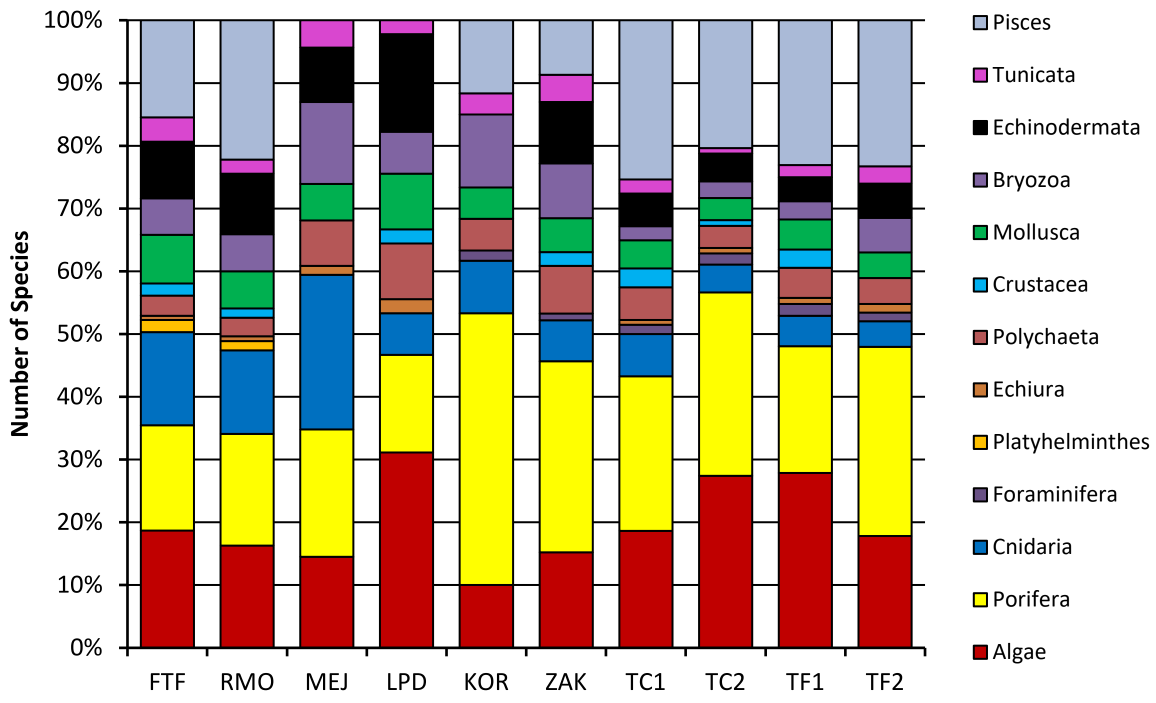


Figure 8. The relative abundance of groups, in each station.

The species that occurred at all CIGESMED stations (frequency: 100%) were *Agelas oroides, Petrosia ficiformis, Spirastrella cunctatrix, Lithophaga lithophaga, Schizomavella mamillata and Halocynthia papillosa*. The species that were present at 9 stations were *Palmophyllum crassum, Chondrosia reniformis, Cliona viridis* and *Leptopsammia pruvoti*. Sixty-nine species were present at least at 5 stations. A total of 243 species occurred at less than 50% of the stations. Eighty-nine species were only found at one station.

Only 6 species, namely, *Padina pavonica, Paramuricea clavata, Bonellia viridis, Myriapora truncata, Flabellia petiolata and Chromis chromis*, were found to be present at least in two French stations with high abundances (marked as 100 in Table 2). In the Greek stations (Ionian Sea), 7 species had high abundances. These species were *Peyssonnellia* spp., *Agelas oroides, Chondrosia reniformis, Spirastrella cunctatrix, Rhynchozoon neapolitanum, Schizomavella mamillata* and *Chromis chromis*. A total of 12 species were found to occur abundantly at least in two Turkish stations. These species were *Mesophyllum alternans, M. expansum, Peyssonnelia polymorpha, P. dubyi, P. squamaria, A. oroides, S. cunctatrix, Hoplangia durotrix, Leptopsammia pruvoti, Rocellaria dubia and C. chromis*. This shows that different species formed dense populations in three regions. Among the species, only *C. chromis* was present abundantly in all regions. However, if species with high abundance at least in one station taken into account, 13 species were found in the French stations, 32 species in the Greek stations and 17 species in the Turkish stations. Among them, species belonging to genera *Mesophyllum* and *Peyssonnelia* were common in all regions.

The nMDS analysis based on the presence-absence data of species at stations showed that there were three species associations at the similarity level of 50% and two associations at the similarity level of 40% (Figure 9). At the highest similarity level (50%), stations along to the coast of each country grouped together. However, among the French stations, LPD joined to the other French stations with a relatively low similarity value (40%). The stations FTF and RMO seem to have more or less a similar species composition. Stations in Ildırı and Fethiye Bays separately joined to each other with a high similarity value (>60%).

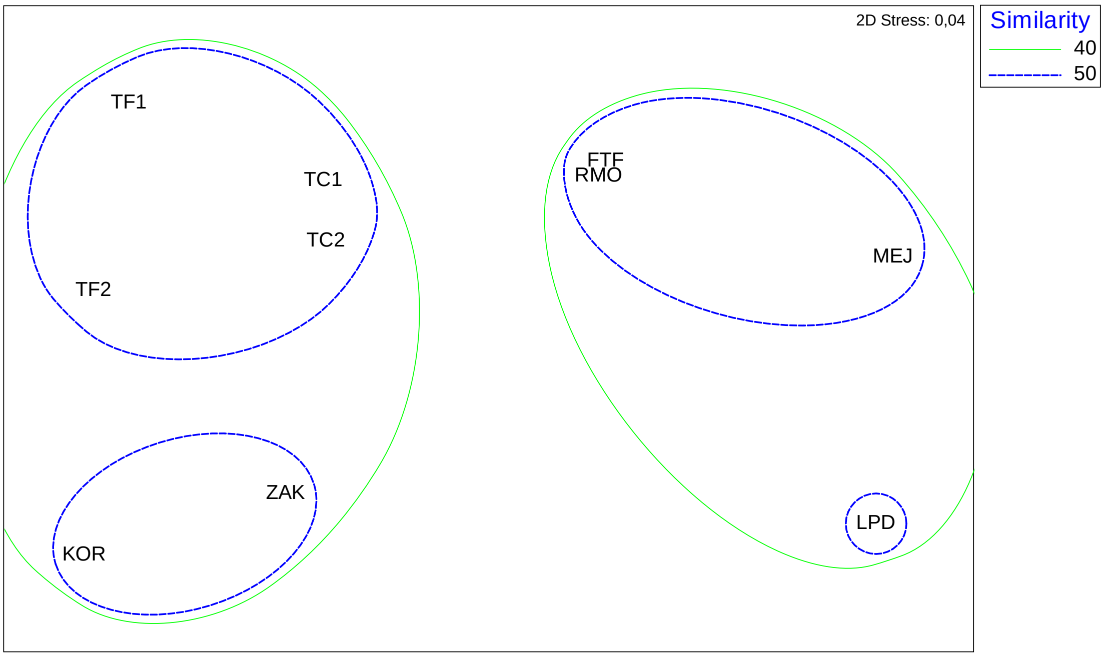


Figure 9. nMDS plot showing similarity among stations, based on presence-absence data.

Based on the semi-quantitative data presented in Table 2, the nMDS analysis produced a similar pattern to that based on the presence-absence data (Figure 10). The eastern and western Mediterranean stations were placed in the different corners in the graph and joined to each other with a low similarity level (14%).

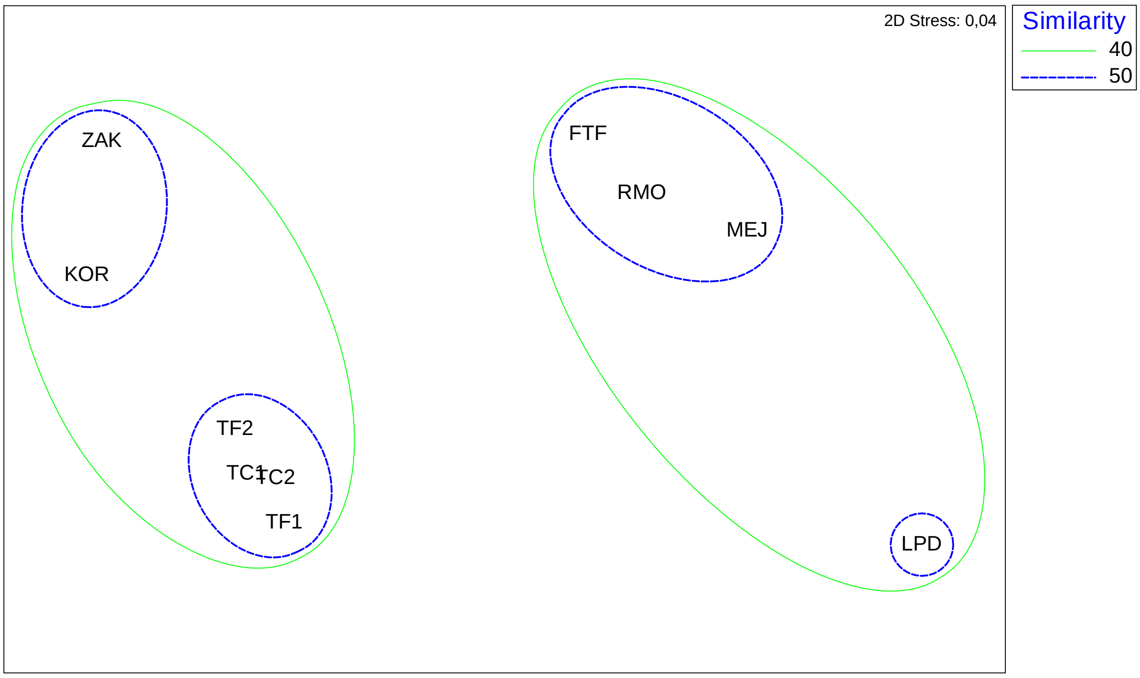


Figure 10. nMDS plot showing similarity among stations, based on semi-quantitative data.

TASK 2.2. EASY METHODS FOR BIODIVERSITY AND GOOD HEALTH ASSESSMENTS [APRIL 2013 – FEBRUARY 2015]

CONTRIBUTING PARTNERS: EGE, HCMR, NMPZ, CNRS-IMBE.

Within the framework of the CIGESMED project, two methods were applied to assess the coralligenous assemblages and threats on them at stations; under-water visual observation and photo-quadrat. In the first method, a rope with 50 m long was loosely attached horizontally on the coralligenous wall and species present along the rope was noted by divers and recorded with a digital camera. Apart from this, to realize the general health state of the coralligenous habitats and to determine threats directly affecting coralligenous habitats such as presence of ghost-nets, discharge from a pollution source, sediment depositions and necrosis, coralligenous habitats were randomly observed with several divers and took notes on them. The semi-quantitative data presented in Table 2 were constructed based on notes taken during under-water visual observations. Video-recordings were examined to list species that were escaped diver’s attentions while diving.

For the study of coralligenous assemblages at stations, a non-destructive method, namely photo-quadrat, was chosen and applied according to the CIGESMED protocol. Although there was a debate regarding the frame size to be used in the photo-quadrat system, it was later reached a consensus that using a larger (50x50 cm in dimension) quadrate in all stations would bring a standard to collect data and enable us to make a comparison between coralligenous assemblages across the Mediterranean. As written in the protocol in detail, at each station, three replicates of photo-quadrate samples each with 9 quadrates placed in a square three by three, covering an area of 6.75 m^2, were taken (Figure 11, 12).

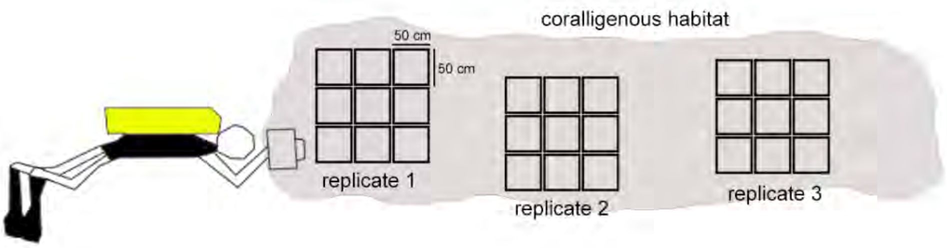


Figure 11. A schematic picture showing the application of photo-quadrate method in the field.

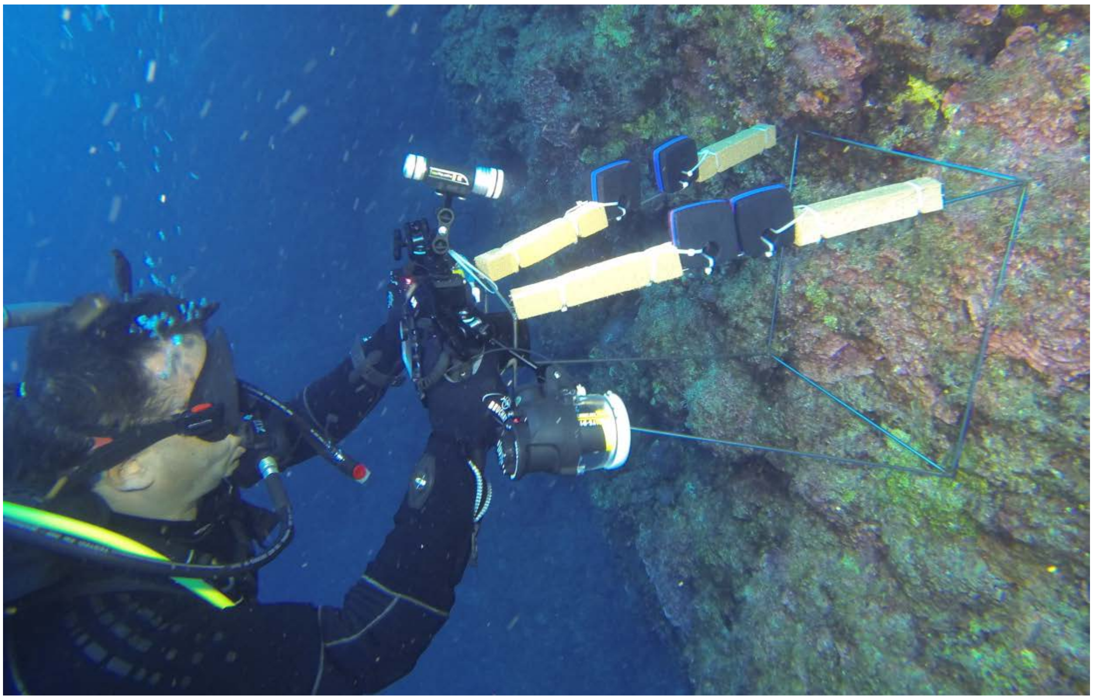


Figure 12. Taking a picture by the photo-quadrate system used in the Turkish stations.

The photographs taken from the coralligenous stations were then analyzed by using the software photoquad that is freely available on the website http://www.mar.aegean.gr/sonarlab/photoquad/index.php.

In assessing the species composition and percent coverage of the coralligenous species within the quadrate, uniform point option (100 point) was used (Figure 13). The results from the analysis were then exported to an Excel page and constructed a species x sample matrix.

The species-coverage data gathered from different stations in a standard protocol would form the backbone for the rapid assessment of the health status of the coralligenous habitat at the CIGESMED stations. Not only the percent coverages of sensitive or tolerant species, but also the percent coverages of sediment depositions, bleaching and invasive alien species would be used in evaluating the good or bad states of coralligenous habitats by using different biotic indices including Index-Cor. One of the metric of this index is the ratio between tolerant and sensitive species. Therefore, assigning coralligenous species to ecological groups explained in the paper by Borja et al. (2000) is needed to estimate which ecological group dominates coralligenous assemblages, through which a health status evaluation of the habitat would be possible. Faunistic and abiotic (e.g. sediment deposits) data gathered during under-water visual observations would be used in the COARSE index (Gatti et al., 2015), that are based on several descriptors in three layers of coralligenous habitats, namely basal, intermediate and upper layer. However, the validation of this index should be performed in the eastern Mediterranean, as the upper layer that is characterized by large gorgonians is absent in southern stations of the region.

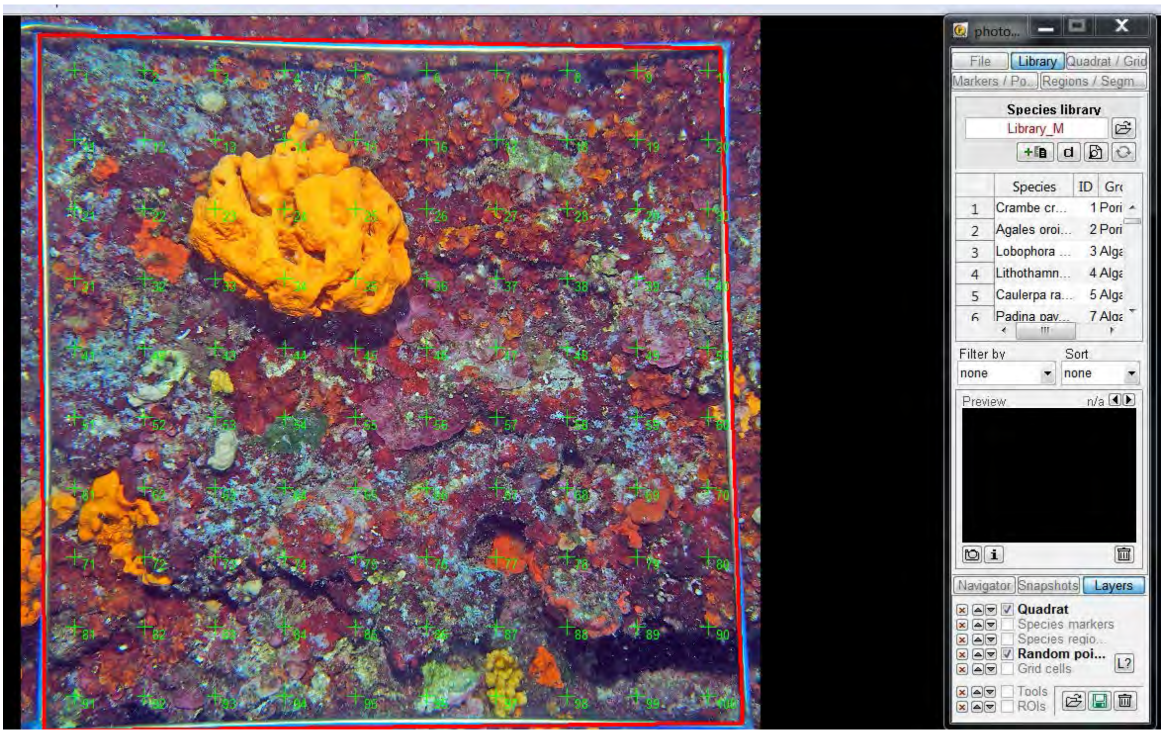


Figure 13. Analyzing a photograph (taken from station TC1) by using the uniform point option of the photoquad software.

TASK 2.3. COMPARISONS OF IMAGE PROCESSING AND ANALYSIS OF BENTHIC QUADRAT METHODS AND ADAPTATION [AUGUST 2013 – FEBRUARY 2016]

CONTRIBUTING PARTNERS: EGE, HCMR, NMPZ, CNRS-IMBE.

ANALYSIS OF PHOTO-QUADRATES ACROSS THE MEDITERRANEAN

Four stations (TC1, TC2, TF1 and TF2) in Turkey, 2 station (KOR and ZAK) in Greece and 3 stations (FTF, RMO and MEJ) in France were selected to assess the structures of coralligenous assemblages by using the photo-quadrate method. At each station, three replicates covering a surface area of 6.75 m^2 were photographed and analyzed by using photoQuad software. Analyzing a total of 243 photographs by 100 point-uniform points yielded 136 species belonging to 11 taxonomic groups (Chlorophyta, Rhodophyta, Ochrophyta, Porifera, Cnidaria, Bryozoa, Polychaeta, Platyhelminthes, Mollusca, Echinodermata and Tunicata). Porifera (49 species) and Bryozoa (20 species) were represented by the highest number of species (Figure 14). Rhodophyta and Cnidaria had 17 species each. Algae (inc. Chlorophyta, Rhodophyta and Ochrophyta) possessed 30 species. The other groups comprised a few number of species at stations.

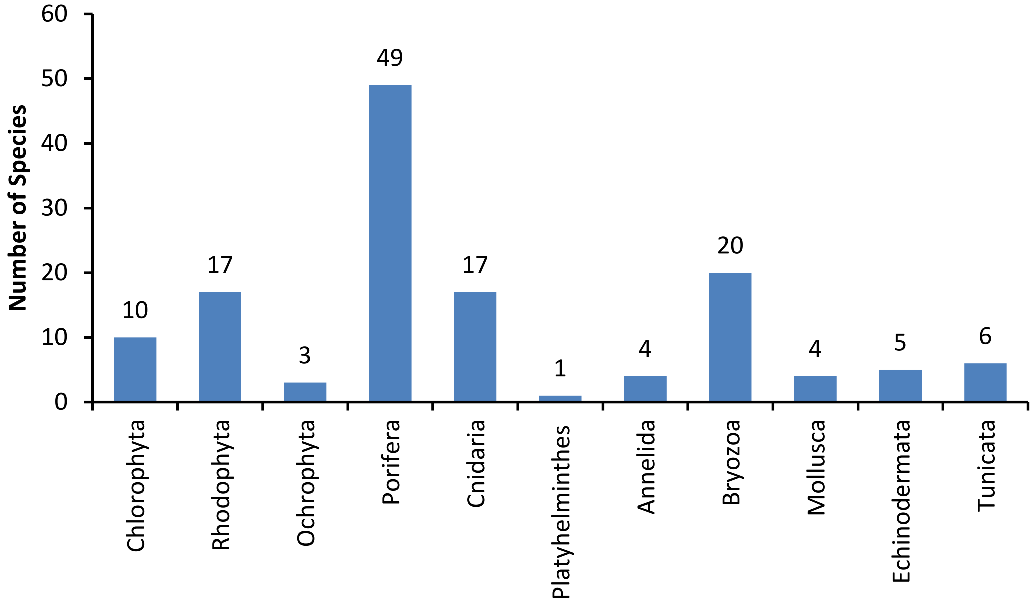


Figure 14. Total number of species in each taxonomic group found at stations.

Rhodophyta comprised 41% of total number of points identified on photographs from all stations, followed by Porifera (14%) and Cnidaria (10%) (Figure 15). Holes on coralligenous walls (8.6%) and sediment depositions (7.7%) also covered large areas on quadrates. Bleaching was widely observed in the eastern Mediterranean stations and covered a total surface of 5.8%. Taxonomic and non-taxonomic groups that comprised a surface area between 1 and 5% in quadrates were Chlorophyta, Unidentified (spp.), turf-forming algae (mixed) and Bryozoa.

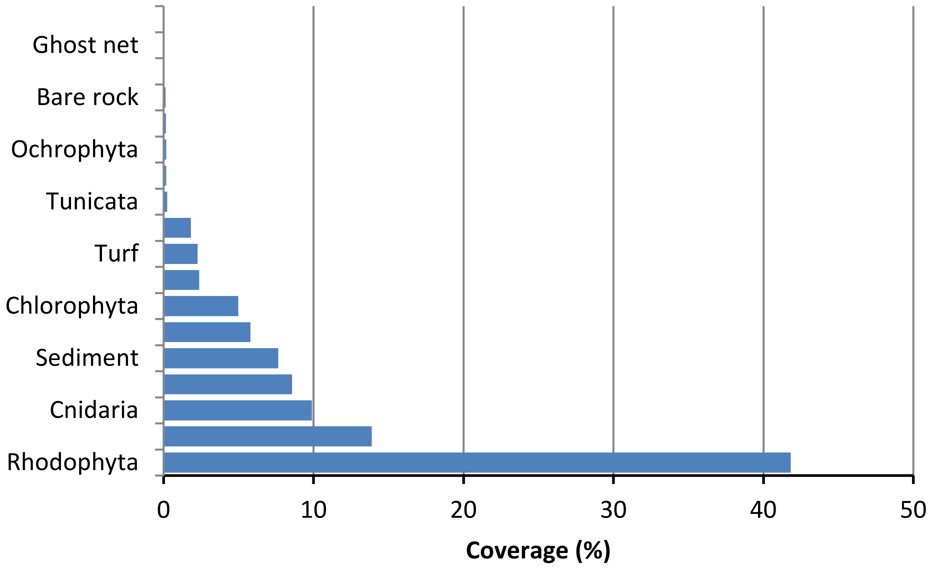


Figure 15. Total percentages of taxonomic/non-taxonomic groups and abiotic features in terms of the number of points on photographs.

The average percent coverages of the taxonomic / non-taxonomic components in each station are indicated in Figure 16. Rhodophyta comprised 50% of the total surface areas at stations TC1, TC2, TF1, TF2 and ZAK. This group attained its maxima at station TF1, accounting for 79% of coverage of total coralligenous habitat. This group was also dominant at station MEJ, but its percent coverage was around

40%. At this station, Chlorophyta (*Flabellia petiolata*) also dominated the coralligenous habitat, comprising 21% of total surface. The dominant taxonomic group was Porifera (36% of total area) at station KOR, Cnidaria at stations FTF (32%) and RMO (33%). Sediment deposits were found at all stations, but their percent coverages were higher than 15% at two stations (TC2, FTF). Algal bleaching was recorded at all Turkish stations and ZAK, but none at the French stations. Algae-forming turfs were determined at all stations and were particularly important (>5%) at stations KOR and MEJ. Bryozoa were found at all stations, but their percent coverages were lower than 1% at the Aegean Sea stations (TC1 and TC2) and TF1, and higher at station KOR (7%). The average percent coverages of other components within quadrates were lower than 1%, except for that of Tunicata at station KOR, where they covered a surface area of 1.1%.

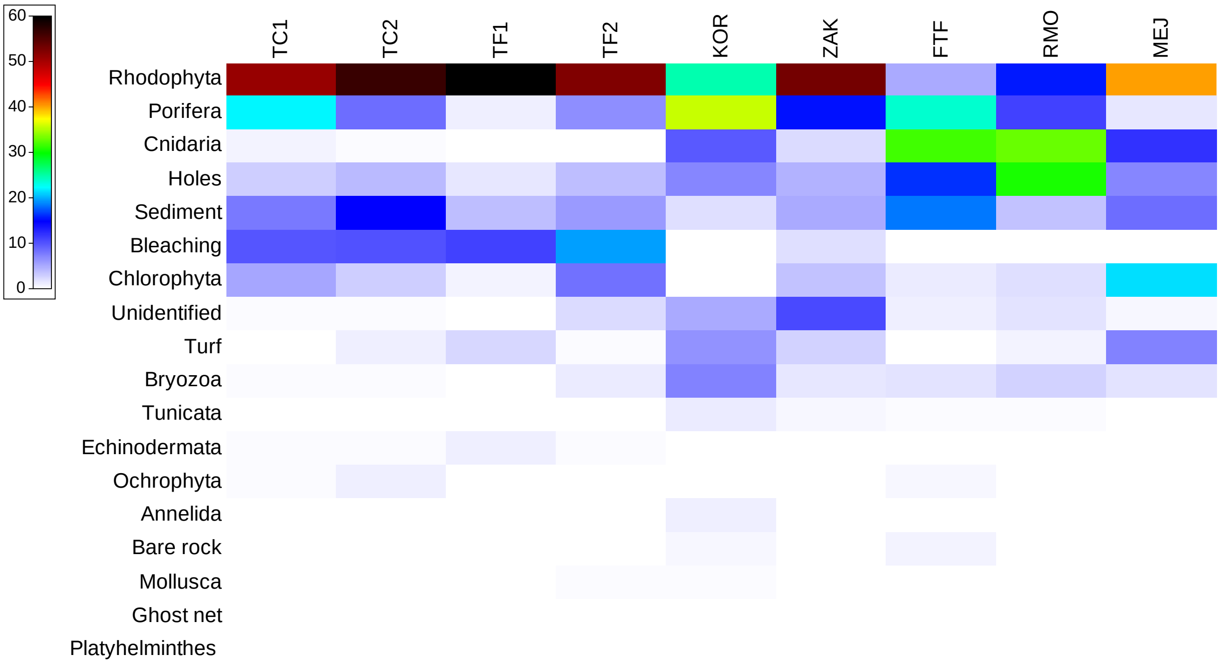


Figure 16. Average percent coverages of biotic and abiotic components in coralligenous habitats at stations.

The genera that dominated/formed coralligenous habitats varied across the Mediterranean (Figure 17). The genera *Mesophyllum* and *Peysonnelia* comprised more than 50% of coverages on the habitat at stations along the coast of Turkey. The genus *Mesophyllum* alone accounted for 42% of total surface area at station TF1, but was not reported at stations FTF and MEJ or represented by low cover percentages (<2%) at stations KOR, ZAK and RMO. In contrast to other genera, the genus *Peyssonnelia* was wide-spread in the Mediterranean and comprised relatively high percent coverages (>10%) at all stations, except for FTF (3%). Two genera of sponges (*Crambe* and *Spirastrella*), which are morphologically similar to each other, occurred only at the eastern Mediterranean stations and reached to the average maximum coverage (11%) at station TC1. Three genera (*Paramuricea*, *Eunicella* and *Parazoanthus*) were only reported from the western Mediterranean stations. The genus *Paramuricea* covered larger areas (>15%) at stations FTF and RMO, *Eunicella* at MEJ (10%) and *Parazoanthus* at FTF (11%). Among these species, only *Parazoanthus* was encountered at the eastern Mediterranean stations during under-water visual observations. Although it was found at all stations in the Aegean Sea and Gulf of Lions, the genus *Flabellia* was densely settled at station MEJ (21%). The genus *Agelas* densely occurred at one station (TC1) in Turkey and two stations in Greece, but its average coverage was lower than 2%

in other stations. The erect sponge *Axinella* occurred at all stations but its coverage did not exceed to 2.5%.

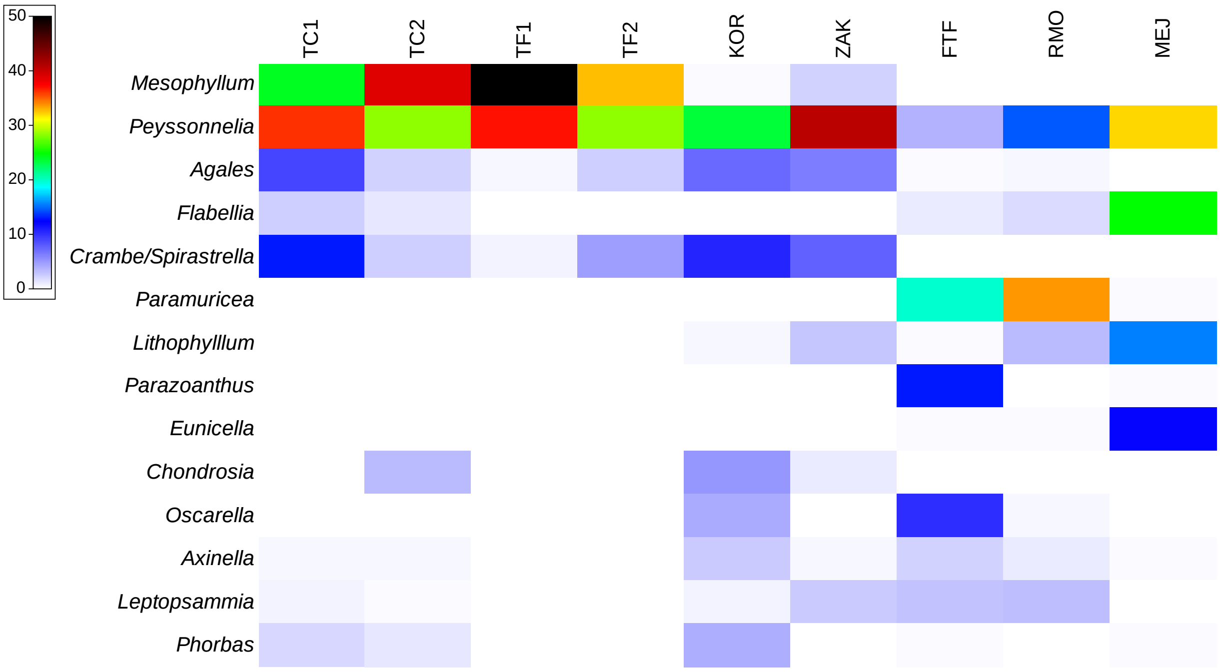


Figure 17. Average percent coverages of genera mainly dominating coralligenous habitats at all stations.

Coralligenous species that covered large surface areas in coralligenous habitats varied among stations (Figure 18). Two species of *Mesophyllum*, namely *M. alternans* and *M. expansum* were dominant coralline algae along the coast of Turkey, but the former species covered large areas at stations in Ildır Bay and the latter species at stations in Fethiye Bay. In addition, the dominant species of *Peyssonnelia* in Ildır Bay was *P. squamaria*, whereas *P. polymorpha* was dominant in Fethiye Bay, indicating different coralligenous assemblages in the Aegean and Levantine Seas. As specimens of *Peysonnelia* were not identified to species level in the Greek and French stations, it is not known at this stage which species dominated coralligenous habitats in these stations. The gorgonians *Paramuricea clavata* and *Eunicella cavolinii* were solely found in the Gulf of Lions and dominated the coralligenous assemblages. As many sponge specimens were not identified to the species level at the French stations, the sponge species with high percent coverages in the coralligenous habitats were not observed, whereas *Agelas oroides* in the Turkish and Greek stations covered larger areas together with the encrusting sponge, *Spirastrella cuntratrix*. *Lithophyllum* spp. were among the main constructors of coralligenous habitats at station MEJ.

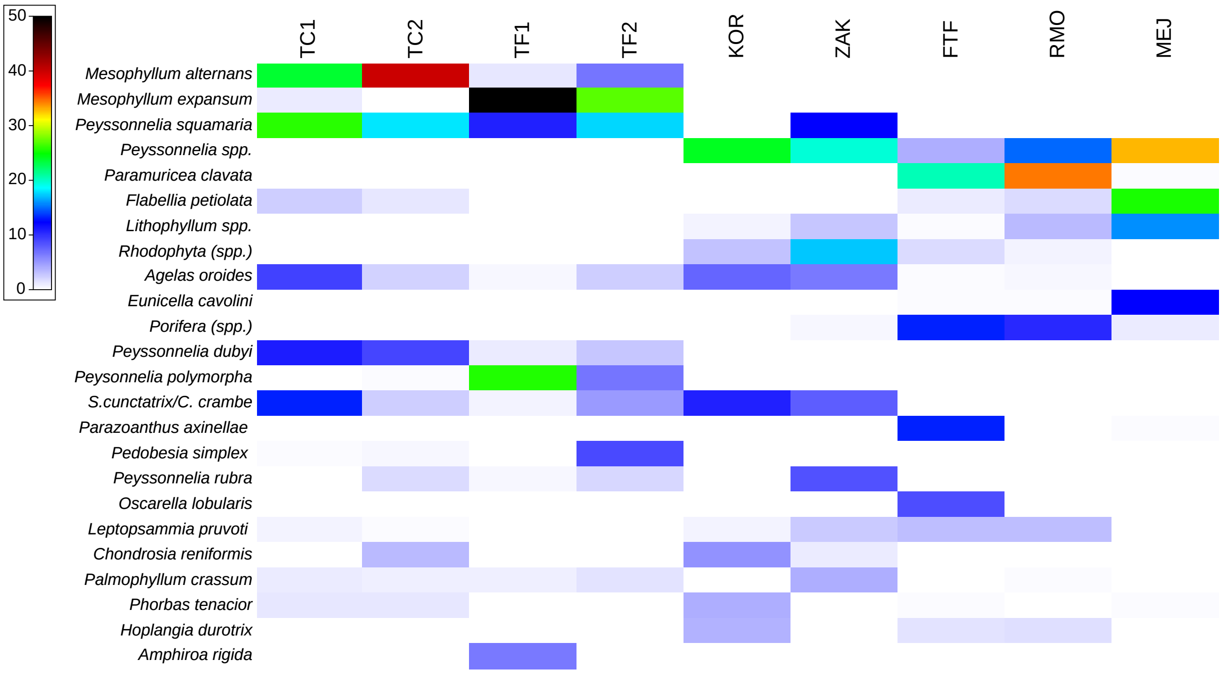


Figure 18. Average percent coverages of species mainly dominating coralligenous habitats at all stations.

The highest mean number of species (37 species) per unit area (6.75 m^2) in coralligenous habitats was found at station KOR, followed by stations ZAK (29 species) and FTF (25 species). The lowest average number of species was estimated at station TF1 (12 species), where *Mesophyllum expansum* covered the majority of spaces within quadrates. Except for stations KOR and RMO, the standard error average was lower than 3, showing less natural variability in the average number of species at stations.

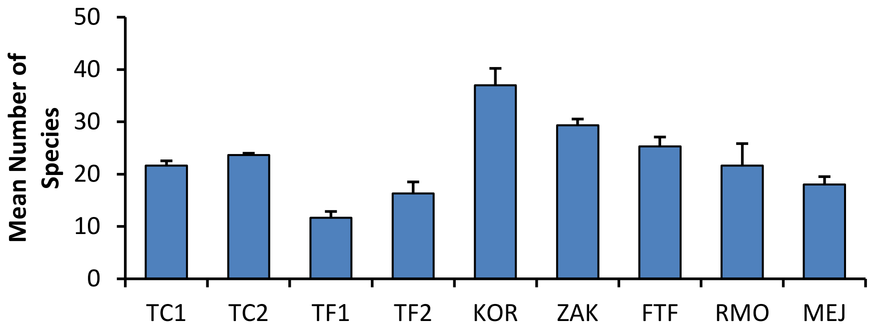


Figure 19. Average number of coralligenous species at each station with + standard error.

The average Shannon-Weiver diversity index (H') values ranged from 1.89 (TF1) to 3.90 (KOR) at stations (Figure 20). The average diversity index values were always higher than 3 in the Greek stations, and higher than 2 at other stations (except for TF1).

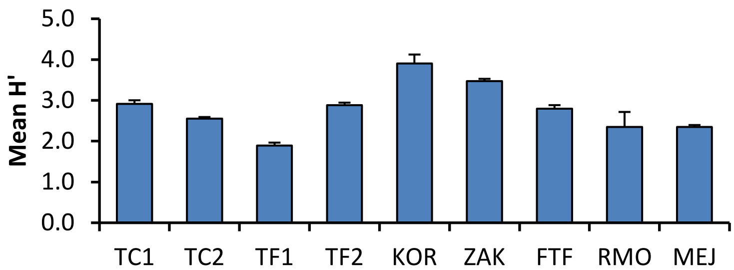


Figure 20. Average H' values at each station with + standard error.

Paralleled with the H' values, the Pielou's evenness index (J') values attained its highest scores at stations KOR and ZAK, and its lowest score at station TF1 (Figure 21). Three stations (TF2, KOR, ZAK) had J'values higher than 0.7, showing that spaces in coralligenous habitats were relatively uniformly occupied by coralligenous species, whereas at stations RMO and TF1, J' values were around 0.5, indicating one or two conspicuous species dominating the coralligenous habitats. At RMO, *Paramuricea clavata* and *Peyssonnelia* species covered almost 41% of coralligenous wall surfaces. AT TF1, *Mesophyllum expansum* alone occupied 41% of surface areas within quadrates.

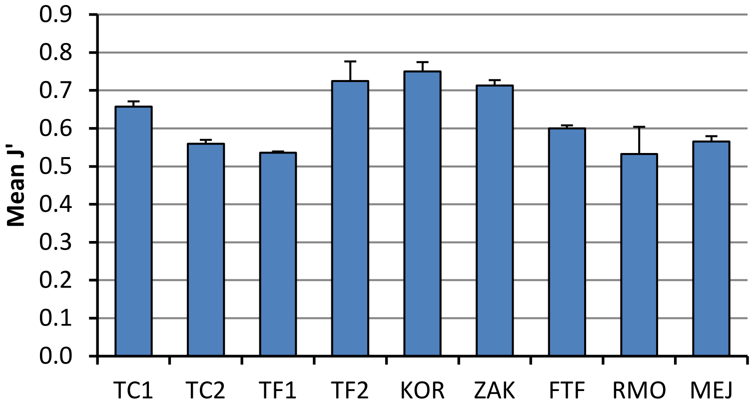


Figure 21. Average J' values at each station with standard error.

The cluster analysis based on the Bray-Curtis similarity indicated that there were three major coralligenous assemblages at the studied stations at the similarity level of 30%. All samples taken from stations of each country clustered into different groups (Group A: Turkish stations, Group B: Greek stations, Group C: French stations) in the dendrogram and nMDS plots (Figure 22). The coralligenous assemblages developed at the Aegean and Levantine Sea were mainly characterized by having 6 species, namely *Peyssonnelia squamaria*, *Mesophyllum alternans*, *Spirastrella cunctatrix*, *P. dubyi*, *Agelas oroides* and *Palmophyllum crassum*, that contributed (totally 70%) much to the similarity of the group A (SIMPER analysis). The group B comprised the species, *S. cunctatrix*, *A. oroides*, *Peyssonnelia* spp., Rhodophyta (spp.) and *Neogonioliton mamillosum* that were responsible for the high similarity (average similarity value: 55%) within the group. The French stations were mainly characterized by having *Peyssonnelia* spp. (contribution=17%), Porifera (spp.) (14%), *Flabellia petiolata* (10%), *Paramuricea clavata* (8%), *Lithophyllum* spp. (6%) and *Myriapora truncata* (%). Trough the data presently collected it can be seen that *Peyssonnelia* species were among the main constructors at all stations and were responsible for the similarity and dissimilarity of stations. However, the main problem here is that specimens of *Peyssonnelia* were identified to the species level at Turkish stations, but only to genus level at all the other stations, resulting in an "artificial" dissimilarity among stations. Similarly, many sponge specimens and coralline algae were identified to the group level (as Porifera spp. or Rhodophyta spp.) at the French and Greek stations, respectively. If the taxonomic entities of these specimens are solved, then we would have a chance to see a "true" picture regarding the characteristics of coralligenous assemblages across the Mediterranean. However, if the 40% similarity level is taken into account, in this case, there were 5 coralligenous assemblages occurring in the regions. The Turkish stations were splitted into two; the Aegean Sea coralligenous assemblage and the Levantine Sea coralligenous assemblage. The striking difference between these assemblages was that *M. alternans* and *P. squamaria* dominated the Aegean Sea coralligenous assemblages, whereas *M. expansum* and *P. polymorpha* dominated the Levant coralligenous assemblages. In the Gulf of Lions, coralligenous assemblage determined at station MEJ was quite different from those occurring at other stations. At this station, *Lithophyllum* spp., *Eunicella* *cavolini*, *Flabellia petiolata* and *Myriapora truncata* covered large areas on coralligenous habitats, whereas at other stations *Paramuricea clavata* dominated the coralligenous assemblages.

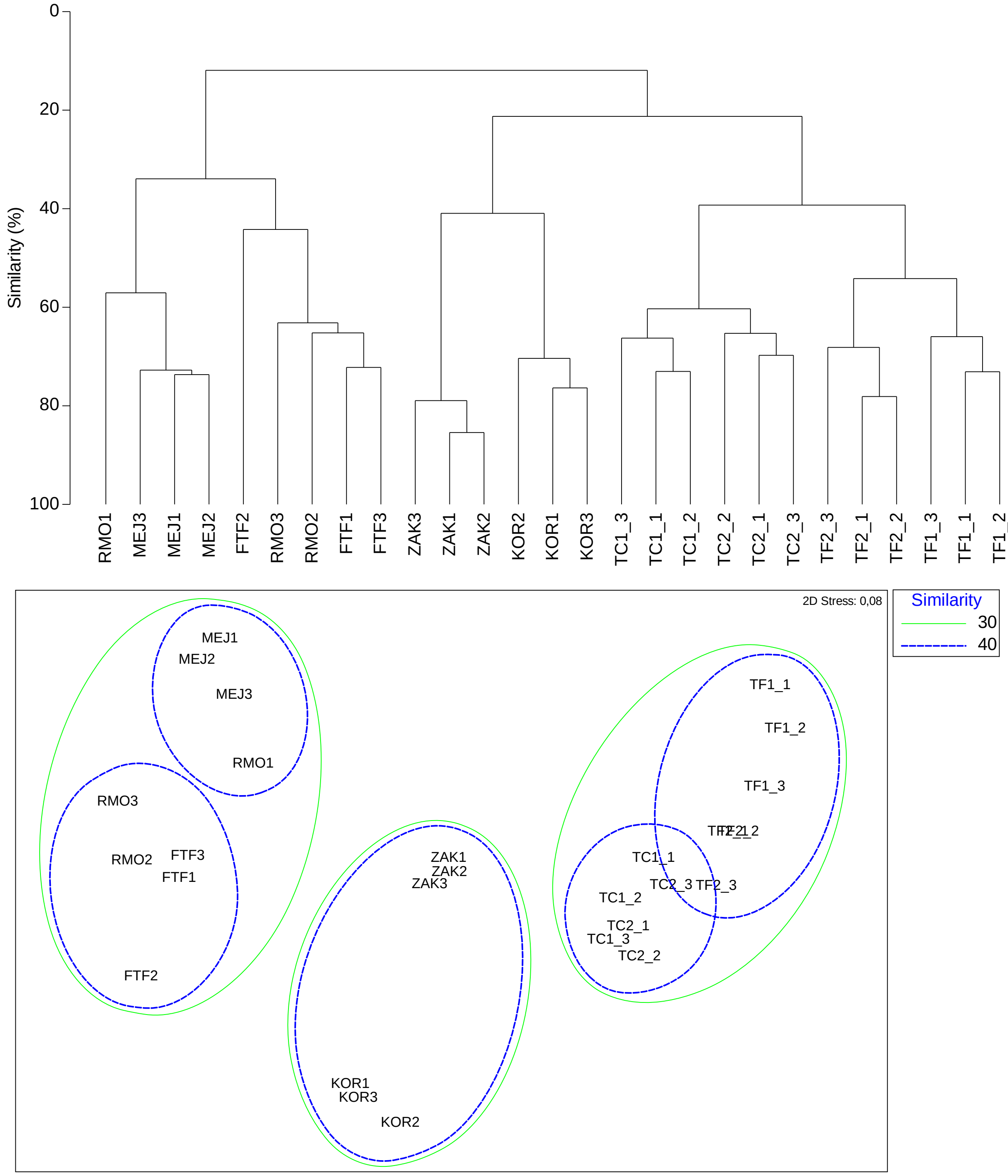


Figure 22. Dendrogram and nMDS plots showing similarity among stations, based on photo-quadrate data.

The species that represented high correlations (r>0.6, Pearson correlation analysis) with the MDS axes (MDS I and II) were shown in Figure 23. The highest correlation values were estimated between MDS I and the long-transformed data (points/coverage) of the following species, *Peyssonnelia squamaria* (r=-0.83), Porifera (spp.) (r=0.83), *Peyssonnelia* spp. (r=0.78) *Mesophyllum expansum* (r=-0.71), *P. dubyi* (r=-0.69), *Palmophyllum crassum* (r=-0.67), *M. alternans* (r=-0.67), *P. polymorpha* (r=-0.66) and *Paramuricea clavata* (r=0.64). They were the species responsible for creating the discrimination between the eastern and western Mediterranean coralligenous assemblages. The Ionian stations were mainly characterized by the high percent coverages of *Peyssonnelia* spp., *Spirastrella cunctatrix* and *Agelas oroides*. However, the coralligenous assemblage at station KOR differed from that at station ZAK in holding several sponges (e.g. *Phorbas tenacior*, *Ircinia variabilis*, *Axinella cannabiana*), cnidarians (e.g. *Hoplangia durotrix*, *Caryophyllia inornata*), bryozoans (*Rhynchozoon neapolitanum*, *Schizomavella* (*Schizomavella*) *mamillata*) that were absent or represented by a few number of species at station ZAK.

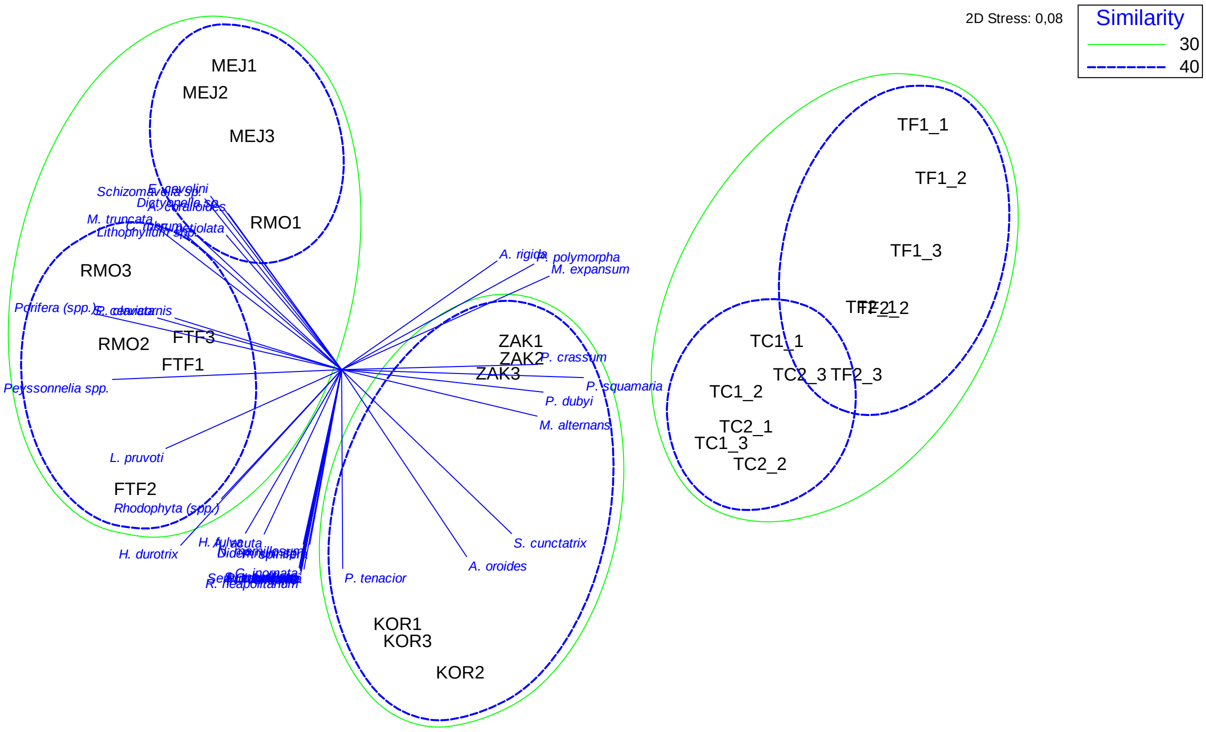


Figure 23. nMDS plot of samples based on species point/coverage data and the correlation of important species (r>0.6) with MDS axes, represented by superimposed vectors. The similarity among stations was estimated using the Bray-Curtis similarity index and was secondarily over-imposed on the nMDS plot.

EVALUATION OF 3D PHOTOMOSAICS AS A TOOL FOR THE EVALUATION OF CORALLIGENOUS COMMUNITIES

During the initial efforts of testing the application of CIGESMED protocol in Greece, it was applied the Current SfM and multi-view 3D reconstruction software implementations in order to assess its capability for producing 3D mosaics of coralligenous community faces. These could possibly serve both as high-resolution visual maps to monitor changes over time and the basis from which to extract quantitative information regarding habitat complexity and/or rugosity. A suitable rocky wall surface with coralligenous communities and high topographic complexity was selected at 27 m depth at the sampling station at Lambiri and 130 underwater photographs were taken of an area of about 30 m^2 with high vertical and horizontal image overlap (~ 30-40%). A pre-calibrated optical system comprising a Nikon D200 camera and a Tokina 10-17mm fisheye lens in an underwater housing with a 9-inch optical glass dome port was used to capture RAW digital image files. Artificial lighting was provided by two INON z-240 underwater strobes. All images were processed accordingly for proper colour rendering using common settings in Adobe Lightroom 5.2 and exported in jpeg format with minimum compression. Agisoft Photoscan 1.1 was used for the 3D surface reconstruction and mosaic image blending.

About 95% of the photos taken (122) were successfully aligned (some failed due to increased backscatter from the floating particles and some others due to little image overlap and errors during the capture phase), and a complete high-resolution 3D model of the rocky wall part with about 2.5 million polygons was produced. The final photo-realistic 3D model comprises both the surface layer of the coralligenous community and highly erect species, such as *Axinella cannabina* sponges (Figure 24), thus proving that the technique is quite capable of modeling complex geometries that are typical of the coralligenous habitats. The underlying resolution of the 3D model is very high and could possibly be used to assess total and mean rugosity over the whole area or specific sub-areas, however –because of the lack of scale reference in the model– such an assessment was not possible at the time. In the next steps of this ongoing evaluation we will be applying the technique in parallel with the application of the CIGESMED protocol during the upcoming sampling sessions. This will enable us to do one-to-one comparisons of the different methodologies for the estimation of rugosity (the *in situ* assessment proposed in the CIGESMED protocol as opposed to the one based on 3D image modeling) and also create visual records of the stations in the form of photo-realistic mosaics with high spatial accuracy on which measurements of length and volume can be made.

Figure 24. Photo-realistically rendered views around the vertical axis of the full 3D model of a rocky wall. The model comprises both the surface layer of the coralligenous community and highly erect species, such as Axinella cannabina sponges.

TASK 2.4. CONTRIBUTION TO THE ASSESSMENT OF INJURIES AND WELL LIVING OF CORALLIGENOUS [JUNE 2014 - FEBRUARY 2016]

CONTRIBUTING PARTNER: EGE.

Deteriorations (e.g. algal bleaching) in coralligenous habitats together with some threats directly influencing the well-living of coralligenous such as sediment depositions and the settlement of invasive alien species were observed and quantified at coralligenous stations.

ALGAL BLEACHING

Algal bleaching was only reported at all coralligenous stations in the Aegean and Levantine Seas, and at one station (Zakynthos) in the Ionian Sea (Figure 25). No algal bleaching was observed at stations in the Gulf of Lions. The average coverage of algal bleaching ranged from 1.89% (station ZAK) to 19% (stations TF2). Algal bleaching was an important phenomenon at stations along the coast of Turkey, accounting for at least 10% of surface areas in coralligenous habitats. The species that were excessively subjected to bleaching were *Mesophyllum alternans* and M. *expansum*. At some samples, 1/3 of thalli of these species were bleached. It is interesting to note that algal bleaching seems to occur solely in the eastern Mediterranean. The impacts of global warming and regional fluctuations in sea-water temperature on algal bleaching should be investigated.

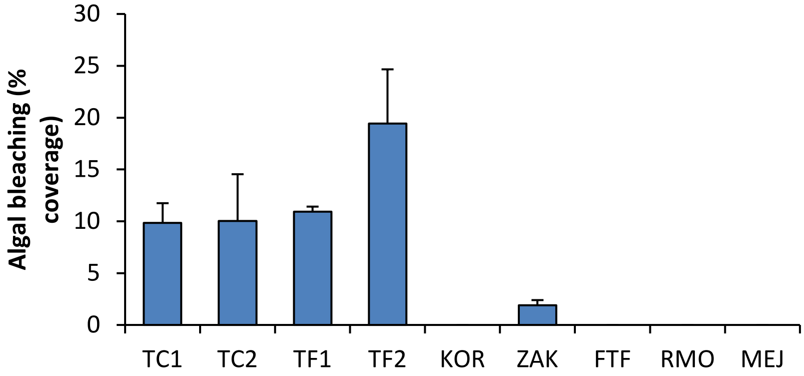


Figure 25. Average percent coverage of algal bleaching at coralligenous stations.

SEDIMENT DEPOSITS

Sediment deposits on coralligenous habitats were observed at all stations studied. The average coverage ranged from 3.5% (station RMO) to 15% (station FTF) (Figure 26). Stations in the Aegean Sea had two or three times higher sediment depositions than those in the Levantine Sea. It is known that the amount of sediment depositions on coralligenous habitats is influenced by the discharges of pollution sources nearby. In Ildır Bay (Aegean Sea), coralligenous habitats were very close to fish farming cages, explaining why sediment depositions were high at stations in this bay. It is known that the inclination of coralligenous wall also affects the amount of sediment accumulations in coralligenous habitats. As only vertical wall was considered in the CIGESMED project, the results from all stations studied are more or less comparable. At Fethiye stations and Zakynthos which are protected stations, sediment deposits were relatively less important.

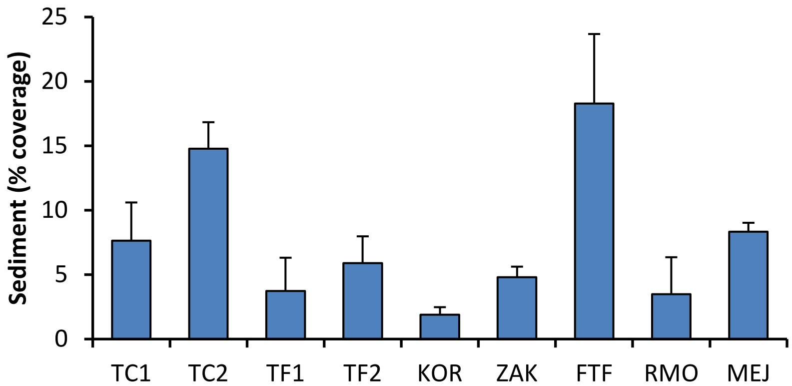


Figure 26. Average percent coverage of sediment deposits at coralligenous stations.

INVASIVE ALIEN SPECIES

Through the under-water visual observations and photo-quadrate analysis, a total of 9 species belonging to 6 taxonomic groups were reported from coralligenous stations. All of them were found at stations along the coast of Turkey, except for *Caulerpa cylindracea* that was also observed at station FTF in the Gulf of Lions. Four species (*Amphistegina lobifera*, *Eurythoe complanata*, *Synaptula reciprocans* and *Encelycore anatina*) have not been reported on coralligenous habitat before. Half of the number of species observed belonged to Pisces. All of the species were considered as Lessepsian migrants (i.e. species introduced to the Mediterranean from the Red Sea via the Suez Canal). *Sargocentron rubrum*, *Siganus* spp. had dispersed populations on coralligenous at stations TF1 and TF2, whereas the fangtooth moray *E. anatina* was observed ay one location with only one specimen. The invasive alien foraminifer, *A. lobifera*, seems to have well acclimatized in the environmental conditions in the Aegean Sea, where thalli of some coralline algae were party covered by its shells. If the population of it is outbursted in the area, it has a potential to cover all available surfaces in coralligenous habitats, might suffocate algae and sponges and result in mass mortalities of coralligenous species. The wide-spread invasive alien species, *C. cylindracea* was determined both by visual observations and photo-quadrate analysis. It was only observed at station TC1 and its maximum percent coverage was estimated as 2.7%. The brown alga *Stypopodium schimperi* and the fire-worm *Eurythoe complanata*, and the holothuroid *Synaptula reciprocans* were rare and only occurred at the Turkish stations.

Table 2. The list of alien species found on coralligenous habitats and their relative abundance at coralligenous stations of France, Turkey and Greece [1 = low (rare or isolated individuals), 10 = average (dispersed population), 100 = abundant (abundant and dense population)]

		FRANCE				GREECE		TURKEY			
	Species/Stations	**FTF**	**RMO**	**MEJ**	**LPD**	**KOR**	**ZAK**	**TC1**	**TC2**	**TF1**	**TF2**
	CHLOROPHYTA										
TR,FR	*Caulerpa cylindracea* Sonder, 1845	1						10	10		
	OCHROPHYTA										
TR	*Stypopodium schimperi* (Kützing) M.Verlaque & Boudouresque, 1991							1			
	FORAMINIFERA										
TR	*Amphistegina lobifera* Larsen, 1976							10	10	1	
	POLYCHAETA										
TR	*Eurythoe complanata* (Pallas, 1766)									1	1
	ECHINODERMATA										
TR	*Synaptula reciprocans* (Forskall, 1775)									1	1
	PISCES										
TR	*Enchelycore anatina* (Lowe, 1838)										1
TR	*Sargocentron rubrum* (Forsskål, 1775)									10	10
TR	*Siganus rivulatus* Forsskål & Niebuhr, 1775									10	10
TR	*Siganus luridus* (Rüppell, 1829)									10	10

AMENDMENTS TO THE ORIGINAL WORK PLAN (IF APPLICABLE) AND ITS RATIONALE

The original work plan was mostly maintained and successfully applied in WP2. The late production of the final version of protocols delayed the field works in the countries, but in the last year all tasks planned were successfully carried out. Although the location and number of coralligenous stations were changed according to the topographical features of coralligenous habitats, we reached to main goals described in the original work plan.

MAIN OUTPUTS

.

Deliverable	Title	Remarks	Status
D2.2.1	Assessing and monitoring of biodiversity and of major impact, including environmental variables	A joint-paper regarding the coralligenous species diversity across the Mediterranean is under the preparation The paper will also include impacts of abiotic (sedimentation) and biotic (invasive alien species) on coralligenous assemblages.	✓
D2.3.1	Testing and comparisons through dedicated software of image processing and analysis of 2D benthic quadrat samples.	A joint-paper regarding structures of coralligenous assemblages at coralligenous stations determined by photo-quadrate method is being prepared.	✓
D2.4.1	Elements susceptible to help the construction of indicators	The results of WP2 is being/will be used in biotic indices already developed (Index-Cor) or to be developed. Results regarding these indices will be published.	✓

LEADING PARTNER: IFREMER

OBJECTIVES

The Workpackage 3 of the CIGESMED program is based on the methodology developed in the project INDEX-COR launched in 2011 and completed in 2014. This program associates IFREMER and AAMP (Agency for the Protected Marine Areas) for the definition of an ecological index allowing the evaluation of ecological status of coralligenous bottoms: the INDEX-COR method (Sartoretto et al., 2014)[6].

The WP3 of CIGESMED ERA-NET program used this method and had to (i) accurately calculate the value of INDEX-COR with the dataset obtained during the fieldwork, (ii) accurately assess the sensibility of INDEX-COR in comparison with other methods in order to define and to evaluate the ecological status of the coralligenous assemblages. In this context, three objectives were identified:

1- to improve the INDEX-COR method in French coasts areas,
2- to test and adapt this method in the eastern part of Mediterranean Sea,
3- to compare the INDEX-COR index with other methods used to evaluate the ecological status of the benthic coralligenous communities.

The list of fFrench sites selected to improve the INDEX-COR method was determined by applying a suite of criteria to the list of the studied stations in the framework of the projectgram performed by AAMP-IFREMER. The goal was to increase, in the same ecoregion, the number of sites with a different ypes of impacts (e.g. gradients of seawage outfalls impacts). Concerning the testing of theis method in the eastern basin of Mediterranean Sea, the studied sites were selected in Greece (Gulf of Corinth). In addition, a detailed guide was sent to Turkish team (Ege University) for the application of the method (Annex A). A similar guide was provided to test another method (RVA method) and another index (COARSE index) (Gatti et al., 2012; 2014). At last, we compared 4 different indexes defined to evaluate the ecological status of coralligenous assemblages: INDEX-COR, COARSE, CAI and ESCA (Deter et al., 2012; Cecchi et al., 2014; Gatti et al., 2015; Sartoretto et al., 2014). The following goal was to accurately assess the sensibility of these indexes to the different pressures affecting the coralligenous assemblages to help MPA's manager and other stakeholders to regulate human activities for a good ecological status of coralligenous assemblages.

---

[6] Sartoretto S., David R., Aurelle D., Chenuil A., Guillemain D., Thierry de Ville d'Avray L., Féral J.-P., Çinar M.E., Kipson S., Arvanitidis C., Schohn T., Daniel B., Sakher S., Garrabou J., Gatti G., Ballesteros E., An integrated approach to evaluate and monitor the conservation state of coralligenous bottoms: the Index-Cor method. Proceedings RAC/SPA 2nd Mediterranean Symp. on the Conservation of coralligenous and other calcareous bio-concretions, Portorož (Slovenia), 29-30/10/2014, pp. 159-164

SHORT PROGRESS SUMMARY OF THE RESPECTIVE WORK TASKS

TASK 3.1: TEST OF A NEW INDEX OF ECOLOGICAL STATUS OF CORALLIGENOUS BOTTOMS [APRIL 2013 – FEBRUARY 2015].

CONTRIBUTING PARTNERS IFREMER AND CNRS-IMBE

Results about the INDEX-COR method and the interpretation of the corresponding index, obtained during AAMP-IFREMER project and during the achievement of the task 3.1, were submitted for publication to *Marine Pollution Bulletin*[7].

The following presentation refers to summaries of the methodological aspects, results and interpretation of INDEX-COR values to assess the ecological status of coralligenous assemblages.

METHODOLOGICAL ELEMENTS

1- Field work

To apply the INDEX-COR method, a study area was selected along the French Mediterranean coast between Marseille and Saint- Raphaël. The western zone, from the Gulf of Fos to Marseille, is characterized by high turbidity and sediment inputs due to the estuary of the Rhône River: thus, coralligenous habitats can be found starting as shallow as 12 – 15m depth. On the contrary, the eastern zone, from Toulon to Saint-Raphaël, is generally characterized by clear waters, which allow coralligenous habitats to develop down to 100 – 110m depth.

In this area two densely populated cities are present: Marseilles (1.8 million inhabitants) and Toulon (560,000 inhabitants). The major sources of human pressure along the coast are the sewage outfalls associated to the urban zones. In total, six main stations for sewage treatment and discharge are present in the study area. Some of them are in the surface: Calanque of Cortiou (Marseilles), Cap Sicié (Toulon W), Figuerolle (La Ciotat). Others are located between 35m and 45m depth: Sainte Marguerite (Toulon east), Cavalaire and Bonne-Terrasse (Saint-Tropez sud). These sewage outfalls affect directly the communities that characterize soft and hard substrates. Human activities, such as SCUBA diving and yachting, may also be source of perturbations especially during summer. Other sources of pressures include professional and recreational fisheries, industry and tankers anchoring (mainly restricted to the Gulf of Fos).

In total, 53 stations undergoing different degrees of human pressure were sampled (fig. 27). In each station, two transects (15m long × 1m wide) indicated by prefixed rubber bands were randomly placed at the same depth, orientation and type of dominant facies (e.g. gorgonians, macroalgae, etc.). Data were collected by two SCUBA divers: a photographer and an observer.

[7] Sartoretto S., Schohn T., Bianchi C.K., Morri C., Garrabou J., Ballesteros, Ruitton S., Verlaque M., Daniel B., Charbonnel E., Blouet S., David D., Féral J.-P., Gatti G. (submitted) An integrated method to evaluate and monitor the ecological status of coralligenous habitats: the INDEX-COR approach. *Mar. Poll. Bull.*

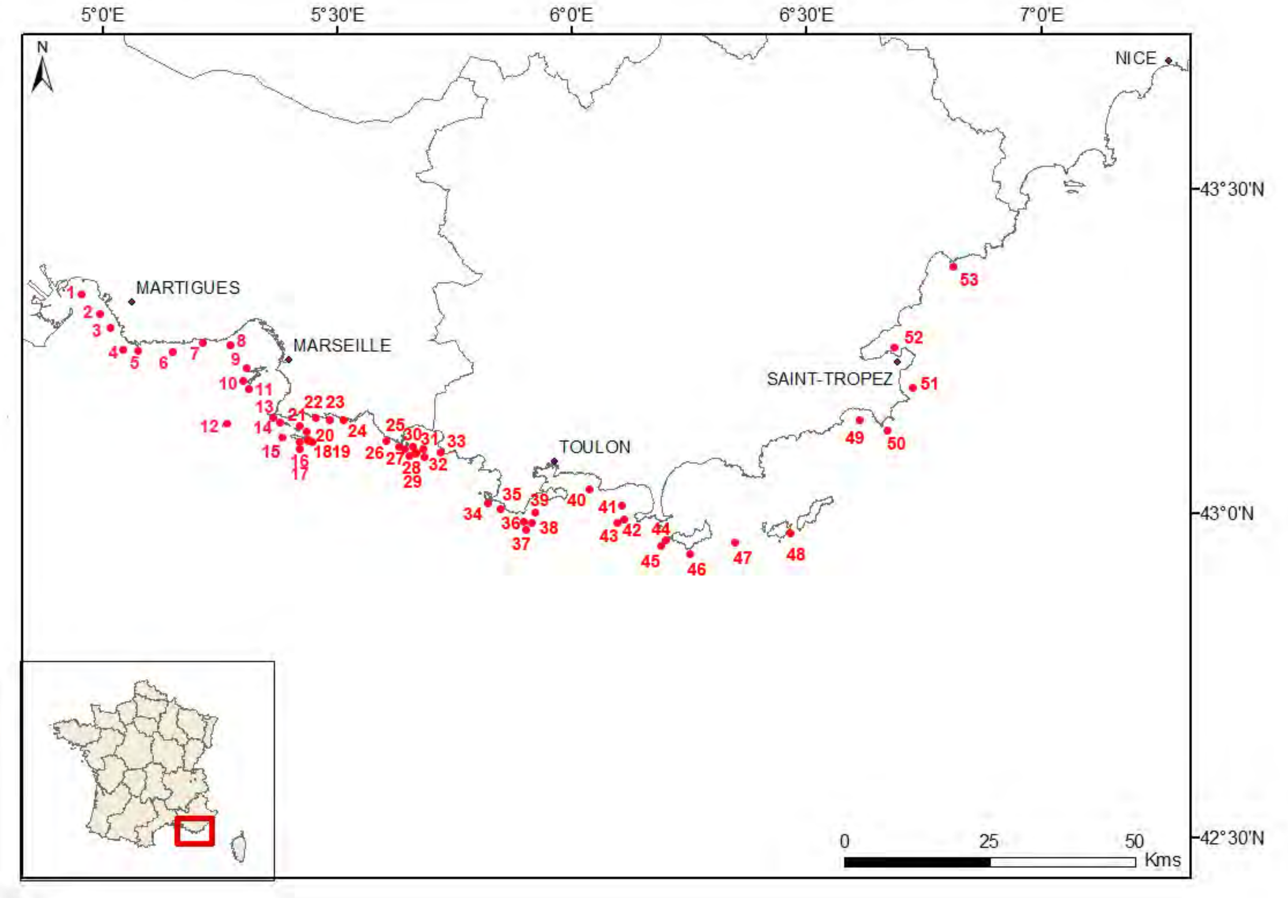


Figure 27. Localization of studied sites along French coasts to test and calibrate the INDEX-COR method.

The first diver shot at least 30 photographs (hereafter called "photoquadrats"), 15 along each transect, using a 60cm × 40cm frame (fig. 28). A digital camera (Sony Alpha Nex-5 with 16-3.5mm zoom-lens) equipped with housing and dome was fixed, with a metallic structure, 50cm over the quadrat frame; 4 SOLA lamps were installed at the top of each vertical side of the structure.

The second diver was devoted to take notes (fig. 3), along each transect, about: (i) general parameters i.e. depth, orientation, slope (vertical, inclined and sub-horizontal), presence of marine litter, dominant facies), (ii) conspicuous benthic sessile and mobile (echinoderms, crustacean decapods and nudibranchs only) species recognizable visually without sampling; (iii) the percent cover of erect species (gorgonians and sponges) (cf. section 2.3.3). The percent cover was estimated considering five classes: 0 (absent); 1 (isolated colonies); 2 (10% < cover ≤ 25%); 3 (25% < cover ≤ 50%); 4 (50% < cover ≤ 75%); 5 (cover > 75%). Where necessary, cover classes were then modified according to the amount of colonies affected by necrosis. The observation of more than 50% of affected colonies (i.e. more than 10% of necrosed surface for gorgonians) along a transect implied a downgrade (e.g. from 5 to 4).

Figure 28. Photoquadrat equipped with a digital camera and 4 SOLA Lights.

Figure 29. Data acquisition along transect by the diver-observer.

2. Data management

A- Characterization of the stations and assessment of the pressure level

In the absence of specific criteria for the quantification of the impact of human pressures affecting coralligenous habitat, a Level of Pressure (LP) [type and intensity] was estimated, for each station, according to an 'expert judgement' and to the observations of the diver-observer, especially for the sediment deposition. Four main types of pressures were taken into account: (i) organic matter and sediment inputs, (ii) diving/anchoring, (iii) fishing, and (iv) litter (Ballesteros, 2006). The intensity of the pressures was assessed considering 4 levels: 0 (no pressure), 1 (low), 2 (moderate) and 3 (high). Then, the LP was calculated for each station as the sum of the values obtained for the four pressures. The LP theoretically varies from 0 ('pristine') to 12 (highly impacted).

B- Image analyses

Photoquadrats were analyzed with the free software PhotoQuad (Trygonis & Sini, 2012), using the uniform point count technique. The number of points necessary to obtain a good estimation of the taxonomic richness was preliminarily tested. Rarefaction curves based on the asymptotic model of Michaelis-Menten (Keating & Quinn, 1998) were used to assess the variation of the taxonomic richness according to the number of points. Finally, 100 uniform points were chosen for the analyses of the photoquadrats. A library of species (or higher taxa) (appendix B) and abiotic elements (e.g. sediment, bare rock, black shadow, etc.) was created and uploaded in the software, then each point was directly labeled with the name of the element beneath it. Therefore, for each image, the percent relative abundance of each taxon/abiotic element was obtained.

Figure 30. Image analysis with PhotoQuad software using 100 uniform points (Grand Congloue, Marseille's area).

C- Selection and definition of the metrics

In this study, three metrics were selected to define a synthetic index:

(i) Taxa Sensitivity (TS), considering only the sensitivity to organic matter and sediment input;

(ii) Observable Taxonomic Richness (OTR), as a surrogate of the coralligenous assemblage biodiversity;

(iii) Structural Complexity (SC), considering the stratified structure of coralligenous assemblages.

TS builds on the existing indexes for the characterization of soft substrate benthic communities, particularly the AMBI and related indices (Borja et al., 2000; Pinedo et al., 2015). The AMBI index considers the succession of 5 groups of species showing different levels of sensitivity to the input of organic matter, along an organic enrichment gradient, as determined by (Pearson & Rosenberg, (1978). Compared to soft substrate, the knowledge about coralligenous assemblages is too scarce to allow identification of a similar assemblage succession, along an organic enrichment gradient. To overcome this obstacle, we applied a Delta-Gamma model (Stefansson, 1996) on the relative abundance of each taxon obtained from images analyses, according to the level of pressure due to organic matter and sediment input estimated for the study stations. This statistical approach allowed distinguishing four groups of sensitivity:

- Group I (GI): taxa neutral to organic matter and sediment input;
- Group II (GII): opportunistic taxa;
- Group III (GIII): tolerant taxa;
- Group IV (GIV): sensitive taxa.

The computation of TS is based on the AMBI index formula (Borja et al., 2000):

$$TS = (0 \times \%Group\ I + 0.5 \times \%Group\ II + 1 \times \%Group\ III + 2 \times \%Group\ IV)$$

where %Group is obtained by adding up the percent relative cover of the species belonging to each group.

The second metrics – OTR – refers to the total number of those taxa that are recognizable visually, on photoquadrats and *in situ*. Sessile and mobile macrobenthic organisms (echinoderms, nudibranchs, crustaceans) having a high patrimonial value or a particular ecological role were also considered.

Finally, the third metrics – SC – is based on the assumption that the impact of human activities may reduce the structural complexity of the coralligenous habitats (Gatti et al., 2012). Following this approach, three layers were considered to characterize the structure of coralligenous assemblages: (i) a basal layer, composed by encrusting, or with limited vertical growth, organisms (< 5cm); (ii) an intermediate layer, characterized by sessile organisms with moderate vertical growth (5cm to 15cm); and (iii) an upper layer, constituted by sessile macrobenthic species with considerable vertical growth (mainly sponges and gorgonians, > 15cm). The scores for basal and intermediate layers were defined as the total percent abundance of the taxa belonging to them, estimated from the photoquadrats. The score of the upper layer, instead, was defined as the percent cover of gorgonians and large sponges (e.g. *Axinella polypoides*) observed *in situ*, along the transects.

To summarize the layer's scores in a Structural Complexity (SC) value, a Principal Component Analysis (PCA) was performed with the abundance scores of the layers of all the stations; axes 1 and 2 explained 47.37% and 33.56% of the total variance respectively. Simplifying the results of the PCA (see appendix B for details), the formulas for the calculation of the coordinates of each layer along the two axes were defined. Then, the coordinates of each station ($C1_{station}$ and $C2_{station}$) were calculated as the sum of the coordinates of the three layers along the axes:

$$C(1, 2)_{station} = C(1, 2)_{basal} + C(1, 2)_{intermediate} + C(1, 2)_{upper}.$$

The coordinates of a hypothetical reference site (RS) with scores equal to zero for each layer were calculated according to the formulas showed in table 3 ($C1_{RS}$ = 2.108 and $C2_{RS}$ = 1.980). Then, the SC value was defined as the distance of each station from the RS, on the plane formed by the two axes:

$$SC = \sqrt{[(2.108-C1_{station})^2 + (1.980-C2_{station})^2]}$$

C. Definition of INDEX-COR index

After the demonstration of complementary information of the three above mentioned metrics (TS, OTR and SC) (Pearson's $r < 0.48$ with a multiple correlation matrix), the INDEX-COR (IC) formula was defined through a linear model based on those metrics. Results (multiple $r^2 = 0.56$, $p < 0.0001$) indicated the following proposed formula:

$$IC = 0.44 \times TS + 0.49 \times TR + 1.3 \times SC$$

RESULTS AND INDEX-COR VALUES INTERPRETATION

1. Characterization of the assemblages and pressure levels

Coralligenous communities sampled in this study were mainly characterized by (i) facies with gorgonians (*Paramuricea clavata* and *Eunicella cavolini*), (ii) facies with sciaphilic to hemisciaphilic green algae, dominated by *Codium* spp., *Flabellia petiolata* and *Halimeda tuna*, (iii) facies with sciaphilic algae dominated by Phaeophyceae and Rhodophyceae, and (iv) “facies of impoverishment”, showing highly degraded assemblages. The facies with gorgonians was mainly found on steep cliffs, which represented the most diffused geomorphological type among the sampling stations. The other facies were mainly associated to low inclination platforms or to coralligenous outcrops. Sampling stations were distributed among 15m and 51m depth, because of the extreme variability of the environmental conditions characterizing the study area. In total, 20 stations resulted as lightly impacted (LP = 2 to 5). They were mainly located in the National Park of Calanques and within or nearby the National Park of Port-Cros. Thirty stations were characterized by a moderate level of pressure (LP = 6 to 8), whereas the highest values of LP (9 to 12) corresponded to stations located in the Gulf of Fos or directly exposed to sewage outfalls (tab. 3).

2. Metrics assessment

The TS values varied from 1.3 (station 1) to 72.3 (station 9). The lowest values (TS < 20) corresponded to stations particularly exposed to sediment inputs, due to the effects of Rhône river waters (stations 1 and 5) or of the Cortiou sewage outfall (station 14). On the contrary, the highest values (TS > 60) were linked to the stations located far from the coastline or to high steep cliffs. For the full dataset, 152 different taxa were identified. In each site, the OTR varied from 17 to 76 taxa (tab. 3). In few cases, high numbers of taxa were observed in highly impacted stations. In these cases, values are likely due to cryptic species present in cavities sheltered from sediment inputs and physical impacts. Finally, the values of the SC ranged between 0.7 to 5.6 (tab. 3). The lowest values (SC < 2) corresponded to those stations that are exposed to sewage outfall or to highly impacted stations (all pressures combined). On the contrary, the highest values (SC > 5) corresponded to low impacted sites or sites “protected” from the sedimentation (high steep cliffs), characterized by dense *P. clavata* populations or by beds of *H. tuna* and *F. petiolata*, located between 30 and 35 m depth.

3. Synthetic index and correlation with the LP

The INDEX-COR (IC) varied from 17.8 to 70.3 (tab. 3). The poorest ecological status (IC < 30) corresponded to the four stations located in the Gulf of Fos (West of Marseilles), characterized by the proximity to the Rhône river (input of sediment) and by a large concentration of human activities (industries, fishing, anchoring of large tankers). At the opposite side, the healthiest coralligenous habitats (IC > 60) were observed in 8 stations located within the boundaries of marine protected areas or offshore, mainly characterized by high steep cliffs. In order to respond to the stakeholders needs, five classes of ecological status were proposed (IC maximum values: 75):

IC < 15: bad;

15 ≤ IC < 30: poor;

30 ≤ IC < 45: moderate;

45 ≤ IC < 60: good;

IC ≥ 60: high.

The majority of the stations (36) resulted in a good or high ecological status (fig. 5). The highest values (IC > 60) were scarcely impacted by human activities (2 < LP < 6). In conclusion, the IC showed negatively correlated with the LP (τ = -0.607, p < 0.0001) (fig. 6), lowest IC values corresponding to the most impacted stations, and the highest to the least impacted ones.

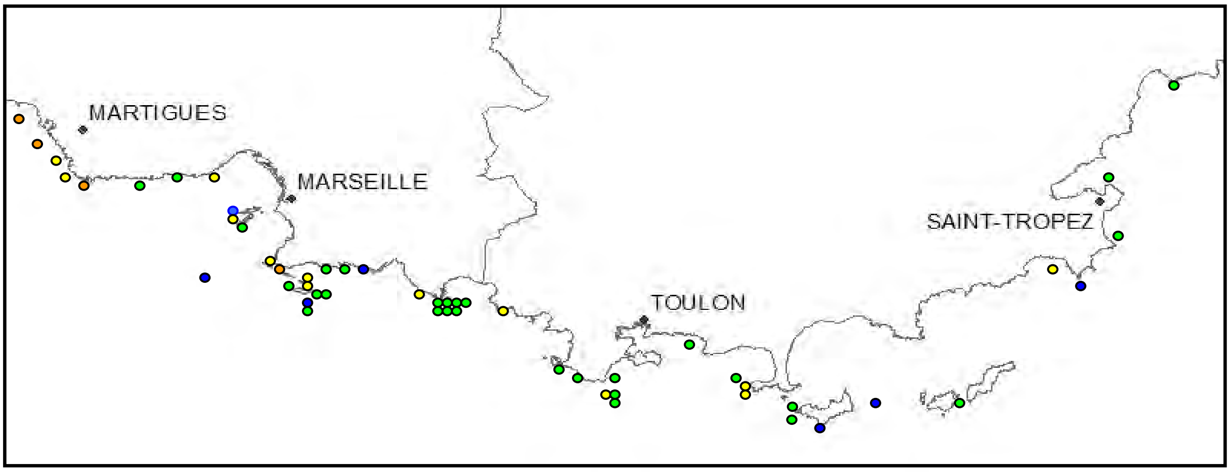


Figure 31. Color-coded representation of the ecological status of coralligenous habitats along the coasts of Provence. Orange: poor state; yellow: moderate state; green: good state; blue: high state.

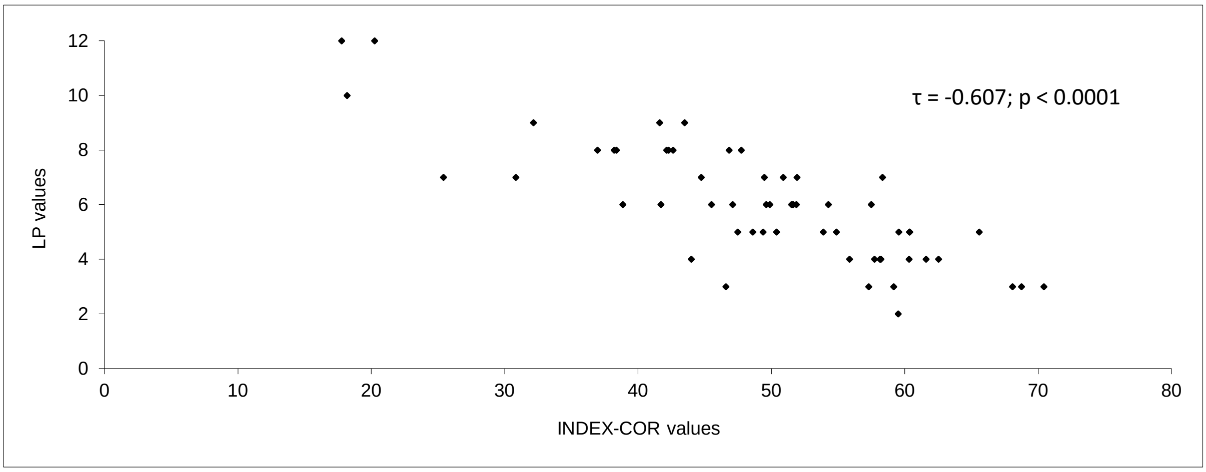


Figure 32. Correlation between INDEX-COR and the Level of Pressure (LP). τ: Kendall's coefficient.

Table 3. INDEX-COR (IC) values, metrics (TS = Taxa Sensitivity; OTR = Observed Taxonomic Richness; SC = Structural Complexity) scores, Level of Pressure (LP) and conservation status defined with 5 classes, for the 53 stations sampled along the French Mediterranean coast. Classes' boundaries: bad (IC < 15), poor (15 ≤ IC < 30); moderate (30≤ IC< 45); good (45 ≤ IC < 60); high (IC ≥ 60).

Station	Name station	TS	OTR	SC	IC	LP	Conservation status	Station	Name station	TS	OTR	SC	IC	LP	Conservation status
1	Fd Golfe Fos	1.2	31	1.6	17.8	12	poor	28	Petit Mourre	44.1	51	2.1	47,1	6	good
2	Auguette	25.1	17	0.7	20.3	12	poor	29	Grd Mourre	47.1	56	4.0	53,4	5	good
3	Bonnieu	48.5	28	1.5	37.0	8	moderate	30	Rosier	60.8	41	2.0	49,4	7	good
4	Arnette	45.5	33	1.6	38.3	8	moderate	31	Pain Sucre	31.5	59	3.8	47,7	8	good
5	San Christ	12.2	33	3.0	25.4	7	poor	32	Levant	52.5	61	3.4	57,4	6	good
6	Le Bois	58.3	53	5.1	58.3	4	good	33	Pte Défend	36.0	48	2.2	42,2	8	moderate
7	Méjean	45.0	59	2.3	51.7	7	good	34	P. christian	47.0	51	3.6	50,4	5	good
8	Large Niolon	32.6	50	2.1	41.6	9	moderate	35	Mourret	69.1	42	5.5	58,1	4	good
9	Tiboulen	72.1	55	5.3	65.6	5	high	36	Sêche W	26.8	37	1.7	32,1	9	moderate
10	Pte Luque	34.6	45	3.7	42.1	8	moderate	37	Sêche S	32.5	61	3.3	48,5	5	good
11	Cap Caveau	37.8	51	2.9	45.4	6	good	38	Sêche E	44.9	63	4.7	56,7	5	high
12	Planier	58.6	76	5.6	70.3	3	high	39	Deux frères	54.0	54	3.1	54,3	6	good
13	Fromage	23.6	59	2.9	43.1	8	moderate	40	Oursinière	42.2	57	2.5	49,7	6	good
14	Matelot	6.9	29	0.8	18.3	10	poor	41	Armoire	40.6	60	3.2	51,4	6	good
15	Moyade	51.5	58	4.1	56.4	3	good	42	Fourmigue	14.4	65	3.0	42,1	9	moderate
16	Imp. Milieu	58.9	74	4.2	67.7	3	high	43	S. Fourmigue	26.2	36	1.3	30,9	7	moderate
17	Imp. Large	43.2	49	3.0	46.9	3	good	44	W Porquerolle	38.3	55	2.8	47,4	5	good
18	Caramassaigne	55.3	62	3.6	59.5	2	good	45	SW Porquerolle	40.8	66	2.8	53,9	5	good
19	Grd Congloue	54.2	60	3.4	57.7	4	good	46	Cap d'arme	58.1	76	4.3	68,4	3	high
20	Sud Plane	35.9	45	2.9	41.7	6	moderate	47	Sarranier	63.9	60	3.1	61,5	4	good
21	Nord Plane	31.3	49	1.1	39.2	6	moderate	48	Pte Vaisseau	62.2	49	3.4	55,8	4	good
22	Sormiou	47.2	46	2.7	46.8	8	good	49	Maconnais	34.8	54	1.7	44,0	4	moderate
23	Morgiou	36.9	62	2.3	49.6	5	good	50	Quairol	54.4	63	3.8	60.1	5	high
24	Devenson	66.5	55	4.9	62.6	4	high	51	Roche Rousso	58.5	56	4.5	59,0	3	good
25	Figuerolle	32.4	42	2.8	38.5	8	moderate	52	Basse Rabiou	39.4	59	2.6	49,6	6	good
26	N Bec de l'Aigle	54.9	60	3.5	58.1	7	good	53	Roche Mérou	54.4	48	3.1	51,5	6	good
27	S Bec de l'Aigle	59.3	44	3.0	51.6	6	good								

CONCLUSIONS

The INDEX-COR approach offers a detailed methodology and an index to assess the ecological status of coralligenous habitats. Its application needs SCUBA diving experience and skills, as well as detailed knowledge on the habitat and the marine organisms hosted. On average, 2 days are required to acquire and analyse the data, for each station. Moreover, the level of efficacy of an index is directly linked to (i) the knowledge about the habitat considered (distribution, natural dynamics, functionality, response to the different pressures, etc.) and (ii) a good characterization of human pressures which is difficult in a complex three dimensional habitat as coralligenous outcrops. Unfortunately, there is not much knowledge on the coralligenous habitats and their associated communities (Ballesteros, 2006). Thus, basic studies to fill the gaps of knowledge are strongly recommended.

TASK 3.2: APPLICATION OF INDEX-COR IN THE AEGEAN AND LEVANTINE BASINS AND COMPARISONS [FEBRUARY 2014 – APRIL 2015].

CONTRIBUTING PARTNERS: IFREMER, EGE AND HCMR

After the experience obtained on the interpretation of the INDEX-COR index values (task 3.1) and after the presentation of these results in RAC-SPA congress in (Portoróz, Slovenia - October 2014), we planed the application of INDEX-COR in the eastern basin of Mediterranean Sea for the second part of 2015 (General Meeting of CIGESMED program, Mytilini, May 2015). The general conditions (meteorology, avaibility of field team) did not allow us to organize the mission. So, we planned the mission for 2016, between the 9th and the 15th may. In total, 4 sites exposed to different levels of impact (mainly sediment inputs): three in the western part of the gulf of Corinth (impacted sites) and one in the eastern part (could be seen as a site of reference) (fig. 33).

In each site, two different types of data will be monitored in order to access to the calculation of INDEX-COR and COARSE indexes:

- ↳ along two transects of 15m long: (i) 30 photographies with quadrat, (ii) notes by diver-observer concerning general informations (depth, orientation, slope, turbididy, marine litter,...) and number of taxa observed *in situ* (INDEX-COR index);
- ↳ in complement of these informations, measure the thickness of calcareous layer with a knife (6 replicates well distributed over the observed surface) (COARSE index)

In a logistical point of view, the field work will be perform with help of two local diving clubs:

- ➢ Techdivingteam (Loutraki, Greece)
- ➢ Ionian Divers (Patras, Greece)

The mission was prepared with the help of the Hellenic Center for Marine Research (Yiannis Issaris) and the University of Aegean (Maria Sini).

An adaptation of the library used will be necessary. The analysis of values will be focused on the adaptation of the interpretation grid of INDEX-COR values to evaluate the ecological status of coralligenous assemblages along the coasts of Greece. This work will be performed in partnership with HCMR and the University of Aegean.

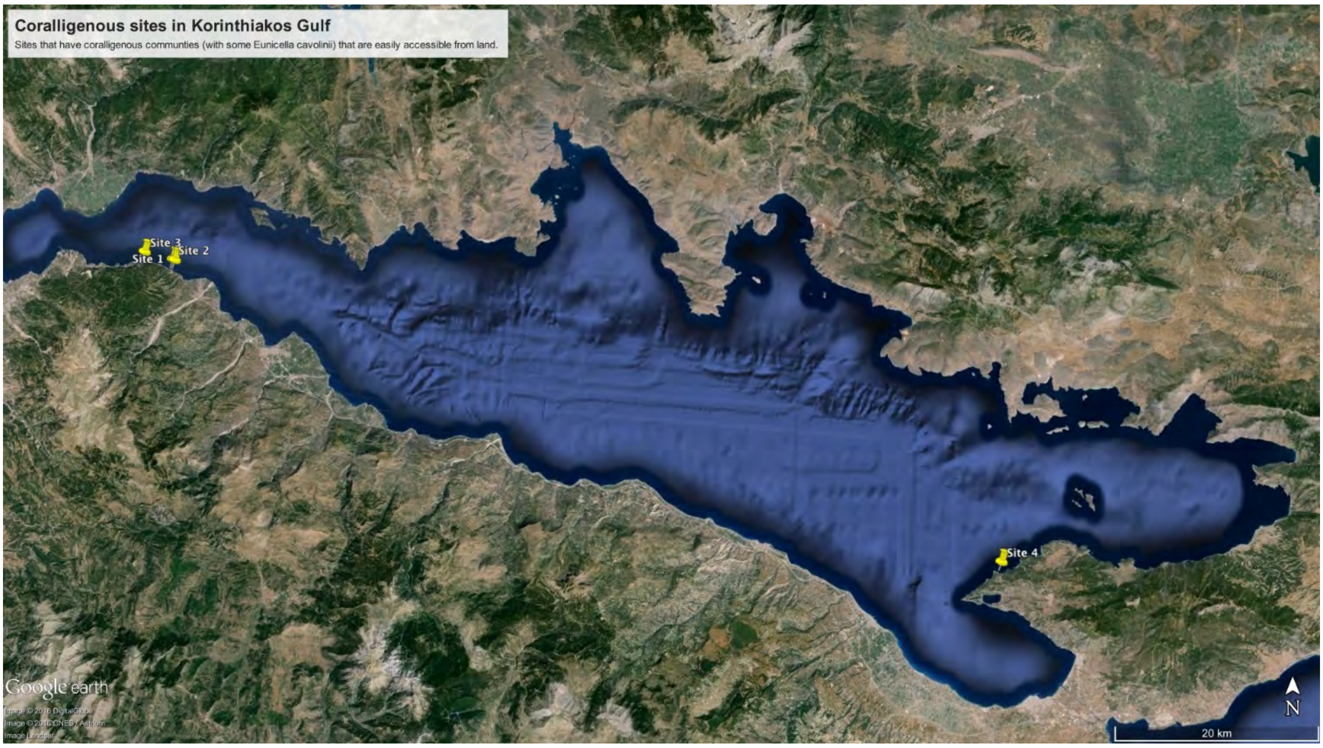


Figure 33. Localization in Gulf of Corinth of studied sites during the mission planed in may 2016 to test INDEX-COR and COARSE methods.

TASK 3.3: COMPARISON OF THE DIFFERENT METHODS AND INDICES [OCTOBER 2014 – FEBRUARY 2016].

This third task of the WP3 compare 4 indexes established to evaluate the ecological status of coralligenous assemblages and based on different approaches:

- ➢ characterization of the structural complexity (COARSE index),
- ➢ evaluation based on the macroalgae assemblages linked to coralligenous outcrops (ESCA index),
- ➢ index based on the evaluation on sediment, bryozoans and bioconstructors abundance (CAI index),
- ➢ an integrated approach taking account the taxa sensitivity to sediment and organic matter inputs, the observable richness and the structural complexity (INDEX-COR index).

To compare these different methods of evaluation, we considered two datasets:

- ➷ the INDEX-COR dataset obtained along French coasts,
- ➷ the last one obtained in Greece.

Actually, CAI and ESCA index are calculated on images with a size compatible with INDEX-COR method. For the COARSE index, complementary data will be obtained during the mission for the Greek dataset.

Concerning the French stations, preliminary results about indexes are presented in table 2. To calculate their values, we applied the calculation of metrics described in publications (Deter et al., 2012; Cecchi et al., 2014; Gatti et al., 2015). About ESCA index based on macroalgae communities, this work is being run with the collaboration of Dr L. Piazzi (University of Pisa).

Globally, for a same level of pressure (LP) (see table 4), the classification resulting by the values of ESCA and INDEX-COR index seem to be similar. The COARSE index shows more variability and the CAI seems to overestimate the ecological status of coralligenous assemblage. Only green or high level of ecological status are noted. These differences seem to be confirmed by (i) the absence of correlation between CAI and COARSE and LP evaluate and given table 1, (ii) a positive correlation between ESCA and INDEX-COR and LP values. This variability of classification could be due to the difference of sensibility to the level of pressure on coralligenous assemblages of the metrics taking account for indexes.

To test this hypothesis, after the ESCA values calculation, we will consider the values of each metric included in ESCA, COARSE, INDEX-COR and CAI indexes. A statistical analysis will be conducted with the values characterizing the 4 components of the LP (O.M/sediment input, physical impact, marine litter impact, fishing impact). According to these results a more accurate analysis will be conducted considering sub-metrics included in each metric (e.g. basal, intermediate, upper layers notes comprising the third metric of INDEX-COR). Statistical analysis will be conducted considering these values and other indexes of biodiversité (Richness index, Shannon index and Simpson index (based on the total number of taxa observed to calculate INDEX-COR index). A calculation of a new index taking account different metrics coming from the different methods of evaluation will test to propose a more robust index. At last, a test with the Greek dataset will be perform to verify the validity of evaluation in the eastern basin of Mediterranean Sea.

Table 4. Classification obtained of the French sites sampled. Values given for each index correspond to a calculation based on the EQR formula in WFD (Index value/Index maximal value). The color code is also based on the principles of WFD classification. Blue: high ecological status; green: good ecological status; yellow: moderate ecological status; orange: poor ecological status and red: bad ecological status.

Station	ESCA	COARSE	INDEX-COR	CAI
Méjean	-	0.593	0.649	0.616
Large Niolon	-	0.408	0.521	0.716
Tiboulen	-	0.621	0.820	0.688
Planier	0.674	0.661	0.881	0.677
Caveau	-	0.738	0.569	0.811
Fromages	-	0.418	0.533	0.708
Moyade	-	0.875	0.716	0.787
Plane Nord	-	0.204	0.486	0.712
Plane Sud	-	0.482	0.522	0.811
Impérial milieu	-	0.473	0.851	0.776
Morgiou	-	0.857	0.617	0.763
Figuerolle	0.429	0.010	0.480	0.605
Bec aigle W	-	0.535	0.729	0.831
Bec aigle E	0.677	0.383	0.648	0.713
Rosiers	-	0.254	0.618	0.522
Levant	-	0.566	0.719	0.813
Sêche W	0.458	0.280	0.402	0.739
Sêche E	-	0.738	0.755	1
2 frères	0.786	0.809	0.679	0.816
Oursinières	0.484	0.240	0.624	0.586
Fourmigue	-	0.527	0.544	0.740

AMENDMENTS TO THE ORIGINAL WORK PLAN (IF APPLICABLE) AND ITS RATIONALE

MAIN OUTPUTS

Deliverable	Title	Remarks	Status
D3.1.1	Testing of metrics along French Coasts	Metrics were tested and combined in a global index allowing to propose an interpretation grid to evaluate the ecological status of coralligenous assemblages (submitted scientific article)	✓
D3.2.1	Testing of metrics in East Mediterranean	INDEX-COR method and index was tested in Greece (Gulf of Corinth). An evaluation of ecological status was obtained with the grid determined during the task 3.1.1.	✓
D3.2.2	Listing of Coralligenous facies in the field sites	Coralligenous facies were consider in the calculation and the interpretation of metrics and global indexes applied on the French and Greek datasets.	✓ ✗

WP4: INNOVATIVE MONITORING TOOLS

LEADING PARTNER: CNRS

OBJECTIVES

- To.stabilize and validate the nomenclature of coraligenous algae (molecular biology approach).
- To monitor the taxonomic composition of coralligenous, in space and time
- To assess and monitor biodiversity, cryptic species? and biological invasions
- To provide tools helping to design MPA?
- To contribute to a powerful integrated/synthetic index (WP 3)

SHORT PROGRESS SUMMARY OF THE RESPECTIVE WORK TASKS

TASK 4.1: BASIC AND FUNDAMENTAL KNOWLEDGE: THE TAXONOMIC COMPOSITION OF THE CORALLIGENOUS INGENEER SPECIES, AND ITS VARIATION IN SPACE AND TIME USING GENETIC TOOLS [SEPTEMBER 2013 – OCTOBER 2016].

The understanding of the ecology of an ecosystem relies on identifications of the species composing the ecosystem. Red algae are the main bio-engineer species, and the most basal ones (they are closely linked with the rock of the substratum, and themselves form perennial calcareous structures), their taxonomy is tremendously complex and they are very difficult to identify. In such situation molecular tools are very useful. Using such tools, we already identified four cryptic species (totally isolated genetically) in the builder red alga *Lithophyllum stictaeforme/cabiochiae*. Although they cannot be identified by naked eye, these species started probably to diverge since a very long time ago. Our preliminary data suggest that the different cryptic species of *Lithophyllum* were ecologically differentiated according to light conditions. More refined ecological analyses based on this initial data set (Sanger sequencing), and additional data on the distributions of the distinct *Lithophyllum* lineages (based on metabarcoding, see below) are under way. The fact that one may confuse several ecologically differentiated species as a single generalist species argues for the importance of molecular approaches for environmental monitoring. We originally encountered some difficulties for the other red algae but now all DNA extractions are made, and the methods were set up long ago for obtaining DNA sequences starting from this step. Therefore, new results are expected in the near future for the other genera of red algae found in the coralligenous habitats, in particular for the genus *Mesophyllum* which, together with *Lithophyllum*, represents the most abundant builder red algae in coralligenous habitats. A recent paper (Peña *et al.,* 2015 [8]) revised the distribution and taxonomy of *Mesophyllum* in the Atlantic and western Mediterranean. This study lacked samples from the Eastern Mediterranean basin and we will soon fill in this gap because we succeeded in amplifying molecular markers from three independent genomes (mitochondrial: *cox1*, chloroplastic: psbA, and nuclear: 28S) for *Mesophyllum expansum* (25 specimens) and *M. alternans* (21 specimens) (these amplicons are now being sequenced by the Sanger method by

[8] Peña V, De Clerck O, Afonso-Carrillo J, Ballesteros E, Bárbara I, Barreiro R, Le Gall L 2015 An integrative systematic approach to species diversity and distribution in the genus *Mesophyllum* (Corallinales, Rhodophyta) in Atlantic and Mediterranean Europe. **European Journal of Phycology** 50(1), doi: 10.1080/09670262.2014.981294

a private society). Other species as well as non identified rhodophytes, from Greece (Ionian Sea, Aegean Sea), Cyprus and Turkey (Levantine Sea) are presently undergoing the same sequencing analyses, while samples from Gilbraltar will soon follow.

For the bryozoan model species, we also revealed deeply divergent clades with the mitochondrial marker cox1. Two distinct but closely related lineages are observed in the Ionian Sea and the Aegean Sea (one for each sea). They are very divergent from the other lineages which are observed in the Western Mediterranean (our sampling is very important in the region of Provence, we also covered several locations in Corsica, and several close locations in the Gibraltar straight area). New data (from two nuclear markers) did not confirm that the mitochondrial lineages observed in France were true cryptic species. What is very likely however is that the eastern Mediterranean lineages of *Myriapora truncata* are indeed reproductively isolated from western ones for this species, so there are cryptic species (at least two).

More importantly, we obtained the whole transcriptome sequence of at least an individual of several lineages, for both the red alga *Lithophyllum* and the bryozoan *Myriapora truncata*. Based on thousands of expressed genes (reconstructed using bioinformatics methods), we established the genetic diversity of these coralligenous builder species. In individuals from which transcriptomes were analysed in *Lithophyllum* there was an average of about 2 to 4 heterozygous nucleotidic sites /1000 (based on the coding part of expressed gene sequences). For the bryozoan, these values are surprisingly similar (3-4 /1000 sites). These values correspond to the lower limit of the range of diversity among the species we studied until now in the same Mediterranean locations (the gorgonian *Eunicella cavolinii*: 2.3-4/1000, *Ophioderma longicauda* brittlestars brooding lineage: 4/1000, lecithotrophic lineage: 6-7/1000, and the planctotrophic sea urchins *Echinocardium mediterraneum: 6.5/1000 and E. cordatum*: 14.5/1000). This stresses the importance of preserving these two ecosystem engineer species (as well as the gorgonian *E. cavolinii*, and probably other ones) because, due to their low genetic diversity, their possibility of adaptation to rapid environmental change is limited and as a consequence they are more vulnerable. Such transcriptome data also provide thousands of nuclear markers which will enable accurate analyses of local adaptations, spatial structure and species delimitation, for which we have hundreds of samples from contrasted habitats. These analyses will be undertaken in 2016-2017 in Aurélien De Jode's PhD.

TASK 4.2: A NEW ECOSYSTEM MONITORING TOOL: A MULTISPECIFIC INDEX OF INTRASPECIFIC DIVERSITY [SEPTEMBER 2014 – OCTOBER 2016].

Intraspecific diversity is important because this is the ground on which species can adapt to perturbations. The spatial structuring of the genetic diversity within species also provides important information on connectivity whose the knowledge is crucial for biodiversity management. For these reasons, intraspecific diversity could be a powerful indicator of good environmental status (Rossberg *et al.* 2016[9]). Comparing genetic structure in several species collected at the same locations in the French Mediterranean coasts, we could identify areas of lower and higher intraspecific diversity, and also common barriers to gene flow in the bay of Marseilles. Importantly for bioindication, the average genetic diversity within species per location is consistently higher (for all species) in the two areas with lowest

[9] Rossberg AG, Usitaalo L, Berg T, Zaiko A, Chenuil A, Uyarra MC, Borja A, Lynam CP. 2017. Quantitative criteria for choosing targets and indicators for sustainable use of ecosystems. **Ecological Indicators** 72:215-224 doi:10.1016/j.ecolind.2016.08.005

human impact (we used the proxy of the human density of population) and consistently lower in the well-known industrial polluted area of the Etang de Berre. We found an association between the strength of genetic differentiation (limitation to connectivity) and the life history parameters of the species (Cahill *et al*., 2016[10]): lecithotrophic larvae have intermediate genetic structure, planctotrophic larvae have low genetic structure, species without larvae have very high genetic structuring (to be submitted to Molecular ecology, see below). The Marseilles barrier to gene flow (migration) is very well explained by the currents using precise MARS 3D models with physicist colleagues (Pairaud et al., 2011[11]).

The similarity or dissimilarity matrices among the same localities for the coralligenous community species composition obtained by metabarcoding will be available in January 2017. Comparing community composition with intraspecific genetic allele compositions, while knowing environmental conditions and physical connectivity matrices, will allow separating the connectivity and the differential selection forces in shaping biodiversity distribution. This distinction is very important for developing monitoring tools. Our study will be the first one allowing such accurate analyses.

We already obtained from Bertrand Millet (collaborator at the Mediterranean Institut of Oceanography-MIO lab in Marseilles) the current connectivity matrix corresponding to a larva of *Myriapora truncata*. A Mantel test comparing this matrix with a matric of genetic distance will help in assessing the interplay between connectivity and differential selection in driving individual or allelic spatial distribution in this bryozoan.

AMENDMENTS TO THE ORIGINAL WORK PLAN (IF APPLICABLE) AND ITS RATIONALE

D4.1.1 Barcoding protocol allowing identification of the taxonomic composition of the coralligenous building algae (using COI, and if necessary intronic markers):

No delay, no amendment.

D4.1.2 Description of the taxonomic composition of the coralligenous building algae in several geographical locations (chosen from the three main partners study sites), and within geographical area, in various environments:

Delays

Although we rapidly obtained satisfactory results on DNA extractions, we subsequently observed strange values suggesting DNA or PCR contaminations or misidentifications. We have obtain some evidence that this was caused by the epiphytes (DNA from very young or small life stages of red algae are extracted together with the main red alga targedted). We thus had to re-prepare all samples, taking higher amounts of tissus, cleaning more thoroughly the sample, and extract DNA with a more time-consuming (manual) method. About 200 samples were processed in June 2016. PCR amplification and DNA sequencing were carried out. Results will be compared with data available in Genbanks (a recent publication on *Mesophyllum* spp. and an ongoing publication on *Lithophyllum* spp.) provide numerous well identified reference samples. This step allowed us to identify 4 cryptic species in *Lithophyllum* sp (*stictaeforme* and *cabiochiae* are not well defined actually but we focused on this species complex [SC]) which are totally isolated reproductively, and to show that such SC are not restricted to the French Mediterranean coast. Delays were also due to the addition of a new important and very promising research activity.

Innovative research added to the original work plan

---

[10] Cahill A E, Aurelle D, Boissin E, Bouzaza Z, David R, Dubois S, De Jode A, Egea E, Erga Z, Ledoux J B, Mérigot B, Weber A, Chenuil A. 2016. Determinants of connectivity in the marine environment: a multispecies approach. **Integrative and Comparative Biology** 56, E29.

[11] Pairaud IL, Gatti J, Bensoussan N, Verney R, Garreau P. 2011. Hydrology and circulation in a coastal area off Marseille: Validation of a nested 3D model with observations, **Journal of Marine Systems** 88:20-33

We realized at the beginning of the project, that technical progress opened important opportunities: we decided to do metabarcoding in order to characterize the entire biogenomic diversity (in metazoans and *Lithophyllum* red algae) of coralligenous samples. This method istarts with an environmental sample extracting itSs DNA (envDNA), amplifying it for a barcoding molecule (often *cox1* for animals) with universal primers, and sequencing the content. Based on barcoding databases (in particular, BOLD, or Genbank) we can then deduce the species content of the sample. If species are not in the DB, we can nevertheless obtain several biodiversity indices as interesting. We set up the technique. Test samples (including various negative and positive controls) were already sequenced on a MISeq platform and the DNA sequences were analyzed. A variety of phyla was recovered. Sample processing took a lot of work time (sieving, separating mineral/organic phases…) because we used a high number of samples to test (PCR replicates, local replicates, variable ecological conditions per locality, numerous localities). All 250 samples are now ready for PCR and sequencing (DNA is extracted). They include about 10 samples from Turkey for which visual taxonomic identification was carried out with high precision and will serve as a reference to compare metabarcoding/ traditional taxonomic inventory and a few from Greece. Most were from the bay of Marseilles and will allow studying the relationships between the species composition of the community (allowing the distinction among *Myriapora* lineages and among *Lithophyllum* cryptic species) and environmental factors (Figures 34-35) and connectivity.

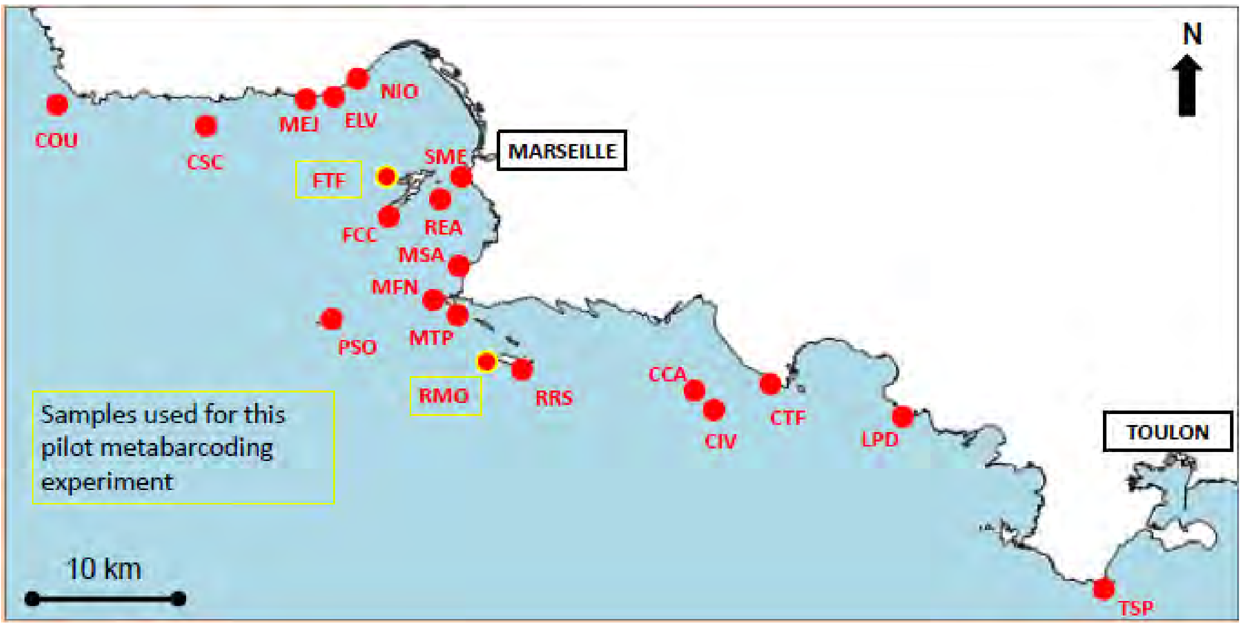


Figure 34: Sampling locations for Metabarcoding. Twenty locations are on the map. In each of them, several sites were sampled (reported environmental factors: orientation, rugosity, depth…) and four replicates samples were collected per site. This leads to 250 samples for which DNA is already extracted. Localities in boxes were analysed in the pilot metabarcoding study. The other samples will all be processes in December 2016.

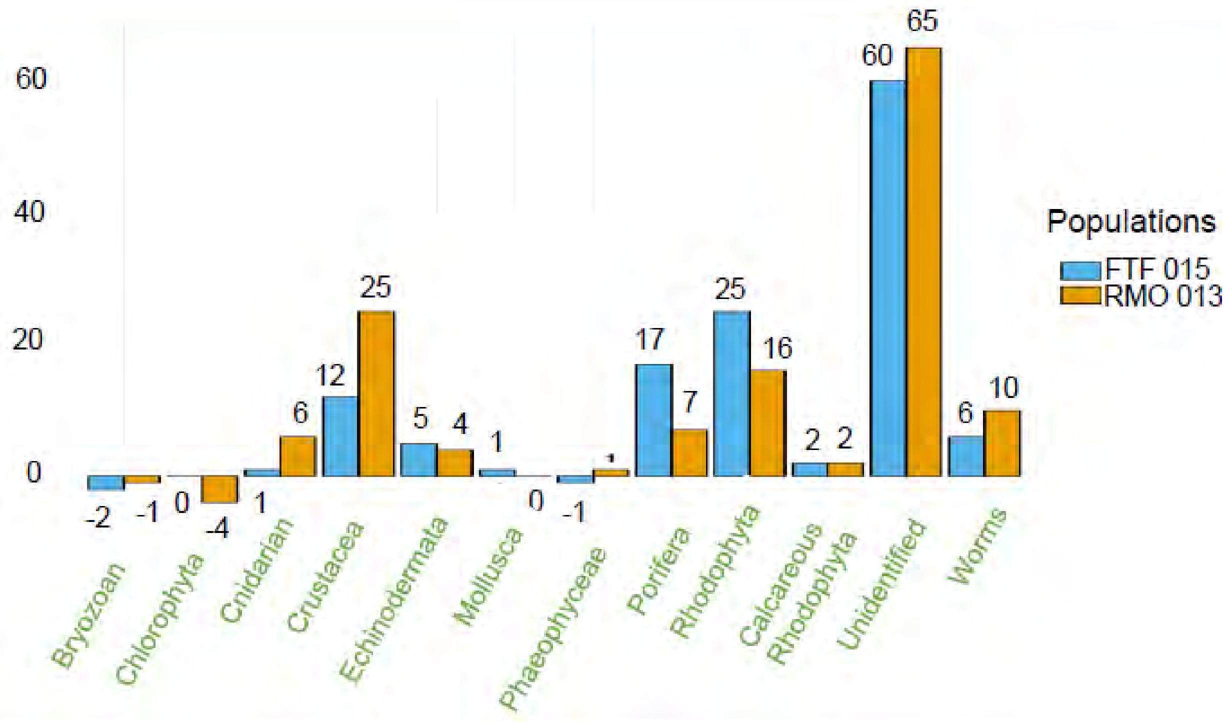


Figure 35: Results of pilot metabarcoding analysis (from two localities in boxes in Fig. 34). This plot describes the difference between the number of taxa distinguished by visual methods and by metabarcoding with the *cox1* marker when the bar is positive, this means that metabarcoding found more numerous species than visual analysis. Except for Bryozoans (but see below) and Rhodophytes, metabarcoding is always much more powerful for describing biodiversity than eye. By correcting the bioinformatics pipeline which we had not refined at the time we made the plot, we could change the Bryozoan value which is now positive. For Rhodophytes, we used additional marker (28S) which discriminates among *Lithophyllum* cryptic species (not shown).

D4.2.1 Development of genetic tools for identification and monitoring:

The methods are all set up. However data are not available for entire samples. When they will be available, we will be able to compare our indicators among themselves (metabatcoding diversity values, and local indices of multiple species relative intraspecific diversity) and with those developed and tested in WP3, and with anthropogenic pressure.

MAIN OUTPUTS

Deliverable	Title	Remarks	Status
D4.1.1	Barcoding protocol allowing to identify the taxonomic composition of the coralligenous building algae (using COI, and if necessary intronic markers).	Although simple methods of tissue preservation and DNA extraction were set up soon in the project, we realized we had to be more cautious and re-did most sample provessing and DNA extractions. For PCR-primer selection, no changes were made from previous reports. Markers PSBa and 28S are the best, and COI appears less easy to amplify, and not more informative than the other two.	✓
D4.1.2	Description of the taxonomic composition of the coralligenous building algae in several geographical locations (chosen from the three main partners study sites), and within geographical area, in various environments	We suffered delays (see section on amendments) but we enriched the initial work plan with a much more innovative and powerful approach, metabarcoding (see above). Results are expected for the end of 2016. Since a preliminary run (about 35 samples) has been done until the end, and all samples are processed until DNA extraction, processing the other 220 samples, for which we use automatized methods (extractions are done for 96 samples in a day, PCR also) should not take time and suffer delays.	✓ ✗
D4.2.1	Development of genetic tools for identification and monitoring	The methods are all set up. However data are not available for whole samples. When they will be available, we will be able to compare our indicators among themselves and with those developed and tested in WP3, and with anthropic pressure.	✓ ✗

WP5: CITIZEN SCIENCE NETWORK IMPLEMENTATION

LEADING PARTNER: HCMR &CNRS

OBJECTIVES

- To develop a framework for a citizen science network
- To successfully implement citizen science activities in all study sites of the project.

SHORT PROGRESS SUMMARY OF THE RESPECTIVE WORK TASKS

TASK 5.1: DESIGN OF THE STRUCTURE AND FUNCTIONING OF THE CITIZEN SCIENCE NETWORK [SEPTEMBER 2013 – FEBRUARY 2016].

In the framework of CIGESMED a specialized Citizen Science project was launched, aiming to engage enthusiast divers in the study and monitoring of Mediterranean coralligenous assemblages through the gathering of basic information regarding their spatial occurrence, assemblage structure and associated pressures or threats.

The Task has been initiated during the first year of the project by raising discussions on the possible ways to develop the web application so that to serve as many diver categories as possible. The citizen science application should be combined with seminars for divers to train them with the best quality information and the communication of the skills needed for this kind of crowd sourcing activity, based on previous experience. During the second reporting period, the discussions turned to what kind of protocol is needed for the safe collection of reliable data and information by all divers so that to obtain the best potential in data for: (a) characterization of the status of the sites, (b) identification of possible pressures and threats to the corraligenous habitat, (c) recording of new sites with coralligenous habitat. The overall principle proposed was to “keep it as simple as possible” in both the data and information to be collected and also the process for the divers. The Consortium agreed that by following the above, an international network of dedicated coralligenous observers, spanning over large marine areas could be established.

Accordingly, for its active and successful implementation, a data collection protocol and a multilingual website were developed, comprising an educational module and a data submission platform. Georeferenced data reporting focuses on: (a) basic topographic and abiotic features for the preliminary description of each site, and the creation of data series for sites receiving multiple visits; (b) presence and relative abundance of typical conspicuous species, as well as (c) existence of pressures and imminent threats, for the characterization and assessment of coralligenous assemblages.

A variety of tools is currently provided in the form of a specifically-developed website (http://cs.cigesmed.eu) and an Android smartphone application (figure 36) to guide end users with all relevant information and instructions and support submission of observations. An additional visual aid is prepared in the form of a submersible identification guide (figure 37) which participants can carry with them underwater. Divers have the choice to report additional information and are encouraged to upload their photographs. The long-term goal is the development of an active community of amateur observers providing widespread and ecologically significant data on coralligenous assemblages.

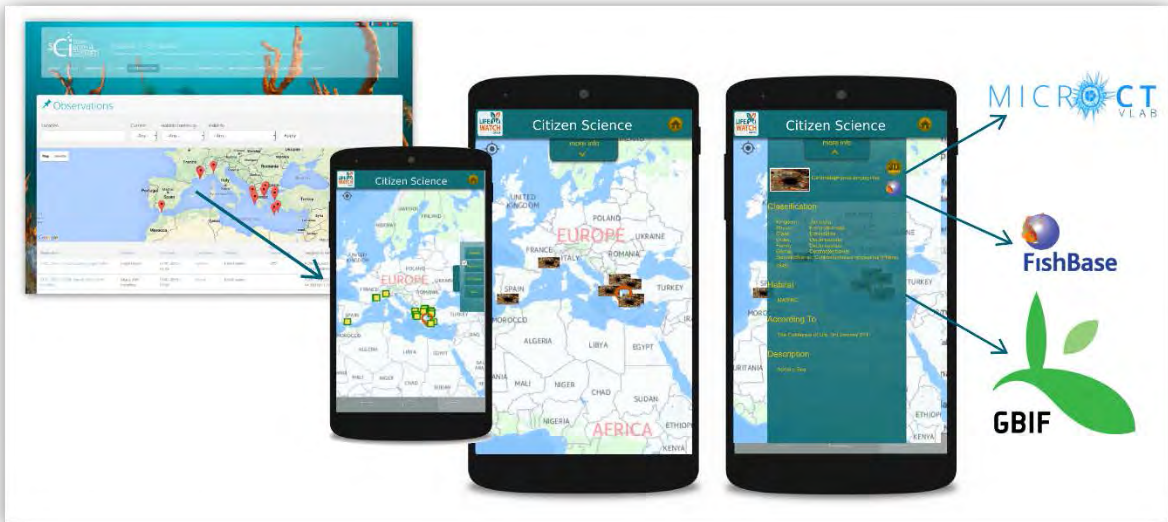


Figure 36. Interface of the smartphone application displaying the exchange of information between different applications of LifeWatchGreece infrastructure and global biodiversity databases.(after Gerovasileiou et al; 2016)

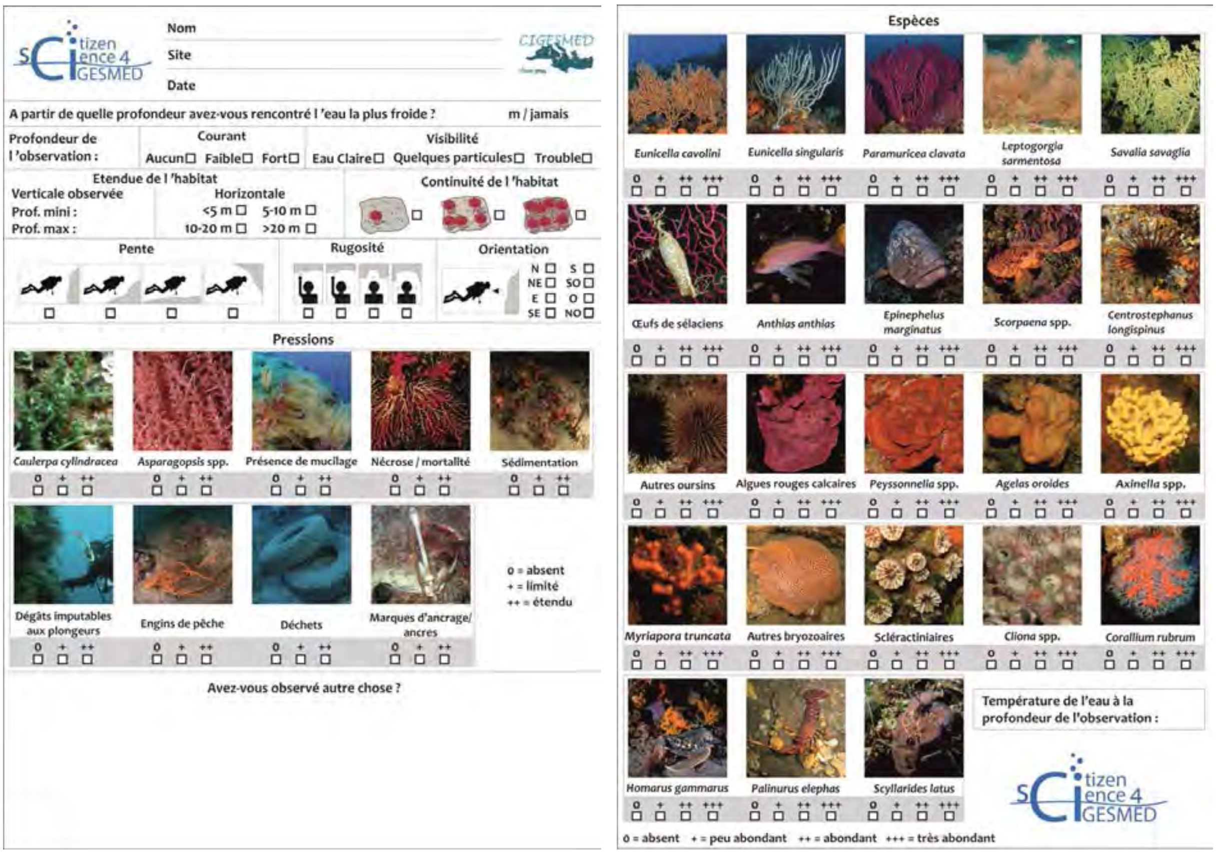


Figure 37. Observation form used underwater and for the data submission platform of the CIGESMED for divers website.

TASK 5.2: IMPLEMENTATION OF THE CITIZEN SCIENCE PILOT PROJECT [NOVEMBER 2013 – FEBRUARY 2016].

The implementation process was a "trial and error" that finally ended up in a fine-tunned mode of implementation. This was a rather necessary process to ensure the implementation of the citizen science activity in perpetuity and to adhere it to current divers citizen science initiatives. For this purpose, the project was communicated to recreational divers and divers associations in all three participating countries and the results of the discussions were carefully taken into account during the development of the web application and the tools to be provided. Therefore, although the first prototype of the web application was ready by the end of the first year of the project, it subsequently took several cycles of reconstruction of its various components to make sure that the intended infrastructure would be the appropriate one to be used by all diver categories and that it would facilitate the development of the needed network.

Field trials for the implementation and optimization of the developed CS protocol took place at carefully selected sites in all the three participating Mediterranean states: France (Marseille), Greece (National Marine Park of Zakynthos) and Turkey (Izmir). These trials included briefings to volunteer divers from local dive centres and associations, experimental dives for data collection followed by interviews, questionnaires and discussions, so as to come up with a more simplified list of requirements that clearly address the CIGESMED project objectives and make the data collection and reporting procedures as easy as possible for the participants. During these trials, the idea of developing an educational CS module to ensure a basic understanding of coralligenous bioherms and their associated communities also emerged, and was subsequently constructed.

Preliminary data gathering was performed by the researchers and divers involved in CIGESMED project, thus allowing the assessment of coralligenous sites in four regions: Western Mediterranean, Ionian Sea, Aegean Sea and Levantine Sea.

AMENDMENTS TO THE ORIGINAL WORK PLAN (IF APPLICABLE) AND ITS RATIONALE

MAIN OUTPUTS

Deliverable	**Title**	**Remarks**	**Status**
D5.1.1	Prototype of the web infrastructure for the citizen scientists (multi-lingual)	The web infrastructure has been delivered and is available and functional on the web for all users in all languages.	✓
D5.2.1	Citizen scientist reports	Reports presenting the data collected from the pilot application of the citizen science protocol in Greece and France are prepared. In these reports, the user experience and the lessons learnt are also presented and discussed.	✓
D5.2.2	Scientific document on the reliability of the data collected by the citizen scientists	The methodological paper is submitted to Biodiversity Data Journal and accepted for publication by the reviewers and editor, pending revisions.	✓

WP6: DATA MANAGEMENT, MAPPING AND ASSIMILATION TOOLS

LEADING PARTNER: CNRS

OBJECTIVES

The main objective of WP6 was to discuss about tools to manipulate data, develop data bases and visualizations of data produced by the protocol (WP2) for the studied ecosystems. Finally, WP6 must bring coherent, inter-calibrated and formatted data on coralligenous organisms, respecting the F.A.I.R. data principles (a set of guiding principles to make data **F**indable, **A**ccessible, **I**nteroperable, and **R**e-usable). New interfaces will present a dynamical map of these data and their links, based on a complex system approach (Graphs). The knowledge trees development was canceled due to the failure of the partner LIGAMEN. It is replaced, however, by equivalent technologies (trees are a kind of graphs, and results of meetings with members of the STIC community showed that multi scale graphs are most adapted for CIGESMED objectives).

SHORT PROGRESS SUMMARY OF THE RESPECTIVE WORK TASKS

TASK 6.1. PRODUCE A DYNAMIC MAPPING OF EXISTING META-DATA [MARCH 2014 – FEB 2015]

In order to make the dynamic map of the metadata, it was necessary to identify the possible types of metadata, then to define the mandatory fields, on the one hand because they are imposed in the European standards, on the other hand because they are necessary to describe in a robust way the data produced under CIGESMED. A robust description allows a real understanding of the veracity (i.e. meaning) and a reproducibility of the data. This description was carried out in conjunction with the development of field protocols (WP2) and contexts for use in genetic approaches (WP4) and index constructions (WP3). The writing of the protocols was followed by tests of the various factors measured and their effectiveness, notably the level of comprehension by observers but also by users having no pragmatic knowledge of the field. The metadata should not be too complex (to be filled by the greatest number, and have a real consistency at a large scale), but nevertheless sufficiently robust to allow reuse in different contexts by non-specialists.

The metadata concern:

- mapping of context profiles and species assemblages
- libraries of taxa common to the different regions to describe the contents of photo quadrats
- photos quadrats by site and description of sites
- intercalibration of the types and modes of data acquisition (material and conditions)
- sampling allowing the phyogeographic approach (naming of the echatillons in particular)
- sampling of substrates (called scrapings)

The data model used to develop the database reproduces the metadata and completes it with integrity rules. The metadata and its interdependencies are described in the data dictionary, and allow to avoid problems of polysemy.

During the implementation of the protocols, modifications of the data and details on the modes of acquisition were necessary. These have made it possible to improve metadata description, and have been inserted in the protocols available online on CIGESMED website. This approach concerning all countries is necessarily iterative and cannot be considered complete until the protocols are implemented in different contexts. The first map described in a theoretical way a system of necessary metadata, which then evolved according to the needs and the implementation of the protocols (year 1 and 2). On the other hand, a monitoring of the evolution of these standards has been implemented.

The definition of metadata formats was done at different workshops organised during CIGESMED meetings and online via forms (example: http://www.cigesmed.eu/Structural-descriptors-on-species), based on “national” standards (SINP metadata standards and MNHN national repositories) as well as internationally proposed standards and languages (EML, INSPIRE, TDWG). The use of language standards has proved difficult to apply to all of the factors monitored, and should be adjusted when editing datapapers for each data set.

This mapping of the metadata will have to evolve according to the development of common standards, but also and especially of the needs generated by the new uses. In the future, new "layers" of information will be needed (intermediate data types) that will increase the potential for use of these data and their integration into transdisciplinary data mining processes. These additional layers, which enrich the description of the data, are based on a thesaurus, in the process of being constructed (- Structural descriptors on species and taxa - Anthropocentric descriptors on species and taxa - Descriptors on species and taxa - Contextual descriptors of studied sites). To develop this thesaurus, the CIGESMED community relies on a tool developed by the CESAB (Centre de synthèse et d’analyse de la biodiversité), the "Thesauform" [http://thesaurus.cesab.org/ThesauformCesab/home], which allows for each term / qualifier of data to propose a definition and then, via successive votes, to obtain consensus on the definitions of descriptors. This work should be continued after the end of the CIGESMED project, with a new consortium, called IndexMed. IndexMed wich is a CIGESMED community emulation, will allow to use CIGESMED data among other as a case study at the European scale as a long term process. This consortium aims to identify and raise the scientific locks related to data quality and heterogeneity. The use of graph-based model started during CIGESMED on meta data and datasets of CIGESMED allows to consider them, despite their differences, at a similar level, and improves decision support using emerging data mining methods (collaborative clustering, machine learning, mining graphs, knowledge representation, etc.)..

TASK 6.2. PRODUCE A DYNAMIC MAPPING OF CIGESMED DATA SET [MARCH 2015 – OCT 2016]

Work on the data began when the first data sets were sufficiently complete. The same principle was adopted for all the datasets. The mode of visualization chosen is based on graph theory that allows mixing numerical data with expert jugement data (non quantifyed but qualifyed, and often non ordonate). In a first step, a visualization prototype was developed based on the analyses of photo quadrats. The data model has been simplified to make any data adaptable. This model takes the form "object / attribute / attribute value", a model formalizable in different languages (OWL, RDF) and allowing to connect distant and multiformat systems (RSS, WMS, WFS, XML, JSON). To make this visualization, the requests are configurable and described in David *et al*. 2016a.

In order to map the data on a large scale in a generic system, the architecture was defined during the EGI workshop in Amsterdam and described in David et al. 2016b (figure 38)

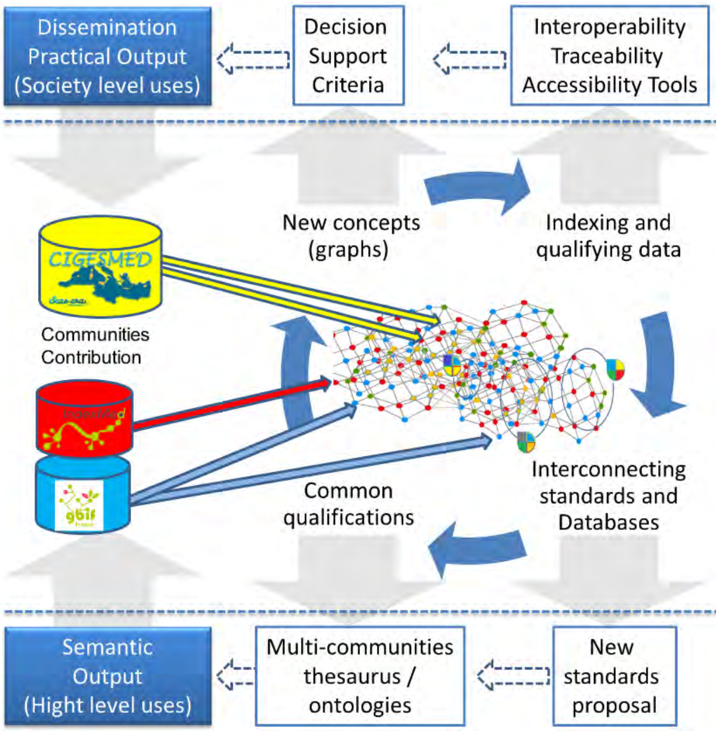


Fig. 38: This figure shows the iterative quality approach using CIGESMED data-sets and workflox and IndexMed demar-che Output[12].

Equivalencies are used to link hetero-geneous objects and construct graphs, where objects are nodes and attribute's modalities are links. The main output is a new model of dataset, stored in a graph database (graph matrix) and accessible with web-services for visualization and integrated flux. A second output is the improving of multi-community thesaurus necessary to build new common ecological concepts. The next step of this project is the recognition of patterns of context in the graph matrix that will contribute to decision criteria.

The first dynamic maps were developed as part of a workshop of the IndexMed consortium with the aim of digitizing data on graphs (figure 39).

Most of the future representations and maps will have to be drawn from the conclusions of this seminar. It will be necessary to carry out data curation (cleaning) in order to improve their interoperability with other information systems and/or larger interdisciplinary approaches.

---

[12] David (R.), Féral (J.-P.), Archambeau (A.-S.), .Bailly (N.), Blanpain (C.), Breton (V.), De Jode (A.), Delavaud (A.), Dias (A.), Gachet (S.), Guillemain (D.), Lecubin (J.), Romier (G.), Surace (C.), Thierry de Ville d'Avray (L.), Arvanitidis (C.), Chenuil (A.), Çinar (M.E.), Koutsoubas (D.), Sartoretto (S.), Tatoni (T.) 2016. IndexMed projects : new tools using the CIGESMED DataBase on Coralligenous for indexing, visualizing and data mining based on graphs. *In* : S. Sauvage, J.-M. Sánchez-Pérez, A. Rizzoli (Eds.) ***Proc. 8th International Congress on Environmental Modelling and Software***, Toulouse, France, 11-13 july 2016

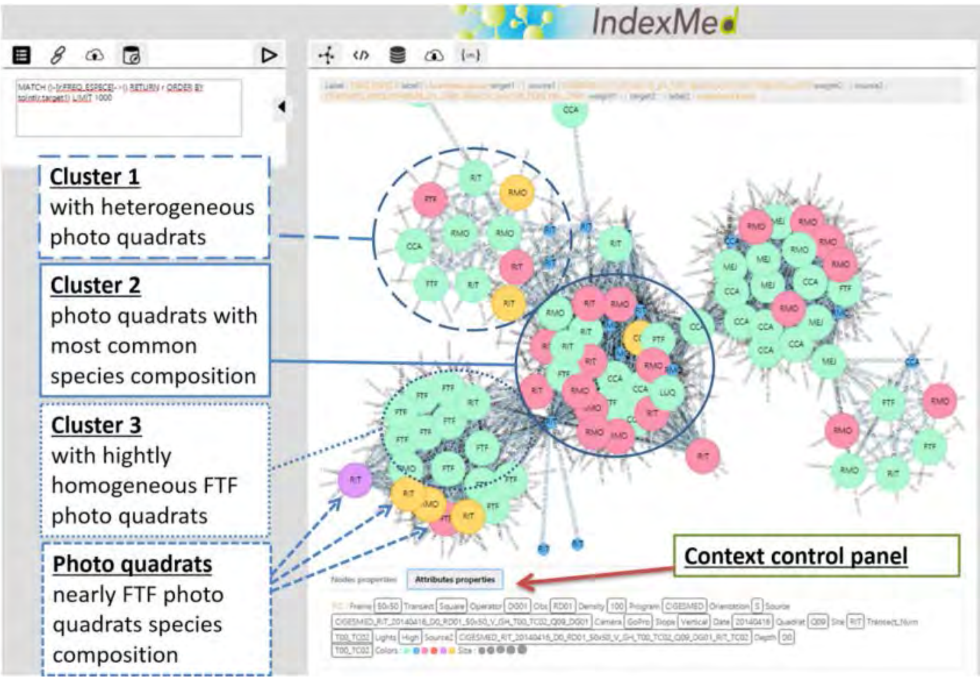


Fig. 39: Example of an application of the prototype graph to a data set of 100 photo-quadrats made on coralligenous habitats in Marseille[12].

TASK 6.3. PRODUCE METHODOLOGICAL DOCUMENT FOR THE MAPPING ANALYSIS, FOR THE EVALUATION OF THE DATA ROBUSTNESS AND FOR THE EFFICACY OF INDICATORS [MARCH 2015 – OCT 2016]

This document is currently being developed. It contains a first version of the data management plan.The conclusions of the last IndexMed meeting and especially the workshops organized in this direction (metadata and data papers) will be transcribed. It is an important issue that will allaw data preservation, data reproductibility and data reusability in the future, according to the rescent numerical accessibility laws at European level.

AMENDMENTS TO THE ORIGINAL WORK PLAN (IF APPLICABLE) AND ITS RATIONALE

The knowledge trees development as tools to sort, organize and illustrate the large heterogeneous sets of produced data was canceled due to the failure of the partner LIGAMEN. This failure increased the work of the CNRS team concerning dissemination and vizualisation tools but the building of the IndexMed community helped to construct visualization prototypes and to replace beneficially trees of knowledge as initialy proposed by multi scale graphs. This also resulted in a change of WP leader.

Dissemination towards scientists, decision makers, environmental managers and general public was provided with several tools by the CNRS team with open source tools. Data users like STIC community, on the side of the CIGESMED community, was added as one of a strategic goal of end users. Data qualification processes of CIGESMED, data sets and methods are being disseminated by diffusing in the STIC community *via* the IndexMed consortium as free study cases, and open dataset that can be freely used in several kind of data sciences (data mining, data representations, data integration, data qualification and improvement of standards / thesaurus). Data re-usability will also be improved by data papers productions and future animations of data management plan foreseen by the IndexMed Consortium).

MAIN OUTPUTS

Deliverable	**Title**	**Remarks**	**Status**
D6.1.1	Dynamic mapping of existing meta-data	Realized	✓
D6.3.1	Dynamic mapping of data set	Realized	✓
D6.3.2	Methodological document for the mapping analysis, for the evaluation of the data robustness and for the efficacy of indicators	First draft realized, publication in progress (supported by IndexMed in the future)	✓ ✗

WP7: OUTREACH, STAKEHOLDER ENGAGEMENT & DISSEMINATION

LEADING PARTNER: HCMR

OBJECTIVES

- To deliver the project's messages to all interested parties
- To connect the ideas and practices of the project to the efforts of targeted user groups and to the society at large

SHORT PROGRESS SUMMARY OF THE RESPECTIVE WORK TASKS

TASK 7.1: OUTREACH [MARCH 2013 – FEBRUARY 2016].

The strategy behind this WP included the following aspects all over the period of its implementation: (i) well-defined target groups, which we aimed to include all potential interested parties; (ii) detailed plan of activities; (iii) clear and comprehensible communication language; (iv) incorporation of the project's provocative messages into contemporary societal messages and mottoes; (v) development of mechanisms to capture the feedback of the interested parties to the project's messages; (vi) link project's activities with the everyday practices of the audience.

A first set of of activities for the outreach included participation of the Consortium members to a large number of Conferences, Symposia and Workshops, which are listed at the attached CIGESMED Dashboard activity file (available on line). This set was necessary to achieve not only the communication of the main objectives of the project but also for the development of links with other projects, targeting to Marine Biodiversity, such as EMBOS (The European Marine Biodiversity Observatory), LifeWatch (ESFRI Research Infrastructure), DEVOTES (DEVelopment Of innovative Tools for understanding marine biodiversity and assessing good Environmental Status), VECTORS (VECTORS of Change in European Marine Ecosystems and their Environmental and Socio-Economic Impacts) and EU BON (**Building the European Biodiversity Observation Network)**, to cite a few.

For the needs of the communication strategy a flayer was developed by the WP leader and the project coordinator, which provides the basic information on the project.

The project was also communicated to much larger events, which were taking place in the premises of the participating institutes, such as open days: the members of the Consortium ceased the opportunity to talk about the project to a much large audience during events for large societal groups such as exhibitions for the Climate change and TEDx events.

This outreach activity continued all over the entire life of the project with the target audience categories to be: Researchers and scientists, students, educators, environmental managers, policy makers and stakeholders from all the economic sectors including industry.

TASK 7.2: DISSEMINATION [MARCH 2013 – FEBRUARY 2016].

The strategy of this Task was to allow for activities that deliver the GIGESMED message to as many recipients as possible.

The main dissemination means of the project was its web site, which has been hosted by CNRS-IMBE. The web site has been initiated since the time of the kick-off meeting in Crete and since then it has been populated with data and information that do not only refer to the CIGESMED Consortium but also to the broader Marine Biodiversity of the Mediterranean. The web site eventually became very powerful in disseminating the relevant information not only to the strictly scientific community but also to other stakeholders, such as the environmental managers and policy makers who have a decisive role in the habitat protection and conservation. Until now an impressive number of visits has been recorded: near 250 000 hits (end of November 2016)

The web site also includes the citizen science application which has been one of the primary means of the project's outreach activity. Divers now use the site in order to have information on the habitat and the species it hosts, their external morphology and the key characters for their identification, their appearance in the natural habitat under dime light and full light conditions, and the expected pressures and threats they would see when visiting the habitat in their preferred sites. They can also have an overview how they are expected to insert the information after their visits.

Finally, the divers can find the cell phone application to download and information on the tablet they can use underwater for the collection of the relevant data and information.

The more impressive outreach activity was the production of various articles for the scientific audience and for the society at large: 353 articles have been produced by a collective number of 50 authors. Five web sites have been created from which information on the project is broadcasted.

AMENDMENTS TO THE ORIGINAL WORK PLAN (IF APPLICABLE) AND ITS RATIONALE

MAIN OUTPUTS

Deliverable	**Title**	**Remarks**	**Status**
D7.1.1	Dissemination and outreach plan of activities		✗ ✓
D7.1.2	Project's web site	Website fully operating in four languages http://www.cigesmed.eu/	✓

5. KEY FINDINGS AND CONCLUSIONS.

Consortium

Key findings/achievments:

- Creation of a pluridisciplinary consortium beyond the temporal boundaries for the project
- Agreement for a general definition of coralligenous, making it acceptable on all the Mediterranean coasts.

Conclusions/lessons to learn:

- There is a need to extend the scope to economy, society and law sciences

Coralligenous assessment and threats

Key findings/achievments:

- Enabled to encounter common species on coralligenous in the eastern and western parts of the Mediterranean
- Different species assemblages were assessed in the large scale and even small scale (between the Aegean and Levantine Sea), indicating the heterogeneity of the coralligenous habitats
- The main difference in coralligenous assemblages between the eastern and western Mediterranean sites studied is the absence or rarity of large erect forms (e.g. gorgonians) in the eastern Mediterranean
- Invasive alien species and bleaching were the major factors influencing the health of coralligenous habitats

Conclusions/lessons to learn:

- Teams in different countries should have been closely worked together in field and laboratory works to minimize bias derived from observations of different scientific teams
- Environmental variables should have been measured at all sites in order to relate biotic and abiotic data, and to realize which variables explain best the variances occurring in assemblages
- A long term monitoring programme with fixed quadrates is needed to determine drastic changes in coralligenous habitats due to global warming and introduction of invasive alien species.
- The study area should be enlarged, involving Italy, Spain and countries in the southern Mediterranean Sea to contribute towards better understanding of the diversity of species assemblages in coralligenous habitat.

Species, traits and environment

Key findings/achievments:

- Reusable large scale protocols with same shared typology, vocabulary and data formats (cartography, sampling, photo quadrats analyses, genetic analyses)
- The only way to share, use and understanding indicators at large scale is to determine what is common or not at a large scale – species, type of habitats, human and natural impacts

Conclusions/lessons to learn:

- More training is needed to construct a robust observatory network
- Efficient observations needs long term monitoring of sites also equipped of sensors
- Contextualisation is the only way to understand differencies and trends
- Repetability of measurement must be improved in the future

Indication

Key findings/achievments:

- An integrated index taking into account 3 complementary informations: (i) the level of impact of sediment and organic matters input, (ii) the taxonomic richness of assemblages

and (iii) the structural complexity. This method allows evaluating more accurately the ecological status of coralligenous assemblages.
- Informations concerning the ecological status of coralligenous assemblages in Eastern Basin of Mediterranean Sea.

Conclusions/lessons to learn:
- Comparaison among the different existing indices has to be made, in order to assess the ecological status of coralligenous and its maintenance.

Innovation

Key findings/achievments:
- Divergent lineages coexist within several morphological/nominal species, among coralligenous builder species, both for red algae and bryozoans
- A powerful metabarcoding protocol is set up and metabarcoding reveals far more species than eye examination, making it promising for high frequency future monitoring
- Full transcriptome sequences were obtained for builder species (the first for a coralline red alga, and also the first one the Bryozoan phylum) : Genetic diversity within coralligenous builder species is very low, making them vulnerable to environmental change.

Citizen Science and long term monitoring

Key findings/achievments:
- Multilingual CS website developed
- Data collection protocol, with educational module and data submission platform
- Geo-referenced data reporting focus: (a) basic topographic and abiotic features; (b) presence and relative abundance of typical conspicuous species, (c) existence of pressures and imminent threats
- Variety of tools is provided to facilitate end users

Conclusions/lessons to learn:
- Theoretical aspects: Simplicity; Efficiency; Implementation
- Tools: Ever evolving; Focus on the needs of the CS
- To adjust the tablets for all areas of the Mediterranean
- Long-term goal - the development of active community of amateur observers providing widespread and ecologically significant data; ecological quality assessment of coralligenous reefs based on CS data.

Data management, use and vizualiztion

Key findings/achievments:
- A first pool of realistic, identified and commonly defined factors at a large scale to monitor GES on coralligenous habitats.
- Open access, open data, open source results taking into account the "F.A.I.R." principles at a European level for coralligenous habitats
- A strong link with the IndexMed Consortium and tools, emulated by research activities of WP6 membres, and that have now the goal to improve open access

Conclusions/lessons to learn:
- To be possible, the development of an active community of observers at a large scale using the same vocabulary, the same meaning of data absolutely needs iterative processes to improve thesaurus. It is the sine qua non condition for a long-term observatory with respect for "F.A.I.R." principles and European laws on scientific data.
- Graph approaches are rarely used in ecology. But STIC community (using and testing it on CIGESMED Data) confirmed that it is the main way to build decision support tools in most of environmental (and human) sciences in the future.

Outreach

Key findings:

- Long-term goal - the development of active community of amateur observers providing widespread and ecologically significant data
- Campaigns, carried out: (a) Conferences, Symposia, Workshops and Project meetings
- Audience: Researchers, scientists, students, educators, environmental managers, policy makers and stakeholders, economic sectors including industry; (b) Citizen Science: Publicity and access to Consortia through Research Infrastructure projects and initiatives; (c) Project flyer
- Dissemination: Project web site, publications, Open days and show cases

Conclusions:

- Theoretical aspects: Visibility; Communication; Integration
- Community building: Web site functioning as the main gear
- The “multiplier effect”
- Interaction with the audiences

6. ADDED VALUE OR BARRIERS OF INTERNATIONAL COOPERATION

ADVANTAGES OF THE INTERNATIONAL COOPERATION

1. Collecting and sharing data
2. Studying different coralligenous assemblages across the Mediterranean
3. Gaining experiences through the international cooperation
4. Using facilities in other institutions (i.e. genetic analyses)
5. Standardizing methods throught exchanging knowledge and experiences from different areas
6. Scientific collaboration between multi-national research groups to tackle common scientific questions
7. Expanding of research to broader geographical and biological scales
8. Standardization of methodological approaches and consensus building on the interpretation of the results
9. Provide fruitful interface between different disciplines in which a number of young researchers can flourish through the implementation of their MSc or PhD project
10. Raising awareness towards sensitive habitats at the basin scale, thus highlighting the potentially broad impact of local actions, both + and –
11. Reducing over-expending resources by working in concert and not in isolation
12. Creating solidarity and harmonization among multi-national scientific groups

DISADVANTAGES/BARRIERS OF THE INTERNATIONAL COOPERATION

1. Compromises that have to be made on the approach, methods and result interpretation;
2. Different logistic systems don't always allow smooth cooperation;
3. Different time-scales at which the states get involved (3 starting dates);
4. Larger bureaucratic, unnecessary processes than in the EU-funded projects (7FP).
5. Rules differing bewteen countries, e.g. rule of TUBITAK (national scientific agency in Turkey) 1001 Project. It emphasizes that the budget for travelling abroad can not be exceeded 10.000 TL (ca. 3000 €) that largely hinders the Turkish researchers to join to the meetings/field works in partner countries.

7. INDICATORS.

Indicators	Number
Publications (books, articles in national or international journals)	2 (+11)
Communications (in national or international scientific events) and conferences	45
Policy reports, briefings, …	
Organisation of seminars and conferences	5
Advanced training (Master thesis, PhD thesis, other)	17
Models	
Computational applications	1
Pilot installations	
Laboratory prototypes	
Patents	
Others	

8. LIST OF PUBLICATIONS

PAPERS

2016

Gerovasileiou (V.), Dailianis (T.), Panteri (E.), Michalakis (N.), Gatti (G.), Sini (M.), Dimitriadis (C.), Issaris (Y.), Salomidi (M.), Filiopoulou (I.), Doğan (A.), Thierry de Ville d'Avray (L.), David (R.), Çinar (M.E.), Koutsoubas (D.), Féral (J.-P.), Arvanitidis (C.) 2016. CIGESMED for divers: Establishing a citizen science initiative for the mapping and monitoring of coralligenous assemblages in the Mediterranean Sea. **Biodiversity Data Journal 4**: e8692. doi: org/10.3897/BDJ.4.e8692

Over the last decade, inventorying and monitoring of marine biodiversity has significantly benefited from the active engagement of volunteers. Although several Citizen Science projects concern tropical reef ecosystems worldwide, none of the existing initiatives has yet specifically focused on their Mediterranean equivalents. Mediterranean coralline reefs known as "coralligenous", are bioherms primarily built by calcifying rhodophytes on hard substrates under dim-light conditions; they are considered hotspots of biodiversity and are extremely popular among divers due to their complex structure, conspicuous biological wealth and high aesthetic value. Nevertheless, data on their distribution, structure and conservation status is lacking for several Mediterranean areas while they are vulnerable to an increasing number of threats.

In the framework of CIGESMED SeasEra (ERAnet) project a specialized Citizen Science project was launched, aiming to engage enthusiast divers in the study and monitoring of Mediterranean coralligenous assemblages through the gathering of basic information regarding their spatial occurrence, assemblage structure and associated pressures or threats. For its active implementation, a data collection protocol and a multilingual website were developed, comprising an educational module and a data submission platform. Georeferenced data reporting focuses on: (a) basic topographic and abiotic features for the preliminary description of each site, and the creation of data series for sites receiving multiple visits; (b) presence and relative abundance of typical conspicuous species, as well as (c) existence of pressures and imminent threats, for the characterization and assessment of coralligenous assemblages. A variety of tools is provided to facilitate end users, while divers have the choice to report additional information and are encouraged to upload their photographs. The long-term goal is the development of an active community of amateur observers providing widespread and ecologically significant data on coralligenous assemblages.

2015

Tsiamis (K.), Aydogan (Ö.), Bailly (N.), Balistreri (P.), Bariche (M.), Carden-Noad (S.), Corsini-Foka (M.), Crocetta (F.), Davidov (B.), Dimitriadis (C.), Dragičević (B.), Drakulić (M.), Dulčić (J.), Escánez (A.), Fernández-Álvarez (F.A.), Gerakaris (V.), Gerovasileiou (V.), Hoffman (R.), Izquierdo-Gómez (D.), Izquierdo-Muñoz (A.), Kondylatos (G.), Latsoudis (P.), Lipej (L.), Madiraca (F.), Mavrič (B.), Parasporo (M.), Sourbès (L.), Taşkin (E.), Tűrker (A.), Yapici (S.) 2015. New Mediterranean Biodiversity Records (July 2015). **Mediterranean Marine Science 16**: 472-488. doi:10.12681/mms.1440

This Collective Article offers the means to publish biodiversity records in the Mediterranean Sea. The current article includes species records from the CIGESMED expeditions in the National Marine Park of Zakynthos (Greece).

Up to now, the CIGESMED Consortium scientific production has been primarily consisted of publications in conference proceedings in a surprising high number of international events (e.g. marine ecology and environment, bioindication, citizen sciences, computer sciences and big data, biodiversity standards). The reasons for this publication pattern are provided below:

(1) The first challenge for CIGESMED was to find coherence between partners in a domain which generally open a lot of discussions: what is coralligenous? Indeed this term created by Lamark (1801) and subsequently was used by Marion (1883) to give a scientific term to the area where the Provencal fishermen stretched their nets (*broundo*). The choice of this name was related to the abundance of red coral found on this type of bottom in Marseilles area (producing coral). These hard bottoms, difficult to access from the surface, have finally been studied in the decades of sixties and seventies and several attempts to provide a "scientific" definition have been made. However the criteria used were highly variable and were always pointing back to the original term of coralligenous, rendering the entire process very confusing. Probably, the most useful result of CIGESMED was the dedicated, concerted and exhaustive action in order to find a definition acceptable by all interested parties, both scientists and stakeholders. It took a substantial amount of time and it dramatically increased the workload in the field to document the different aspects of species assemblages and facies of both western and eastern Mediterranean.

(2) Accordingly, all of the above attempt, including definitions and monitoring protocols, jointly made by all members of the Consortium, needed to be communicated to the broad scientific community at many events and finally to the stakeholders and policy makers. This also had a time effect on the start of the field work of the project.

(3) Field Works were also necessary to create and calibrate protocols and to test indicators. Laboratory analyses (molecular biology) were also time consuming. This is particularly aggravated by the fact that the coralligenous habitat is very heterogeneous in the composition, abundance/coverage and 3D structure and function. The picture becomes more variable when comparisons need to be made between the habitats studied in the western and eastern basin of the Mediterranean. As a result, a great deal of uncertainty in all the measures used and indicators tried occurred, which encroached an enormous amount of time to sort out and decide which way the results are: (a) scientifically sound, (b) policy relevant, (c) supported with continuous data by the community in perpetuity.

(4) The citizen science activity required significant preparatory work and the networking began only in May 2015. Many aspects are still in progress in the framework of the created consortium on coralligenous.

Below, we provide the list of articles presently in preparation or submitted. Others are also planed.

WP2

CIGESMED participants. Coralligenous assemblages of the Mediterranean: A inter-calibrated dataset

Status: *In prep*. Journal: Data publishing type

(Brief description: This article describes in detail the dataset on the abiotic physical features of the coralligenous formations and on the biotic data of its assemblages in all the sampling sites visited during the implementation of the CIGESMED project. The entire list of species ever reported from the Mediterranean coralligenous habitat is also provided. Special attention is paid to the detailed description of the metadata, while both the data and their metadata are stored and made available in proper databases, following the GBIF Darwin Core. The dataset is distributed under the terms of the Creative Commons Attribution License (CC BY 4.0) and harvested by the major aggregators, notably the OBIS and GBIF.)

Arvanitidis et al. Coralligenous assemblages: Taxonomic vs functional efficiency

Status: *In prep*. Journal: *Marine Ecology* publishing type

(Brief description: The paper builds on the concept of taxonomic sufficiency and extends it to the functional level. The taxonomic sufficiency concept predicts that when the information is aggregated to higher than species taxonomic level the multivariate community trend does not change much till the family, in relatively undisturbed conditions. Under severe disturbance, the trend derived by species and higher levels are very similar to each other. This finding can save time and resources in the classic environmental impact assessment studies. The functional aspect, however, if this concept that is the aggregation of the information to higher levels of the functional complexity, has never been tested before. Therefore, the paper attempts to demonstrate whether the trends provided by the taxonomic and functional information matrices are convergent or divergent and what might their implications be on the environmental impact and ecological quality assessment of the coralligenous habitat.)

Çinar, M.E., Féral, J-P., Arvanitidis, C., David, R., Taşkın, E., Dailianis, T., Doğan, A., Gerovasileiou, V., Dağli, E., Aysel, V., Issaris, Y., Bakir, K., Salomidi, M., Sini, M., Açik, S., Evcen, A., Dimitriadis, C., Koutsoubas, D., Sartoretto, S., Önen, S., *et al*. Coralligenous assemblages across the Mediterranean Sea (alternatively adding, with special emphasis on threads on them)

Status: *In prep.* Journal: *Marine Biology Research* publishing type

(Brief description: The paper will focus on the different assemblages in coralligenous habitats across the Mediterranean Sea, with special emphasis on the alien species and bleaching of coralline algae in the Levantine coast. A core species list, including those with high cover percentages in specific or larges scales, and those distributed widely at sites. Univariate and multivariate techniques will be employed to characterize specific assemblages occurring in the region and to assess structures of coralligenous communities based on percent coverages of the upper layer species. The importance of alien species will be mentioned and discussed in the paper. The relationships between environmental variables and biotic data will be encountered.)

WP3

Sartoretto S., Schohn T., Bianchi C.K., Morri C., Garrabou J., Ballesteros, Ruitton S., Verlaque M., Daniel B., Charbonnel E., Blouet S., David R., Féral J.-P., Gatti G. An integrated method to evaluate and monitor the ecological status of coralligenous habitats: the INDEX-COR approach.

(Brief description: A new method based on photographic sampling coupled with in situ observations was applied to 53 stations along the French Mediterranean coasts, to assess the integrity of coralligenous habitats affected by different levels of anthropogenic pressures. The health state of the assemblages that characterized the reefs was then assessed by an index – the INDEX-COR – that integrates three metrics: (i) the sensitivity of the taxa to organic matter and sediment deposition, (ii) the observable taxonomic richness and (iii) the structural complexity of the assemblages. The sensitivity of INDEX-COR was tested and showed a good correlation with the Global Level of Pressure (GLP), calculated for each station according to expert judgement and field observations. The INDEX-COR aims at being a robust and effective tool for the monitoring of coralligenous bottoms, as needed by stakeholders and coastal managers.)

Status: *Submitted* Journal: *Marine Pollution Bulletin*

Gatti G., Piazzi L., David R., Montefalcone M., Schon T., Féral J.-P., Sartoretto S. A comparison among coralligenous-based indices for the assessment of the marine ecological quality.

(Brief description: To date, only few indices aimed to assess the ecological status of coralligenous reefs have been proposed. The Coralligenous Assemblage Index (CAI – Deter et al., 2012), the Ecological Status of Coralligenous Assemblages (ESCA – Cecchi et al., 2014) index, the COralligenous Assessment by ReefScape Estimate (COARSE – Gatti et al., 2015) index and the Index-Cor (Sartoretto et al., 2014) were compared among each other and against some classical univariate indices (e.g. the Shannon diversity Index) in 21 sites along the southern coasts of France. The four coralligenous-based indices are built on different approaches and combining various metrics. Results showed that the indices are not always concordant in indicating the ecological quality of coralligenous habitats and coastal waters, some metrics being more sensitive than others to the increasing pressure levels.)

Status: *In prep.* Journal: *Ecological Indicators*

WP4

De Jode A, Dubois S, Haguenauer A, Sini M, Gerovasileiou V, Dailianis T, Dimitriadis C, Baud A, Sartoretto S, Erga Z, Féral J.-P, David R, & Chenuil A. Phylogeographic and ecological distribution of cryptic lineages in the bioconstructing bryozoan *Myriapora truncata* [Envisaged Subtitle: Species delimitation using few transcriptome and numerous mitochondrial sequences].

(Brief description: a/ Mitochondrial sequences in about three hundred individuals revealed deep phylogeographic lineages in this species, from the Gibraltar strait to the Levantine Sea. We examine the distribution of genetic lineages across geography and ecological characteristics of their habitats. b/ We provide the first transcriptome data in the phylum Bryozoa (20 000 open reading frames) obtained from RNA sequencing of a dozen individuals. With these data, we confirmed the divergence between lineages and establish species delimitations. We could thus characterize the polymorphism at the whole genome level (expressed genes) and it appears particularly low in this species, compared to other Mediterranean marine invertebrates, suggesting high vulnerability).

Status: *In prep*. Journal: *Molecular Ecology*

De Jode A, Erga Z, Haguenauer A, Féral J.-P, Sartoretto S, Le Gall L, David R & Chenuil A. Ecologically differentiated distributions among highly divergent cryptic species in the bioconstructing red alga Lithophyllum stictaeforme/cabiochae.

(Brief description: Several mitochondrial, chloroplastic and nuclear lineages, perfectly congruent, establish the presence of divergent cryptic species in Lithophyllum Stictaeforme/cabiochae, the distinction between the two species names (*L. stictaeforme* and *L. cabiochiae*) proving to be ungrounded. The distribution among lineages, examined at fine grain in the bay of Marseille and nearby regions, from hundreds of individuals, reveals a strong spatial genetic structure, coherent with low dispersal ability based on known life cycle and biology in this species complex. The ecological distribution of the different lineages suggests niche differentiation among cryptic species. We sequenced whole transcriptomes of few individuals and could thus characterize the polymorphism at the whole genome level (expressed genes): it appears particularly low in this species, compared to other Mediterranean coralligenous species, suggesting high vulnerability of this keystone species of the coralligenous habitats. Niche differentiation among lineages makes this species complex a potential tool for ecological monitoring).

Status: In prep. Journal: Molecular Ecology

De Jode A, David R, Dubar J, Rostan J, Féral J.-P, David R., Arvanitidis C., Çinar M.E., Doğan A., & Chenuil A. High density metabarcoding of coralligenous communities.

(Brief description: 240 samples from 22 locations (19 in the Bay of Marseilles plus three Eastern Mediterranean ones) and several ecological profiles (for each location) were analysed by metabarcoding using a COI region (for animals and some red algae) and a 28S region (for some red algae, in particular the *Lithophyllum stictaeforme/cabiochiae* species complex). Metabarcoding appears extremely powerful to distinguish among taxa (many more taxa are identified within most phyla by metabarcoding than by eye) and samples are well differentiated. Congruence between metabarcoding and composition established by careful examination of the samples (Turkish samples) prior to grinding is good, with some discrepancies. The influence of ecological factors (orientation, depth, rugosity, and slope) will be analysed).

Status: *In prep*. Journal: *Ecology Letters.*

Chenuil A., De Jode A., Féral J.-P., Haguenauer A., Selva M., David R., Gerovasileiou V, Dailianis T, Dimitriadis C, Jimenez O., et al. Barcoding of bio-constructing coralline red algae in Eastern and western Mediterranean reveal deep breaks and new species.

(Brief description: DNA sequences of coralline samples were obtained for three DNA regions that appeared suitable for the barcoding of rhodophytes: COI (mitochondria), psbA (chloroplast) and 28S (nucleus). Compared with already published barcodes, they reveal new/similar lineages in eastern Mediterranean, in particular for the important builder genus *Mesophyllum*).

Status: in preparation. Journal: not yet defined.

David R, Dubar J, De Jode A, Féral J.-P., Chenuil A., et al. A protocol for coralligenous community analysis and monitoring: from under water sample collection to community description proxies.

(Brief description: This protocol paper describes (i) the composition and how to use a newly designed succion sampler made up to collect hard bottom coralligenous community samples, (ii) simple samples processing on the boat and back to the lab, (iii) how simple data (weigh, volume, and number of taxa distinguishable by eye) can be analyzed. Results on those simple data analyses are congruent with expectations thus promising for future monitoring applications.)

Status: *In prep*. Journal: not yet defined.

WP5

Gatti G., Dimitriadis C., Doğan A., Çinar M.E., Koutsoubas D., Gerovasileiou V., Dailianis T., Arvanitidis C., Chenuil A., David R., Féral J.-P. et al. Data reliability and feedbacks from CIGESMED for divers, a citizen science initiative focusing on coralligenous reefs.

(Brief description: Citizen Science for CIGESMED is a European project aiming to engage enthusiast divers in the study and monitoring of Mediterranean coralligenous assemblages through the gathering of some simplified information. A specific protocol for underwater observation was developed along with data-recording dive slates, to acquire information about: (a) basic topographic and abiotic features for the preliminary description of each site and the creation of data series for sites receiving multiple visits, (b) presence and relative abundance of typical conspicuous species, as well as (c) existence of pressures and imminent threats, for the characterization and assessment of coralligenous assemblages.

The testing of the protocol and the associated guidance material was achieved through the involvement of volunteer divers in preliminary field trials at different areas of the Mediterranean. In order to test the reliability of the protocol and identify possible correction factors for the obtained datasets, the validity of the answers provided by divers was assessed in comparison to those provided by scientists.)

Status: *In prep*. Journal: *Citizen Science publishing type*

CONFERENCES & PROCEEDINGS

2017

Gerovasileiou V., Dailianis T., Sini M., Issaris Y., Salomidi M., Gatti G., Michalakis N., Dimitriadis C., Panteri E., Doğan A., Thierry de Ville d'Avray L., David R., Çinar M.E., Koutsoubas D., Féral J-P., Arvanitidis C. 2017. Engaging enthusiast divers in the study and monitoring of Mediterranean coralligenous assemblages: Citizen Science for CIGESMED. 3rd European Conference on Scientific Diving. Funchal, Madeira, Portugal, 22-23 March 2017.

2016

David R., Féral J.-P., Archambeau A.-S., Auber D., Bailly N., Blanpain C., Breton V., Dias A., Cohen-Nabeiro A., Delavaud A., Gachet S., Goffaux R., Gibert K., Herrera H., Ienco D., Julliard R., Lecubin J., Legre Y., Loïs G., Méndez Muñoz V., Meunier J.-C., Mougenot I., Pamerlon S., Romier G., Specht A., Surace C., Tatoni T.2016. Results of IndexMed GRAIL Days 2016: How to use standards to build GRAphs and mIne data for environmentaL research. The 2016 Biodiversity Information TDWG Annual Conference.Using data visualisation for sustainable biodiversity: knowledge and insights from heterogeneous data.Santa Clara de San Carlos, Costa Rica, 5-9 December 2016, Oral

David R, Féral J-P, Archambeau A-S, Bailly N, Blanpain C, Breton V, Couvet D, Delavaud A, Dias A, Gachet S, Mougenot I, Lecubin J., Leydet M, Raynal J-C, Robert S, Romier G., Specht A, Surace C., Tatoni T, 2016 Graph approach of heterogeneous data, the new possibilities developed by the IndexMed consortium for data mining in Mediterranean ecology. Sfé 2016, Intn. Conference on Ecological Sciences, 24-28 October 2016, Marseille, Oral

David R, Féral J-P, Archambeau A-S, Bailly N, Blanpain C, Breton V, De Jode A, Delavaud A, Dias A, Gachet S, Guillemain D, Lecubin J, Romier G, Surace C, Thierry de Ville d'Avray L, Arvanitidis C, Chenuil A, Çinar ME, Koutsoubas D, Sartoretto S, Tatoni T 2016. IndexMed projects: new tools using the CIGESMED DataBase on Coralligenous for indexing, visualizing and data mining based on graphs, ACO 2016 A connected ocean: new approaches, new technologies, new challenges for knowledge of ocean processes, IEEE Oceanic Engineering Society, Brest, 11-13 October 2016, Oral

David R, Féral J-P, Archambeau A-S, Bailly N, Blanpain C, Dias A, Lecubin J, Romier G, Surace C 2016 IndexMed: Original solutions to manage the heterogeneity of marine ecology data in the

Mediterranean Sea. 51st European Marine Biology Symposium, EMBS, Rhodes, Grèce, 26-30 September 2016, Oral

David R., Féral J.-P., Archambeau A.-S., .Bailly N., Blanpain C., Breton V., De Jode A., Delavaud A., Dias A., Gachet S., Guillemain D., Lecubin J., Romier G., Surace C., Thierry de Ville d'Avray L., Arvanitidis C., Chenuil A., Çinar M.E., Koutsoubas D., Sartoretto S., Tatoni T. 2016. IndexMed projects: new tools using the CIGESMED DataBase on Coralligenous for indexing, visualizing and data mining based on graphs. In: S. Sauvage, J.-M. Sánchez-Pérez, A. Rizzoli (Eds.) Proceedings 8th International Congress on Environmental Modelling and Software, Toulouse, France, 11-13 July 2016

Féral J-P, Çinar M E, Sartoretto S, Chenuil A, Arvanitidis C, David R, Koutsoubas D 2016 CIGESMED project: evidence-based management for coralligenous habitats in the mediterranean sea. 51st European Marine Biology Symposium, EMBS, Rhodes, Grèce, 26-30 septembre 2016, Oral

Gatti G., Gerovasileiou V., Dailianis T., Panteri E., Issaris Y., Sini M., Salomidi M., Dimitriadis C., Nikitas M., Doğan A., Thierry de Ville d'Avray L., David R., Çinar M.E., Koutsoubas D., Arvanitidis C., Sartoretto S., Chenuil A., Féral J.-P. 2016. Citizen science for CIGESMED: pour une cartographie et un suivi des habitats coralligènes à l'échelle Méditerranéenne. Colloque LITEAU, Observation et recherche en appui aux politiques du littoral et de la mer. Brest, France, 14-15 January 2016, Oral, p.34

Gatti G., Piazzi L., Schon T., David R., Montefalcone M., Féral J.-P., Sartoretto S. 2016. A comparison among coralligenous-based indices for the assessment of the marine ecological quality.51st European Marine Biology Symposium, EMBS, Rhodes, Greece, 26-30 September 2016, Oral

Gatti G., Piazzi L, Schon T, David R, Montefalcone M, Féral J-P, Sartoretto S. A comparison among coralligenous-based indices for the assessment of the marine ecological quality. Sfé 2016, Intn. Conference on Ecological Sciences, 24-28 October 2016, Marseille, Oral

2015

Dailianis, T., Gerovasileiou, V., Issaris, Y., Salomidi, M., Sini, M., Gerakaris, V., Mantzani, E.-N., Nalmpanti, M., Arvanitidis, C., David, R. & J-P. Féral: Assessment of a coralligenous assemblage in Korinthiakos Gulf, Ionian Sea, SW Greece, 13th International Congress of Zoogeography and Ecology of Greece and Adjacent Regions, Heraklion, Greece, 7-11 October 2015, Oral

Dailianis T., Sini M., Gerovasileiou V., Dimitriadis C., Sapouna A., Vatikiotis K., Katsoupis C., Çinar M.E., Féral J-P., Koutsoubas D. & C. Arvanitidis: Ecological assessment of coralligenous assemblages in the National Marine Park of Zakynthos (Ionian Sea, Greece). International Symposium "Marine Protected Areas in Greece and the Mediterranean: Designing for the Future by Applying Lessons Learnt from the Past", Zakynthos, Greece, 4-6 December 2015, Oral

David R, Féral J-P 2015 INDEXMED, A consortium charged with the task of indexing mediterranean biodiversity data, a new way for datamining in ecology The 2015 Biodiversity Information TDWG Annual Conference, Using biodiversity informatics tools for management, 28 September - 01 October 2015, Nairobi, Kenya, Oral

David (R.), Féral (J.-P.), Gachet (S.), Dias A., Blanpain (C.), Lecubin (J.), Diaconu (C.), Surace (C.), Gibert (K.) 2015 A first prototype for indexing, visualizing and mining heterogeneous date in Mediterranean ecology within the IndexMed consortium interdisciplinary framework. In: SITIS 2015, 11th International Conference on Signal-Image Technology & Internet-Based Systems (SITIS), 23-27 November 2015, Bangkok, Thailand, pp. 232-239, DOI:10.1109/SITIS.2015.119

Gerovasileiou, V., Dailianis, T., Panteri, E., Gatti, G., Issaris, Y., Sini, M., Salomidi, M., Dimitriadis, C., Michalakis, N., Dogan, A., Thierry de Ville d'Avray, L., David, R., Çinar, M.E., Koutsoubas, D., Arvanitidis, C. & J.-P. Féral: Establishing a citizen science initiative for the mapping and monitoring of coralligenous assemblages in the Mediterranean Sea, 13th International Congress of Zoogeography and Ecology of Greece and Adjacent Regions, Heraklion, Greece, 7-11 October 2015, Poster

Panteri E., Arvanitidis C., Bailly N., Dailianis T., Faulwetter S., Gerovasileiou V. & N. Michalakis: Citizen Science initiatives in the Mediterranean basin. EGI [European Grids Infrastructure] Conference 2015, Lisbon, Portugal, 18-22 May 2015, Oral

Sevastou K., Papadopoulou N., Smith C., Teixeira H., Piroddi C., Katsanevakis S., Féral J.-P., Chenuil A., David R., Kiriakopoulou N., Cochrane S. 2015 Defining keystone species in European regional seas: what are the candidates for the Mediterranean? 11th Panhellenic Symposium on Oceanography and Fisheries, Mytilene, Lesvos island, Greece, 13-17 May 2015, pp. 553-556.

2014

Çinar M.E., Féral J.-P., Arvanitidis C., David R., Taşkın E., Dailianis T., Doğan A., Gerovasileiou V., Dağlı E., Aysel V., Bakır K., Salomidi M., Sini M., Açık S., Dimitriadis C., Koutsoubas D., Önen S. 2014. Preliminary assessment of macrobenthic assemblages of coralligenous habitats across the Mediterranean Sea. Proceedings RAC/SPA 2nd MEditerranean Symp. on the Conservation of coralligenous and other calcareous bio-concretions, Portorož (SIovenia), 29-30 October 2014, pp. 207-208

Dailianis T., Crowd sourcing initiatives in the Mediterranean basin, Citizens Observatories: Empowering European Society - Open Conference, 2014 December 4th, Brussels, Belgium.

David R., Dubois S., Erga Z., Guillemain D., Thierry de Ville d'Avray L., Arvanitidis C., Çinar M., Sartoretto S., Zuberer F., Chenuil A., Féral J.-P. 2014 CIGESMED.'s protocol and network (Coralligenous basEd. Indicators to evaluate and monitor the "Good Environmental Status" of MEd.iterranean coastal waters). Proceedings 5th Intn. Symposium Monitoring of Mediterranean coastal areas: problems and measurement techniques, Livorno (Italy) 17-19 June 2014, F. Benincasa (Ed.), pp. 828-843; CNR-IBIMET: Florence (IT), ISBN 978-88-95597-19-5

David R., Arvanitidis C., Çinar M.E., Sartoretto S., Dogan A., Dubois S., Erga Z., Guillemain D., Thierry de Ville d'avray L., Zuberer F., Chenuil A., Féral J.-P., CIGESMED. Protocols: how to implement a multidisciplinary approach on a large scale for coralligenous habitats surveys.ProceedingsRAC/SPA 2nd Mediterranean Symp. on the Conservation of coralligenous and other calcareous bio-concretions, Portorož (SIovenia), 29-30 October 2014, pp. 66-71

David R., Arvanitidis C., Çinar M.E., Sartoretto S., Doğan A., Dubois S., Erga Z., Guillemain D., Thierry de Ville d'Avray L., Zuberer F., Chenuil A., Féral J.-P., CIGESMED habitat's characterization: a simple and reusable typology at the Mediterranean scale. RAC/SPA 2nd MEditerranean Symp. on the Conservation of coralligenous and other calcareous bio-concretions, Portorož (SIovenia), 29-30 October 2014, pp. 211-212

Féral J.-P., Arvanitidis C., Chenuil A., Çinar M.E., David R., Frémaux A., Koutsoubas D., Sartoretto S., Coralligenous basEd. Indicators to evaluate and monitor the « Good Environmental Status » of the MEDiterranean coastal waters, a SeasEra project. (*invited plenary*) ProceedingsRAC/SPA 2nd Mediterranean Symp. on the Conservation of coralligenous and other calcareous bio-concretions, Portorož (SIovenia), 29-30 October 2014, pp. 15-21

Panteri E., Faulwetter S., Arvanitidis C., Dailianis T., Chatzigeorgiou G, Chatzinikolaou E., Pafilis E., Pavloudi C., Uher T, D Rycroft S., Kroupa A., Smith V., Penev L., Baker E., Féral J.-P., Romain R. Crowd Sourcing Initiatives in the Mediterranean Basin, The 2014 Biodiversity Information TDWG Annual Conference, 26 - 31 October 2014; Jönköping, Sweden

Sartoretto S., David R., Aurelle D., Chenuil A., Guillemain D., Thierry de Ville d'Avray L., Féral J.-P., Çinar M.E., Kipson S., Arvanitidis C., Schohn T., Daniel B., Sakher S., Garrabou J., Gatti G., Ballesteros E., An integrated approach to evaluate and monitor the ecological status of coralligenous bottoms: the Index-Cor method. ProceedingsRAC/SPA 2nd Mediterranean Symp. on the Conservation of coralligenous and other calcareous bio-concretions, Portorož (SIovenia), 29-30 October 2014, pp. 159-164

Thierry De Ville d'Avray L., David R., Guillemain D., Arvanitidis C., Chenuil A., Çinar M.E., Sartoretto S., Féral J.-P. 2014. CIGESMED: Coralligenous populations study based on spatial variability of habitat profiles, by the mean of photo-quadrats and image processing software (PhotoQuad), Intn. Mediterranean Conservation Sciences Conference, Tour du Valat.

2013

David R. 2013, Ensuring coherent networks of MPAs: WS5A3 instrument and actions in the European water: « Currently discussed MPA improvement and new solutions for the Mediterranean Sea: information management with the example of coralligenous hábitat.3rd International marine protected areas congress, October 21-27 2013, Marseille

Gatti G., Sartoretto S. 2013. Evaluating quality of coralligenous assemblages: preliminary results of the rapid visual assessment method.40thCIESM congress proceedings, October 28th-November 1st 2013, Marseille, France

Posters

2016

David R., Féral J.-P., Archambeau A.-S., Bernard L., Blanpain C., Dias A., Gachet S., Gilbert K., Lecubin J., Leydet M., Romier G., Surace C. 2016. Projet IndexMed: des réponses originales à l'hétérogénéité des données écologiques en Méditerranée; Colloque LITEAU, Observation et recherche en appui aux politiques du littoral et de la mer. Brest, France, 14-15 January 2016, poster, p. 47

Gatti G., Dimitriadis C., Gerovasileiou V., Dailianis T., Panteri E., Issaris Y., Sini M., Salomidi M., Michalakis N., Doğan A., Thierry de Ville d'Avray L., David R., Çinar M.E., Koutsoubas D., Arvanitidis C., Féral J.-P. Citizen Science for CIGESMED: involving divers in marine biological monitoring. 51st European M**arine Biology Symposium, EMBS**, Rhodes, Greece, 26-30 September 2016, poster.

Gatti G., Dimitriadis C., Gerovasileiou V., Dailianis T., Panteri E., Issaris Y., Sini M., Salomidi M., Michalakis N., Doğan A., Thierry de Ville d'Avray L., David R., Çinar M.E., Koutsoubas D., Arvanitidis C., Féral J.-P. Citizen Science for CIGESMED: involving divers in marine ecological monitoring. Sfé 2016, Intn. Conference on Ecological Sciences, 24-28 October 2016, Marseille, poster.

Gatti G., Dimitriadis C., Gerovasileiou V., Dailianis T., Panteri E., Issaris Y., Sini M., Salomidi M., Michalakis N., Doğan A., Thierry de Ville d'Avray L., David R., Çinar M.E., Koutsoubas D., Arvanitidis C., Féral J.-P. Citizen Science for CIGESMED, or how to engage divers in marine ecological monitoring: first steps of a new project. 1st European Citizen Science Association Conference, Berlin, Germany, 19-21 May 2016, poster.

2015

De Jode A., Dubois S., Erga Z., David R., Guillemain D., Féral J.-P., Zuberer F., Chenuil A. 2015. Understanding ecological functioning of coralligenous habitats, and building New Indicators based on genetic tools to assess their GES (good environmental status), Conference Aix-Marseille et la Méditerranée: défis et coopérations scientifiques, February 2015, 12th

David R., Arvanitidis C., Çinar M.E., Koustoubas D., Sartoretto S., Chenuil A., Féral J.-P. 2015. Défis et coopérations scientifiques concernant les habitats marins méditerranéens « coralligènes » dans le cadre du programme européen CIGESMED, Conference Aix-Marseille et la Méditerranée: défis et coopérations scientifiques, February 2015, 12th

David R., Arvanitidis C., Çinar M.E., Sartoretto S., Koutsoubas D., Chenuil A., Gatti G., Féral J.-P., with contributors. Challenges and scientific cooperation for the study of mediterranean coralligenous habitats: CIGESMED European program. 13th European Ecological Federation (EEF) and 25thItalian Ecological Society joint conference, Rome, Italy, 21-25 September 2015.

2014

Çinar M.E., Féral J.-P., Arvanitidis C., David R., Taşkın E., Dailianis T., Doğan A., Gerovasileiou V., Dağlı E., Aysel V., Issaris Y., Bakir K., Salomidi M., Sini M., Acik S., Evcen A., Dimitriadis C., Koutsoubas D., Sartoretto S., Önon S. 2014. CIGESMED or how to integrate combined scientific and amateur large sets of heterogeneous data on coralligenous habitats for the effective evaluation of the "Good Environmental Status" of the Mediterranean Sea?, RAC/SPA 2nd Mediterranean Symp. on the Conservation of coralligenous and other calcareous bio-concretions, Portorož (SIovenia), 29-30 October 2014

David R. 2014. Field methods to improve datasets on coralligenous habitats for the effective evaluation of the "Good Environmental Status" of the Mediterranean Sea?5th Intn. Symposium Monitoring of Mediterranean coastal areas: problems and measurement techniques, Livorno (Italy) 17-19 June 2014

David R. 2014. Ideas about information management for multidisciplinary network observatory, Rencontre annuelle de l'OHM Littoral Méditerranéen; Marseille, France, March 2014, 25th.

Dubois S., David R., Chenuil A., Féral J.-P. 2014. CIGESMED: Genetic structure population of the bryozoan Myriaporatruncata, builder and component of the coralligenous, Intn. Mediterranean Conservation Sciences Conference for the young scientists, La Tour du Valat, 28-30 April 2014.

Erga Z., David R., Chenuil A., Féral J.-P. 2014. CIGESMED: Cryptic species and genetic structure population of the corallinale complex of species Lithophylum cabiochae/stichtaeforme, builder and component of the coralligenous, Intn. Mediterranean Conservation Sciences Conference for the young scientists, La Tour du Valat, 28-30 April 2014

Erga Z., David R., De Jode A., Verlaque M., Dubois S., Le Gall L., Guillemain D., Zuberer F., Féral J.P., Chenuil A. 2014. Strong genetic structure in Lithophyllum cabiochiae/stictaeforme around Marseilles. Local adaptation, niche differentiation or just lack of connectivity? Annual conference of French Phycology Society, 2014, November 24th, Paris, France

Erga Z., David R., Guillemain D., Zuberer F., Dailianis T., Gerovasileiou V., Sini M., Koutsoubas D., Verlaque M., Féral J-P., Chenuil A. 2014. Distribution of genetic diversity within Lithophyllum stictaeforme/cabiochiae in the NW Mediterranean, 7th National Conference of the Hellenic Ecological Society (HELECOS), Helecos, Greece, 9-12 October 2014

Guillemain D., David R., De Ville d'Avray L., Féral J.-P. 2014. CIGESMED: Implementation of coralligenous habitats characterization protocols for the effective evaluation of the good environmental status of the Mediterranean Sea. Cartography of coralligenous habitats by profiles surveys, Intn. Mediterranean Conservation Sciences Conference for the young scientists, La Tour du Valat, 28-30 April 2014.

Thierry de Ville d'Avray L., Ami D., Chenuil A., David R., Féral J.-P. 2014. How food security can be linked to the ecological and economic status of the coralligenous habitats of the Mediterranean Sea? 3rdIntn. Conference on Biodiversity and the UN Millennium Development Goals: Biodiversity and Food Security - From Trade-offs to Synergies, 29-31 October 2014, Aix-en-Provence, France.

EVENT (OUTREACH)

Presentation of CIGESMED project in various meetings:

Meeting	Date	Place	Audience
Biodiversity Informatics 2013	09/05/2013	Rome, Italy	Scientific Community, >50 participants
International Polychaeta Conference	12/08/2013	Sydney, Australia	Scientific Community, >50 participants
Kick-off meeting of EMODNET	18/09/2013	Ostend, Belgium	Scientific Community, <50 participants
National Strategy for protected species	01/10/2013	Ankara, Turkey	Scientific Community / Stakeholders, <50 participants
EMBOS meeting	16/10/2013	Riga, Latvia	Scientific Community, <50 participants

3rd International marine protected areas congress	21-27/10/2013	Marseille, France	Scientific Community / Stakeholders, >50 participants
40th CIESM congress	28/10-01/11/2013	Marseille, France	Scientific Community / Stakeholders, >500 participants
VECTORS annual assembly	05-07/11/2013	Athens, Greece	Scientific Community / Stakeholders, >50 participants
EMBOS meeting	20-22/11/2013	Anavyssos, Greece	Scientific Community, <50 participants
EU BON WP3, 4	25-27/11/2013	Solsona, Spain	Scientific Community, <50 participants
LifeWatch Board	28-29/11/2013	Lecce, Italy	Scientific Community, <50 participants
OBIS Steering Group meeting	04-06/12/2013	Ostend, Belgium	Scientific Community, <50 participants
MAPMED SC meeting	05-07/12/2013	El Alamein, Egypt	Scientific Community, <50 participants
EuroLag Conference	16-19/12/2013	Lecce, Italy	Scientific Community, <50 participants
ViBRANT meeting	29/01/2014	Brussels, Belgium	Scientific Community, <50 participants
Vigie Mer Steering Committee on participative sciences or marine habitat	10/02/2014	Aix-en-Provence, France	Policy community, <50 participants
LifeWatch Technical Meeting	03-04/02/14	Granada, Spain	Scientific Community, <50 participants
EMBOS meeting	18-20/02/14	Oristano, Italy	Scientific Community, <50 participants
Annual meeting OHM Littoral Méditerranéen	25/03/2014	Marseille, France	Scientific Community, <50 participants
Species under protection	01/04/2014	Ankara, Turkey	Scientific community, <50 participants
Indexmed: interoperability of ecological data bases	05/06/2014	Marseille, France	Scientific community, >50 participants
Open Repositories 2014	09-13/06/2014	Helsinki, Finland	Scientific community, 500 participants
5th International Symposium Monitoring of Mediterranean coastal areas: problems and measurement techniques	17-19/06/2014	Livorno, Italy	Scientific community, 150 participants
The 2014 Biodiversity Information TDWG Annual Conference	26-31/10/2014	Jönköping, Sweden	Scientific community, 200
13th International Congress of Zoogeography and Ecology of Greece and Adjacent Regions	7-11/10/2015	Heraklion, Greece	Scientific community, 100 participants
7th National Conference of the Hellenic Ecological Society (HELECOS)	09-12/10/2014	Mytilene, Lesvos island, Greece	Scientific community, 100 participants
RAC/SPA 2nd Mediterranean Symposium on the Conservation of coralligenous and other calcareous bio-concretions	29-30/10/2014	Portorož, Slovenia	Scientific community, stakeholders, end users, 100 participants
3rd International Conference on Biodiversity and the UN Millennium Development Goals : Biodiversity and Food Security	29-31/10/2014	Aix-en-Provence, France	Scientific community, , stakeholders >200 participants
Annual conference of French Phycology Society	24/11/2014	Paris, France	Scientific community, 200 participants

2nd EU BON Stakeholder Roundtable	27/11/2014	Berlin, Germany	Scientific community, >50 participants
Ministry of Environments and Urbanization	20/12/2014	Ankara, Turkey	Turkish Ministry of Environments and Urbanization, <50 participants
Aix-Marseille et la Méditerranée: défis et coopérations scientifiques	12/02/2015	Marseille, France	Scientific community, general public and stakeholders, 200 attendants.
11th Panhellenic Symposium on Oceanography and Fisheries	13-17/05/2015	Mytilene, Lesvos island, Greece	Scientific community, 100 participants
EGI [European Grids Infrastructure] Conference 2015	18-22 May 2015	Lisbon, Portugal	Scientific community, stakeholders, > 300 participants
Divers' Association of Thessaloniki, Greece	05/08/2015	Thessaloniki, Greece	General public and stakeholders, ca. 30 attendants
Research expedition in Jbel Moussa Presentation of the CIGESMED for divers CS initiative and CIGESMED protocols in the framework of MedKeyhabitats Project (UNEP/MAP-RAC/SPA)	07-14/09/2015	Morroco	Scientific community, ca. 20 attendants.
The 2015 Biodiversity Information TDWG Annual Conference	28/09-01/10/2015	Nairobi, Kenya	Scientific community; stakeholders, end users, 300 attendants
11th International Conference on Signal-Image Technology & Internet-Based Systems (SITIS)	23-27/11/2015	Bangkok, Thailand	Scientific community (mostly computer sciences), 200 attendants
Colloque LITEAU, Observation et recherche en appui aux politiques du littoral et de la mer	14-15/01/2016	Brest, France	Scientific community, > 200 participants
8th International Congress on Environmental Modelling and Software	11-13/07/2016	Toulouse, France	Scientific community, 200 participants
51st European Marine Biology Symposium, EMBS	26-30/09/2016	Rhodes, Greece	Scientific community, >100
ACO 2016 - A connected ocean: new approaches, new technologies, new challenges for knowledge of ocean processes	11-13/10/2016	Brest, France	Stackholders, Scientific community, 1400 participants
International Conference on Ecological Sciences-Sfé 2016	24-27/10/2016	Marseille, France	Scientific community; stakeholders, end users, 600 attendants
The 2016 Biodiversity Information TDWG Annual Conference	5-9/12/2016	Santa Clara de San Carlos, Costa Rica	Scientific community; stakeholders, end users, xx attendants

WEBSITES

http://www.cigesmed.eu

http://cs.cigesmed.eu (Citizen Science)

2/2016-today: ongoing dissemination of the CIGESMED for divers CS initiative through Facebook

MEETINGS & WORKSHOPS

CIGESMED' meeting were hosted by the 3 participant countries.

17-19 April 2013: Kickoff in Heraklion (Greece)

June 2013: Field trip to intercalibrate photographic methods Marseille (France)

6-9 May 2014: First annual meeting and general assembly, Izmir (Turkey)

21 October 2014: First Committee of External Advisers in Marseille (France)

19-22 May 2015: Second annual meeting, general assembly and Committee of External Advisers, Mytilini (Greece)

14-16 December 2015: Working group on scientific papers to be published, Marseille (France)

17-18 December 2015: Working group on **how to enlarge the disciplinary spectrum** preparing answers to the next calls for proposals (H2020, ANR, etc.) Marseille, (France)

27-29 June 2016: final meeting in Marseille (France).

9. SPECIES LIST

The list of coralligenous species and their relative abundance at coralligenous stations of France, Turkey and Greece [1 = low (rare or isolated individuals), 10 = average (dispersed population), 100 = abundant (abundant and dense population)] *Alien species. TR: Turkey, GR: Greece, FR: France

Countries		FRANCE				GREECE		TURKEY			
	Species/Stations	**FTF**	**RMO**	**MEJ**	**LPD**	**KOR**	**ZAK**	**TC1**	**TC2**	**TF1**	**TF2**
	CHLOROPHYTA										
TR	*Anadyomene stellata* (Wulfen) C.Agardh, 1823								1		
TR,FR	**Caulerpa cylindracea* Sonder, 1845	1						10	10		
GR	*Cladophora pellucida* (Hudson) Kützing, 1843						10				
TR	*Cladophora* sp.							1	1		
FR,GR,TR	*Codium bursa* (Olivi) C.Agardh, 1817	100	10	10	10		1		10		
FR	*Codium coralloides* (Kützing) P.C.Silva, 1960	1	1	1	1						
FR,GR	*Codium effusum* (Rafinesque) Delle Chiaje, 1829	1	1	1			10				
FR	*Codium vermilara* (Olivi) Delle Chiaje, 1829				1						
TR	*Derbesia tenuissima* (Moris & De Notaris) P.L.Crouan & H.M.Crouan, 1867								1	1	
FR,TR	*Flabellia petiolata* (Turra) Nizamuddin, 1987	100	100					10	10		
FR,TR	*Halimeda tuna* (J.Ellis & Solander) J.V.Lamouroux, 1816	10	100	10	10			1	1		
FR,GR,TR	*Palmophyllum crassum* (Naccari) Rabenhorst, 1868	10	10	10		1	100	10	10	10	10
TR	*Pedobesia simplex* (Meneghini ex Kützing) M.J.Wynne & Leliaert, 2001							1	1	1	10
FR,TR	*Pseudochlorodesmis furcellata* (Zanardini) Børgesen, 1926	100	1	1	1			1	1		
FR	*Valonia macrophysa* Kützing, 1843		1								
TR	*Valonia utricularis* (Roth) Agardh, 1823								1		
	PHAEOPHYCEAE										
FR	*Colpomenia sinuosa* (Mertens ex Roth) Derbès & Solier, 1851	1		1							
TR	*Cutleria chilosa* (Falkenberg) P.C.Silva, 1957									1	
FR	*Cystoseira amentacea* (C.Agardh) Bory de Saint-Vincent, 1832	10	10								
FR	*Dictyopteris polypodioides* (A.P.De Candolle) J.V.Lamouroux, 1809				1						
FR,GR,TR	*Dictyota dichotoma* (Hudson) J.V.Lamouroux, 1809	10	10		1		1		1		
FR	*Dictyota fasciola* (Roth) J.V.Lamouroux, 1809	10	10								
TR,GR	*Halopteris* spp.						10	1	1		
TR	*Lobophora variegata* (J.V.Lamouroux) Womersley ex E.C.Oliveira, 1977							1	1	1	
FR,TR	*Padina pavonica* (Linnaeus) Thivy, 1960	100	100	100	10			1	1		
TR	**Stypopodium schimperi* (Kützing) M.Verlaque & Boudouresque, 1991							1			
TR	*Zanardinia typus* (Nardo) P.C.Silva, 2000							1		1	
	RHODOPHYTA										
TR	*Acrodiscus vidovichii* (Meneghini) Zanardini, 1868									1	
FR,TR	*Amphiroa rigida* J.V.Lamouroux, 1816	1							1	100	1
TR	*Amphiroa beauvoisii* J.V.Lamouroux, 1816									1	

GR,TR	*Amphiroa cryptarthrodia* Zanardini, 1844						10		1	1	10
FR	*Chrysymenia ventricosa* (J.V.Lamouroux) J.Agardh, 1842	1			1						
TR	*Dasya rigidula* (Kützing) Ardissone, 1878								1		
FR	*Ellisolandia elongata* (J.Ellis & Solander) K.R.Hind & G.W.Saunders, 2013	10	1								
TR	*Gelidium serra* (S.G.Gmelin) E.Taskin & M.J.Wynne 2013									1	
FR	*Halymenia elongata* C.Agardh, 1822	1	1								
FR	*Halymenia floresii* (Clemente) C.Agardh, 1817	1									
TR	*Hildenbrandia* sp.									1	
TR	*Irvinea boergesenii* (Feldmann) R.J.Wilkes, L.M.McIvor & Guiry, 2006							1	1	1	
TR	*Jania adhaerens* J.V.Lamouroux, 1816							1	1	1	
TR	*Jania rubens* (Linnaeus) Lamouroux, 1816								1		
FR	*Jania* sp.	1									
TR	*Kallymenia microphylla* J.Agardh, 1851							1			
FR	*Liagora viscida* (Forsskål) C.Agardh, 1822	1	1								
TR	*Lithothamnion crispatum* Hauck, 1878								1	1	
FR,TR	*Lithophyllum stictaeforme* (Areschoug) Hauck, 1877	100	10	10	10					1	
GR,TR	*Lithophyllum* sp.					1	100	1	1	1	1
TR	*Meredithia microphylla* (J.Agardh) J.Agardh, 1892							1			
FR,TR	*Mesophyllum alternans* (Foslie) Cabioch & M.L.Mendoza, 1998	10	10		10			100	100	10	10
FR,TR	*Mesophyllum expansum* (Philippi) Cabioch & M.L.Mendoza, 2003	100	10		10			1		100	100
TR	*Mesophyllum lichenoides* (J.Ellis) Me.Lemoine, 1928							1	1	1	1
GR,TR	*Mesophyllum* sp.					1	100		1		1
GR,TR	*Neogoniolithon mamillosum* (Hauck) Setchell & L.R.Mason, 1943					10	10			1	
TR	*Nitophyllum punctatum* (Stackhouse) Greville, 1830									1	
TR	*Peyssonnelia dubyi* P.L.Crouan & H.M.Crouan, 1844							100	100	10	10
TR	*Peyssonnelia polymorpha* (Zanardini) F.Schmitz, 1879							1	1	100	100
FR,GR,TR	*Peyssonnelia rosa-marina* Boudouresque & Denizot, 1973	10	1				10			1	
FR,GR,TR	*Peyssonnelia rubra* (Greville) J.Agardh, 1851	10						1	10	10	1
FR,GR,TR	*Peyssonnelia squamaria* (S.G.Gmelin) Decaisne, 1842	1	1				100	100	100	100	100
TR,FR,GR	*Peyssonnelia* spp.	100	10		10	100	100				
TR	*Rodriguezella strafforelloi* F.Schmitz ex J.J.Rodríguez y Femenías, 1895									1	
FR,TR	*Sphaerococcus coronopifolius* Stackhouse, 1797	1	1	1	1			1			
FR,TR	*Tricleocarpa fragilis* (Linnaeus) Huisman & R.A.Townsend, 1993	100								1	
GR	Rhodophyta (spp.)					10	100				
	FORAMINIFERA										
GR,TR	*Miniacina miniacea* (Pallas, 1766)					10	100	10	1	10	1
TR	**Amphistegina lobifera* Larsen, 1976							10	10	1	
	PORIFERA										
FR,GR,TR	*Acanthella acuta* Schmidt, 1862	1	1	1		1		1	10	10	10
FR,GR,TR	*Agelas oroides* (Schmidt, 1864)	10	10	1	1	100	100	100	100	100	100
TR	*Aplysina aerophoba* Nardo, 1833								10		10
FR,TR	*Aplysina cavernicola* (Vacelet, 1959)	1						100	1		1

GR	*Aplysilla rosea* (Barrois, 1876)					1					
FR,TR	*Aplysilla sulfurea* Schulze, 1878	1						10	1	1	1
GR,TR	*Axinella cannabina (Esper, 1794)*					10		10	10	10	10
FR,GR,TR	*Axinella damicornis* (Esper, 1794)	10	10	10		10	10	10	1		
FR,TR	*Axinella polypoides* Schmidt, 1862				1			10	10	1	1
FR	*Axinella verrucosa* (Esper, 1794)	1	10	1							
GR,TR	*Axinella* spp.						1			1	
GR,TR	*Cacospongia mollior* Schmidt, 1862						10	1			
FR	*Cacospongia* spp.	10	1	1							
TR	*Calyx nicaeensis* (Risso, 1826)							1			
GR,TR	*Corticium candelabrum* Schmidt, 1862					1		1			
TR	*Chondrilla nucula* Schmidt, 1862								10		
FR,GR,TR	*Chondrosia reniformis* Nardo, 1847	10	10	1		100	100	1	10	1	1
GR,TR,FR	*Crambe crambe* (Schmidt, 1862)	10	10	10	1		100	100	100	100	100
FR,TR	*Clathrina clathrus* (Schmidt, 1864)	10	10	10				1	1		
FR	*Clathrina lacunosa* (Johnston, 1842)			1							
GR,TR	*Cliona celata* Grant, 1826					1	10	10	10	1	1
GR,TR	*Cliona schmidti* (Ridley, 1881)					1	10	10	1	0	1
FR,GR,TR	*Cliona viridis* (Schmidt, 1862)	10	10	10		1	100	1	10	1	1
TR	*Crella* sp.										1
GR	*Dendroxea lenis* (Topsent, 1892)						10				
GR	*Dictyonella incisa* (Schmidt, 1880)					1	1				
FR	*Dictyonella* spp.	10	1								
TR	*Dysidea avara* (Schmidt, 1862)									1	
FR,GR,TR	*Dysidea fragilis* (Montagu, 1814)		1			1	100	10	10	1	1
TR	*Erylus discophorus* (Schmidt, 1862)								1		
TR	*Geodia cydonium* Schmidt, 1862							1	1		
GR	*Fasciospongia cavernosa* (Schmidt, 1862)						1				
TR	*Haliclona* (*Reniera*) *cinerea* Grant, 1826									1	
FR,GR,TR	*Haliclona (Halichoclona) fulva* (Topsent, 1893)	1	1			10	100	10	10		10
FR,GR	*Haliclona* (*Soestella*) *mucosa* (Griessinger, 1971)	1	1			1	10				
GR,TR	*Haliclona* sp.						1		1	1	1
FR,GR	*Hemimycale columella* (Bowerbank, 1874)	1	1		1		10				
GR	*Hexadella pruvoti* Topsent, 1896					1					
FR,GR,TR	*Hexadella racovitzai* Topsent, 1896	1	1	1		1			1		
FR	*Hippospongia* spp.	1									
GR,TR	*Ircinia variabilis* (Schmidt, 1862)					10		1			1
GR,TR	*Ircinia* sp.						1		1		
GR	*Merlia* sp.						10				
TR	*Mycale* sp.										1
FR	*Myceliospongia araneosa* Vacelet & Perez, 1998	1	1								
GR	*Oscarella balibaloi* Pérez, Ivanisevic, Dubois, Pedel, Thomas, Tokina & Ereskovsky, 2011					100					
FR	*Oscarella lobularis* (Schmidt, 1862)	1	1								
GR	*Oscarella imperialis* Muricy, Boury-Esnault, Bézac & Vacelet, 1996						10				
FR,GR	*Oscarella tuberculata* (Schmidt, 1868)	10	1			1					
GR	*Penares* sp.						100				

FR,GR,TR	*Petrosia* (*Petrosia*) *ficiformis* (Poiret, 1789)	10	10	1	1	1	1	1	1	1	10
FR,GR,TR	*Phorbas tenacior* (Topsent, 1925)	10	10	1		10	10	100	100		10
TR	*Phorbas fictitius* (Bowerbank, 1866)								1	1	
TR	*Phorbas* sp.							1			
FR,GR,TR	*Pleraplysilla spinifera* (Schulze, 1879)	1				10	100	10	10	10	
GR,TR	*Prosuberites longispinus* Topsent, 1893					1		1			
GR,TR	*Terpios gelatinosa* (Bowerbank, 1866)					1	10	1	1	1	1
TR	*Tethya aurantium* (Pallas, 1766)								1		
TR	*Sarcotragus* sp.							1			
GR,TR	*Sarcotragus foetidus* Schmidt, 1862						10	10	1	1	
GR,TR	*Sarcotragus spinosulus Schmidt, 1862*						1	1	1		
FR,TR	*Scalarispongia scalaris* (Schmidt, 1862)		1					1			
GR,TR,FR	*Spirastrella cunctatrix* Schmidt, 1868	10	10	10	1	100	100	100	100	10	100
FR	*Spongia* (*Spongia*) *lamella* (Schulze, 1879)	1	1								
FR,GR,TR	*Spongia* (*Spongia*) *officinalis* Linnaeus, 1759	1	1		1	1		1	1	1	
TR	*Suberites domuncula* (Olivi, 1792)								1		
TR	Porifera (spp.)							1			
	CNIDARIA										
FR	*Aglaophenia* spp.	1	1								
FR,TR	*Aiptasia mutabilis* (Gravenhorst, 1831)	1	1	1				1			
FR	*Alcyonium acaule* Marion, 1878	10		1							
FR	*Alcyonium coralloides* (Pallas, 1766)	10	10	1							
FR	*Alicia mirabilis* Johnson, 1861			1							
FR	*Anemonia viridis* (Forsskål, 1775)	10	10	1							
FR	*Balanophyllia* (*Balanophyllia*) *europaea* (Risso, 1826)	10	10								
FR,GR,TR	*Caryophyllia* (*Caryophyllia*) *inornata* (Duncan, 1878)	10	10			100	10	1		1	
FR,TR	*Caryophyllia* (*Caryophyllia*) *smithii* Stokes & Broderip, 1828	10						1			
FR	*Cereus pedunculatus* (Pennant, 1777)	1	1	1							
FR,TR	*Cerianthus membranaceus* (Spallanzani, 1784)	1	1	1	1				1	1	
FR	*Cladocora caespitosa* (Linnaeus, 1767)			1							
FR	*Corallium rubrum* (Linnaeus, 1758)	10	10	10							
FR	*Corynactis viridis* Allman, 1846	1									
FR	*Cribrinopsis crassa* (Andrès, 1881)	1		1							
FR,TR	*Eudendrium* spp.	10						1			
FR	*Eunicella cavolini* (Koch, 1887)	10	10	10	1						
FR	*Eunicella singularis* (Esper, 1791)	10	10	10							
FR	*Eunicella verrucosa* (Pallas, 1766)		1	1							
FR,GR,TR	*Hoplangia durotrix* Gosse, 1860	10	10			100		100	10	10	100
FR	*Leptogorgia sarmentosa* (Esper, 1789)			1							
FR,GR,TR	*Leptopsammia pruvoti* Lacaze-Duthiers, 1897	10	10	10		1	100	100	100	10	10
GR,TR	*Madracis pharensis* (Heller, 1868)	10	10			10	10	10	10		10
FR	*Paramuricea clavata* (Risso, 1826)	100	100	100							
FR,TR	*Parazoanthus axinellae* (Schmidt, 1862)	10	10	10	10			10	1		
GR,TR	*Polycyathus muellerae* (Abel, 1959)					10	1	1			
FR,TR	*Phyllangia americana mouchezii* (Lacaze-Duthiers, 1897)	1	1							1	
FR	*Epizoanthus paxii* Abel, 1955	1									
GR	Hydrozoa (spp.)						1				
GR	Scleractinia (spp.)						10				

	PLATYHELMINTHES										
FR	*Prostheceraeus moseleyi* Lang, 1884		1								
FR	*Prostheceraeus roseus* Lang, 1884		1								
FR	*Prostheceraeus* spp.	1									
FR	*Pseudobiceros splendidus* (Lang, 1884)	1									
FR	*Yungia aurantiaca* (Delle Chiaje, 1822)	1									
	ECHIURA										
FR,TR	*Bonellia viridis* Rolando, 1821	100	100	10	10			1	1	1	1
	POLYCHAETA										
GR,TR	*Hermodice carunculata* (Pallas, 1766)					10	10	1	1	1	1
TR	**Eurythoe complanata* (Pallas, 1766)									1	1
FR,TR	*Eupolymnia nebulosa* (Montagu, 1818)	10	10	10	10			1			
FR,GR,TR	*Bispira volutacornis* (Montagu, 1804)				1		1	1			
GR	*Myxicola infundibulum* (Montagu, 1808)						1				
TR	*Myxicola aesthetica* (Claparède, 1870)							1		1	
FR	*Sabella pavonina* Savigny, 1822	1		1	1						
FR,GR,TR	*Sabella spallanzanii* (Gmelin, 1791)	10	1	1	1		1	1		1	1
GR	Serpulidae (sp.)					1	10				
GR,TR,FR	*Salmacina* spp. / *Filograna* spp.					1	1		1		
GR,TR,FR	*Protula tubularia* (Montagu, 1803)	10	10	1			10	1	1	1	1
FR,TR	*Serpula vermicularis* Linnaeus, 1767	1	1	1				1	1	1	
	CRUSTACEA										
FR,GR,TR	*Dardanus calidus* (Risso, 1827)	1					1	1			
TR	*Dromia personata* (Linnaeus, 1758)							1			
FR	*Inachus phalangium* (Fabricius, 1775)	1									
TR,FR	*Palinurus elephas* (Fabricius, 1787)	1	1					1	1		
FR,GR,TR	*Scyllarides latus* (Latreille, 1803)				1		1			1	
FR,TR	*Scyllarus arctus* (Linnaeus, 1758)		1							1	
TR	*Stenopus spinosus* Risso, 1827							1		1	
	MOLLUSCA										
	Gastropoda										
FR	*Aplysia* spp.	1	1								
FR	*Caloria elegans* (Alder & Hancock, 1845)	1									
FR	*Cerithium* spp.				1						
FR,TR	*Cratena peregrina* (Gmelin, 1791)	1						1			
FR	*Doris verrucosa* Linnaeus, 1758	1									
FR	*Felimare orsinii* (Vérany, 1846)	1	1								
FR,TR	*Felimare picta* (Schultz in Philippi, 1836)	1	1							1	
FR	*Felimare tricolor* (Cantraine, 1835)	10	1	1							
FR	*Felimare villafranca* (Risso, 1818)			1							
FR,GR,TR	*Flabellina affinis* (Gmelin, 1791)	1					1	1			
FR,TR	*Janolus cristatus* (Delle Chiaje, 1841)	1	1						1		
FR	*Thuridilla hopei* (Vérany, 1853)				1						
GR	*Thylacodes arenarius* (Linnaeus, 1758)						1				
FR	*Haliotis tuberculata lamellosa* Lamarck, 1822	1	1								
GR,TR	*Peltodoris atromaculata* Bergh, 1880						1	1		1	
TR	*Phyllidia flava* Aradas, 1847								1		1
	Bivalvia										

FR,TR,GR	*Lithophaga lithophaga* (Linnaeus, 1758)	10	10	10	1	1	100	10	10	10	10
GR	*Ostrea* sp.					1					
GR,TR	*Rocellaria dubia* (Pennant, 1777)					10	10	10	100	10	100
	Cephalopoda										
FR,TR	*Octopus vulgaris* Cuvier, 1797	10	10	1	1			1		1	
	BRYOZOA										
FR	*Adeonella calveti* (Canu & Bassler, 1930)	10	10	1							
FR	*Adeonella pallasii* (Heller, 1867)			1							
GR	*Beania magellanica* (Busk, 1852)						10				
FR,TR	*Caberea boryi* (Audouin, 1826)	1								1	
GR	*Cellaria* sp.					1					
GR	*Cellepora* sp.						1				
TR	*Celleporina caminata* (Waters, 1879)							1	1		
FR	*Dentiporella sardonica* (Waters, 1879)	10	10	1							
FR	*Idmidronea* spp.			1							
FR,GR	*Myriapora truncata* (Pallas, 1766)	100	100	10	10		100				
FR	*Pentapora fascialis* (Pallas, 1766)	10	10	10							
GR,TR	*Reptadeonella violacea* (Johnston, 1847)						100	1			
FR	*Reteporella* spp.	10	10	10							
GR	*Rhynchozoon neapolitanum* Gautier, 1962					100	100				
FR,GR,TR	*Schizomavella* (*Schizomavella*) *mamillata* (Hincks, 1880)	10	10	10	10	100	100	10	10	1	10
GR	*Schizoretepora serratimargo* (Hincks, 1886)					1					
TR	*Scrupocellaria* sp.										1
FR	*Smittina cervicornis* (Pallas, 1766)	1	1		1						
FR	*Turbicellepora avicularis* (Hincks, 1860)	10	10	10							
GR	*Turbicellepora coronopus* (Wood, 1844)					1					
GR,TR	*Smittina* spp.					10	100			10	1
TR,GR	Bryozoa (spp.)					10	100		1		1
	ECHINODERMATA										
FR,TR	*Antedon mediterranea* (Lamarck, 1816)	1	1							100	10
FR,GR,TR	*Arbacia lixula* (Linnaeus, 1758)	1	10	1	1		1			10	1
FR	*Astrospartus mediterraneus* (Risso, 1826)	1									
FR,GR,TR	*Centrostephanus longispinus* (Philippi, 1845)	1	1				1			1	
FR,TR	*Coscinasterias tenuispina* (Lamarck, 1816)	1	1					1	1		
FR,GR,TR	*Echinaster* (*Echinaster*) *sepositus* (Retzius, 1783)	10	10	10	10		1		1		
FR,GR,TR	*Hacelia attenuata* Gray, 1840		1		1		1	1			
FR	*Holothuria* (*Holothuria*) *tubulosa* Gmelin, 1791	1	1	1	1						
FR,GR,TR	*Holothuria* (*Panningothuria*) *forskali* Delle Chiaje, 1823	10	10	10			1	1			1
FR,TR	*Holothuria* (*Roweothuria*) *poli* Delle Chiaje, 1824		1					1			
FR,GR,TR	*Holothuria* (*Platyperona*) *sanctori* Delle Chiaje, 1823				1		1	1	1		
FR	*Marthasterias glacialis* (Linnaeus, 1758)	1		1							
GR	*Ophidiaster ophidianus* (Lamarck, 1816)						1				
FR	*Ophiocomina nigra* (Abildgaard, in O.F. Müller, 1789)	1									
FR	*Ophioderma longicauda* (Bruzelius, 1805)	1	1								
FR,TR	*Ophiothrix fragilis* (Abildgaard, in O.F. Müller, 1789)	1	1					1			
FR,GR,TR	*Paracentrotus lividus* (Lamarck, 1816)	10	10	10	10		1		1		
FR,GR,TR	*Sphaerechinus granularis* (de Lamarck, 1816)	1	1		1		1	10	1		
TR	**Synaptula reciprocans* (Forskall, 1775)									1	1

	TUNICATA										
FR	*Aplidium pseudolobatum* (Pérès, 1956)	1		1							
TR	*Aplidium elegans* (Giard, 1872)							1			
FR	*Clavelina* spp.	10	1								
FR	*Diazona violacea* Savigny, 1816			1							
GR	*Didemnum commune* (Della Valle, 1877)						100				
GR,TR	*Didemnum maculosum* (Milne Edwards, 1841)						100			1	
GR,TR	*Didemnum* sp.					10	1	1			
FR	*Diplosoma spongiforme* (Giard, 1872)	1									
FR,GR,TR	*Halocynthia papillosa* (Linnaeus, 1767)	10	10	10	1	10	10	10	10	10	10
FR	*Polyclinum aurantium* Milne Edwards, 1841	1	1								
FR	*Pycnoclavella* spp.	10									
TR	Tunicata (sp.)										1
	PISCES										
FR,GR,TR	*Anthias anthias* (Linnaeus, 1758)	10	10			1	10	1		1	
FR,GR,TR	*Apogon imberbis* (Linnaeus, 1758)	1	1			10	10	1	1	10	10
FR,TR	*Boops boops* (Linnaeus, 1758)	1						1			
FR	*Chelon labrosus* (Risso, 1827)		1								
FR,GR,TR	*Chromis chromis* (Linnaeus, 1758)	100	100			100	100	100	100	100	100
FR,GR,TR	*Coris julis* (Linnaeus, 1758)	10	1				100	10	10	10	10
FR,TR	*Dentex dentex* (Linnaeus, 1758)		1							1	
FR	*Diplodus cervinus cervinus* (Lowe, 1838)		10								
FR,TR	*Diplodus puntazzo* (Walbaum, 1792)	1	1					1		1	
FR,GR,TR	*Diplodus sargus sargus* (Linnaeus, 1758)	10	10			1	10	10	10	10	1
FR,GR	*Diplodus vulgaris* (Geoffroy Saint-Hilaire, 1817)	1	1			1	10	100	10	1	1
TR	**Enchelycore anatina* (Lowe, 1838)										1
TR	*Epinephelus costae* (Steindachner, 1878)										1
FR,TR	*Epinephelus marginatus* (Lowe, 1834)	1	1							1	
TR	*Gobius auratus* Risso, 1810							1		1	
FR,TR	*Gobius cruentatus* Gmelin, 1789	1							1		
FR	*Gobius xanthocephalus* Heymer & Zander, 1992	1						1			
FR,TR	*Labrus merula* Linnaeus, 1758		1					1	1	1	
FR,TR	*Labrus viridis* Linnaeus, 1758	1						1	1	1	1
TR	*Labrus mixtus* Linnaeus, 1758							1			
FR,TR	*Mullus surmuletus* Linnaeus, 1758	1	10					1	1		1
FR,TR	*Muraena helena* Linnaeus, 1758		10					1		1	
FR,TR	*Oblada melanura* (Linnaeus, 1758)	1	1					10		1	
TR	*Parablennius gattorugine* (Linnaeus, 1758)							1	1		
FR,TR	*Parablennius rouxi* (Cocco, 1833)	1	1					1			
FR,TR	*Phycis phycis* (Linnaeus, 1766)		1						1		
TR	**Sargocentron rubrum* (Forsskål, 1775)									10	10
FR, TR	*Sarpa salpa* (Linnaeus, 1758)	10	10					1	1		
GR,TR	*Sciaena umbra* Linnaeus, 1758					1		1			
FR	*Scorpaena notata* Rafinesque, 1810		1								
FR,TR	*Scorpaena scrofa* Linnaeus, 1758		1					1			
TR	*Scorpaena maderensis* Valenciennes, 1833							1	1	1	1
TR	*Scorpaena porcus* Linnaeus, 1758							1	1		
GR	*Scorpaena* spp.						100				

FR,GR,TR	*Serranus scriba* (Linnaeus, 1758)	1				10	10	10	1	1	1
FR,TR	*Serranus cabrilla* (Linnaeus, 1758)	10	10					1	1		
TR	**Siganus rivulatus* Forsskål & Niebuhr, 1775									1	1
TR	**Siganus luridus* (Rüppell, 1829)									1	1
TR	*Sparisoma cretense* (Linnaeus, 1758)							1		1	
FR,TR	*Spicara maena* (Linnaeus, 1758)	1	10					1		1	
FR,TR	*Spondyliosoma cantharus* (Linnaeus, 1758)	1						1			
FR,TR	*Symphodus melanocercus* (Risso, 1810)	1	1					1	1	1	1
TR	*Symphodus ocellatus* (Linnaeus, 1758)							1	1		
FR,TR	*Symphodus rostratus* (Bloch, 1791)		1					1			1
FR,TR	*Symphodus tinca* (Linnaeus, 1758)	1	10					1	1		
FR,TR	*Symphodus mediterraneus* (Linnaeus, 1758)	1	1						1		
FR,TR	*Symphodus roissali* (Risso, 1810)		10						1		
TR	*Thalassoma pavo* (Linnaeus, 1758)							1		10	10
FR	*Tripterygion tripteronotum* (Risso, 1810)	1	1								
FR,TR	*Tripterygion delaisi* Cadenat & Blache, 1970		1					1	1		
FR,TR	*Sparus aurata* Linnaeus, 1758		10						1		
TR	*Thorogobius ephippiatus* (Lowe, 1839)									1	

10. FURTHER REFERENCES

Ballesteros E., 2006. Mediterranean coralligenous assemblages: a synthesis of present knowledge. Oceanogr. *Mar. Biol. Annu. Rev.* 44, 123–195.

Borja A., Franco J., Pérez V., 2000. A marine biotic index to establish the ecological quality of soft-bottom benthos within European estuarine and coastal environments. *Mar. Pollut. Bull.* 40, 1100–1114.

Cecchi, E., Gennaro, P., Piazzi, L., Ricevuto, E., Serena, F., 2014. Development of a new biotic index for ecological status assessment of Italian coastal waters based on coralligenous macroalgal assemblages. *Eur. J. Phycol*. 49, 298–312.

Deter, J., Descamp, P., Ballesta, L., Boissery, P., Holon, F., 2012. A preliminary study toward an index based on coralligenous assemblages for the ecological status assessment of Mediterranean French coastal waters. *Ecol. Indic.* 20, 345–352.

Gatti, G., Montefalcone, M., Rovere, A., Parravicini, V., Morri, C., Albertelli, G., Bianchi, C.N., 2012. Seafloor integrity down the harbor waterfront: the coralligenous shoals off Vado Ligure (NW Mediterranean). *Adv. Oceanol. Limnol*. 3, 51–67.

Gatti G., Bianchi C.N., Morri C., Montefalcone M., Sartoretto S., 2015. Coralligenous reefs state along anthropized coasts: application and validation of the COARSE index, based on a rapid visual assessment (RVA) approach. *Ecol. Indic.* 52, 567–576.

Keating, K.A., Quinn, J.F., 1998. Estimating species richness: the Michaelis-Menten model revisited. Oikos 81, 411–416.

Pearson T.H., Rosenberg R., 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. *Oceanogr. Mar. Biol. Ann. Rev.* 16, 229–311.

Pinedo S., Jordana E., Ballesteros E., 2015. A critical analysis on the response of macroinvertebrate communities along disturbance gradients: description of MEDOCC (MEDiterranean OCCidental) index. *Mar. Ecol.* 36, 141-154.

Stefansson G., 1996. Analysis of groundfish survey abundance data: combining the GLM and delta approaches. *ICES J. Mar. Sci.* 52, 577–588.

Trygonis V., Sini M., 2012. photoQuad: A dedicated seabed image processing software, and a comparative error analysis of four photoquadrat methods. *J. Exp. Mar. Biol. Ecol*. 424–425, 99–108.

ANNEX A: Methodological guide sent to Turkish team to test INDEX-COR and COARSE index.

ANNEX B: Library used to images analysis with PhotoQuad software (sampling station along French coasts).

ANNEX C:

David (R.), Féral (J.-P.), Archambeau (A.-S.), .Bailly (N.), Blanpain (C.), Breton (V.), De Jode (A.), Delavaud (A.), Dias (A.), Gachet (S.), Guillemain (D.), Lecubin (J.), Romier (G.), Surace (C.), Thierry de Ville d'Avray (L.), Arvanitidis (C.), Chenuil (A.), Çinar (M.E.), Koutsoubas (D.), Sartoretto (S.), Tatoni (T.) 2016. **IndexMed projects : new tools using the CIGESMED DataBase on Coralligenous for indexing, visualizing and data mining based on graphs.** *In* : S. Sauvage, J.-M. Sánchez-Pérez, A. Rizzoli (Eds.) *Proc. 8th International Congress on Environmental Modelling and Software*, Toulouse, France, 11-13 july 2016

ANNEX D: Annual reports of the National Marine Park of Zakynthos (sub-contractor) including a document illustrating an actions inspired by CIGESMED

ANNEX A: Methodological guide sent to Turkish team to test INDEX-COR and COARSE index.

INDEX-COR

1- Equipment:

- photographic camera with 60x40 cm (or 50x50 cm) frame
- graduate rubber band at least 15 m long
- tablet to take notes.

2- Fieldwork:

- Photoquadrat size: 60x40 cm (or 50x50 cm)
- 2 x 15 m long transects at constant depth, 15 photos per transect (total 30 photos for each site).
- 2 divers required, 1 shoots the photographs, the second notes the list of all the species he can observe and the % cover of upper layer species (i.e. > 15 cm height)

3- Image analyses:

PhotoQuad software, 100 points regularly scattered (see the library for taxa/groups details; you can add new species if necessary). The % relative abundance of each taxon/abiotic group is calculate over the sum of the 30 photoquadrats (i.e. 3000 points).

4- Index calculation:

➢ Metric 1:

Taxa Sensitivity (TS) = (0 × % Group I + 0.5 × % Group II + 1 × % Group III + 1.5 × % Group IV)

where Group I = taxa indifferent to organic matter and sediment input; Group II (GII): opportunistic taxa; Group III (GIII): tolerant taxa; Group IV (GIV): sensitive taxa. % Group is obtained by adding up the percent relative abundance of the taxa belonging to each group (see Table 1)

➢ Metric 2:

Observable Taxonomic Richness (OTR) = total number taxa identified by photoquadrats and *in situ* observation. Sessile and vagile macrobenthic organisms (echinoderms, nudibranchs, crustaceans) having a high patrimonial value or a particular ecological role were also considered.

➢ Metric 3:

Structural Complexity (SC). To obtain SC, follow the steps below:

1/ Substitute the % relative abundance of the basal (BS), intermediate (IS) and upper (US) -layers in the following formulas:

Axis	Layer	Coordinates along the axis
Axis 1	basal	$C1_{basal}$= -0.6849 x (BS-9.414)/4.554
	intermediate	$C1_{intermediate}$= 0.165 x (IS-8.550)/5.585
	upper	$C1_{upper}$= -0.710 x (US-37.640)/28.261
Axis 2	basal	$C2_{basal}$= -0.261 x (BS-9.414)/4.554
	intermediate	$C2_{intermediate}$= -0.965 x (IS-8.550)/5.585
	upper	$C2_{upper}$= 0.028 x (US-37.640)/28.261

(Layer's % relative abundance is obtained by adding up the % relative abundance of the species belonging to each of them).

2/ For each axis, add up the coordinates of the layers, to obtain the coordinates of the sampling station: $C1_{basal} + C1_{intermediate} + C1_{upper} = C1_{station}$; $C2_{basal} + C2_{intermediate} + C2_{upper} = C2_{station}$.

3/ Substitute the coordinates of the station in the following formula, to obtain the value of the metric: $SC = \sqrt{((2.108-C1_{station})^2 + (1.980-C2_{station})^2)}$

INDEX-COR (IC) = 0.44TS+ 0.49OTR + 1.3SC

Table 1. List of the species and of the higher taxa (alphabetic order), with their sensitivity group. Group I (GI): taxa indifferent to organic matter and sediment input; Group II (GII): opportunistic taxa; Group III (GIII): tolerant taxa; Group IV (GIV): sensitive taxa.

Taxon	Sensitivity group	Taxon	Sensitivity group
Acanthella acuta	GIV	*Halocynthia papillosa*	GIV
Adeonella calveti	GIV	*Hemimycale columella*	GII
Agelas oroides	GIII	*Hexadella* spp.	GIV
Alcyonium spp.	GII	*Hoplangia durotrix*	GIII
Aplidium undulatum	GIV	*Ircinia* spp.	GII
Aplysilla sulfurea	GIV	*Leptogorgia sarmentosa*	GII
Aplysina cavernicola	GIV	*Leptopsammia pruvoti*	GIII
Axinella damicornis	GII	Foliose *Lithophyllum* spp.	GIII
Axinella verrucosa	GII	Foliose *Mesophyllum* spp.	GIII
Cacospongia spp.	GI	*Myriapora truncata*	GI
Caryophyllia inornata	GII	*Oscarella* spp.	GIV

Caryophyllia smithii	GII	*Palmophyllum crassum*	GIII
Chondrosia reniformis	GI	*Paramuricea clavata*	GII
Clavelina spp.	GIV	*Parazoanthus axinellae*	GI
Cliona spp.	GI	*Petrosia ficiformis*	GIII
Codium coralloides	GIII	Encrusting *Peyssonnelia* spp.	GIII
Codium effusum	GIII	Foliose *Peyssonnelia* spp.	GIII
Encrusting calcareous rhodophyta	GI	*Phorbas tenacior*	GII
Corallium rubrum	GII	*Pleraplysilla spinifera*	GIV
Crambe crambe	GIII	*Polyclinum aurantium*	GIV
Crella pulvinar	GIV	*Pycnoclavella* spp.	GIV
Dentiporella sardonica	GIV	*Reteporella* spp.	GII
Dysidea spp.	GI	*Rhynchozoon* spp.	GII
Eunicella cavolini	GII	*Sarcotragus* spp.	GIII
Flabellia petiolata	GIII	*Scalarispongia* spp.	GIII
Frondipora verrucosa	GI	*Schizomavella* spp.	GII
Haliclona fulva	GII	*Smittina cervicornis*	GIV
Haliclona mucosa	GIV	*Spirastrella cunctatrix*	GIII
Halimeda tuna	GII	*Zanardinia typus*	GI

COARSE index

1- Equipment:

- One tablet (see slides)
- Clinometer (if not included in the tablet, I adopted this solution and it is practical)
- Compass
- Torch (essential to recognise groups and species for basal and intermediate layer)
- Camera
- Knife
- Yardstick (like this --> are better the plastic ones, the wood brakes earlier)

2- Fieldwork:

3 replicates per site; a replicate is the surface that you can observe in front of you, about 1.5-2m.

1. Mark the **morphotype**
2. When arrived at the defined depth, mark **depth, slope, direction, distance from the bottom***
3. Estimate the **percent cover of basal layer groups**
4. Mark the presence of **boring species** (usually are *Cliona* papillae or massive, I don't know if in Greece there are other borers that you can easily see)
5. Measure the **thickness of calcareous layer** with the knife (6 replicates well distributed over the observed surface) and mark results
6. Mark the **list of intermediate layer species.** Do not take too much time to do this, mark rapidly all species you can easily see at first, then take a look in holes or cleft and then take the **6 photographs.**
7. Assess and mark the **percent cover** of **upper layer species**; assess and mark the **percentage of necrosis and/or epibiosis** of each population; identify, measure (with the yardstick) and mark the height of the higher specimen of each species.

*** distance from the bottom:** usually, where is not too deep, I go rapidly until the bottom, I mark the depth and I return at replicate's depth; the difference between the two depths gives you the distance. You should do this at first in order to do a correct dive. If it is too deep, you can obtain the depth from boat instruments or, at worst, you mark that it is unknown. The data you take from the points 1) and 2) are useful for the geomorphological characterisation, but they do not condition the computation of the quality scores.

This is the general procedure. Actually, you can adapt the order of the actions according to your preferences, in order to optimise the time of the survey. This is what I usually do:

1. I mark mesological characteristics
2. I assess the percent cover of basal layer groups, I look at boring species, then I mark the list of intermediate layer species. For these actions the torch is necessary, so I do everything together and I don't waste time in switching on and off the torch or looking

at it (I fasten all instruments to my jacket so: i) it is easy to find everything knotted; ii) it takes a bit of time to take the instrument).

3. I take the photographs and I measure the thickness of the calcareous layer
4. I take upper layer's data

The order of the actions is not important, you have to find your favourite in order to best optimise the time. For these reason, it is very important to prepare your tablet before the dive, using a defined scheme (as you can see in the slides) that helps you to not forget anything.

Problems & co

- The main difficulty you will find at the beginning concerns the visual estimation of basal layer groups. It is an activity that may need a bit of training, which you can do with the help of the picture below or – surely better – with some photographs. During the training, it is also important to compare your estimations each other, in order to be well "calibrated".
- A second problem may be represented by the turf. Turf, as you know, is used to define all filamentous algae. You don't have to find every single filament because it is impossible, but you can see it well when it covers the bare substratum or the sediment deposed forming a sort of "carpet".
- If you find some turf forming algae or sediment over, for example, calcareous algae (ECR) (it is the same for the other groups) you do not have to consider it as turf/sed but as ECR, because the substratum is covered firstly by ECR. It means that, at the moment, the presence of them do not prevent the life of the ECR, which continues to give its contribution to the reef. I don't know if this point is clear, but the first time you will find this situation I think you will understand what I mean.
- Layers are not identified by the species that compose them, but by the height of the species. This means that if you find some *Paramuricea* smaller than 10 cm, you have to mark them in the list of intermediate layer species.

3- <u>Data treatment:</u>

1/ Over the three replicates:

- Calculate the mean values of: the total cover of upper layer species; the necrosis; the nr. of species of the intermediate layer; the nr. of erect calcified organisms; the % cover of the NTU of the basal layer; the thickness of the calcareous substrate; the borers' scores (see table below).
- Retain only the highest among upper layer species
- For the sensitivity of bryozoans, for each replicate, consider only the most sensitive species; then, sum up over the three replicates the scores assigned to them (see table below).

2/ Assign to each descriptor a score equal to 1, 2 or 3 according to the following rationale:

UPPER LAYER	
1. Total cover of species	1 -> cover < 5% 2 -> 5% ≤ cover ≤ 25% 3 -> cover > 25%
2. Maximum height (MH) ** LMH = Literature max height, the maximum height find in literature for each species	1 -> MH < 0.3 LMH 2 -> 0.3 LMH ≤ MH ≤ 0.6 LMH 3 -> MH > 0.6 MH
3. Necrosis (N)	1 -> N > 75% 2 -> 10% ≤ N ≤ 75% 3 -> N < 10%
INTERMEDIATE LAYER	
4. Nr of species (NS)	1 -> NS < 5 2 -> 5 ≤ NS ≤ 8 3 -> NS > 8
5. Nr of erected calcified organisms (ECO)	1 -> ECO ≤1 2 -> 1 < ECO ≤ 3 3 -> ECO > 3
6. Sensitivity of bryozoans species	0.33 -> *M. truncata* 0.66 -> *P. fascialis*, *A. calveti* 1 -> *S. cervicornis*, *R. grimaldii*
BASAL LAYER	
7. % cover of non-taxonomic units SED/TURF = sediment and turf-forming algae; NCEA = non-calcified encrusting algae; AN = animals; ECR = encrusting calcified rhodophyta The formula *(cover x score)/100* is applied to each NTG, results are then summed up to obtain the overall score for the metric.	1 -> SED/TURF 2 -> NCEA and AN 3 -> ECR
8. Thickness and consistency of calcareous layer	1 -> null penetration 2 -> penetration > 1 cm 3 -> penetration up to 1 cm
9. Borer marks	1 -> common 2 -> occasional 3 -> absent

** LITERATURE MAXIMUM HEIGHT (LMH) FOR UPPER LAYER SPECIES

	1	**2**	**3**
	MH<0.3LMH	0.3 LMH≤MH≤0.6LMH	MH>0.6LMH
Axinella polypoides	< 18 cm	18-36 cm	> 36 cm
Cystoseira zosteroides	< 10 cm	10 – 20 cm	> 20 cm
Eunicella cavolini	< 17 cm	17-33 cm	> 33 cm
Eunicella singularis	< 22 cm	22 – 43 cm	> 43 cm
Eunicella verrucosa	< 20 cm	20 – 40 cm	> 40 cm
Leptogorgia sarmentosa	< 25 cm	25 – 46 cm	> 46 cm
Paramuricea clavata	< 30 cm	30 – 60 cm	> 60 cm
Sabella spallanzanii	<20 cm	20-30 cm	>30 cm

These are the species that I found in my sites. If a species is not in the list, you need to do your own research in the literature.

3/ To calculate the score of each layer: apply the formula following formula:

$$Q_L = (X_L \times Y_L \times Z_L) \times k^{(1-n)}$$

where X_L, Y_L and Z_L are the quality scores assigned to the three descriptors, *k* is the maximum value assumed by the scores (3 in this case), *n* is the number of descriptors considered.

4/ To calculate the COARSE index:

$$Q_O = n / (1/Q_{BL} + 1/Q_{IL} + 1/Q_{UL})$$

where *n* is the number of layers and Q_{BL}, Q_{IL} and Q_{UL} are the quality scores of basal, intermediate and upper layer, respectively.

ANNEX B: Library used to images analysis with PhotoQuad software (sampling station along French coasts).

Kingdom	Phylum	Class	Order	Family	Species
Plantae	Chlorophyta	Ulvophyceae	Dasycladales	Polyphysaceae	*Acetabularia acetabulum* (Linnaeus) P.C. Silva, 1952
Plantae	Chlorophyta	Ulvophyceae	Bryopsidales	Caulerpaceae	*Caulerpa cylindracea* Sonder, 1845
Plantae	Chlorophyta	Ulvophyceae	Bryopsidales	Codiaceae	*Codium bursa* (Olivi) C.Agardh, 1817
Plantae	Chlorophyta	Ulvophyceae	Bryopsidales	Codiaceae	*Codium coralloides* (Kützing) P.C. Silva, 1960
Plantae	Chlorophyta	Ulvophyceae	Bryopsidales	Codiaceae	*Codium effusum* (Rafinesque) Delle Chiaje, 1829
Plantae	Chlorophyta	Ulvophyceae	Bryopsidales	Udoteaceae	*Flabellia petiolata* (Turra) Nizamuddin, 1987
Plantae	Chlorophyta	Ulvophyceae	Bryopsidales	Halimedaceae	*Halimeda tuna* (J. Ellis & Solander) J.V. Lamouroux, 1816
Plantae	Chlorophyta	Incertae sedis	Palmophyllales	Palmophyllaceae	*Palmophyllum crassum* (Naccari) Rabenhorst, 1868
Plantae	Rhodophyta	Florideophyceae	Rhodymeniales	Rhodymeniaceae	*Chrysymenia ventricosa* (J.V. Lamouroux) J. Agardh, 1842
Plantae	Rhodophyta	Florideophyceae	Corallinales	Corallinaceae	*Lithophyllum* sp. Philippi, 1837
Plantae	Rhodophyta	Florideophyceae	Corallinales	Hapalidiaceae	*Mesophyllum* sp. Me. Lemoine, 1928
Plantae	Rhodophyta	Florideophyceae	Ceramiales	Rhodomelaceae	*Osmundaria volubilis* (Linnaeus) R.E. Norris, 1991
Plantae	Rhodophyta	Florideophyceae	Peyssonneliales	Peyssonneliaceae	*Peyssonnelia* sp. Decaisne, 1841
Plantae	Rhodophyta	Florideophyceae	Gigartinales	Phyllophoraceae	*Phyllophora* sp. Greville, 1830
Plantae	Rhodophyta	Florideophyceae	Gigartinales	Sphaerococcaceae	*Sphaerococcus coronopifolius* Stackhouse, 1797
Plantae	Rhodophyta	Florideophyceae	Ceramiales	Rhodomelaceae	*Womersleyella setacea* (Hollenberg) R.E. Norris, 1992
Plantae	Ochrophyta	Phaeophyceae	Dictyotales	Dictyotaceae	*Dictyopteris polypodioides* (A.P. De Candolle) J.V. Lamouroux, 1809
Plantae	Ochrophyta	Phaeophyceae	Dictyotales	Dictyotaceae	*Dictyota dichotoma* (Hudson) J.V. Lamouroux, 1809
Plantae	Ochrophyta	Phaeophyceae	Dictyotales	Dictyotaceae	*Dictyota fasciola* (Roth) J.V. Lamouroux, 1809
Plantae	Ochrophyta	Phaeophyceae	Sphacelariales	Stypocaulaceae	*Halopteris filicina* (Grateloup) Kützing, 1843
Plantae	Ochrophyta	Phaeophyceae	Dictyotales	Dictyotaceae	*Padina pavonica* (Linnaeus) Thivy, 1960
Plantae	Ochrophyta	Phaeophyceae	Tilopteridales	Phyllariaceae	*Phyllariopsis brevipes* (C. Agardh) E.C. Henry & G.R. South, 1987
Plantae	Ochrophyta	Phaeophyceae	Cutleriales	Cutleriaceae	*Zanardinia typus* (Nardo) P.C. Silva, 2000
Animalia	Porifera	Demospongiae	Bubarida	Dyctionellidae	*Acanthella acuta* Schmidt, 1862
Animalia	Porifera	Demospongiae	Agelasida	Agelasidae	*Agelas oroides* (Schmidt, 1864)
Animalia	Porifera	Demospongiae	Dendroceratida	Darwinellidae	*Aplysilla rosea* (Barrois, 1876)
Animalia	Porifera	Demospongiae	Dendroceratida	Darwinellidae	*Aplysilla sulfurea* Schultze, 1878
Animalia	Porifera	Demospongiae	Verongiida	Aplysinidae	*Aplysina cavernicola* (Vacelet, 1959)

Animalia	Porifera	Demospongiae	Axinellida	Axinellidae	*Axinella damicornis* (Esper, 1794)
Animalia	Porifera	Demospongiae	Axinellida	Axinellidae	*Axinella polypoides* Schmidt, 1862
Animalia	Porifera	Demospongiae	Axinellida	Axinellidae	*Axinella* sp. Schmidt, 1862
Animalia	Porifera	Demospongiae	Axinellida	Axinellidae	*Axinella vaceleti* Pansini, 1984
Animalia	Porifera	Demospongiae	Axinellida	Axinellidae	*Axinella verrucosa* (Esper, 1794)
Animalia	Porifera	Demospongiae	Dictyoceratida	Thorectidae	*Cacospongia* sp. Schmidt, 1862
Animalia	Porifera	Demospongiae	Chondrillida	Chondrillidae	*Chondrilla nucula* Schmidt, 1862
Kingdom	**Phylum**	**Class**	**Order**	**Family**	**Species**
Animalia	Porifera	Demospongiae	Chondrisiida	Chondrisiidae	*Chondrosia reniformis* Nardo, 1847
Animalia	Porifera	Calcarea	Clathrinida	Clathrinidae	*Clathrina* sp. Gray, 1867
Animalia	Porifera	Demospongiae	Clionaida	Clionaidae	*Cliona celata* Grant, 1826
Animalia	Porifera	Demospongiae	Clionaida	Clionaidae	*Cliona schmidti* (Ridley, 1881)
Animalia	Porifera	Demospongiae	Clionaida	Clionaidae	*Cliona viridis* Schmidt, 1826
Animalia	Porifera	Demospongiae	Poecilosclerida	Crambeidae	*Crambe crambe* (Schmidt, 1862)
Animalia	Porifera	Demospongiae	Poecilosclerida	Crellidae	*Crella (Grayella) pulvinar* (Schmidt, 1868)
Animalia	Porifera	Demospongiae	Bubarida	Dictyonellidae	*Dictyonella* sp. Schmidt, 1868
Animalia	Porifera	Demospongiae	Dictyoceratida	Dysideidae	*Dysidea* sp. Jonhston, 1842
Animalia	Porifera	Demospongiae	Tetractinellida	Geodiidae	*Erylus deficiens* Topsent, 1927
Animalia	Porifera	Demospongiae	Haplosclerida	Chalinidae	*Haliclona (Halichoclona) fulva* (Topsent, 1893)
Animalia	Porifera	Demospongiae	Haplosclerida	Chalinidae	*Haliclona (Reniera) mediterranea* Griessinger, 1971
Animalia	Porifera	Demospongiae	Haplosclerida	Chalinidae	*Haliclona (Soestella) mucosa* (Griessinger, 1971)
Animalia	Porifera	Demospongiae	Haplosclerida	Chalinidae	*Haliclona* sp. Grant, 1836
Animalia	Porifera	Demospongiae	Poecilosclerida	Hymedesmiidae	*Hemimycale columella* (Bowerbank, 1874)
Animalia	Porifera	Demospongiae	Verongiida	Ianthellidae	*Hexadella pruvoti* Topsent, 1896
Animalia	Porifera	Demospongiae	Verongiida	Ianthellidae	*Hexadella racovitzai* Topsent, 1896
Animalia	Porifera	Demospongiae	Verongiida	Ianthellidae	*Hexadella* sp. Topsent, 1896
Animalia	Porifera	Demospongiae	Dictyoceratida	Spongiidae	*Hippospongia* sp. Schulze, 1879
Animalia	Porifera	Demospongiae	Dictyoceratida	Irciniidae	*Ircinia* sp. Nardo, 1833
Animalia	Porifera	Demospongiae	Dictyoceratida	Irciniidae	*Ircinia variabilis* (Schmidt, 1862)
Animalia	Porifera	Demospongiae	Homosclerophorida	Oscarellidae	*Oscarella lobularis* (Schmidt, 1862)
Animalia	Porifera	Demospongiae	Homosclerophorida	Oscarellidae	*Oscarella* sp. Vosmaer, 1884
Animalia	Porifera	Demospongiae	Homosclerophorida	Oscarellidae	*Oscarella tuberculata* (Schmidt, 1868)
Animalia	Porifera	Demospongiae	Haplosclerida	Petrosiidae	*Petrosia ficiformis* (Poiret, 1789)
Animalia	Porifera	Demospongiae	Poecilosclerida	Hymedesmiidae	*Phorbas* sp. Duchassaing & Michelotti, 1864

Animalia	Porifera	Demospongiae	Poecilosclerida	Hymedesmiidae	*Phorbas tenacior* (Topsent, 1925)
Animalia	Porifera	Demospongiae	Dictyoceratida	Dysideidae	*Pleraplysilla spinifera* (Schulze, 1879)
Animalia	Porifera	Demospongiae	Axinellida	Raspailiidae	*Raspaciona aculeata* (Jonhston, 1842)
Animalia	Porifera	Demospongiae	Dictyoceratida	Thorectidae	*Scalarispongia* sp. Cook & Bergquist, 2000
Animalia	Porifera	Demospongiae	Dictyoceratida	Irciniidae	*Sarcotragus* sp. Schmidt, 1862
Animalia	Porifera	Demospongiae	Clionaida	Spirastrellidae	*Spirastrella cunctatrix* Schmidt, 1868
Animalia	Porifera	Demospongiae	Dictyoceratida	Spongiidae	*Spongia (Spongia) lamella* (Schulze, 1879)
Animalia	Porifera	Demospongiae	Dictyoceratida	Spongiidae	*Spongia (Spongia) officinalis* Linnaeus, 1759
Animalia	Porifera	Demospongiae	Dictyoceratida	Spongiidae	*Spongia* sp. Linnaeus, 1759
Animalia	Porifera	Demospongiae	Suberitida	Suberitidae	*Suberites* sp. Nardo, 1833
Animalia	Porifera	Demospongiae	Tethyida	Tethyidae	*Tethya aurantium* (Pallas, 1766)
Animalia	Cnidaria	Hydrozoa	Leptothecata	Aglaopheniidae	*Aglaophenia elongata* Meneghini, 1845
Animalia	Cnidaria	Hydrozoa	Leptothecata	Aglaopheniidae	*Aglaophenia* sp. Lamouroux, 1812
Animalia	Cnidaria	Anthozoa	Actiniaria	Aiptasiidae	*Aiptasia mutabilis* (Gravenhorst, 1831)
Animalia	Cnidaria	Anthozoa	Alcyonacea	Acyoniidae	*Alcyonium coralloides* (Pallas, 1766)
Animalia	Cnidaria	Anthozoa	Alcyonacea	Acyoniidae	*Alcyonium* sp. Pallas, 1766
Animalia	Cnidaria	Anthozoa	Actinaria	Aliciidae	*Alicia mirabilis* Jonhson, 1861
Kingdom	**Phylum**	**Class**	**Order**	**Family**	**Species**
Animalia	Cnidaria	Anthozoa	Actinaria	Actiniidae	*Anemonia viridis* (Forsskål, 1775)
Animalia	Cnidaria	Anthozoa	Scleractinia	Dendrophylliidae	*Balanophyllia (Balanophyllia) europaea* (Risso, 1826)
Animalia	Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	*Caryophyllia (Caryophyllia) inornata* (Duncan, 1878)
Animalia	Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	*Caryophyllia (Caryophyllia) smithii* Stokes & Broderip, 1828
Animalia	Cnidaria	Anthozoa	Actinaria	Sagartiidae	*Cereus pedunculatus* (Pennant, 1777)
Animalia	Cnidaria	Anthozoa	Spirularia	Cerianthidae	*Cerianthus* sp. Della Chiaje, 1830
Animalia	Cnidaria	Anthozoa	Scleractinia	Scleractinia incertae sedis	*Cladocora caespitosa* (Linnaeus, 1767)
Animalia	Cnidaria	Anthozoa	Alcyonacea	Clavulariidae	*Clavularia* sp. Blainville, 1830
Animalia	Cnidaria	Anthozoa	Alcyonacea	Coralliidae	*Corallium rubrum* (Linnaeus, 1758)
Animalia	Cnidaria	Anthozoa	Actinaria	Actiniidae	*Cribrinopsis crassa* (Andrès, 1881)
Animalia	Cnidaria	Anthozoa	Anthoathecata	Eudendriidae	*Eudendrium* sp. Ehrenberg, 1834
Animalia	Cnidaria	Anthozoa	Alcyonacea	Gorgoniidae	*Eunicella cavolini* (Koch, 1887)
Animalia	Cnidaria	Anthozoa	Alcyonacea	Gorgoniidae	*Eunicella singularis* (Esper, 1791)
Animalia	Cnidaria	Anthozoa	Alcyonacea	Gorgoniidae	*Eunicella verrucosa* (Pallas, 1766)
Animalia	Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	*Hoplangia durotrix* Gosse, 1860

Animalia	Cnidaria	Anthozoa	Alcyonacea	Gorgoniidae	*Leptogorgia sarmentosa* (Esper, 1789)
Animalia	Cnidaria	Anthozoa	Scleractinia	Dendrophylliidae	*Leptopsammia pruvoti* Lacaze-Duthiers, 1897
Animalia	Cnidaria	Anthozoa	Scleractinia	Astrocoeniidae	*Madracis pharensis* (Heller, 1868)
Animalia	Cnidaria	Anthozoa	Alcyonacea	Gorgoniidae	*Paramuricea clavata* (Risso, 1826)
Animalia	Cnidaria	Anthozoa	Scleractinia	Caryophyllidae	*Paracyathus pulchellus* (Philippi, 1842)
Animalia	Cnidaria	Anthozoa	Zoantharia	Parazoanthidae	*Parazoanthus axinellae* (Schmidt, 1862)
Animalia	Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	*Phyllangia americana mouchezii* (Lacaze-Duthiers, 1897)
Animalia	Cnidaria	Anthozoa	Actinaria	Phymanthidae	*Phymanthus pulcher* (Andrès, 1883)
Animalia	Platyhelminthes	Rhabditophora	Polycladidia	Euryleptidae	*Prostheceraeus giesbrechtii* Lang, 1884
Animalia	Annelida	Polychaeta	Sabellida	Sabellidae	*Bispira volutacornis* (Montagu, 1804)
Animalia	Annelida	Polychaeta	Echiuroidea	Bonellidae	*Bonellia viridis* Rolando, 1821
Animalia	Annelida	Polychaeta	Terebellida	Terebellidae	*Eupolymnia nebulosa* (Montagu, 1818)
Animalia	Annelida	Polychaeta	Sabellida	Serpulidae	*Filograna implexa* Berkeley, 1835
Animalia	Annelida	Polychaeta	Sabellida	Serpulidae	*Protula tubularia* (Montagu, 1803)
Animalia	Annelida	Polychaeta	Sabellida	Sabellidae	*Sabella pavonina* Savigny, 1822
Animalia	Annelida	Polychaeta	Sabellida	Sabellidae	*Sabella spallanzanii* (Gmelin, 1791)
Animalia	Annelida	Polychaeta	Sabellida	Serpulidae	*Salmacina* sp. Claparède, 1870
Animalia	Annelida	Polychaeta	Sabellida	Serpulidae	*Serpula* sp. Linnaeus, 1758
Animalia	Annelida	Polychaeta	Sabellida	Serpulidae	*Spirobranchus triqueter* (Linnaeus, 1758)
Animalia	Mollusca	Gastropoda	Littorinimorpha	Apporrhaidae	*Aporrhais pespelecani* (Linnaeus, 1758)
Animalia	Mollusca	Gastropoda		Calliostomatidae	*Calliostoma zizyphinum* (Linnaeus, 1758)
Animalia	Mollusca	Gastropoda	Nudibranchia	Facelinidae	*Cratena peregrina* (Gmelin, 1791)
Animalia	Mollusca	Gastropoda	Nudibranchia	Chromodorididae	*Felimare picta* (Schulz in Philippi, 1836)
Animalia	Mollusca	Gastropoda	Nudibranchia	Chromodorididae	*Felimare* sp. Ev. Marcus & Er. Marcus, 1967
Animalia	Mollusca	Gastropoda	Nudibranchia	Flabellinidae	*Flabellina affinis* (Gmelin, 1791)
Animalia	Mollusca	Gastropoda	Nudibranchia	Flabellinidae	*Flabellina pedata* (Montagu, 1816)
Kingdom	**Phylum**	**Class**	**Order**	**Family**	**Species**
Animalia	Mollusca	Gastropoda	Nudibranchia	Chromodorididae	*Hypselodoris* sp. Stimpson, 1855
Animalia	Mollusca	Gastropoda	Nudibranchia	Proctonotidae	*Janolus cristatus (*Delle Chiaje, 1841)
Animalia	Mollusca	Bivalvia	Limida	Limidae	*Lima* sp. Bruguière, 1797
Animalia	Mollusca	Gastropoda	Nudibranchia	Discodorididae	*Peltodoris atromaculata* Bergh, 1880
Animalia	Mollusca	Gastropoda	Pleurobranchomorpha	Pleurobranchidae	*Pleurobranchus testudinarius* Cantraine, 1835
Animalia	Mollusca	Bivalvia	Pectinida	Spondylidae	*Spondylus gaederopus* Linnaeus, 1758
Animalia	Mollusca	Gastropoda	Sacoglossa	Plakobranchidae	*Thuridilla hopei* (Vérany, 1853)

Animalia	Mollusca	Gastropoda	Littorinimorpha	Vermetidae	*Thylacodes arenarius* (Linnaeus, 1758)
Animalia	Mollusca	Gastropoda	Umbraculida	Umbraculidae	*Umbraculum umbraculum* (Lightfoot, 1786)
Animalia	Bryozoa	Gymnolaemata	Cheilostomatida	Adeonellidae	*Adeonella calveti* (Canu & Bassler, 1930)
Animalia	Bryozoa	Gymnolaemata	Cheilostomatida	Beaniidae	*Beania hirtissima cylindrica* (Hincks, 1886)
Animalia	Bryozoa	Gymnolaemata	Cheilostomatida	Candidae	*Caberea boryi* (Audouin, 1826)
Animalia	Bryozoa	Gymnolaemata	Cheilostomatida	Cellariidae	*Cellaria* sp. Ellis & Solander, 1786
Animalia	Bryozoa	Gymnolaemata	Cheilostomatida	Phidoloporidae	*Dentiporella sardonica* (Waters, 1879)
Animalia	Bryozoa	Gymnolaemata	Cheilostomatida	Microporellidae	*Diporula verrucosa* (Peach, 1868)
Animalia	Bryozoa	Gymnolaemata	Cheilostomatida	Frondiporidae	*Frondipora verrucosa* (Lamouroux, 1821)
Animalia	Bryozoa	Gymnolaemata	Cheilostomatida	Tubuliporidae	*Idmidronea atlantica* (Forbes, in Johnston, 1847)
Animalia	Bryozoa	Gymnolaemata	Cheilostomatida	Myriaporidae	*Myriapora truncata* (Pallas, 1766)
Animalia	Bryozoa	Gymnolaemata	Cheilostomatida	Bitectiporidae	*Pentapora fascialis* (Pallas, 1766)
Animalia	Bryozoa	Gymnolaemata	Cheilostomatida	Phidoloporidae	*Reteporella* sp. Busk, 1884
Animalia	Bryozoa	Gymnolaemata	Cheilostomatida	Phidoloporidae	*Rhynchozoon* sp. Hincks, 1895
Animalia	Bryozoa	Gymnolaemata	Cheilostomatida	Bitectiporidae	*Schizomavella (Schizomavella) mamillata* (Hincks, 1880)
Animalia	Bryozoa	Gymnolaemata	Cheilostomatida	Phidoloporidae	*Schizoretepora serratimargo* (Hincks, 1886)
Animalia	Bryozoa	Gymnolaemata	Cheilostomatida	Celleporidae	*Turbicellepora avicularis* (Hincks, 1860)
Animalia	Echinodermata	Crinoidea	Comatulida	Antedonidae	*Antedon mediterranea* (Lamarck, 1816)
Animalia	Echinodermata	Ophiuroidea	Euryalida	Gorgonocephalidae	*Astrospartus mediterraneus* (Risso, 1826)
Animalia	Echinodermata	Echinoidea	Diadematoida	Diadematidae	*Centrostephanus longispinus* (Philippi, 1845)
Animalia	Echinodermata	Asteroidea	Valvatida	Chaetasteridae	*Chaetaster longipes* (Retzius, 1805)
Animalia	Echinodermata	Echinoidea	Cidaroida	Cidaridae	*Cidaris cidaris* (Linnaeus, 1758)
Animalia	Echinodermata	Asteroidea	Forcipulatida	Asteriidae	*Coscinasterias tenuispina* (Lamarck, 1816)
Animalia	Echinodermata	Asteroidea	Spinulosida	Echinasteridae	*Echinaster (Echinaster) sepositus* (Retzius, 1783)
Animalia	Echinodermata	Echinoidea	Camarodonta	Echinidae	*Echinus melo* Lamarck, 1816
Animalia	Echinodermata	Asteroidea	Valvatida	Ophidiasteridae	*Hacelia attenuata* Gray, 1840
Animalia	Echinodermata	Holothuroidea	Aspidochirotida	Holothuriidae	*Holothuria (Panningothuria) forskali* Delle Chiaje, 1823
Animalia	Echinodermata	Holothuroidea	Aspidochirotida	Holothuriidae	*Holothuria (Roweothuria) poli* Delle Chiaje, 1824
Animalia	Echinodermata	Holothuroidea	Aspidochirotida	Holothuriidae	*Holothuria (Holothuria) tubulosa* Gmelin, 1791
Animalia	Echinodermata	Ophiuroidea	Ophiurida	Ophiotrichidae	*Ophiothrix fragilis* (Abildgaard, in O.F. Müller, 1789)
Animalia	Echinodermata	Echinoidea	Camarodonta	Parechinidae	*Paracentrotus lividus* (Lamarck, 1816)
Animalia	Echinodermata	Echinoidea	Camarodonta	Toxopneustidae	*Sphaerechinus granularis* (Lamarck, 1816)
Kingdom	**Phylum**	**Class**	**Order**	**Family**	**Species**
Animalia	Echinodermata	Echinoidea	Cidaroida	Cidaridae	*Stylocidaris affinis* (Philippi, 1845)

Animalia	Chordata	Ascidiacea	Aplousobranchia	Polyclinidae	*Aplidium* sp. Savigny, 1816
Animalia	Chordata	Ascidiacea	Aplousobranchia	Polyclinidae	*Aplidium undulatum* Monniot & Gail, 1978
Animalia	Chordata	Ascidiacea	Phlebobranchia	Cionidae	*Ciona* sp. Fleming, 1822
Animalia	Chordata	Ascidiacea	Aplousobranchia	Clavelinidae	*Clavelina lepadiformis* (Müller, 1776)
Animalia	Chordata	Ascidiacea	Aplousobranchia	Clavelinidae	*Clavelina* sp. Savigny, 1816
Animalia	Chordata	Ascidiacea	Aplousobranchia	Polycitoridae	*Cystodytes dellechiajei* (Della Valle, 1877)
Animalia	Chordata	Ascidiacea	Phlebobranchia	Diazonidae	*Diazona violacea* Savigny, 1816
Animalia	Chordata	Ascidiacea	Aplousobranchia	Didemnidae	*Didemnum drachi* Lafargue, 1975
Animalia	Chordata	Ascidiacea	Aplousobranchia	Didemnidae	*Didemnum* sp. Savigny, 1816
Animalia	Chordata	Ascidiacea	Aplousobranchia	Didemnidae	*Diplosoma spongiforme* (Giard, 1872)
Animalia	Chordata	Ascidiacea	Stolidobranchia	Pyuridae	*Halocynthia papillosa* (Linnaeus, 1767)
Animalia	Chordata	Ascidiacea	Phlebobranchia	Ascidiidae	*Phallusia fumigata* (Grube, 1864)
Animalia	Chordata	Ascidiacea	Phlebobranchia	Ascidiidae	*Phallusia mammillata* (Cuvier, 1815)
Animalia	Chordata	Ascidiacea	Aplousobranchia	Polycitoridae	*Polycitor crystallinus* (Renier, 1804)
Animalia	Chordata	Ascidiacea	Aplousobranchia	Polyclinidae	*Polyclinum aurantium* Milne Edwards, 1841
Animalia	Chordata	Ascidiacea	Aplousobranchia	Clavelinidae	*Pycnoclavella* sp. Garstang, 1891
Animalia	Chordata	Ascidiacea	Aplousobranchia	Didemnidae	*Polysyncraton* sp. Nott, 1892

International Environmental Modelling and Software Society (iEMSs)
8th International Congress on Environmental Modelling and Software
Toulouse, France, Sabine Sauvage, José-Miguel Sánchez-Pérez, Andrea Rizzoli (Eds.)
http://www.iemss.org/society/index.php/iemss-2016-proceedings

-

IndexMed projects: new tools using the CIGESMED DataBase on Coralligenous for indexing, visualizing and data mining based on graphs

Romain David[1], Jean-Pierre Féral[1], Anne-Sophie Archambeau[2], Nicolas Bailly[3], Cyrille Blanpain[4], Vincent Breton[5], Aurélien De Jode[1], Aurélie Delavaud[6], Alrick Dias[1], Sophie Gachet[1], Dorian Guillemain[1], Julien Lecubin[4], Geneviève Romier[5], Christian Surace[7], Laure Thierry de Ville d'Avray[1], Christos Arvanitidis[3], Anne Chenuil[1], Melih Ertan Çinar[8], Drosos Koutsoubas[3,9], Stéphane Sartoretto[10], Thierry Tatoni[1]

(1) Institut Méditerranéen de Biodiversité et d'Ecologie marine et continentale (IMBE), CNRS, Aix Marseille Université, IRD, and Université d'Avignon, Station Marine d'Endoume, Chemin de la Batterie des Lions, 13007 Marseille, France. romain.david@imbe.fr, jean-pierre.feral@imbe.fr, anne.chenuil@imbe.fr, aurelien.dejode@imbe.fr, alrick.dias@imbe.fr, sophie.gachet@imbe.fr, dorian.guillemain@imbe.fr,laure.thierry@imbe.fr, thierry.tatoni@imbe.fr
(2) GBIF-France, MNHN, CP 48, 43 rue Buffon, 75005 Paris, France. archambeau@gbif.fr, gbif@gbif.fr
(3) HCMR/IMBBC Hellenic Centre for Marine Research, Institute of Marine Biology, Biotechnology & Aquaculture, LifeWatchGreece, Gouves, 71500 Heraklion, Crete, Greece. nbailly@hcmr.gr; arvanitidis@hcmr.gr
(4) Service informatique (SIP), OSU Pythéas, CNRS, Aix Marseille Université, 13007 Marseille, France. cyrille.blanpain@osupytheas.fr, julien.lecubin@osupytheas.fr
(5) Institut des Grilles et du cloud (IDG) France Grilles % LPC Clermont-Ferrand 4 avenue Blaise Pascal 63178 Aubière Cedex breton@idgrilles.fr , genevieve.romier@idgrilles.fr
(6) FRB ECOSCOPE - Pôle pour l'observation et la diffusion des données de recherche sur la biodiversité, Fondation pour la Recherche sur la Biodiversité, 195 rue Saint-Jacques - 75005 Paris, France. aurelie.delavaud@fondationbiodiversite.fr
(7) Laboratoire d'Astrophysique de Marseille (LAM), CNRS, Aix Marseille Université, rue Frédéric Joliot-Curie, 13013 Marseille, France. christian.surace@lam.fr
(8) Department of Hydrobiology, Faculty of Fisheries, Ege University, Bornova, Izmir, Turkey. melih.cinar@ege.edu.tr
(9) National Marine Park of Zakynthos, 29100, Zakynthos, and Dept. Marine Sciences, University of the Aegean, 81100 Mytilini, Greece drosos@aegean.gr
(10) IFREMER,Quartier Brégaillon, 83500 La Seyne-sur-Mer, France. Stephane.Sartoretto@ifremer.fr

Abstract: Data produced by the CIGESMED project (Coralligenous based Indicators to evaluate and monitor the "Good Environmental Status" of the MEDiterranean coastal waters) have a high potential for use by several stakeholders involved in environmental management. A new consortium called IndexMed whose task is to index Mediterranean biodiversity data, makes it possible to build graphs in order to analyse the CIGESMED data and develop new ways for data mining of coralligenous data. This paper presents the prototypes under development that test the ability of graphs approach to connect biodiversity objects with non-centralized data. This project explores the ability of two scientific communities to work together. The uses of data from coralligenous habitat demonstrate the prototype functionalities and introduce new perspectives to analyse environmental and societal responses.

***Keywords**: data qualification, graph, thesaurus, distributed information system, Coralligenous habitats*

1 INTRODUCTION

1.1 Context : Big data and interoperability in ecology

Data mining emerged in the late 90s [Fayyad et al., 1996] as a discipline to extract relevant novel and understandable knowledge from the analysis of preexistent datasets and evolved to an increasingly complex approach which includes ecology, among other disciplines. Although currently it is considered

by most information producers and users in scientific disciplines and industry as the most promising way for making progress and leading to discovery, the use of Big Data in Ecology is still lagging behind from other disciplines [Peters et al., 2014]. In marine biodiversity and its connection with the coastal socio-ecological systems (SES), data production is still very expensive and with a low level of automation. Studies on long term data series and/or large spatial areas are difficult to conduct, and when it is necessary to involve several observers, it must be noted that the robustness and reproducibility of the observation is very often more difficult to obtain.
In a production framework of multi-source data in ecology, the equivalence of observation systems and inter-calibration become crucial. Increasingly, integrative transdisciplinary approaches become necessary in the study of systems where information in each discipline is patchy, imprecise and poorly distributed. Yet all variables (biotic, abiotic, anthropogenic and natural pressures, perceived and rendered ecosystem services, societal perception, etc.) of these systems interact in a wide range of spatio-temporal scales [Féral et al., 2001] [Gachet et al., 2005], [Conruyt et al., 2010]. Some research systems tried to bring out logical interdependencies in socio-ecological systems to facilitate the building of biodiversity and ecosystems services [Laporte et al., 2014]. Several authors and international initiatives also tried to specify, through a hierarchical approach of biodiversity [Noss, 1990], a common minimum set of variables to be measured, complementary to one another and covering the interlinked biodiversity organization levels. They should allow to capture, with current means and tools, the maximum possible information on biodiversity state and trends with the least effort [Pereira et al., 2013], [Kissling et al., 2015]. Similar initiatives are ongoing for climate, weather and ocean [Connecting GEO] to foster the discovery and the analysis of complementary data across spatial and temporal scales.
New opportunities are created by open data formats in ecology [Reichman etal., 2011] and qualification standards usable in data management are developed with the Biodiversity Informatics Standards (formerly Taxonomic Database Working Group) consortium <www.tdwg.org> (Darwin Core Task Group) [Wieczorek et al., 2012]. Other studies focus on the integration of declarative knowledge with numerical and qualitative data [Gibert et al., 2014] or on the post-process of results required to provide understandable knowledge to the end-user [Cortez et al., 2012] [Gibert et al., 2012].

Finally, methods for linking biodiversity and environmental data exist, but they are often limited to an "inventory" aspect of biodiversity (collection, observations, repositories and distribution) and neglect functional aspects. Initiatives like CoL [Catalogue of Life], Data-ONE [Data Observation Network for Earth], EMODnet [European Marine Observation and Data Network], GEO-BON [Group On Earth Observations Biodiversity Observation Network], EU-BON [European Biodiversity Observation Network], GBIF [Global Biodiversity Information Facilities], LifeWatch, OBIS [Ocean Biogeographic Information System], and TDWG [Biodiversity Information Standards] along with Darwin Core and ABCD [Access to Biological Collections Data], are well-known examples for achieving interoperability and standardizing data collection. However, integrative approaches in the coastal management zone need more interoperability at each scale [Féral and David, 2014].

1.2 Coralligenous habitat's case

The “coralligenous habitat”, an endemic bioherm of the Mediterranean Sea, offers such a particularly complex case. Coralligenous habitats are difficult to study because they are patchy, not easily accessible (between 20 m and 120 m deep) and highly variable in local contexts [Ballesteros, 2006]. Due to these difficulties and the intrinsic complexity of this habitat type, comprehensive studies were rare until the 2000s [Laborel, 1961], [Laubier, 1966], [Hong, 1982], [Sartoretto, 1994]. Most of the proposed monitoring protocols / indicators for its ecological health are developed locally or regionally [Deter et al., 2012],[Sartoretto et al., 2016], on a single type of this habitat [Pergent-Martini et al., 2014], [Sini et al. 2015] and use rapid assessment techniques [Bianchi et al., 2007], [Kipson, 2011], [Deter et al., 2012], [Gatti et al., 2015], depending on prevailing environmental conditions.

Coralligenous habitats have been systematically studied at a larger scale within the CIGESMED ERANET'S program (*Coralligenous based Indicators to evaluate and monitor the "Good Environmental Status" of the MEDiterranean coastal waters*). The main CIGESMED's goal was to understand the connections between pressures (natural or anthropogenic) and the ecosystem functioning in order to define and maintain the Good Environmental Status (GES) of the Mediterranean Sea, by studying the typical, complex and poorly known habitats built by calcareous encrusting algae: the coralligenous habitats. This program is in support of the implementation of the Directive 2008/56/EC of the European Parliament and of the Council of the 17th June 2008. It participates establishing a framework for stakeholders community action in the field of marine environmental policy (Marine Strategy Framework Directive - MSFD), and highlighting descriptors 1 (biological diversity), 2 (non-indigenous species) and 6 (seafloor integrity). The Marine Strategy Framework Directive (MSFD) is directing European Member States towards an implementation of the assessment of marine environmental status. Due to their very high specific richness, including commercial species, and the number of aesthetically important seascapes they hold, coralligenous habitats are one of the most popular marine environments [Ballesteros, 2006]. The community of CIGESMED redefined it as : "*reefs in dim-light conditions mainly bio-constructed on hard substratum by calcifying coralline algae widespread throughout the Mediterranean sea, including patchwork of habitats complicated by the action of bio-eroders. These complex biogenic formations provide a number of different conditions of light, food and shelter. They are often considered as biodiversity hotspots gathering numerous sessile and sedentary species such as sponges, bryozoans, corals and gorgonians depending on the region and on the depth, to which hundreds of sciaphilic species are associated. These complex environments are a reservoir of natural resources (fisheries, red coral) and form highly valued landscapes sought by divers*". The data provided by CIGESMED are now used by the IndexMed consortium as a model, for developing data mining and decision support.

1.3 IndexMed, an open consortium

IndexMed is a new consortium in charge of indexing Mediterranean biodiversity data, building and analyzing graphs from heterogeneous databases. It aims to develop new ways for data mining in ecology. This consortium aims to identify and overcome the scientific barriers encountered when working on the quality and heterogeneity of data. The use of emerging data mining methods like graph-based models and analyses allows us to address these issues for improving decision-making support. These methods enable us to detect new patterns of contexts factors, invisible when using multidimensional analyses, that have an accurate capacity to indicate particular situations [Klemes, 2015].

2 METHODS

2.1 The challenge of quality data management to enhance results of data mining

Besides theoretical scientific issues (such as the intrinsic heterogeneity and complexity of biodiversity data, from genes to ecosystems, and their links to environmental parameters), the improvement of data quality is hindered by data management issues, such as: i) the dynamic update of voluminous datasets, ii) the update of reference repositories and standards supporting data management, iii) the heterogeneity of data producers and their motivation to maintain and supply their information systems, and iv) the diversity of the targeted end-users and their skills.

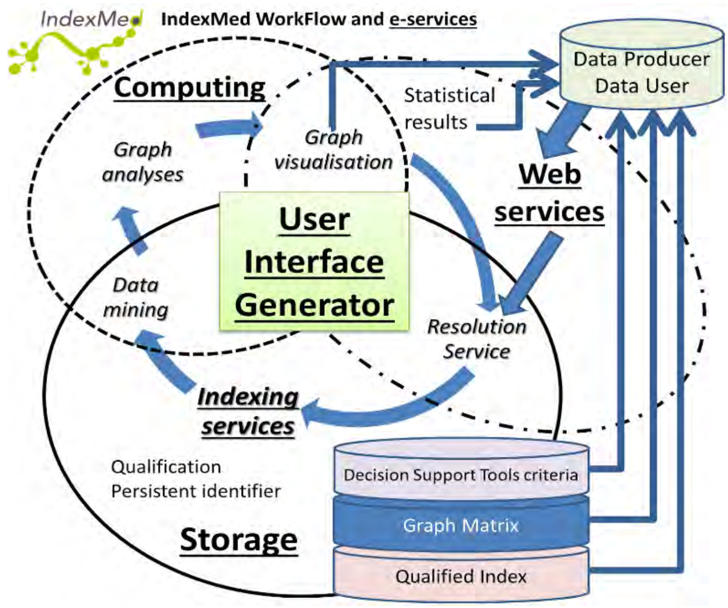
An integrated approach of the complexity of coralligenous was implemented to mutualize dataset production methods and visualize large data collections, and extract knowledge to study ecosystems. Health quality Indicators, targeting different levels of biodiversity (from communities to genomes), were co-constructed and tested by scientists, stakeholders, and by a citizen science network. Within the CIGESMED program, an upgrade of the design of each protocol and the inter-calibration exercises between various observers, materials, methods and organizations allowed to obtain: i) an assessment of the data variability due to natural or anthropogenic conditions and ii) a comparison of the different methods or observers and their efficiency. It showed that, under the above consensual definition of coralligenous, coralligenous habitats are made of a large panel of different species assemblages. For instance, coralligenous habitats from the Eastern and Western Mediterranean basins may share only 2 or 3 conspicuous species. Comparisons between regions are complicated by this lack of common species and the environmental conditions that can deeply change. Other links between typical environments and species (e.g. traits, contexts, structures, etc.) should be used to build indicators and to compare the environmental status between regions at a Mediterranean scale. Only multi-criteria contextualization by common factor value level allows constructing and adapting the indicators at a local scale and highlighting the significance of this indicator. Finally, it was decided to use competencies and tools developed by the IndexMed consortium to analyse all heterogeneous data, and integrate multidisciplinary data related to coralligenous habitats within the same multi-criterial approach but considering them at a comparable level of importance.

Coralligenous habitats are under anthropogenic uses and threats [Ballesteros, 2006]. Elaborating and testing “co-interpretation methods” of analyses (i.e. in the same time, at a same level of integration) is thought to be a keystone to mix in the same studies these heterogeneous data from different socio-economics disciplines and biodiversity disciplines, from the genome to the seascapes level. The ultimate goal is to propose scenarios to reach the sustainable management of biodiversity balancing exploitation and conservation. Data mining methods will be able to bring new perspectives to the disciplinary researches that finally examine interrelated objects (e.g. environmental chemistry, genomics, transcriptomics, metabolomics, population ecology / landscape, socio-ecological systems).

2.2 Workflow and e-services

To be able to use different and distributed datasets for data mining, a prototype of “object resolution service” (i.e. a web service that finds links and dependencies among indexed objects, based on unique objects identification (Figure 1)) that can be replicated by stakeholders is shared on a nodal point.
The aims of this prototype is i) listing available data and data stream, ii) analyzing content of datasets and data streams with standards referential, iii) qualifying streams, datasets with unique identifiers if there is no identifiers, iv) suggesting matches between fields to users /matches between equivalent data rows. The role of this object resolution service is to establish links between data row with different “unique identifiers” (e.g. different versions of data raw, interdependencies between raw data and transformed data, etc.).

Figure 1 - IndexMed WorkFlow and e-services: the resolution service is able to compare the index with storage data in e-infrastructures and other distant XML, JSON Flux from different databases. When necessary, it creates a persistent identifier or link datasets or data records with existing identifiers if they are enough robust. A qualification process is allowed by a scientist interface, adapted to the level and needs of each user. The indexing service allows data for computing services like data mining and graph analyses, and statistical results and graph models are stored and proposed as a new persistent flux. This system is intended to be replicable as a free software and a free service from European grids (EGI and others).



When it is possible, data qualification uses tools, standards and recommendations at both national (SINP [National Information System on Biodiversity], RBDD [Network of Research Databases]) and international levels (MedOBIS [Mediterranean Ocean Biogeographic Information System], OBIS, GBIF [Cryer et al., 2009], Life-Watch, GEO-BON, etc.) along with other research entities (i.e. IRD [Institute of Research for the Development] or MNHN [National Museum of Natural History, Paris]).
Heterogeneity in datasets may be the result of a lack of standards to name and describe data [Kattge et al., 2011; [Madin et al., 2008]. Thus, attention must be paid to the characterisation of concepts by using controlled vocabulary and semantic links between these concepts, which implies building a thesaurus in the first place (a thesaurus appears more appropriate than an ontology because of its flexibility). Several eco-informatic initiatives attempted to build such thesaurus (see [Michener & Jones, 2012; Laporte, 2012]) and it is expected to take them in account.

New data qualifications generated by IndexMed prototypes aim at following the “guidelines on Data Management in Horizon 2020” (V2.1, 15 Feb. 2016) and cover as it is recommended the handling of research data during and after the project, what data are collected, processed or generated, what methodology and standards are applied, whether data will be shared /made open access and finally

how data will be curated and preserved (Horizon 2020 Annotated Grant Agreement for articles 29.2 and 29.3, IP/12/790 on open access in Horizon 2020.
<http://ec.europa.eu/research/participants/docs/h2020-funding-guide/cross-cutting-issues/open-access-data-management/open-access_en.htm>)

3 RESULTS

The first tool developed commonly by the CIGESMED and the IndexMed community for scientists working on biodiversity is a prototype building dynamic maps of data and their possible links based on Graphs [David et al., 2015]. It can be used to establish links between objects of different disciplines and is able to connect data without centralizing them. The first aim is to teach the community how to use the graph approach, featuring a didactic and ergonomic interface (Figure 2) with the aims to improve by step user level. It allows evaluating the data quality level and identifying the best ways to improve their efficiency (e.g. density, sensibility, velocity, accuracy, etc.). A tool permits to keep the new models designed by users (i.e. link and node selections) and new items (more than 1 object in a node) and produces a single stream usable by data centers at different formats (NoSQL exports in RDF, Json, XML formats) with a persistent URL.

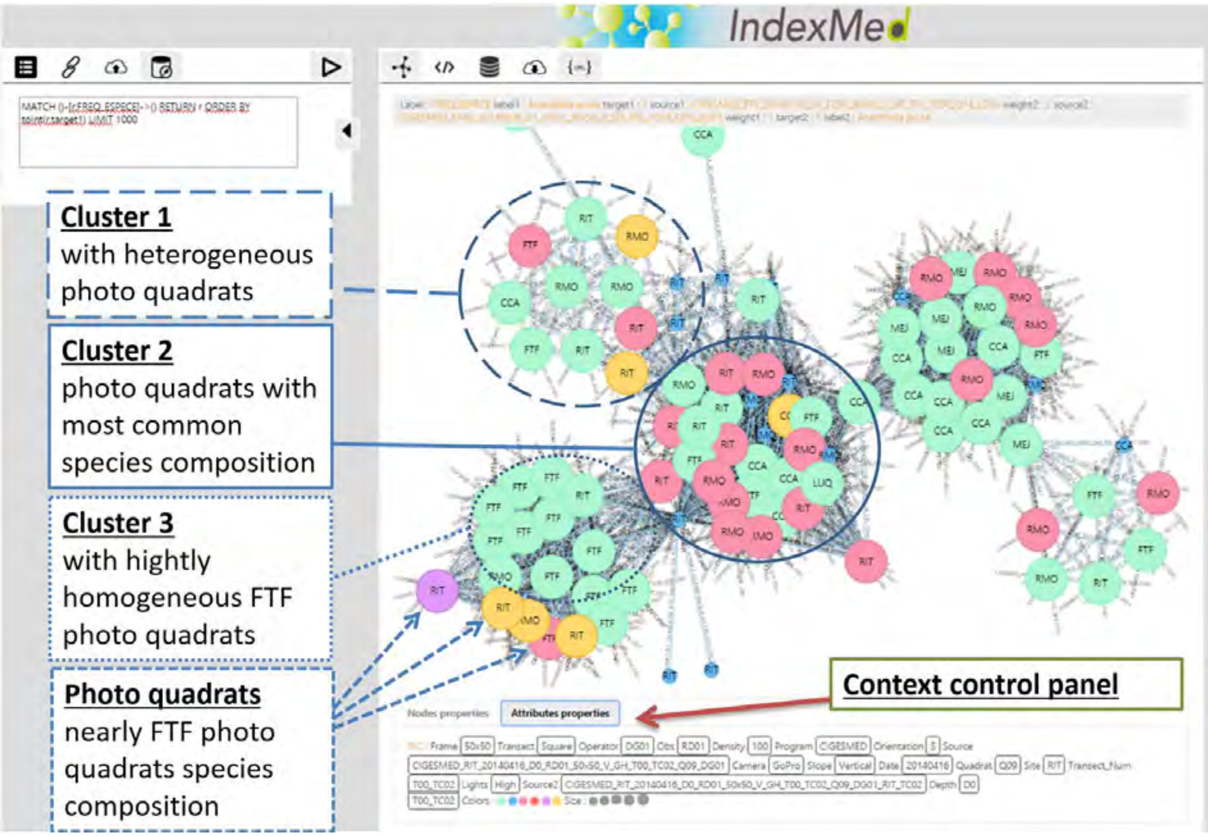


Figure 2 : In this use case of the prototype, photo quadrats selected by the interface are the nodes of the graph, species frequency selected by the user build 1000 links between photo quadrats, the colours of nodes highlight different elements of contexts (here, different observers). Node legends are the names of the observed sites. The more photo quadrats contain similar species assemblages, the more they are attracted. We can observe that some photo quadrats are equivalent of many different sites, and very ubiquitous (cluster 2 in the centre of the graph). In cluster 3 photo quadrats are homogeneous and typical for a site, and near this cluster some photo quadrats of other sites constitute a particular group. Cluster 1 show another type of photo quadrats, less present in each site but represented everywhere.

In the example of figure 2, datasets come from 3 different protocols and data production systems, including one based on photo quadrats analyses with the software photoQuad [Trigonis and Sini, 2012], a cartography of ecological/physical contexts and genetic data. Data objects represented on the graph are photos coming from different sites. Objects can be selected using the context control panel. Clusters visible in figure 2 can be modified by selection of context or species choice for the links. The relative importance of each species can be modified in the links (e.g. depending of the status or a specific trait) and some context elements can be selected to participate to links between nodes. Observers, highlighted by colours of nodes are not evenly distributed. Experience of observers is reflected in the size of nodes.

This interface uses indexed data, data qualification, and data traceability for discovering patterns in the conjunctions of data values with scientific significance.
The graph design can be manipulated on a web browser interface, the request and manipulations steps can be stored on a personal account and the result allows installing a flux at XML or JSON format available on a web service for data mining or another indexing service..

4 DISCUSSION

4.1 organizing data means to organize access and to improve quality

The description of data quality is an objective of the IndexMed consortium <http://www.indexmed.eu> that can be useful for data about coralligenous, based on an analysis of both similarities and differences between databases. Descriptions as metadata form a set of criteria used for data mining. The graph-based model is an abstraction tool that enables the comparison of various databases despite their differences and that improves decision support using emerging data mining methods. Practically, it is intended to give the equivalence of data, based on data dictionaries, thesauri and ontologies. From the established logical relationships, new qualifiers can be deduced including across data heterogeneity.

This work on CIGESMED data quality and their equivalence with other observatory systems involves first the analysis and description of the common elements of each piece of information, and of what differentiates them (fields name, formats, update rate, precision, observers or sensors, etc.). These descriptions are added to the data, and form a supplementary set of criteria used for data mining.
Standard formats and protocols are used to interconnect CIGESMED data with other databases. Standardization makes possible such a work, as well as a special task on interoperability qualities and accessibility of non-centralized data. It uses aggregation and new visualizations for public display, multi-interface, multi-use and multi-format, and must allow (i) the connection between many databases, and (ii) the preparation of inter-calibration works.

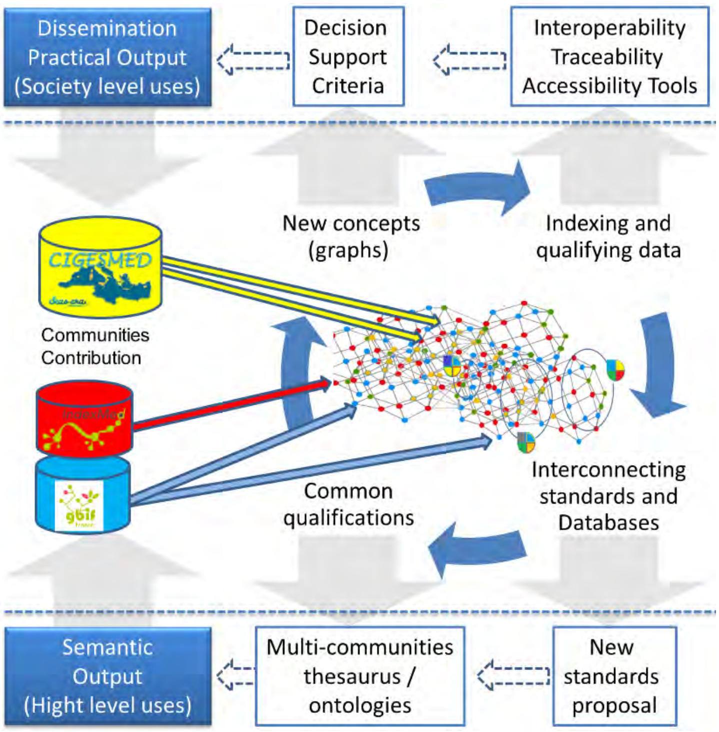


Figure 3: Iterative quality approach and IndexMed Output : It is intended to give the equivalence of data, based on data dictionaries and thesaurus. Some database equivalences allow deducing others, using first specific standards if it exists in each domain and secondary multidisciplinary approach. Equivalencies are used to link heterogeneous objects and construct graphs, where objects are nodes and attribute modalities are links. The main output is a new model of dataset, stored in a graph database (graph matrix) and accessible with web-services for visualization and integrated flux. A second output is the improving of multi-community thesaurus necessary to build new common ecological concepts. The next step of this project is the recognition of patterns of context in the graph matrix that will constitute decision support criteria.

Semantic approaches greatly increase their interoperability and some initiatives using Semantic Web technologies for retrieving Biodiversity data [Amanqui et al., 2014] and developing methods for linking of biodiversity and environmental data already exist, but they often concern only an "inventory" aspect. However, it remains that specific scientific objectives, organizational logic of projects and collection of information are leading to a decentralized data distribution which may hamper environmental research development. In such a heterogeneous system footed on different organizations and data formats, not everything can be homogenized. IndexMed workflow permits to implement an iterative quality demarche (Figure 3) increasing step by step the capacity of each data to be connected to others (i.e. contextual data like biotic, abiotic, anthropogenic and natural pressures, etc.)

The resulting cluster and their correlations to context patterns can be compared with other kinds of analyses: supervised clustering results, statistical ecology approach [Gimenez et al., 2014] and collaborative clustering methods [Forestier et al., 2008] are planned to be used at each part (e.g. a group of nearby nodes with similar patterns of context) of the graph, using job middleware (DIRAC3, [Tsaregorodtsev, 2009]). Another issue is to use "unsupervised" mode, raising the possibility to compare the results of different algorithms to achieve consensus, which acts / results in the most likely scenario. The data mining helps finding managerial values of qualifiers to propose scenarios, and provides new standardized descriptors essential for approaches such as machine learning.

4.2 Efficiency for data mining approach and links with decision support

The chain between data and decision making can be superimposed to the DIKW(U) hierarchy: Data, Information, Knowledge, Wisdom, Understanding [Zeleny, 1987; Ackoff, 1989], replacing Wisdom by Management. In a simplistic view, scientists produce knowledge by analysing data into information and by elaborating theories from information. Data constitute the primary material from which hypotheses are 1) elaborated, and 2) tested. However, even if biodiversity data have been produced in the common framework of the theory of evolution, it has often been done independently in different domains from genes to ecosystems; moreover, biodiversity data are historical in essence, they have a time component: that a species has been observed at a given location at a given time is not reproducible like for physico-chemical experiments. Consequently, every piece of data in each domain may be of importance, and for older ones, they may need to be re-expressed to fit under their current conceptual and standard forms, in particular to use them all in a common approach like here. We are thus dealing with millions of pages of scientific literature and the increasing number of data repositories since Aristotle [Voultsiadou, 2007]. The Biodiversity Heritage Library <http://www.biodiversitylibrary.org/> is already making available almost 50 million pages (and still increasing), mainly up to 1930s because of copyright issues: since the scientific production progresses exponentially, we may talk here about billions of pages. Even narratives of travels and expeditions can be used to extract biodiversity semi-quantitative data [Al-Abdulrazzak et al., 2012].

The development of new data mining tools becomes crucial to explore automatically all sources of biodiversity data, or currently more reasonably semi-automatically, in order to produce the most complete knowledge that constitutes the decision support material (but not the decision-making tools by themselves!). This knowledge is the basis for developing alternative future scenarios about the biodiversity management among which decision and policy-makers will make a political choice. The graph approach may allow going a step further by integrating socio-economic knowledge in these scientifically supported scenarios. Currently, this integration is made at the decision making level, where biodiversity and socio-economics scenarios are on the contrary put in competition, most often to the benefit of the socio-economics scenarios, with too many examples from the domain of fisheries [Froese, 2011].

5 CONCLUSIONS AND RECOMMENDATIONS

Compared with dimensional and multidimensional analyses, which are often used for ecological and environmental purposes, such innovative approaches make possible the investigation of complex research questions and the emergence of new scientific hypotheses. Regarding the first results, environmental scientists and environmental managers from CIGESMED and from the IndexMed consortium have to face different challenges about links between data and well understanding of the meaning of new objects and their variation. For better analysing heterogeneously distributed data spread in different databases and for identifying statistical relationships between observed data and

the emergence of contextual patterns, it will be necessary to create matches and incorporate some approximations.
The area of Decision Support Systems (DSS) focuses on development of interactive software that can use data mining export of IndexMed prototypes. This prototype aims to provide qualifiers that can be interpreted in patterns as answers to relevant decisional questions from the users, thus enhancing a person or a group to make better decisions. Till now, important efforts to develop links between Indexmed and dedicated DSS are required and possible for every particular application [Varanon et al., 2007, Power, 2007]. Specific DSS linked to IndexMed must be experimented where some successful experiences appear in several fields, like self-care management [Marschollek, 2012], water management [Pallottino, 2005], forest ecosystems [Nute, 2004] or air pollution [Oprea, 2005]. IndexMed community is open to contribution. IndexMed software are open source and privileged case studies are open data, and the involved teams plan to set up a forge and a contributory platform for expanding testing graph approaches.

Multidisciplinary approaches are a key as well as the most difficult way to improve data mining and DSS. At a "human" level, it is seriously necessary to encourage the data openness and data sharing, as the only way to give value to data after their primary use [McNutt et al., 2016]. A good start might be to organize more events dedicated to the sharing of experience and expertise, the acquisition of practical methods to construct graphs and value data through "metadata and data papers".

ACKNOWLEDGMENTS

The construction of the first prototype for IndexMed consortium is funded by the CNRS défi "VIGI-GEEK (VIsualisation of Graph In transdisciplinary Global Ecology, Economy and Sociology data-Kernel)" and CNRS INEE through the "CHARLIEE" project. Data used for this article were obtained through the CIGESMED project <www.cigesmed.eu> (ANR conventions n° 12-SEAS-0001-01, 02 and 03 for France; GSRT - 12SEAS-12-C2 for Greece; TUBITAK Project No: 112Y393 for Turkey). The authors acknowledge the support of France Grilles for providing computing resources on the French National Grid Infrastructure. Supplementary acknowledgement to Gergely SIPOS, Jan BOT and Roberta PISCITELLI for the helpful support provided at "design your e-infrastructure" EGI <www.egi.eu> workshop. We acknowledge all the field helpers and students who have participated in data collection in the field and in the lab, as well as in data management.

REFERENCES

Ackoff, R. L., 1989. From data to wisdom. Journal of applied systems analysis, 16(1), 3-9.
Al-Abdulrazzak, D., Naidoo, R., Palomares, M. L. D., Pauly, D., 2012. Gaining perspective on what we've lost: the reliability of encoded anecdotes in historical ecology. PloS one, 7(8), e43386. doi:10.1371/journal.pone.0043386.
Amanqui, F.K., Serique, K.J., Cardoso, S.D., dos Santos, J.L., Albuquerque, A. and Moreira, D.A., 2014. Improving biodiversity data retrieval through semantic search and ontologies. Web Intelligence (WI) and Intelligent Agent Technologies (IAT), 2014 IEEE/WIC/ACM International Conference on Web Intelligence, 11-14 August 2014, Warsaw, Poland, vol.1 (WI), pp.274-281, doi: 10.1109/WI-IAT.2014.44.
Ballesteros, E., 2006. Mediterranean coralligenous assemblages: a synthesis of present knowledge. Oceanography and Marine Biology: An Annual Review, 44, 123-195.
Bianchi, C. N., Cattaneo-Vietti, R., Morri, C., Navone, A., Panzalis, P., Orru, P., 2007. Coralligenous formations in the Marine Protected Area of Tavolara Punta Coda Cavallo(N-E Sardinia, Italy). Biologia marina mediterranea, 14(2), 148-149.
Conruyt, N., Sébastien, D., Vignes-Lebbe, R., Cosadia, S., 2010. Moving from biodiversity information systems to biodiversity information services. Information and Communication Technologies for Biodiversity Conservation and Agriculture, 107-128.
Cryer, P., Hyam R., Miller C., Nicolson, N., Tuama, É.Ó, Page, R., Rees, J., Riccardi, G., Richards, K., Whitev, R., 2009. Adoption of persistent identifiers for biodiversity informatics. Report published by GBIF Secretariat.
Cortez, P., & Embrechts, M. J., 2013. Using sensitivity analysis and visualization techniques to open black box data mining models. Information Sciences, 225, 1-17.
David, R., Féral, J. P., Blanpain, C., Diaconu, C., Dias, A., Gachet,S., Gibert, K., Lecubin, J., Surace, C., 2015. A First Prototype for Indexing, Visualizing and Mining Heterogeneous Data in

Mediterranean Ecology: Within the IndexMed Consortium Interdisciplinary Framework. In 2015 11th International Conference on Signal-Image Technology & Internet-Based Systems (SITIS).232-239.
Deter, J., Descamp, P., Ballesta, L., Boissery, P., & Holon, F., 2012. A preliminary study toward an index based on coralligenous assemblages for the ecological status assessment of Mediterranean French coastal waters. Ecological indicators, 20, 345-352.
Deter, J., Descamp, P., Boissery, P., Ballesta, L., & Holon, F., 2012. A rapid photographic method detects depth gradient in coralligenous assemblages. Journal of Experimental Marine Biology and Ecology, 418, 75-82.
Fayyad, U., Piatetsky-Shapiro, G., & Smyth, P., 1996. From data mining to knowledge discovery in databases. AI magazine, 17(3), 37.
Féral, J.-P., David, R., 2013. L'environnement, un système global dynamique. Zone côtière et développement durable, une équation à résoudre. In: Euzen, A., Eymard, L., Gaill, F. (Eds), 2013. Le développement durable à découvert, CNRS éditions: Paris, September,96-97, ISBN : 978-2-271-07896-4.
Féral, J.-P., Arvanitidis, C., Chenuil, A., Çinar, M.E., David, R., Frémaux, A., Koutsoubas, D., Sartoretto, S., 2014. CIGESMED, Coralligenous based Indicators to evaluate and monitor the « Good Environmental Status » of the MEDiterranean coastal waters, a SeasEra project (www.cigesmed.eu). Proceedings RAC/SPA 2nd Mediterranean Symposium on the Conservation of coralligenous and other calcareous bio-concretions, Portorož, Slovenia, October, 15-21.
Forestier, G., Wemmert, C., Gançarski, P., 2008. Multisource images analysis using collaborative clustering. EURASIP Journal on Advances in Signal Processing, 2008, 133.
Froese, R., 2011. Fishery reform slips through the net. Nature, 475(7354), 7-7.
Gachet, S., Véla, E., Tatoni, T., 2005. BASECO: a floristic and ecological database of Mediterranean French flora. Biodiversity & Conservation, 14(4), 1023-1034.
Gatti, G., Bianchi, C. N., Morri, C., Montefalcone, M., Sartoretto, S., 2015. Coralligenous reefs state along anthropized coasts: Application and validation of the COARSE index, based on a rapid visual assessment (RVA) approach. Ecological Indicators, 52, 567-576.
Gibert, K., Valls, A., Batet, M., 2014. Introducing semantic variables in mixed distance measures: Impact on hierarchical clustering. Knowledge and Information Systems, 40(3), 559-593.
Gibert, K., Conti, D., Vrecko, D., 2012. Assisting the end-user in the interpretation of profiles for decision support. an application to wastewater treatment plants. Environmental Engineering and Management Journal, 11(5), 931-944.
Gimenez, O., Buckland, S.T., Morgan, B.J.T., Bez, N., Bertrand, S., Choquet, R., Dray, S., Etienne, M.P., Fewster, R., Gosselin, F., Mérigot, B., Monestiez, P., Morales, J., Mortier, F., Munoz, F., Ovaskainen, O., Pavoine, S., Pradel, R., Schurr, F.M., Thomas, L., Thuiller, W., Trenkel, V., de Valpine, P., Rexstad, E., 2014. Statistical ecology comes of age. Biology letters, 10(12), 20140698.
Hong,J. S., 1982. Contribution to the study of populations of the coralligenous concretionary bottom from the Marseille region on the northwestern Mediterranean coast. Bull. Korea Ocean Res. Dev. Inst., 4: 1–2.
Kattge, J., Ogle, K., Bönisch, G., Díaz, S., Lavorel, S., Madin, J., Nadrowski, K., Nöllert, S., Sartor, K., Wirth, C., 2011. A generic structure for plant trait databases. Methods in Ecology and Evolution, 2(2), 202-213.
Kipson, S., Fourt, M., Teixidó, N., Cebrian, E., Casas, E., Ballesteros, E., Zabala, M., Garrabou, J., 2011. Rapid biodiversity assessment and monitoring method for highly diverse benthic communities: a case study of Mediterranean coralligenous outcrops. PLoS One, 6(11), e27103.
Kissling, W. D., Hardisty, A., García, E. A., Santamaria, M., De Leo, F., Pesole, G., Freyhof, J., Wissel, S., Konijn, J., Los, W., 2015. Towards global interoperability for supporting biodiversity research on essential biodiversity variables (EBVs). Biodiversity, 16(2-3), 99-107.
Klemeš, J.J. (Ed.), 2015. Assessing and measuring environmental impact and sustainability. Butterworth-Heinemann. 608 pp. ISBN: 9780127999685
Laborel, J., 1961. Le concrétionnement algal "coralligène" et son importance géomorphologique en Méditerranée. Recueil des travaux de la Station marine d'Endoume, 23(37), 37-60.
Laporte, M. A., Garnier, E., 2012. ThesauForm—Traits: A web based collaborative tool to develop a thesaurus for plant functional diversity research. Ecological Informatics, 11, 34-44.
Laporte, M. A., Mougenot, I., Garnier, E., Stahl, U., Maicher, L., Kattge, J., 2014. A semantic web faceted search system for facilitating building of biodiversity and ecosystems services. In Data Integration in the Life Sciences (pp. 50-57). Springer International Publishing.
Laubier, L., 1966. Le Coralligène des Albères. Monographie biocénotique. Adaptations chez les Annélides Polychètes interstitielles. Thès. Fac. Sci. Univ. Paris (Sér. A, No. 4693 No d'ordre 5541), 139-316.

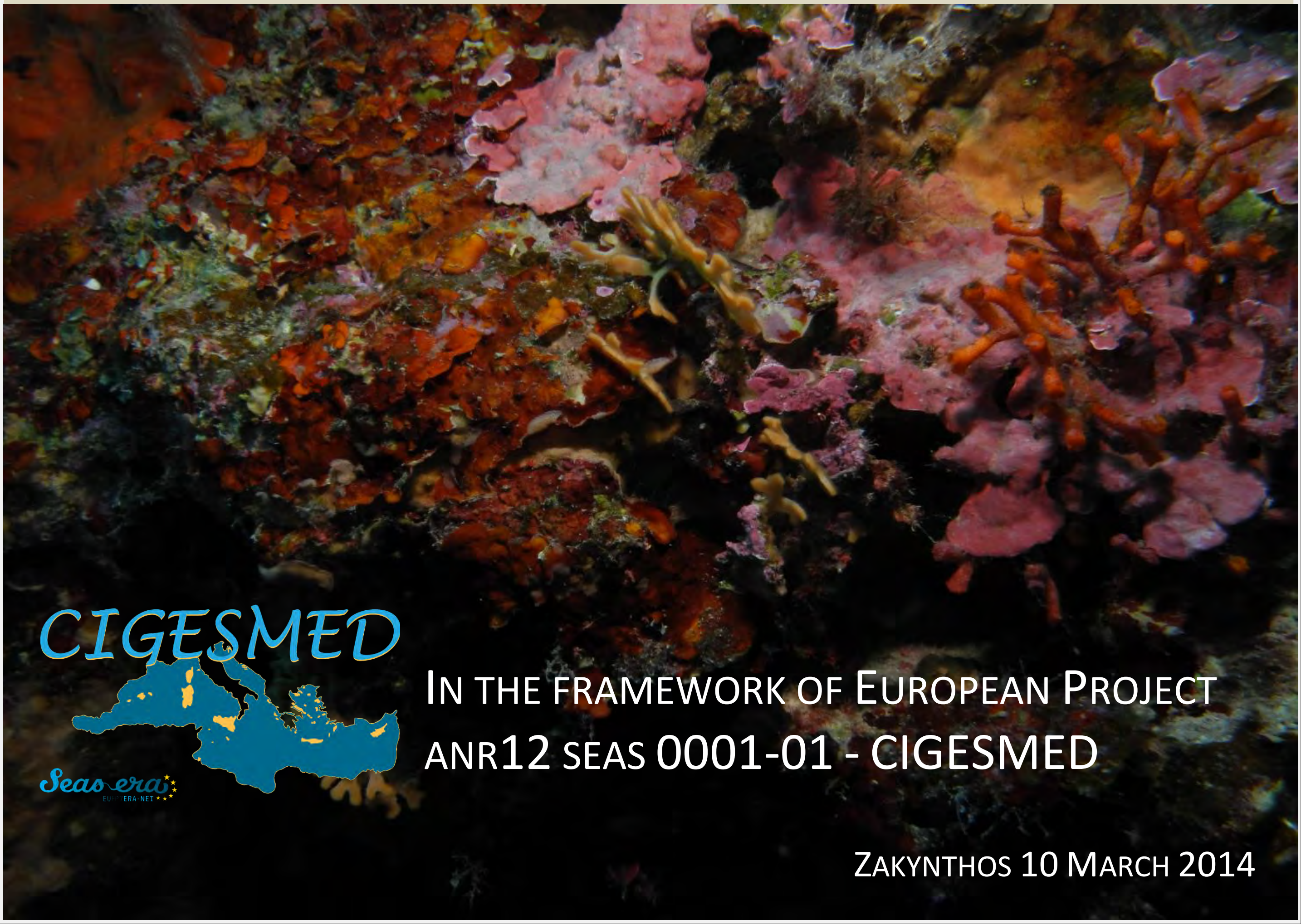
Madin, J. S., Bowers, S., Schildhauer, M. P., Jones, M. B., 2008. Advancing ecological research with ontologies. Trends in Ecology & Evolution, 23(3), 159-168.
Marschollek, M., 2012. Decision support at home (DS@ HOME)–system architectures and requirements. BMC medical informatics and decision making, 12(1), 43.
McNutt, M., Lehnert, K., Hanson, B., Nosek, B. A., Ellison, A. M., King, J. L., 2016. Liberating field science samples and data. Science, 351(6277), 1024-1026.
Michener, W. K., Jones, M. B., 2012. Ecoinformatics: supporting ecology as a data-intensive science. Trends in ecology & evolution, 27(2), 85-93.
Noss, R. F., 1990. Indicators for monitoring biodiversity: a hierarchical approach. Conservation biology, 4(4), 355-364.
Nute, D., Potter, W. D., Maier, F., Wang, J., Twery, M., Rauscher, H. M., Knopp, P., Thomasma, S., Dass, M., Uchiyama, H., Glende, A., 2004. NED-2: an agent-based decision support system for forest ecosystem management. Environmental Modelling & Software, 19(9), 831-843.
Oprea, M., 2005. A case study of knowledge modelling in an air pollution control decision support system. Ai Communications, 18(4), 293-303.
Pallottino,S., Sechi, G.M., Zuddas, P., 2005. A DSS for water resources management under uncertainty by scenario analysis. Environmental Modelling & Software, 20 (8): 1031-1042, doi: 10.1016/j.envsoft.2004.09.012.
Pereira, H.M., Ferrier, S., Walters, M., Geller, G.N., Jongman, R.H., Scholes, R.J., Bruford, M.W., Brummitt, N., Butchart, S.H., Cardoso, A.C., Coops, N.C., Dulloo, E., Faith, D.P., Freyhof, J., Gregory, R.D., Heip, C., Höft, R., Hurtt, G., Jetz, W., Karp, D.S., McGeoch, M.A., Obura, D., Onoda, Y., Pettorelli, N., Reyers, B., Sayre, R., Scharlemann, J.P., Stuart, S.N., Turak, E., Walpole, M., Wegmann, M., 2013. Essential biodiversity variables. Science, 339 (6117): 277-278. doi: 10.1126/science.1229931
Pergent-Martini, C., Alami, S., Bonacorsi, M., Clabaut, P., Daniel, B., Ruitton, S., Sartoretto, S., Pergent, G., 2014. New data concerning the coralligenous atolls of cap corse: an attempt to shed light on their origin. RAC/SPA 2nd Mediterranean Symp. on the Conservation of coralligenous and other calcareous bio-concretions, Portorož (Slovenia), 29-30/10/2014, 129-134.
Peters, D.P., Havstad, K. M., Cushing, J., Tweedie, C., Fuentes, O., Villanueva-Rosales, N., 2014. Harnessing the power of big data: infusing the scientific method with machine learning to transform ecology. Ecosphere, 5(6), 1-15.
Power,D.J., 2007. A Brief History of Decision Support Systems, DSSResources.COM (Editor), World Wide Web, version 4.0", March 2007, http://dssresources.com/history/ dsshistory.html.
Reichman, O. J., Jones, M. B., Schildhauer, M. P., 2011. Challenges and opportunities of open data in ecology. Science, 331(6018).
Sartoretto, S., 1994. Structure et dynamique d'un nouveau type de bioconstruction à Mesophyllum lichenoides (Ellis) Lemoine (Corallinales, Rhodophyta). Comptes rendus de l'Académie des sciences. Série 3, Sciences de la vie, 317(2), 156-160.
Sartoretto,S., Schohn, T., Bianchi, C.N., Morri, M.C., Garrabou, J., Ballesteros, E., Ruitton, S., Verlaque, M., Daniel, B., Charbonnel, E., Blouet, S., David, R., Féral, J.-P., Gatti, G., 2016. An integrated approach to evaluate and monitor the conservation state of coralligenous habitats: the Index-Cor approach. submitted in Ecological Indicators.
Sini, M., Kipson, S., Linares, C., Koutsoubas, D., Garrabou, J., 2015. The Yellow Gorgonian Eunicella cavolini: demography and disturbance levels across the Mediterranean Sea. PloS one, 10(5), e0126253.
Tsaregorodtsev, A., 2009. DIRAC3 . The New Generation of the LHCb Grid Software. Journal of Physics: Conference Series, vol. 219 062029, n° 6.
Trygonis, V., Sini, M., 2012. photoQuad: A dedicated seabed image processing software, and a comparative error analysis of four photoquadrat methods. Journal of Experimental Marine Biology and Ecology, 424, 99-108.
Uraikul, V., Chan, C. W., Tontiwachwuthikul, P., 2007. Artificial intelligence for monitoring and supervisory control of process systems. Engineering Applications of Artificial Intelligence, 20(2), 115-131.
Voultsiadou, E., 2007. Sponges: An historical survey of their knowledge in Greek antiquity. Journal of the Marine Biological Association of the United Kingdom, 87(06), 1757-1763.
Wieczorek, J., Bloom, D., Guralnick, R., Blum, S., Döring, M., Giovanni, R., Robertson, T., Vieglais, D., 2012. Darwin Core: An evolving community-developed biodiversity data standard. PloS one, 7(1), e29715.
Zeleny, M., 1987. Management support systems: towards integrated knowledge management. Human systems management, 7 (1): 59-70.

NATIONAL MARINE PARK OF ZAKYNTHOS

IN COLLABORATION WITH UNIVERSITY OF AEGEAN, DEPT. OF MARINE SCIENCE

1st Annual Report 2013 - 2014

CORALLIGENOUS SURVEY IN THE NORTH – EAST MEDITERRANEAN



CIGESMED

IN THE FRAMEWORK OF EUROPEAN PROJECT ANR12 SEAS 0001-01 - CIGESMED

ZAKYNTHOS 10 MARCH 2014

CORALLIGENOUS SURVEY IN THE NORTH – EAST MEDITERRANEAN

1st Annual Progress Report

Authors:
Koutsoubas D., Sini M., Gerovasileiou V., Dimitriadis C., Sourbes L., Poursanidis D.

WORKING GROUP

Name	Affiliation	Specific tasks
Drosos Koutsoubas	NMPZ	Project coordinator
Laurent Sourbes	NMPZ	Report preparation, administrative and communication tasks
Charalampos Dimitriadis	NMPZ	Report preparation, communication tasks, field work
John Batzakas	Univ. of the Aegean	Report preparation, communication tasks, field work
Vasilis Gerovasileiou	Univ. of the Aegean	Report preparation, communication tasks, field work
Maria Sini	Univ. of the Aegean	Report preparation, communication tasks, field work
Dimitris Poursanidis	Univ. of the Aegean	Report preparation, field work
Zinovia Erga	Univ. of the Aegean / CNRS	Laboratory work

NATIONAL MARINE PARK OF ZAKYNTHOS

HTTP://www.nmp-zak.org

DEPT. OF MARINE SCIENCES, UNIVERSITY OF AEGEAN

HTTP://www.mar.aegean.gr

Front page photos: F. Nikoloudakis

1. INTRODUCTION

The current document is the first annual progress report (1st reporting period) of activities that were undertaken by the National Marine Park of Zakynthos as a subtask in the framework of the European Project CIGESMED according to deliverable requirements of the contract (Ref CNRS: DR12-JE 093 579) signed by NMPZ and CNRS. The first annual report includes the tasks and activities carried out from June of 2013 until February of 2014. The activities of the subtask 'Coralligenous Survey in the North – East Mediterranean' and their relation to the Work Packages (WP) of CIGESMED project are presented in Table 1.

Table 1: NMPZ's activities and their relation to CIGESMED project WPs

NMPZ Activities	Description	Connection to CIGESMED WP's
Activity 1	Coralligenous assessment and monitoring	**WP2** - *Coralligenous assessment and threats in the different basins* **WP3** - *Indicators' development and test*
Activity 2	Management tools	**WP4** - *Innovative monitoring tools* **WP6** - *Data management, mapping and assimilation tools*
Activity 3	Participatory process-Promotion -Public awareness activities	**WP5** - *Citizen science network implementation* **WP7** - *Outreach, dissemination and stakeholder engagement*

2. CIGESMED KICK OFF MEETING

D. Koutsoubas, M.Sini and D. Poursanidis, members of the NMPZ work team, participated in the kick off meeting of CIGESMED project which was held at Heraklion, Crete from 17th to 19th of April 2013.

During the three day meeting they had the opportunity to meet with other project participants, and get acquainted with the project structure, organization, and deliverables. They attended a series of presentations focusing on the description of the different work packages, the presence of coralligenous habitats in France, Greece, and Turkey, the experience obtained from previous citizen science projects (i.e. COMBER), and the application of knowledge trees in information assimilation and data management. The NMPZ members exchanged ideas and technical knowledge regarding the study of coralligenous, contributed to the compilation of a generalized species list regarding flora and fauna of coralligenous communities in Greece, and registered in the Tree of Knowledge – consortium competences. Finally, M. Sini gave a short presentation on the main features and functions of photoQuad, a layer-based image processing software developed at the University of the Aegean, as a potential tool for the assessment of coralligenous communities in the context of CIGESMED project (Figure 1).

Figure 1: PHOTOQUAD Software presentation excerpts

3. CIGESMED FIELD TRIP IN MARSEILLE

V. Gerovasileiou and M. Sini, members of the NMPZ/University of Aegean work team, joined the CIGESMED diving workshop held in Marseille from 2nd to 4th of July 2013. The aim of the workshop was to give the chance to participants from Greece and Turkey to get acquainted with the well-developed coralligenous assemblages found at the Bay of Marseille for future reference and comparison with coralligenous communities found elsewhere.
Two diving fieldtrips were realized during which coralligenous habitats were photographed using quadrats of different size in order to check their efficiency. The participants also had the opportunity to attend the following presentations / discussions: a) Encrusting Coralligenous Rhodophyta – the main algal bioconstructors, by Marc Verlaque (CNRS – MIO), b) Basic principles towards the development of a coralligenous index (IndexCor), by Stéphane Sartoretto (IFREMER), c) Development of photographic and video tools, by Romain Bricout (CNRS associate), d) Hands-on application of photoQuad, by Maria Sini (NMPZ, University of the Aegean). Finally, a round table discussion took place regarding the main biotic, abiotic, and observer attributes that should be considered during future fieldwork and data analysis.

4. COMMUNICATION WITH LOCAL DIVE CLUBS

During August 2013, NMPZ initiated communications with local dive centers and divers so as to obtain information regarding the presence of coralligenous communities along Zakynthos Island coastline. The task included an initial presentation of the coralligenous habitats to the diving centers through the use of visual material (e.g. photos, video). After the briefing, the divers recommended several locations around Zakynthos coasts where coralligenous habitats could possibly be found. The obtained information was used to design the preliminary field survey in the NMPZ.

5. PRELIMINARY FIELD SURVEY IN NMPZ

For the establishment of suitable coralligenous study sites in Zakynthos Island (SW Ionian Sea, Eastern Mediterranean), a preliminary survey was conducted during September 2013 in three locations found at the SW part of the Island within the boundaries of the Marine Protected Area of the National Marine Park of Zakynthos (Figure 2). The choice of the locations was based on information provided by local diving centers and recreational divers, during dedicated interviews regarding the potential presence of coralligenous habitats along Zakynthos coastline. The locations of the examined candidate sites are presented in Figure 3.

Figure 2: The marine protected area of NMPZ including the zoning scheme of protection and the locations of the candidate sampling sites.

Figure 3: Locations of the three candidate sites in the NMPZ

CANDIDATE SITE 1: Marathonisi Islet

Coordinates: 37°40'57.43"N, 20°52'26.49"E

Figure 4: Location of the candidate site at Marathonisi Islet

Divers: Charalampos Dimitriadis (NMPZ), Fanis Nikoloudakis (Divers Paradise Dive club)

Site description

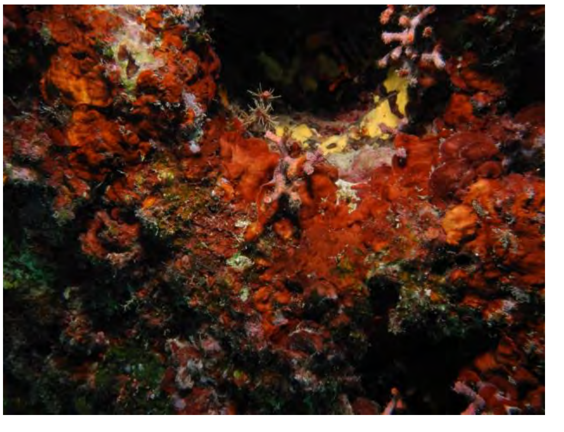
The site is located in zone B of the Marine Protected Area of the National Marine Park of Zakynthos (NMPZ). In particular, the candidate sampling site is situated at the southern part of Marathonisi Islet and starts at around 15 m depth (Figure 4). The underwater topography consists of different habitats (e.g. sandy beds and *Posidonia oceanica* meadows) whereas large boulders with overhangs and crevices are also present. This site is exposed to the prevailing South-Southeast and Southeast winds and is influenced by the water exchange of Laganas Bay with the open Ionian Sea.

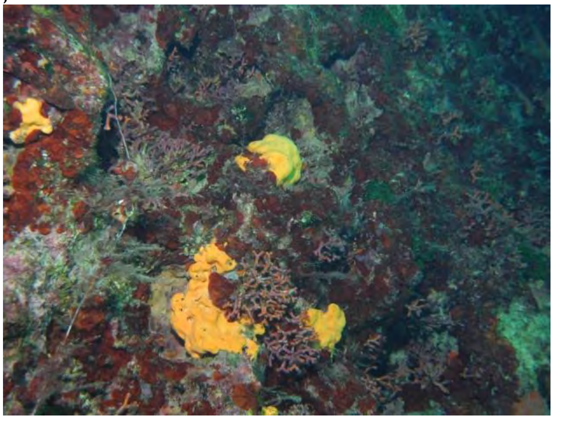
Human Pressures

The preliminary survey and previous studies that have taken place in this area indicate the presence of ghost nets and abandoned long lines, as well signs of potential disturbance due to intense recreational diving activity.

Characteristic photos

Depth 15 – 20 m



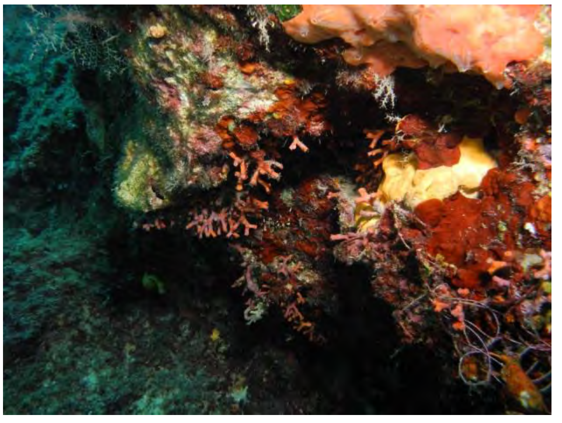


Figure 5: Typical coralligenous communities that can be found at candidate site 1

CANDIDATE SITES 2 & 3: KERI – MAVROS KAVOS

Coordinates:
Site Keri: 37°38'46.15"N, 20°50'9.80"E
Site Mavros Kavos: 37°38'42.32"N, 20°49'48.90"E

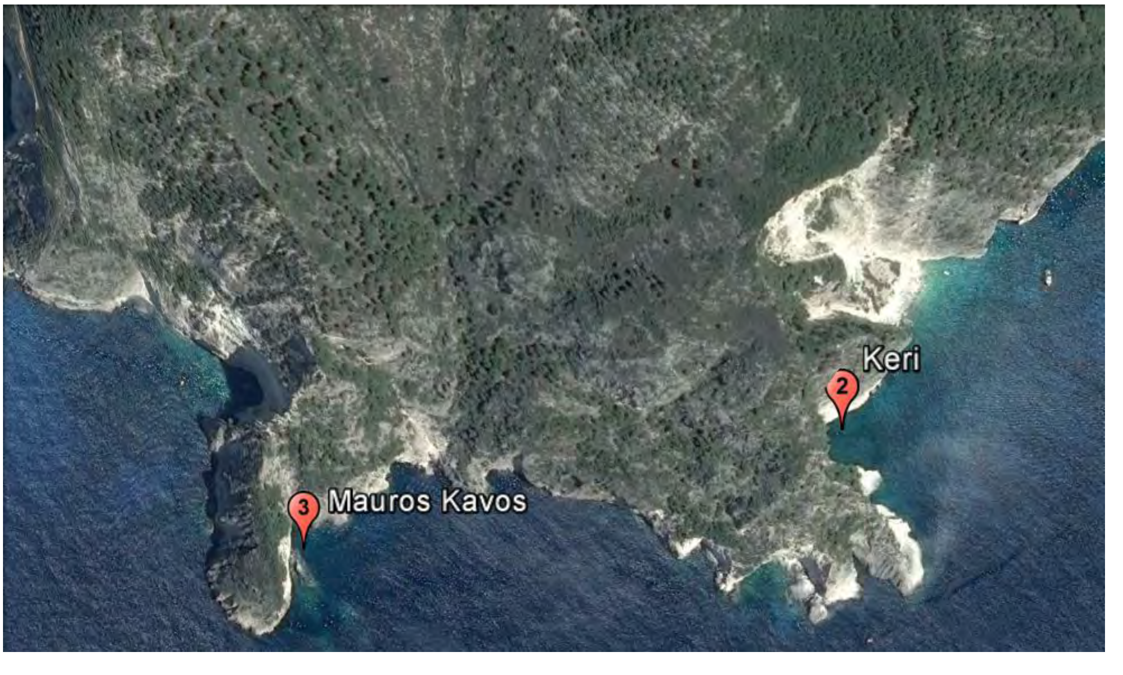


Figure 6: Candidate sites at Keri and Mavros Kavos locations

Divers: Charalampos Dimitriadis (NMPZ), Fanis Nikoloudakis (Divers Paradise Dive club)

Sites description

Both sites are situated at the SW part of Zakynthos Island, close to the westernmost boundaries of the NMPZ. The area is characterized by cooler water temperatures in comparison to Laganas Bay, possibly due to the direct exposure to the open Ionian Sea and the local wind driven upwellings. The topography of both sites is characterized by extensive vertical rocky walls with crevices, overhangs and numerous submerged caves. Rocky cliffs starting from 100 – 150 m above sea level drop vertically to depths of 30 – 40m. These geomorphological features account for the increased shadowy conditions observed locally over the greatest part of the day. At both sites depth of sciaphilic – coralligenous communities were recorded from 10 to 30 m.

Human Pressures

The preliminary survey and previous studies that have taken place in these areas indicate the presence of ghost nets and abandoned long lines, as well signs of potential disturbance due to intense recreational diving activity.

Characteristic photos:

Site KERI – Depth 15 -30m

Figure 7: Typical coralligenous communities that can be found at candidate site 2

Site MAVROS KAVOS – Depth 12-30 m

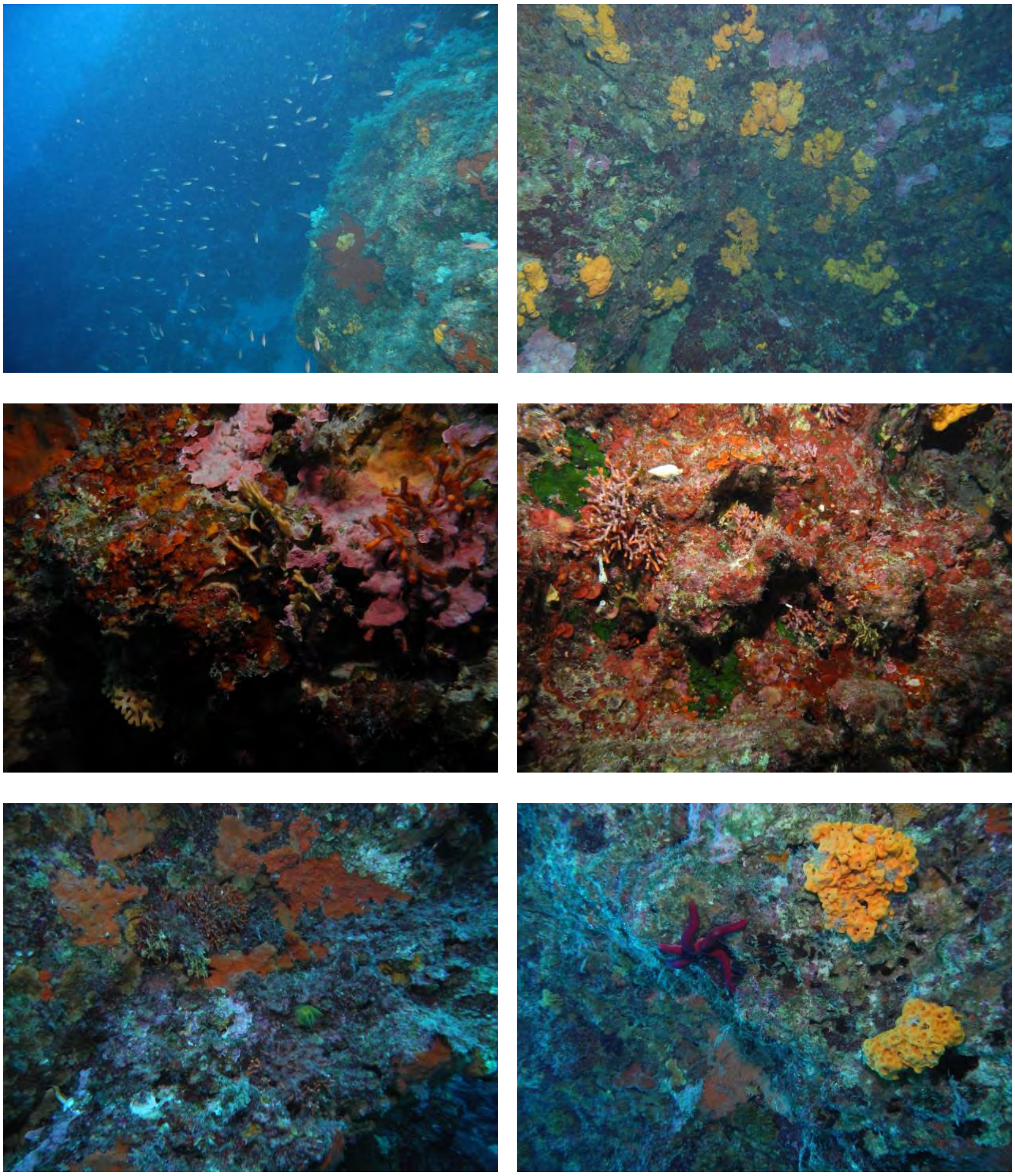


Figure 8: Typical coralligenous communities that can be found at candidate site 3

Species list from the preliminary survey

A total of 42 species were encountered during the preliminary survey (Table 2).

Table 2: Species recorded in the candidate sampling sites of Zakynthos Island.

	Keri	Mavros Kavos	Marathonisi
Rhodophyta			
Amphiroa rigida J.V. Lamouroux, 1816			+
Amphiroa cryptarthrodia Zanardini, *1844*			+
Liagora viscida (Forsskål) C.Agardh, 1822			+
Peyssonnelia spp	+	+	+
Peyssonelia cf. *bornetii*	+	+	+
Peyssonnelia squamaria (S.G. Gmelin) Decaisne, 1841		+	+
Peyssonnelia rosa-marina Boudouresque & Denizot, 1973			+
Peyssonelia cf. *rubra*	+	+	+
Mesophyllum sp.	+		
Mesophyllum alternans (Foslie) Cabioch & M.L.Mendoza, 1998		+	+
Tricleocarpa fragilis (Linnaeus) Huisman & R.A.Townsend, 1993			+
Chlorophyta			
Pseudochlorodesmis furcellata (Zanardini) Børgesen, 1926			+
Palmophyllum crassum (Naccari) Rabenhorst, 1868	+	+	+
Foraminifera			
Miniacina miniacea (Pallas, 1766)		+	
Porifera			
Acanthella acuta Schmidt, 1862	+		
Agelas oroides (Schmidt, 1864)	+	+	+
Aplysilla rosea (Barrois, 1876)			+
Axinella damicornis (Esper, 1794)	+	+	
Cacospongia mollior Schmidt, 1862			+
Chondrosia reniformis Nardo, 1847		+	
Cliona schmidti (Ridley, 1881)			+
Crambe crambe (Schmidt, 1862)	+	+	+
Fasciospongia cavernosa (Schmidt, 1862)			+
Petrosia (Petrosia) ficiformis (Poiret, 1789)	+		+
Phorbas tenacior (Topsent, 1925)	+		
Spirastrella cunctatrix Schmidt, 1868	+	+	+
Terpios gelatinosa (Bowerbank, 1866)			+
Cnidaria			
Caryophyllia sp.		+	
Eudendrium sp.		+	+
Leptopsammia pruvoti Lacaze-Duthiers, 1897	+		+
Madracis pharensis (Heller, 1868)		+	+
Mollusca			
Rocellaria dubia (Pennant, 1777)			+
Annelida			
Hermodice carunculata (Pallas, 1766)			+
Myxicola infundibulum (Montagu, 1808)			+
Protula tubularia (Montagu, 1803)		+	
Bryozoa			
Adeonella sp.	+	+	+
Myriapora truncata (Pallas, 1766)	+	+	+
Rhynchozoon neapolitanum Gautier, 1962		+	
Schizomavella sp.		+	
Echinodermata			
Echinaster sepositus (Retzius, 1783)			+
Ophidiaster ophidianus (Lamarck, 1816)	+	+	
Tunicata			
Halocynthia papillosa (Linnaeus, 1767)			+

Remarks

Based on the observations of the preliminary surveys, coralligenous assemblages at Marathonisi site were only found as enclaves in onverhangs and crevices. On the other hand, the western sites of Keri and Mavros Kavos could potentially be used as sampling sites of Zakynthos, as defined by the geomorphological characteristics (i.e. steep vertical walls) and the associated benthic communities. The scarcity of rich coralligenous communities observed may be due to the prevailing oligotrophic conditions that characterize both the S. Ionian and S. Aegean Seas. Considering this peculiarity, further site investigation is recommended in order to determine the optimum location/s.

6. SCIENTIFIC MEETING BETWEEN NMPZ AND HCMR AND FIELD SURVEY IN THE NORTH AEGEAN SEA

V. Gerovasileiou, member of the NMPZ work team, T. Dailianis and G. Chatzigeorgiou, members of the HCMR work team, met in the framework of a scientific meeting organized by HCMR, the leading collaborator of CIGESMED WP 5, in the framework of COMBER citizen science project, on the 12th of October, in Thessaloniki. The two teams had the opportunity to discuss about the development of the CIGESMED citizen science network, in NMPZ and the rest of Greece.

On the 13th of October they dived in typical coralligenous communities of the North Aegean Sea, in Chalkidiki Peninsula, and identified typical assemblages and species, marking the differences and similarities with communities of the NW Mediterranean, the South Aegean and Ionian seas.

7. PRELIMINARY WORK FOR CITIZEN SCIENCE

The preliminary work for the citizen science component of the project included actions towards the development of a network that will bring together the local dive centers and recreational divers with the scientific group of NMPZ. Diving activity in the Marine Protected Area of NMPZ A is well developed. Four dive centers are operating in the area for more than a decade and a close collaboration of the MPA with the dive centers has recently been established for the co-management of the diving activity. Rough estimations considering the diving activity in the NMPZ suggest that more than 10.000 dives are taking place in this area per year, including both visitor and local resident divers. Hence, the establishment of a citizen science network for the monitoring of coralligenous in Zakynthos Island is feasible and further work towards the development of a cost-

effective, reliable, user friendly and sustainable in the long term scheme should be considered.
The preliminary design of the citizen science network was discussed with the leading collaborator of CIGESMED WP 5 (HCMR members) during two scheduled meetings (October 2013 and February 2014) in order to establish the basic principles of the citizen science network development. In this respect, future actions for the establishment of the CIGESMED citizen science network have been planned in close collaboration with HCMR.

8. PRELIMINARY FIELD SURVEY IN CRETE

In the framework of setting up a common monitoring network of coralligenous stations in Greece, M. Sini and D. Poursanidis, members of the NMPZ/University of Aegean work team, joined members of the HCMR team in order to investigate potential sites in Crete. The fieldtrip was organized by HCMR from 12th to 18th of November 2013. The NMPZ members participated in the dive trips, collected photographs and samples of marine fauna and flora, and contributed to species identification. The two teams discussed about their future collaboration in the realization of the various CIGESMED project tasks (e.g. sampling, monitoring, and citizen science network development).

9. SUMMARY OF ACTIVITIES PROGRESS

During the first year of project's activities implementation several difficulties have been met and successfully resolved. Considering the activities of the current project, NMPZ progress is in line with the requirements that are described in the Technical Annex of the relative contract.

Summary of activities progress of the present project in relation to CIGESMED work packages is provided in the following table.

NMPZ Activities	CIGESMED WP's	NMPZ PROGRESS
Activity 1 *Coralligenous assessment and monitoring*	**WP2** - *Coralligenous assessment and threats in the different basins* **WP3** - *Indicators' development and test*	Preliminary field survey and candidate site selection, preliminary biodiversity assessment of coralligenous communities, preliminary identification of the possible threats and sources of disturbance, collaboration with national partners (HCMR) of CIGESMED project
Activity 2 *Management tools*	**WP4** - *Innovative monitoring tools* **WP6** - *Data management, mapping and assimilation tools*	Not relevant to the current reporting period
Activity 3 *Participatory process- Promotion - Public awareness activities*	**WP5** - *Citizen science network implementation* **WP7** - *Outreach, dissemination and stakeholder engagement*	Communication with local dive clubs, preliminary actions for citizen science network development, collaboration with national partners (HCMR) of CIGESMED project

NATIONAL MARINE PARK OF ZAKYNTHOS

IN COLLABORATION WITH UNIVERSITY OF AEGEAN, DEPT. OF MARINE SCIENCE

2nd Annual Report 2014 - 2015

CORALLIGENOUS SURVEY IN THE NORTH – EAST MEDITERRANEAN

CIGESMED

IN THE FRAMEWORK OF EUROPEAN PROJECT
ANR12 SEAS 0001-01 - CIGESMED
ZAKYNTHOS APRIL 2015

CORALLIGENOUS SURVEY IN THE NORTH – EAST MEDITERRANEAN

2nd Annual Progress Report

Reporting Period: 2014-2015

Authors: Sini M., Gerovasileiou V., Dimitriadis C., Sourbes L., J. Batjakas & D. Koutsoubas

WORKING GROUP

Name	Affiliation	Specific tasks
Drosos Koutsoubas	NMPZ/ Univ. of the Aegean	Project coordinator
Laurent Sourbes	NMPZ	Report preparation, administrative and communication tasks
Charalampos Dimitriadis	NMPZ	Report preparation, administrative and communication tasks, field work
Vasilis Gerovasileiou	Univ. of the Aegean / HCMR	Report preparation, communication tasks, field work
Maria Sini	Univ. of the Aegean	Report preparation, communication tasks, field work
Zinovia Erga	Univ. of the Aegean / CNRS	Laboratory work
Vatikiotis Konstantinos	NMPZ	Field work
Katsoupis Christos	NMPZ	Field work

NATIONAL MARINE PARK OF ZAKYNTHOS

HTTP://www.nmp-zak.org

DEPT. OF MARINE SCIENCES, UNIVERSITY OF AEGEAN

HTTP://www.mar.aegean.gr

Front page photos: K. Vatikiotis, C. Dimitriadis

1. INTRODUCTION

The current document is the second Annual Progress Report (2nd reporting period) of activities that were undertaken by the National Marine Park of Zakynthos as a subtask in the framework of the European Project CIGESMED according to deliverable requirements of the contract (Ref CNRS: DR12-JE 093 579) signed by NMPZ and CNRS. It includes the tasks and activities carried out from February 2014 until April 2015. The activities of the subtask '*Coralligenous Survey in the North – East Mediterranean*' and their relation to the Work Packages (WP) of CIGESMED Project are presented in Table 1.

Table 1: NMPZ's activities and their relation to CIGESMED Project WPs

NMPZ Activities	Description	Connection to CIGESMED WP's
Activity 1	Coralligenous assessment and monitoring	**WP2** - *Coralligenous assessment and threats in the different basins* **WP3** - *Indicators' development and test*
Activity 2	Management tools	**WP4** - *Innovative monitoring tools* **WP6** - *Data management, mapping and assimilation tools*
Activity 3	Participatory process-Promotion -Public awareness activities	**WP5** - *Citizen science network implementation* **WP7** - *Outreach, dissemination and stakeholder engagement*

2. 2nd GENERAL ASSEMBLY OF CIGESMED PROJECT

D. Koutsoubas, M. Sini and V. Gerovasileiou, members of the NMPZ/University of the Aegean work team, participated in the General Assembly of CIGESMED project which was held in Izmir, Turkey from the 6th to the 9th of May 2014. During the meeting they had the opportunity to discuss with other Project participants as well as to present the results derived from the 1st reporting period (1st Annual Report) with respect to Zakynthos study sites and Project objectives (Figure 1).

The members of the NMPZ/University of the Aegean work team exchanged ideas and technical knowledge regarding field work (e.g. study sites, protocols), preliminary results (e.g. species lists), data analyses, citizen science, and potential post-CIGESMED initiatives.

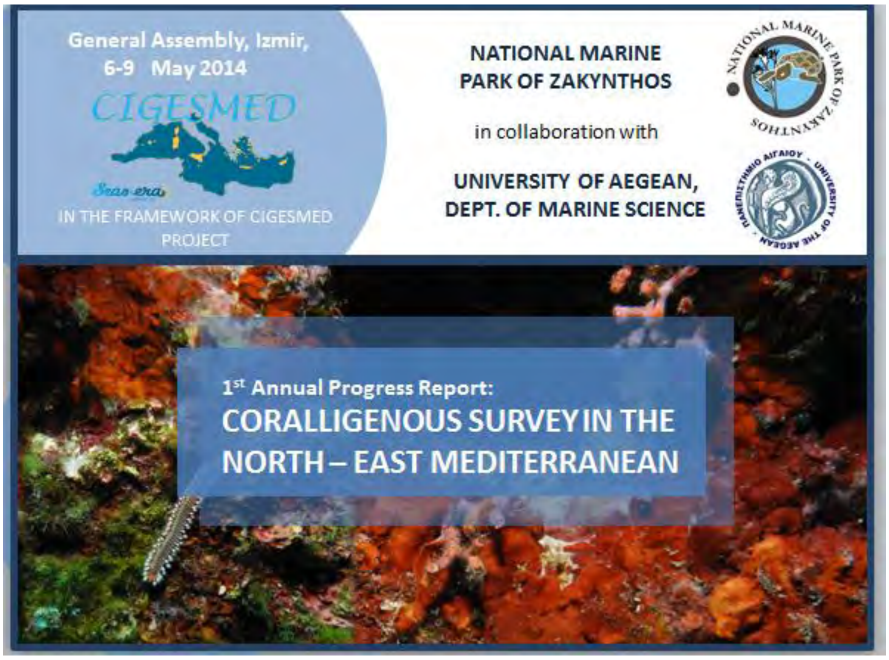


Figure 1: Presentation of NMPZ/University of the Aegean work team progress with respect to the 1st reporting period of CIGESMED project

3. PARTICIPATION IN SCIENTIFIC SYMPOSIA

Z. Erga, D. Koutsoubas, V. Gerovasileiou and M. Sini, members of the NMPZ/University of the Aegean working group along with other members of the CIGESMED Working Group, presented part of the CIGESMED results to the 7th National Conference of the Hellenic Ecological Society (HELECOS) '*Ecology: Linking Systems, Climaxes and Research Topics*', where they participated with the following Poster contribution:

- Erga Z., David R., Guillemain D., Zuberer F., Dailianis T., Gerovasileiou V., Sini M., Koutsoubas D., Verlaque M., Féral J-P. & A. Chenuil: *Distribution of genetic diversity within* Lithophyllum stictaeforme/cabiochiae *in the NW Mediterranean*, 7th National Conference of the Hellenic Ecological Society (HELECOS), 9-12 October 2014, Mytilene, Greece.

M. Sini and V. Gerovasileiou, members of the NMPZ/University of the Aegean working group, participated in the three Symposia on the '*Conservation of Mediterranean Marine Key Habitats*", which were organized by the RAC-SPA/UNEP-MAP in Portoroz, Slovenia, on 27-31/10/2014:

- 5th Mediterranean Symposium on Marine Vegetation (27-28 October 2014)
- 2nd Mediterranean Symposium on the conservation of Coralligenous and other Calcareous Bio-concretions (29-30 October 2014)

- 1st Mediterranean Symposium on the conservation of Dark Habitats (31 October 2014)

Members of the NMPZ/University of the Aegean working group presented the results of their individual research activities on Eastern Mediterranean sciaphilic assemblages and also contributed to the following CIGESMED Poster contribution:

- Çinar M.E., Feral J-P., Arvanitidis C., David R., Taşkin E., Dailianis T., Doğan A., Gerovasileiou V., Dağli E., Aysel V., Issaris Y., Bakir K., Salomidi M., Sini M., Açik S., Evcen A., Dimitriadis C., Koutsoubas D., Sartoretto S., Önen S. and contributors, 2014. Preliminary assessment of coralligenous benthic assemblages across the Mediterranean Sea. 207-208. [In Bouafif C., Langar H. and A. Ouerghi (editors). 2014. Proceedings of the second Mediterranean Symposium on the conservation of Coralligenous and other Calcareous Bio-Concretions. RAC/SPA, Tunis, 247 pp.].

During the Symposia members of the NMPZ/University of the Aegean working group discussed with other CIGESMED partners from CNRS (France) and Ege University (Turkey) about the ongoing progress of different work packages, and potential post-CIGESMED initiatives.

Finally, D. Koutsoubas has briefly presented the CIGESMED Project in the framework of the 3nd International Workshop on Advancing Conservation Planning in the Mediterranean Sea, "Light and shade in the management and conservation of the Mediterranean Sea: Priorities for the near future", 8-10 April, Lecce (Italy).

4. INTERNAL MEETING OF GREEK PARTNERS

During the 22nd and 23rd of December 2014, NMPZ organized an internal project meeting (held in Thessaloniki, Greece), between NMPZ, University of Aegean and HCMR work team members. During this meeting D. Koutsoubas, C. Dimitriadis, V. Gerovasileiou and C. Arvanitidis discussed several issues regarding the progress of the various CIGESMED work packages, and set up a preliminary time-schedule including future tasks that need to be realized at Zakynthos Island.

5. PROCUREMENT OF EQUIPMENT

In November 2014, NMPZ was equipped with HOBO Water Temperature Pro v2 data loggers (Figure 2), which will be installed at Zakynthos sampling sites during the next sampling period, in order to set up a long-term benthic temperature sampling station. Loggers' data are anticipated to contribute to the monitoring and the better understanding of the local environmental conditions.

Figure 2: Onset's Waterproof Data Logger system which will be installed at Zakynthos sampling sites for a long –term temperature monitoring.

6. ACTIVITIES RELATED TO CITIZENS SCIENCE WP

V. Gerovasileiou and M. Sini, transferred knowledge and experiences obtained by the NMPZ management authority during previous Citizen Science Projects, and, in collaboration with HCMR, they contributed to the overall design and development of the CIGESMED Citizen Science approach. Furthermore, they participated in the Report writing for the CIGESMED Project "Work Package 5: Citizen Science Network Implementation".

7. FIELD WORK

As stated in the 1st Progress Report, due to the scarcity of coralligenous formations in Zakynthos that was evidenced during the preliminary surveys, further site investigation was considered essential in order to determine the optimum sampling location(s). In this context, an additional joint NMPZ/University of the Aegean and HCMR survey from members of the Working Groups took place during June 2014 in order to further investigate the previously identified locations.

Site exploration for coralligenous communities

The survey focused on the most promising locations of last year's survey, that is Keri and Mavros Kavos (see 1st Interim Progress Report). This area is located at the SW part of Zakynthos Island, close to the westernmost boundaries of the NMPZ protected area and is characterized by relatively cool water temperatures, possibly due to direct exposure to the open Ionian Sea and local wind-driven up-welling. The location can be characterized as generally pristine, yet it should be noted that it is included among the most popular recreational diving areas of the island, and is regularly visited by groups of divers every day during the summer period (May to October) in an organized way by the local Diving Clubs. The latter means that dive masters and instructors usually escort groups of divers, while during pre-dive briefing sessions they inform divers about the protection measures that are active in the Protected Area of the NMPZ, the fragility of marine organisms and the importance of their habitats (established after close collaboration with the scientific personnel of the NMPZ Management Agency). Extensive vertical rocky walls with crevices, overhangs and numerous submerged caves characterize the topography of the specific location. Rocky cliffs starting from 100-150 m above sea level drop vertically to depths down to 30-40 m. These geomorphological features account for the increased shadowy conditions observed locally over the greatest part of the day. The selection of new diving sites was based on examination of the superficial morphology of the coast, study of the bathymetry of the area, alongside relevant information provided by the local Diving Clubs and by in situ observations made by the scientific personnel of the NMPZ management agency involved in the CIGESMED Project based on previous diving experience. A total, of five sites were investigated (Figure 3; Table 2) over this particular site exploration.

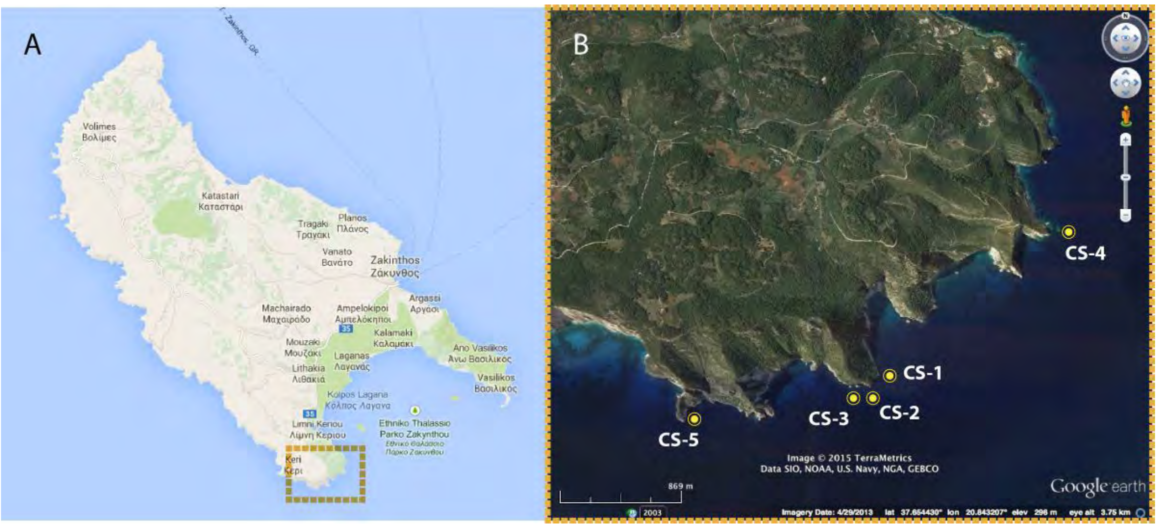


Figure 3: Map of Zakynthos (A) showing the surveyed area and the five potential candidate sites investigated (B).

Table 2: Coordinates and depth range of the potential candidate sites surveyed at Zakynthos.

Site name	Latitude	Longitude	Depth range
CS-1	37.647284°	20.845715°	15-20 m
CS-2	37.646343°	20.844765°	23-25 m
CS-3	37.646158°	20.843603°	25-29 m
CS-4	37.656884°	20.860451°	30-35 m
CS-5	37.644985°	20.830411°	15-25 m

At least one exploratory dive was performed at each site, the aim of which being to assess the existence and extent of coralligenous communities, as well as to provide a rough estimation of topography and depth range. Sites CS-1, CS-2 and CS-3 were considered as the most suitable for studying coralligenous communities in the framework of the CIGESMED Project (Figures 4-6). Sites CS-4 and CS-5 were excluded from further investigation, due to interrupted or rare presence of coralligenous formations (which were mainly in the form of enclaves). Specifically, CS-4 featured a steep muddy slope extending down to 35 m depth, with emerging irregular rocky outcrops forming small walls, crevices and overhangs. However, the absence of shadowy conditions resulted in the restricted development of sciaphilic assemblages mainly under overhangs, in crevices, or within *Posidonia oceanica* rhizomes, while on the upper surface of the rocks photophilic algae species (mostly *Cystoseira* spp.) patches predominated (Figure 7). At CS-5, coralligenous enclaves were confined at the semi-vertical walls at the entrance of a semi-submerged marine cave, thus not extending at a length suitable for deploying transects (Figure 8). Out of the cave photophilic algae dominated assemblages prevailed.

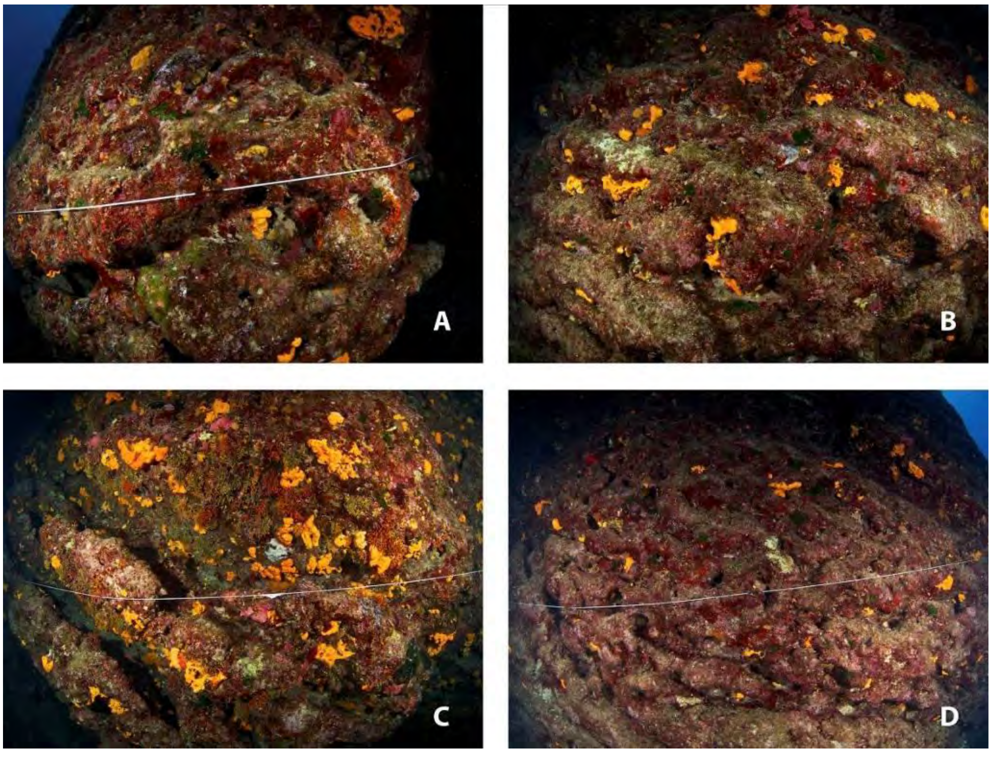


Figure 4: Photos showing coralligenous assemblages across the transect line at site CS-1.

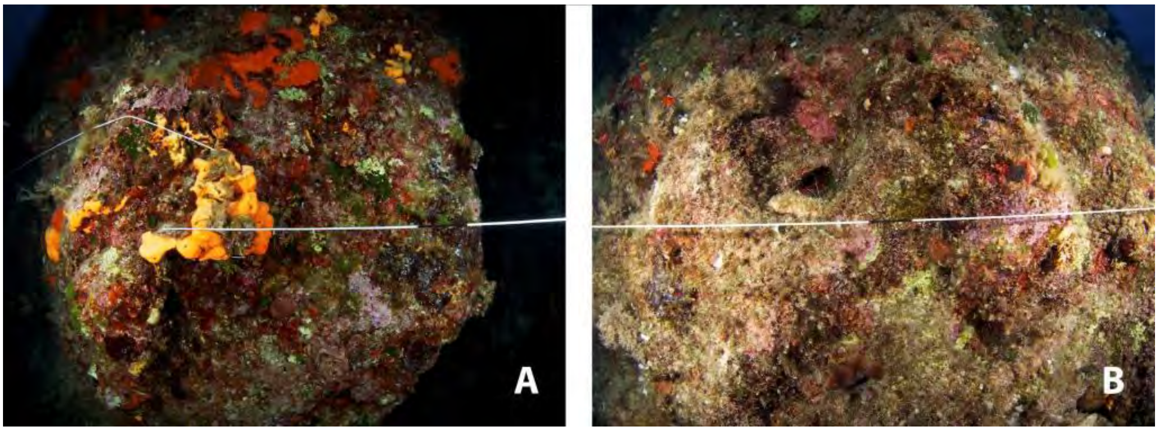


Figure 5: Photos showing coralligenous assemblages across the transect line at site CS-2.

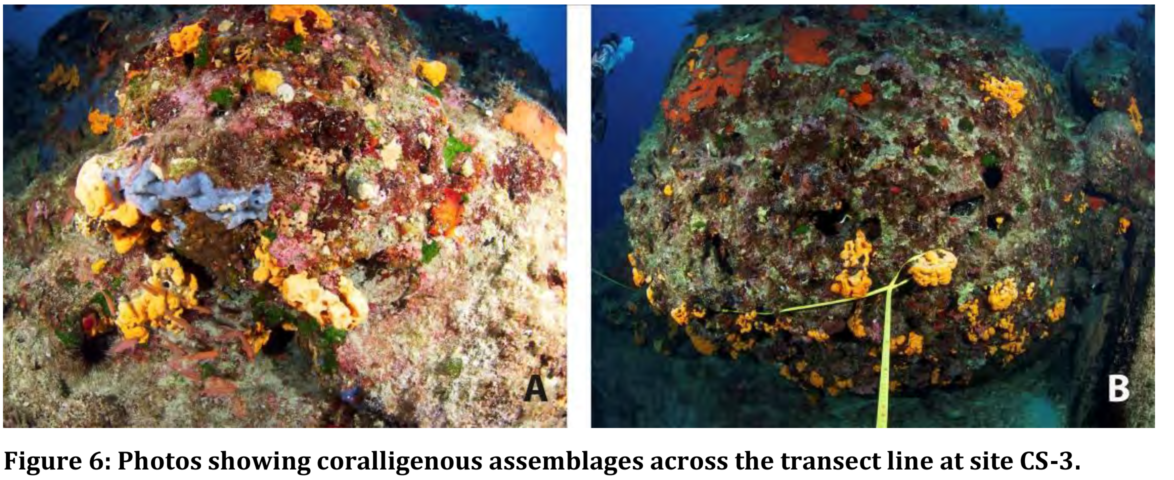


Figure 6: Photos showing coralligenous assemblages across the transect line at site CS-3.

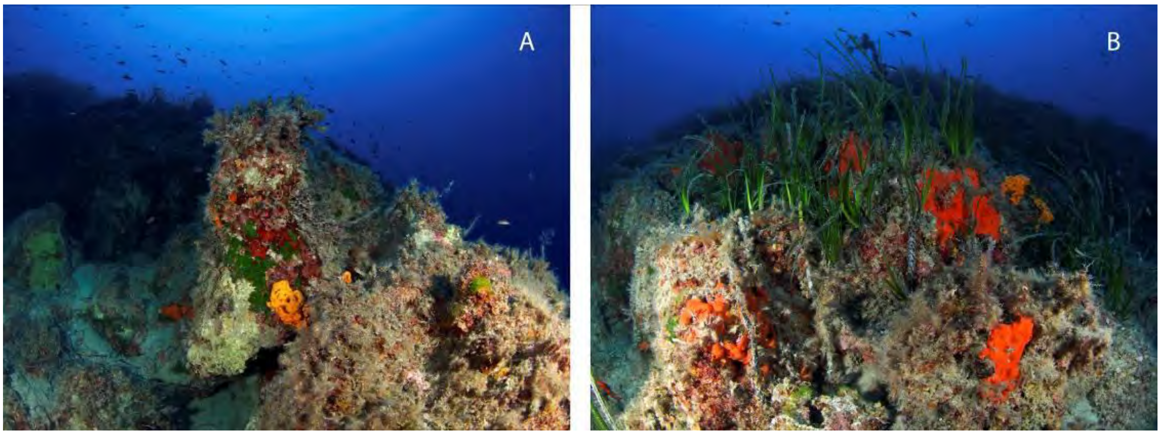


Figure 7: Aspects of potential candidate site CS-4, showing limited coralligenous formations under overhangs (A) or pre-coralligenous communities combined with *Posidonia oceanica* patches (B).

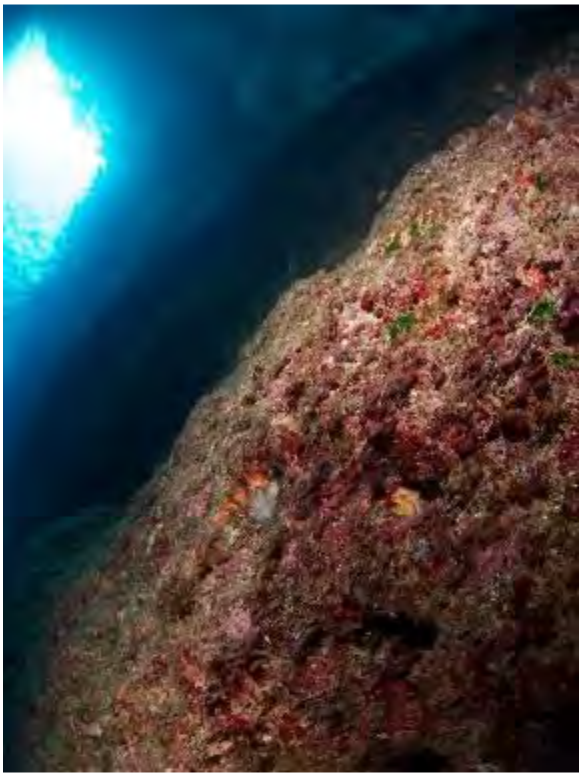


Figure 8: Aspect of potential candidate site CS-5, showing limited coralligenous enclaves confined at the semi-vertical walls at the entrance of a semi-submerged cave.

Characterization and mapping of the selected sites

According to information obtained during the exploratory phase at each site, a marked nylon line or a measuring tape (i.e. the sampling transect) was set-up along those parts of the wall that were characterized by a representative cover of coralligenous communities. The sampling transect was used in order to describe community composition, as well as the main structural characteristics of the habitat, using the following field methods. At each five-meter segment of the transect, a diver recorded topographic parameters (i.e. orientation, inclination and rugosity (see Appendix of present report – "*Habitat Mapping Protocol*"). Along the same five-meter segments, a second diver estimated biotic cover through visual census (see Appendix of present report – "*Biotic Cover Protocol*"). Additionally, biotic cover was also estimated using the first steps of the rapid visual assessment (RVA) approach (Gatti et al., 2015; see Appendix of present report – "*RVA Protocol*"). Finally, wide-angle photo-samples were taken by means of a Panasonic 8 mm fisheye lens on an Olympus OM-D E-M5 micro 4:3 camera, at predetermined length intervals of 5 m distance. At each step two photo-samples were taken: one close-up, roughly covering a surface of 1 to 2 m^2, and a general aspect photograph covering a more extended area. This was done in order to obtain a photographic archive of each transect that enables validation of the *in situ* visual assessment, as well as for future reference. All field sampling techniques used follow the requirements of the proposed CIGESMED Protocols (Module 1: Protocol «*Profiles and stands cartography*»).

Recorded topographic data for the three selected Zakynthos sites are presented in Table 3, while the studied transects are illustrated in Figure 9, according to the estimated orientation. A total of 105 meters of coralligenous communities was assessed, at an average depth of 28 m. Representative photographs from each site's transect are presented in Figures 4 to 6.

Table 3: Topographic characteristics of the three selected Zakynthos sites as recorded *in situ* (inclination and rugosity abbreviations according to the CIGESMED protocol – V: vertical; C: ceiling; T: tiny; S: small; M: medium; L: large)

	Segment (m)	Orientation	Inclination	Rugosity
SITE CS-1	0-5	SW	V	S
	5-10	W	V	L
	10-15	SW	C	L
	15-20	S	V	M
	20-25	S	C	L
	25-30	SE	V	M
	30-35	NE	V	L
	35-40	NE	C	S
	40-45	E	C	S
	45-50	SE	V	T
SITE CS-2	0-5	SE	V	S
	5-10	S	V	M
	10-15	S	V	M
	15-20	SE	V	M
SITE CS-3	0-5	S	V	S
	5-10	E	V	M

10-15	SE	V	S
15-20	S	V	S
20-25	S	V	M
25-30	SW	V	M
30-35	SE	V	L

Figure 9: Tracing of the diving transects surveyed at each studied site. Each site consists of 5-meter segments of varying orientation.

Species recorded in the study sites

A total of 50 taxa belonging to 10 major taxonomic groups (Table 4) were recorded at the selected sites during the fieldwork, mostly consisting of macroalgae (11) and sponges (11) (Figure 10). The highest number of taxa was recorded at site CS-1 (44), followed by CS-3 (27) and CS-2 (16). Furthermore, samples of the bryozoan *Myriapora truncata* and encrusting calcareous algae (whilst targeting samples of *Lithophyllum* spp.) were collected for genetic analysis. Given the characteristics of the sites, the proposed CIGESMED Protocol (Module 4: '*Sampling protocol for population genetics*') could not be followed, as the coralligenous communities were not continuous, and it was not possible to obtain sufficient amount of samples from predetermined orientations and slopes. The collected samples for genetic analysis were properly dried and stored in bottles and then were forwarded to CNRS for further laboratory genetic analyses.

Table 4: Species recorded *in situ* at the three selected Zakynthos sites

Taxa / Site	Site CS-1	Site CS-2	Site CS-3
Macroalgae			
Codium bursa (Olivi) C.Agardh	+	+	+
Codium coralloides (Kützing) P.C. Silva	+		
Palmophyllum crassum (Naccari) Rabenhorst	+	+	+
Cystoseira spp.	+	+	+
Padina pavonica (Linnaeus) Thivy	+	+	+
Lithophyllum spp.	+		+
Neogoniolithon mamillosum (Hauck) Setchell & L.R.Mason			+
Mesophyllum spp.	+	+	+
Peyssonnelia rubra (Greville) J.Agardh	+		+
Peyssonnelia squamaria[(S.G.Gmelin) Decaisne,1842]	+		+
Peyssonnelia spp.		+	+
Porifera			
Agelas oroides Schmidt, 1864	+	+	+
Chondrosia reniformis Nardo, 1847	+	+	+
Cliona celata Grant, 1826	+		
Cliona schmidtii (Ridley, 1881)	+		
Cliona viridis (Schmidt, 1862)	+	+	+
Haliclona (Soestella) mucosa Griessinger, 1971	+		
Pleraplysilla spinifera Schulze, 1879	+		
Spirastrella cunctatrix Schmidt, 1868	+	+	+
Ircinia spp.	+		
Phorbas tenacior Topsent, 1925			+
Dictyonella spp.			+
Anthozoa			
Caryophyllia (Caryophyllia) inornata Duncan, 1878	+		
Hydrozoa spp.	+		
Madracis pharensis Heller, 1868	+	+	+
Leptopsammia pruvoti Lacaze-Duthiers, 1897	+	+	+
Polychaeta			
Bispira volutacornis Montagu, 1804	+		
Myxicola infundibulum (Montagu, 1808)	+		
Sabella spallanzanii Gmelin, 1791	+		
Protula spp. Montagu, 1803	+		
Serpula vermicularis Linnaeus, 1767	+		+
Hermodice carunculata (Pallas, 1766)	+		
Mollusca			
Lithophaga lithophaga (Linnaeus, 1758)	+		
Rocellaria dubia (Pennant, 1777)	+		
Thylacodes arenarius (Linnaeus, 1758)	+		
Vermetidae spp.	+		
Crustacea			
Dardanus calidus (Risso, 1827)	+		
Palinurus elephas (Fabricius, 1787)			+
Scyllarides latus (Latreille, 1803)	+		
Echinodermata			
Holothuria sanctori Delle Chiaje, 1823	+		
Ophidiaster ophidianus Lamarck, 1816	+		+
Sphaerechinus granularis Lamarck, 1816			+
Bryozoa			
Adeonella calveti Canu & Bassler, 1930	+	+	+
Myriapora truncata Pallas, 1766	+	+	+

Reptadeonella violacea (Johnston, 1847)	+		
Rhynchozoon spp.	+	+	+
Schizomavella spp.	+		+
Tunicata			
Halocynthia papillosa Linnaeus, 1767	+	+	+
Microcosmus sabatieri Roule, 1885	+		
Miniacina miniacea Pallas, 1766	+		
Total species number	**44**	**16**	**27**

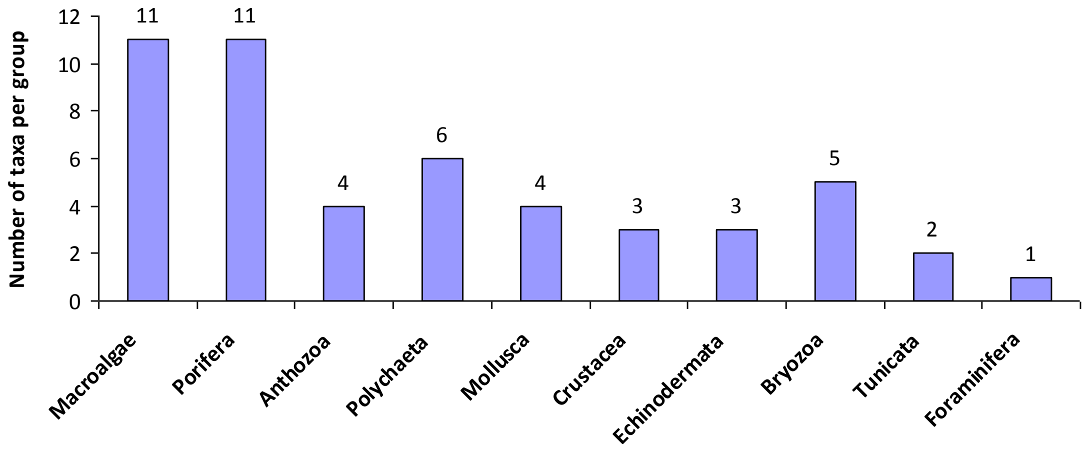


Figure 10: Number of taxa recorded at the three study sites of Zakynthos per taxonomic group.

Easy methods for biodiversity and good health assessments

The assessment of coralligenous communities in the study area of the NMPZ was performed by two divers. The first diver estimated visually (Figure 11) the percent spatial coverage of sessile biota in the three sites described above. The followed methodology was based on the CIGESMED protocol (Module 1: Protocol «*Profiles and stands cartography*») with modifications (see Appendix 1-3 at the end of the Report). The scientific diver estimated in each segment of the transect line (5 m width x 2 m height) the percent coverage of the following 9 morphological and taxonomic categories: calcareous encrusting algae, non-calcareous encrusting algae, erect algae, turf-forming algae, encrusting sponges, massive sponged, scleractinians, encrusting bryozoans, and erect bryozoans. Furthermore, the diver created a list of the species recorded across the transect line at each site.

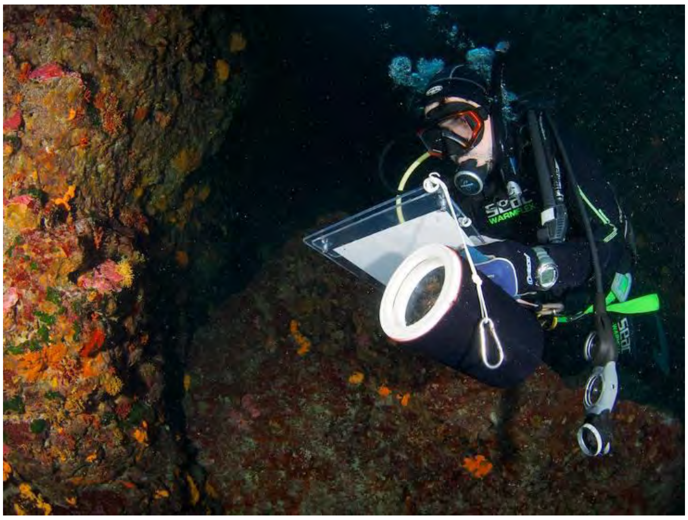


Figure 9: Diver estimating visually the percent spatial coverage of sessile biota in sites CS-1.

A second scientific diver was responsible for implementing the first steps of the rapid visual assessment (RVA) approach for the characterization of coralligenous outcrops (Gatti et al., 2015). RVA was not performed in CS-2 due to the small extent of coralligenous communities in this location and its proximity to CS-3. The species list presented in Table 4 includes *in situ* records by the two scientific divers.

Coverage results are presented in tables 5-8. Macroalgae dominated at all sites, with a mean coverage of 80.5%, while sessile animals had a mean coverage of 19.5%. Specifically, calcareous encrusting algae had a higher coverage at CS-1 and lower in CS-3 where erect algae (e.g. *Cystoseira* spp.) prevailed. Turf-forming algae dominated in CS-2. The highest coverage of sessile animals was found in CS-1 (27.5%). Porifera was the dominant animal phylum in all sites (12.5%) followed by Bryozoa (6.5%). Scleractinia presented a small coverage in all sites (0.4%).

Coralligenous communities in all sites were characterized by intermediate three-dimensional complexity; the majority of the recorded species belonged to the intermediate (1-10 cm height) and basal levels (1 cm height) according to the bionomic categorization of the RVA protocol (Gatti et al. 2015). Only one ascidian species (*Microcosmus sabatieri*) created an upper layer (>10 cm height) at CS-1. Five bio-eroding species were spotted in the three sites: the sponges *Cliona celata*, *C. viridis* and *C. schmidtii* and the bivalve molluscs *Lithophaga lithophaga* and *Rocellaria dubia*. The assessment of thickness and consistency of calcareous layer showed that penetration in CS-1 ranged between 0.4 and 1.2 cm and in CS-3 between 1.5 and 2.8 cm.

Table 5: Coverage of sessile biota for each segment of the transect at CS-1.

Taxa / Segment	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	30-45	45-50
Calcareous encrusting algae	10	60	50	10	40	40	35	30	5	0
Non-calcareous encrusting algae	0	20	10	50	20	20	15	15	5	5
Erect algae	30	0	0	0	0	0	0	0	10	70

Turf-forming algae	55	0	20	25	0	0	0	0	55	20
Encrusting sponges	3	0.5	3	2	5	10	5	25	10	5
Massive sponged	1	7	7	5	15	15	17	5	5	0
Scleractinia	0	0.5	0	0	2	0	3	0	0	0
Encrusting bryozoans	0.5	2	0	3	3	10	20	20	0	0
Erect bryozoans	0.5	10	10	5	15	5	5	5	10	0

Table 6: Coverage of sessile biota for each segment of the transect at CS-2.

Taxa / Segment	0-5	5-10	10-15	15-20
Calcareous encrusting algae	10	20	20	5
Non-calcareous encrusting algae	20	0	10	10
Erect algae	5	10	15	15
Turf-forming algae	40	60	45	60
Encrusting sponges	10	5	5	0
Massive sponges	5	5	5	0
Scleractinia	0	0	0	0
Encrusting bryozoans	5	0	0	5
Erect bryozoans	5	0	0	5

Table 7: Coverage of sessile biota for each segment of the transect at CS-3.

Taxa / Segment	0-5	5-10	10-15	15-20	20-25	25-30	30-35
Calcareous encrusting algae	5	5	5	10	20	0	10
Non-calcareous encrusting algae	5	10	10	10	10	0	20
Erect algae	20	40	40	25	10	30	20
Turf-forming algae	60	30	30	40	40	65	10
Encrusting sponges	5	10	10	5	5	0	0
Massive sponges	5	5	5	5	10	5	30
Scleractinia	0	0	0	0	0	0	5
Encrusting bryozoans	0	0	0	0	0	0	5
Erect bryozoans	0	0	0	5	5	0	0

Table 8: Mean coverage of sessile biota in the three sites.

Taxa / Site	CS-1	CS-2	CS-3	Mean
Calcareous encrusting algae	28	13.8	7.9	16.5
Non-calcareous encrusting algae	16	10	9.3	11.8
Erect algae	11	11.3	26.4	16.2

Turf-forming algae	17.5	51.3	39.3	36
Encrusting sponges	6.9	5	5	5.6
Massive sponges	7.7	3.8	9.3	6.9
Scleractinia	0.6	0	0.7	0.4
Encrusting bryozoans	5.9	2.5	0.7	3
Erect bryozoans	6.6	2.5	1.4	3.5
Macroalgae	72.5	86.3	82.9	80.5
Sessile animals	27.5	13.8	17.1	19.5

8. ACTIVITIES PROGRESS AND FUTURE PLANNING

Summary of activities progress of the present project in relation to CIGESMED work packages is provided in the following table.

NMPZ Activities	CIGESMED WP's	NMPZ PROGRESS
Activity 1 *Coralligenous assessment and monitoring*	**WP2** - *Coralligenous assessment and threats in the different basins* **WP3** - *Indicators' development and test*	Field survey and candidate site investigation, preliminary biodiversity assessment of coralligenous communities, development of easy methods for biodiversity and good health assessment, collaboration with national partners (HCMR) of CIGESMED project
Activity 2 *Management tools*	**WP4** - *Innovative monitoring tools* **WP6** - *Data management, mapping and assimilation tools*	Participation in monitoring tools design
Activity 3 *Participatory process- Promotion - Public awareness activities*	**WP5** - *Citizen science network implementation* **WP7** - *Outreach, dissemination and stakeholder engagement*	Close collaboration with HCMR

9. REFERENCES

Gatti G., Bianchi C. N., Morri C., Montefalcone M., Sartoretto S., 2015. Coralligenous reefs state along anthropized coasts: Application and validation of the COARSE index, based on a rapid visual assessment (RVA) approach. *Ecological Indicators* 52: 567–576.

10. APPENDIX

Biotic Cover Protocol

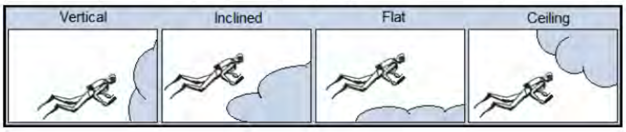
	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
ALGAE Calcareous Encrusting																				
ALGAE NON Calcareous Encrusting																				
Erect ALGAE																				
TURF																				
PORIFERA Encrusting																				
PORIFERA massive																				
Scleractinia																				
BRYOZOA encrusting																				
BRYOZOA erect																				
Adeonella																				
Myriapora																				
SERPULIDS																				
TUNICATI																				

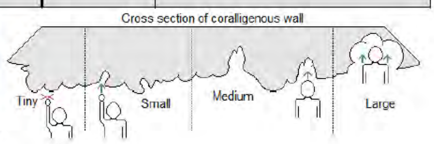
Notes:

Habitat Mapping Protocol

GPS start		**GPS end**		**Ημερομηνία**	

Τμήμα (m)	Προσαν (μοίρες)	Κλίση				Ανωμαλία εδάφους				Σκουπίδια	Παρατηρήσεις
		F	I ~45°	V	C	T	S	M	L	Υλικό	
0-5											
5-10											
10-15											
15-20											
20-25											
25-30											
30-35											
35-40											
40-45											
45-50											
50-55											
55-60											
60-65											
65-70											
70-75											
75-80											
80-85											
85-90											
90-95											
95-100											
0-5											
5-10											
10-15											
15-20											
20-25											
25-30											
30-35											
35-40											
40-45											
45-50											
50-55											
55-60											
60-65											
65-70											
70-75											
75-80											
80-85											
85-90											
90-95											
95-100											





Rapid Visual Assessment (RVA) Protocol

MORPHOTYPE	Depth	Max Depth	Slope	Orient

Substrate penetration (cm)	1:	2:	3:	4:	5:	6:	

Bioeroders	Absent	Occasional	Abundant

Basal Layer ≤ 1 cm (Cover %)				
Calc Algae %	Non-Calc Encr algae %	Animal %	Turf - Filamentous %	Sediment %

Intermediate Layer ≤ 10 cm
LIST OF SPECIES
6 PHOTOS !!!

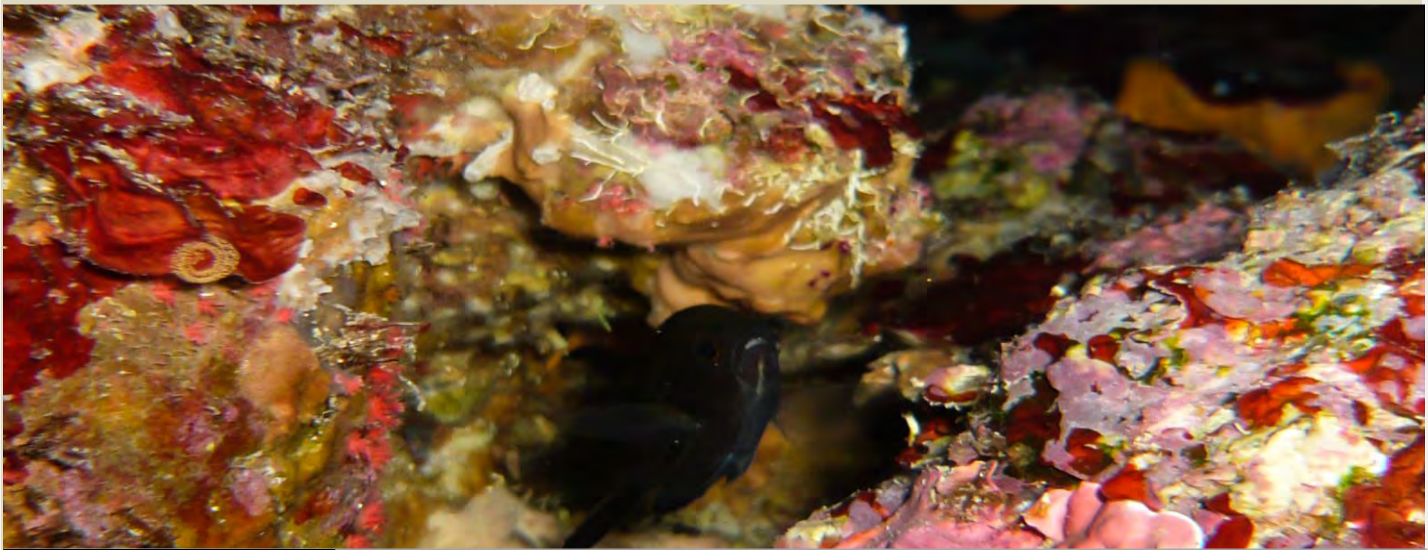
Upper Layer > 10 cm				
Species	Cover %	Max height	Epibiosis %	Necrosis %

Selected field work photos (by T. Dailianis, M. Sini, K. Vatikiotis, C. Katsoupis, C. Arvanitidis, V. Gerovasileiou)


SUZUKI

National Marine Park of Zakynthos

in collaboration with
University of Aegean, Dept. of marine science
Hellenic Centre of marine research



3rd Annual Report 2015 - 2016

CORALLIGENOUS SURVEY IN THE NORTH – EAST MEDITERRANEAN

In the framework of European Project
ANR12 seas 0001-01 - CIGESMED
Zakynthos May 2016

CORALLIGENOUS SURVEY IN THE NORTH – EAST MEDITERRANEAN

3rd Annual Progress Report

Reporting Period: 2015-2016

Authors: Dimitriadis C., Sini M., Gerovasileiou V., Sourbes L., J. Batjakas & D. Koutsoubas

WORKING GROUP

Name	Affiliation	Specific tasks
Drosos Koutsoubas	NMPZ/ Univ. of the Aegean	Project coordinator for NMPZ
Laurent Sourbes	NMPZ	Report preparation, administrative and communication tasks
Charalampos Dimitriadis	NMPZ	Report preparation, administrative and communication tasks, field work
Vasilis Gerovasileiou	HCMR/NMPZ	Report preparation, communication tasks, field work
Maria Sini	Univ. of the Aegean/ NMPZ	Report preparation, communication tasks, field work
Elpiniki Kali	NMPZ	Report preparation, administrative and communication tasks
Anna Thalassini-Vali	NMPZ	Report preparation, administrative and communication tasks
Vatikiotis Konstantinos	NMPZ	Field work

NATIONAL MARINE PARK OF ZAKYNTHOS
HTTP://www.nmp-zak.org

DEPT. OF MARINE SCIENCES, UNIVERSITY OF AEGEAN
HTTP://www.mar.aegean.gr

Front page photos: C. Dimitriadis

1. INTRODUCTION

The current document is the third Annual Progress Report (3rd reporting period) of activities that were undertaken by the National Marine Park of Zakynthos as a subtask in the framework of the European Project CIGESMED according to deliverable requirements of the contract (Ref CNRS: DR12-JE 093 579) signed by NMPZ and CNRS. It includes the tasks and activities carried out from April 2015 until May 2016. The activities of the subtask '*Coralligenous Survey in the North – East Mediterranean*' and their relation to the Work Packages (WP) of CIGESMED Project are presented in Table 1.

Table 1: NMPZ's activities and their relation to CIGESMED Project WPs

NMPZ Activities	Description	Connection to CIGESMED WP's
Activity 1	Coralligenous assessment and monitoring	**WP2** - *Coralligenous assessment and threats in the different basins* **WP3** - *Indicators' development and test*
Activity 2	Management tools	**WP4** - *Innovative monitoring tools* **WP6** - *Data management, mapping and assimilation tools*
Activity 3	Participatory process-Promotion -Public awareness activities	**WP5** - *Citizen science network implementation* **WP7** - *Outreach, dissemination and stakeholder engagement*

2. GENERAL ASSEMBLY OF CIGESMED PROJECT 2015

D. Koutsoubas, C. Dimitriadis, M. Sini and V. Gerovasileiou, members of the NMPZ/University of the Aegean work team, participated in the General Assembly of CIGESMED project which was held in Mitilene, Greece from the 18th to the 24th of May 2015. During the meeting they had the opportunity to discuss with other Project participants as well as to present the results derived from the 2nd reporting period (2nd Annual Report) with respect to Zakynthos study sites and Project objectives (Figure 1). In more details, C. Dimitriadis presented the progress of the tasks that were assigned to the NMPZ during the second year of CIGEMED project duration. These tasks included: i) Field surveys that have been conducted (Characterization and mapping of the selected sites) following the requirements of the proposed CIGESMED Protocols «Profiles and stands cartography», ii) Collection of samples of the bryozoan *Myriapora truncata* and encrusting calcareous algae (whilst targeting samples of *Lithophyllum* spp.) for genetic analyses, iii) Preliminary assessment of community composition and structural patterns.

The members of the NMPZ/University of the Aegean work team exchanged ideas and technical knowledge regarding field work (e.g. study sites, protocols), preliminary results (e.g. species lists), data analyses, citizen science, and potential post-CIGESMED initiatives.

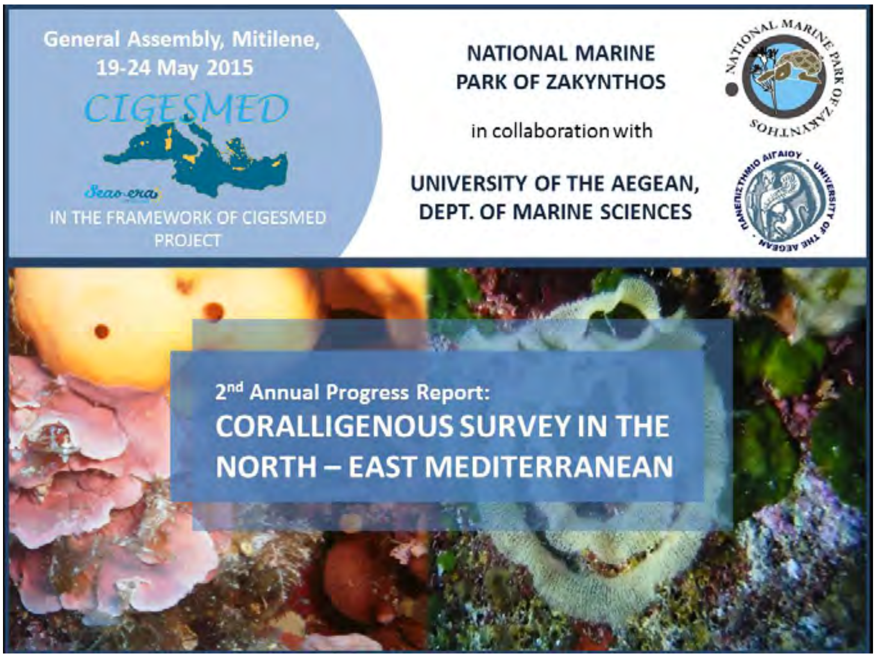


Figure 1: Presentation of NMPZ/University of the Aegean work team progress with respect to the 2nd reporting period of CIGESMED project

3. WORKING MEETING IN MARSEIILE, DECEMBER 2015

D. Koutsoubas, M. Sini and V. Gerovasileiou participated to the activities of the working meeting which was held in Marseille at December 2015. During the meeting they were involved in the designing and planning of publications and promotional actions with respect to CIGESMED project results and outputs. At the same time, they were also involved in the discussion of how to expand and enlarge CIGESMED project activities to the next call of proposals.

4. INTERNAL MEETING OF GREEK PARNTERS 2015

During the 28th and 30th of December 2015, NMPZ organized an internal project meeting (held in Thessaloniki, Greece), between NMPZ, University of Aegean and HCMR work team members. During this meeting D. Koutsoubas, C. Dimitriadis, V. Gerovasileiou and M. Sini discussed several issues regarding the progress of the various CIGESMED work packages, and set up a time-schedule including future tasks that need to be realized at Zakynthos MPA.

5. PARTICIPATION IN SCIENTIFIC SYMPOSIA

V. Gerovasileiou member of the NMPZ/University of the Aegean/HCMR working group along with other members of the CIGESMED Working Group, presented part of the CIGESMED results to the 13th International congress on the zoogeography and ecology of Greece and adjacent regions (ICZEGAR) held in Crete from 7 to 11 October 2015, with the following Poster contribution:

- Gerovasileiou V., Dailianis T., Panteri E., Gatti G., Issaris Y., Sini M., Salomidi M., Dimitriadis C., Michalakis N., Doğan A., Thierry de Ville d'Avray L., David R., Çinar M.E., Koutsoubas D., Arvanitidis C., Féral J-P. Establishing a citizen science initiative for the mapping and monitoring of coralligenous assemblages in the Mediterranean Sea. Proceedings of 13th ICZEGAR conference, 7-11 October, Herakelion, Greece, 119p.

The members of the NMPZ/University of the Aegean/HCMR working group along with other members of the CIGESMED working group participated in the publication regarding Citizen Science activities of CIGESMED project which was presented as a the poster presentation at the 1st ECSA Conference 2016 *'Citizen Science – Innovation in Open Science, Society and Policy'* held in Berlin from 19 to 21 May 2016:

- Gatti G., Dimitriadis C., Gerovasileiou V., Dailianis T., Panteri E., Issaris Y., Sini M., Salomidi M., Michalakis N., Doğan A., Thierry de Ville d'Avray L., David R., Çinar M.E., Koutsoubas D., Arvanitidis C., Féral J-P. 2016. Citizen Science for CIGESMED, or how to engage divers in marine ecological monitoring: first steps of a new project. Proceedings of the First International ECSA Conference, 19–21 May, Berlin, Germany, 63p.

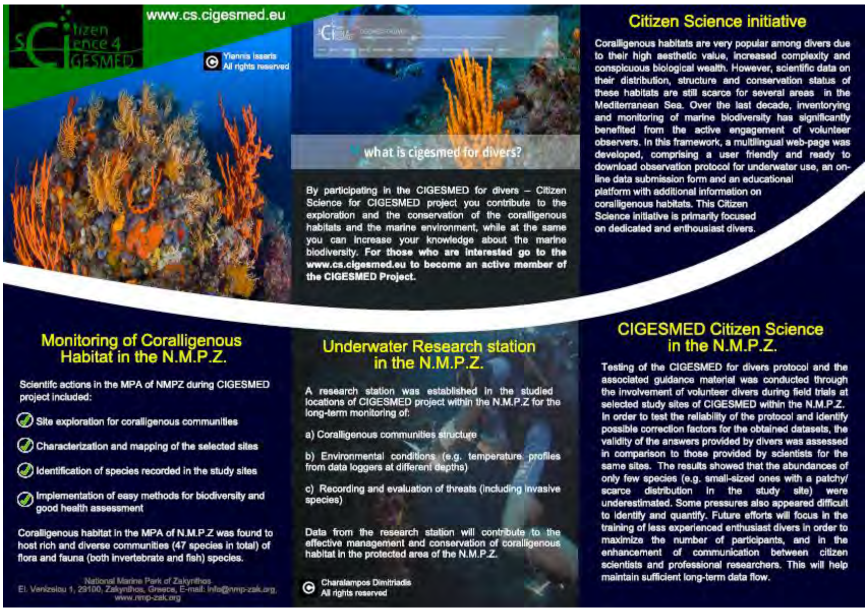
During the International Symposium 'Marine Protected Areas in Greece and the Mediterranean: Designing for the Future by Applying Lessons Learnt from the Past' which was organized by the Management Agency of the National Marine Park of Zakynthos and held in Zakynthos from 4 to 6 December 2015 the member of CIGESMED working group C. Arvanitidis presented orally the activities of CIGESMED project. At the same time, assessment of coralligenous habitat in the marine protected area of NMPZ was also presented by the members of NMPZ/University of the Aegean/HCMR working group under the following CIGESMED Poster contribution:

- Dailianis T., Sini M., Gerovasileiou V., Dimitriadis C., Sapouna A., Vatikiotis K., Katsoupis C., Çinar M.E., Féral J-P., Koutsoubas D., Arvanitidis C. 2015. Ecological assessment of coralligenous assemblages in the National Marine Park of Zakynthos (Ionian Sea, Greece). Proceedings of the International Symposium 'Marine Protected Areas in Greece and the Mediterranean: Designing for the Future by Applying Lessons Learnt from the Past', Zakynthos, Greece, 4-6 October, 32p.

During the Symposia members of the NMPZ/University of the Aegean/HCMR working group discussed with other CIGESMED partners from CNRS (France) and Ege University (Turkey) about the ongoing progress of different work packages, and potential post-CIGESMED initiatives.

6. DESSIMINATION

A new promotional trifold leaflet, was created by the members of NMPZ/University of the Aegean/HCMR working group regarding the activities of CIGESMED project that were carried out at the Marine Protected Area of NMPZ. The original template of the leaflet was delivered to CNRS in pdf format of high resolution for further use and exploitation (WP6).



Further dissemination/promotional/outreach actions included the communication of CIGESMED activities in the MEDPAN Network as well as the engagement of local stakeholders (diving clubs, dedicated divers) to Citizen Science activities of the project.

7. FIELD WORK

Following the previous surveys (2014) in the NMPZ for the exploration of coralligenous communities (see 2nd progress report for the candidate sites), NMPZ/University of the Aegean/HCMR working group established the final research site for the study and monitoring of coralligenous habitat in the Marine Protected Area of NMPZ during June of 2015. All other candidate sites that were surveyed during 2014 were excluded from further investigation, due to interrupted or rare presence of coralligenous formations. The research site is located at Lakka/Mavros Cavos area which is located at the SW part of Zakynthos Island, close to the westernmost boundaries of the NMPZ protected area and is characterized by relatively cool water temperatures, possibly due to direct exposure to the open Ionian Sea and local wind-driven up-welling. The location can be characterized as generally pristine, yet it should be noted that it is included among the most popular recreational diving areas of the island, and is regularly visited by groups of divers every day during the summer period (May to October) in an organized way by the local Diving Clubs. The latter means that dive masters and instructors usually escort groups of divers, while during pre-dive briefing sessions they inform divers about the protection measures that are active in the Protected Area of the NMPZ, the fragility of marine organisms and the importance of their habitats (established after close collaboration with the scientific personnel of the NMPZ Management Agency). Extensive vertical rocky walls with crevices, overhangs and numerous submerged caves characterize the topography of the specific location. Rocky cliffs starting from 100-150 m above sea level drop vertically to depths down to 30-40 m. These geomorphological features account for the increased shadowy conditions observed locally over the greatest part of the day.
Two research stations were established and surveyed within the research site of NMPZ (Table 1). Their topographic features are presented in table 1. The conducted surveys at these stations aimed to:

- Identify coralligenous communities structure
- Identify the environmental conditions
- Record and evaluate the threats

For the identification of the environmental conditions of the surveyed stations, 6 HOBO Water Temperature Pro v2 data loggers (Figure 3) were installed in order to set up a long-term benthic temperature sampling station (Figure 4). The loggers were installed at fixed depths (0, 5, 10, 20, 30, 40m). Loggers' data are anticipated to contribute to the monitoring and the better understanding of the local environmental conditions.

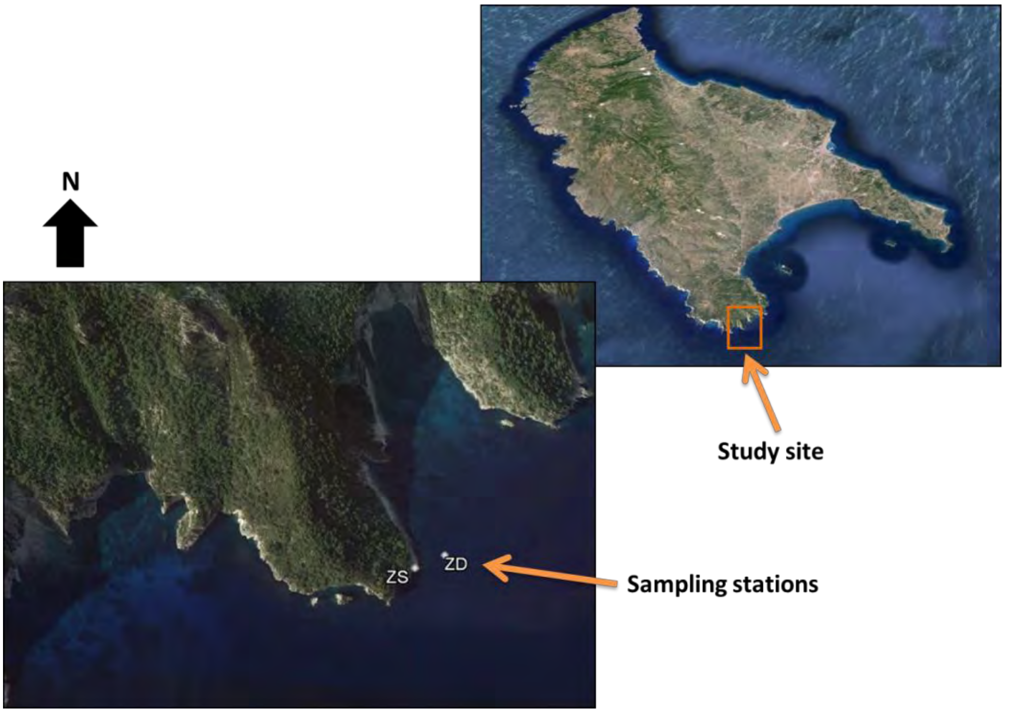


Figure 2: Map of Zakynthos showing the surveyed site and the two sites investigated (ZS and ZD)

Table 2. Topographic features of the surveyed sampling stations

Station	Transect	Coordinates		Date	Depth range	Orientation	Inclination	Rugosity
		Latitude	Longitude					
ZS	**ZSA**	37.647239°	20.845430°	5/6/2015	15-17	W	Vertical	Large
ZS	**ZSB**	37.647239°	20.845430°	5/6/2015	15-17	S, SW	Vertical	Medium
ZS	**ZSC**	37.647239°	20.845430°	5/6/2015	15-17	NE	Vertical	Large
ZD	**ZDA**	37.647548°	20.846123°	6/6/2015	38-39	NW	Inclined / Subvertical	Medium-Large
ZD	**ZDB**	37.647548°	20.846123°	6/6/2015	38-39	W	Vertical	Medium-Large
ZD	**ZDC**	37.647548°	20.846123°	6/6/2015	38-39	SW	Vertical	Medium-Large

Figure 3: Onset's Waterproof Data Logger system which was installed at Zakynthos sampling sites for a long –term temperature monitoring.

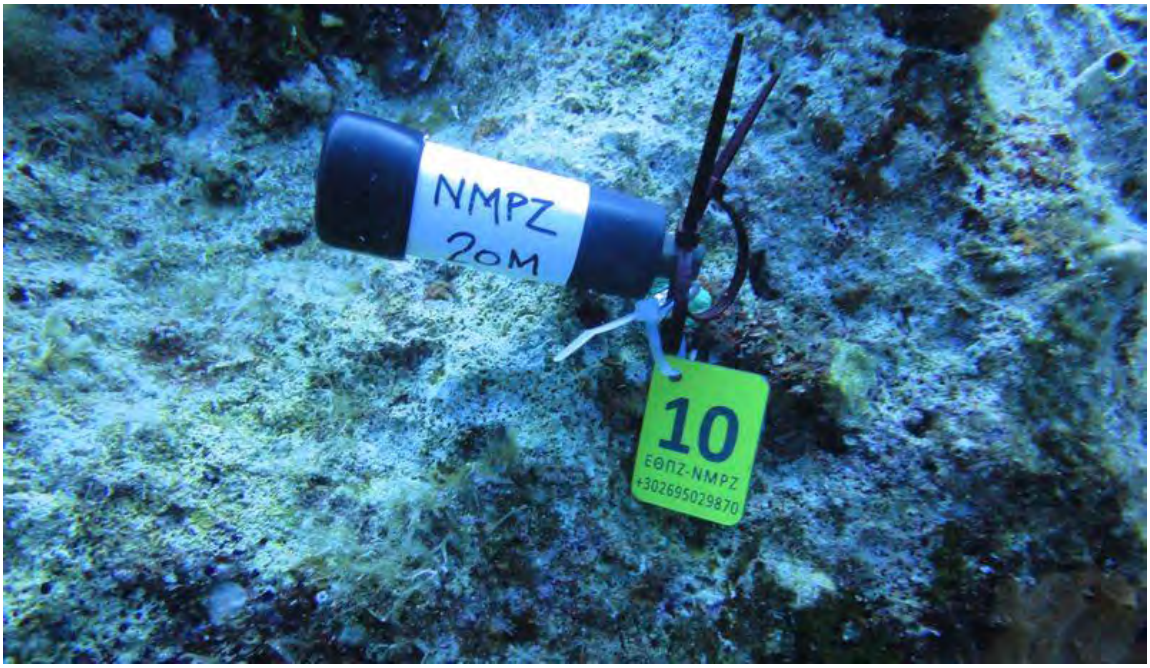


Figure 4: Installed data loggers at the sampling site of NMPZ

All the standard protocols and techniques of CIGESMED project were used during the surveys as they are thoroughly described at the 2nd progress report. The collected data were processed, inserted to a data base and then sent to the leader of CIGESMED WP2 for further analysis.

Moreover, additional samples of specimens of coralligenous species that are common across the Mediterranean such as *Mesophyllum sp* and *Myriapora truncata*, were also collected from the study area during the surveys. These samples were sent to the laboratory of IMBE for molecular analysis (WP4).

8. SPECIES RECORDED IN THE STUDY SITE

A total of 95 taxa belonging to 14 major taxonomic groups (Table 3) were recorded at the selected sites during the fieldwork, mostly consisting of Porifera (28) and Echinodermata (9) (Figure 5). The highest number of taxa (75) was recorded at the shallower station (ZS) while at the deep station (ZD) were recorded 68 taxa.

At the ZS station, most dominant taxa were Porifera (19) and Echinodermata (9), while at the ZD station were Porifera (22) and Rhodophyta (8) (Figure 5). More specific, the most abundant sponges at the ZS stations were *Agelas oroides* and *Crambe crambe*. Echinoderms while they had a "relative" high number of species (9) at the ZS station, their abundance was rather low. At the ZD station most abundant sponges were *Agelas oroides*, *Axinella* spp., *Chondrosia reniformis*, *Clionia viridis*, *Dysidea fragilis*, *Haliclona (Halichoclona) fulva*, *Penares* sp., *Pleraplyssila spinifera* and *Spirastrella cuncantrix* and from the rhodophytes were *Lithophyllum* sp., *Mesophyllum* sp., *Peyssonnelia rubra*, *Peyssonnelia squamaria*, and *Peyssonnelia* spp., respectively (Table 3).

Table 3. The list of coralligenous species and their relative abundance at coralligenous stations of Zakynthos [1 = low (rare or isolated individuals), 10 = average (dispersed population), 100 = abundant (abundant and dense population)] *Alien species.

Species/Stations	***ZS***	***ZD***
ALGAE		
Encrusting calcareous algae	100	
Red algae unid.1		100
Turf-forming algae	100	10
CHLOROPHYTA		
Cladophora pellucida (Hudson) Kützing, 1843	10	
Codium bursa (Olivi) C.Agardh, 1817	1	
Codium effusum (Rafinesque) Delle Chiaje, 1829		10
Palmophyllum crassum (Naccari) Rabenhorst, 1868	100	100
PHAEOPHYCEAE		
Dictyota dichotoma (Hudson) J.V.Lamouroux, 1809		1
Halopteris spp.	10	1
RHODOPHYTA		
Amphiroa cryptarthrodia Zanardini, 1844		10
Lithophyllum sp.		100
Mesophyllum sp.	100	100
Neogoniolithon mamillosum (Hauck) Setchell & L.R.Mason, 1943		10

Peyssonnelia rosa-marina Boudouresque & Denizot, 1973	10	10
Peyssonnelia rubra (Greville) J.Agardh, 1851	100	100
Peyssonnelia squamaria (S.G.Gmelin) Decaisne, 1842	10	100
Peyssonnelia spp.	100	100
FORAMINIFERA		
Miniacina miniacea (Pallas, 1766)	100	10
PORIFERA		
Agelas oroides (Schmidt, 1864)	100	100
Axinella damicornis (Esper, 1794)	1	10
Axinella spp.	1	100
Cacospongia mollior Schmidt, 1862	10	10
Chondrosia reniformis Nardo, 1847	1	100
Crambe crambe (Schmidt, 1862)	100	
Cliona celata Grant, 1826	10	
Cliona schmidti (Ridley, 1881)	10	10
Cliona viridis (Schmidt, 1862)	10	100
Dendroxea lenis (Topsent, 1892)	10	
Dictyonella incisa (Schmidt, 1880)		1
Dysidea fragilis (Montagu, 1814)		100
Fasciospongia cavernosa (Schmidt, 1862)		1
Haliclona (Halichoclona) fulva (Topsent, 1893)	1	100
Haliclona (*Soestella*) *mucosa* (Griessinger, 1971)	1	10
Haliclona sp.		1
Hemimycale columella (Bowerbank, 1874)		10
Ircinia sp.	1	
Merlia sp.	10	
Oscarella imperialis Muricy, Boury-Esnault, Bézac & Vacelet, 1996		10
Penares sp.	1	100
Petrosia (*Petrosia*) *ficiformis* (Poiret, 1789)		1
Phorbas tenacior (Topsent, 1925)	1	10
Pleraplysilla spinifera (Schulze, 1879)	1	100
Terpios gelatinosa (Bowerbank, 1866)	10	
Sarcotragus foetidus Schmidt, 1862	1	10
Sarcotragus spinosulus Schmidt, 1862		1
Spirastrella cunctatrix Schmidt, 1868		100
CNIDARIA		
Caryophyllia (*Caryophyllia*) *inornata* (Duncan, 1878)	10	10
Leptopsammia pruvoti Lacaze-Duthiers, 1897	1	100
Madracis pharensis (Heller, 1868)	10	10
Polycyathus muellerae (Abel, 1959)	1	
Hydrozoa (spp.)	1	
Scleractinia (spp.)	10	10
POLYCHAETA		
Hermodice carunculata (Pallas, 1766)	10	10

Bispira volutacornis (Montagu, 1804)	1	
Myxicola infundibulum (Montagu, 1808)	10	1
Sabella spallanzanii (Gmelin, 1791)	1	
Serpulidae (sp.)	10	10
Salmacina spp. / *Filograna* spp.	1	1
Protula tubularia (Montagu, 1803)	10	
CRUSTACEA		
Dardanus calidus (Risso, 1827)	1	
Scyllarides latus (Latreille, 1803)	1	
MOLLUSCA		
Gastropoda		
Flabellina affinis (Gmelin, 1791)	1	
Thylacodes arenarius (Linnaeus, 1758)	1	1
Peltodoris atromaculata Bergh, 1880		1
Bivalvia		
Lithophaga lithophaga (Linnaeus, 1758)	100	
Rocellaria dubia (Pennant, 1777)	10	10
BRYOZOA		
Adeonella spp.	100	100
Beania magellanica (Busk, 1852)		10
Cellepora sp.	1	
Myriapora truncata (Pallas, 1766)	100	100
Reptadeonella violacea (Johnston, 1847)	100	
Rhynchozoon neapolitanum Gautier, 1962	10	100
Schizomavella (*Schizomavella*) *mamillata* (Hincks, 1880)	100	100
Encrusting bryozoa	100	
ECHINODERMATA		
Arbacia lixula (Linnaeus, 1758)	1	1
Centrostephanus longispinus (Philippi, 1845)	1	1
Echinaster (*Echinaster*) *sepositus* (Retzius, 1783)	1	
Hacelia attenuata Gray, 1840	1	
Holothuria (*Panningothuria*) *forskali* Delle Chiaje, 1823	1	
Holothuria (*Platyperona*) *sanctori* Delle Chiaje, 1823	1	
Ophidiaster ophidianus (Lamarck, 1816)	1	1
Paracentrotus lividus (Lamarck, 1816)	1	1
Sphaerechinus granularis (de Lamarck, 1816)	1	1
TUNICATA		
Didemnum commune (Della Valle, 1877)		100
Didemnum maculosum (Milne Edwards, 1841)	1	100
Didemnum sp.	1	
Halocynthia papillosa (Linnaeus, 1767)	10	1
PISCES		
Anthias anthias (Linnaeus, 1758)	1	10
Apogon imberbis (Linnaeus, 1758)	10	

Chromis chromis (Linnaeus, 1758)	100	100
Coris julis (Linnaeus, 1758)	100	100
Diplodus sargus sargus (Linnaeus, 1758)		10
Diplodus vulgaris (Geoffroy Saint-Hilaire, 1817)		10
Scorpaena spp.	100	1
Serranus scriba (Linnaeus, 1758)	1	10

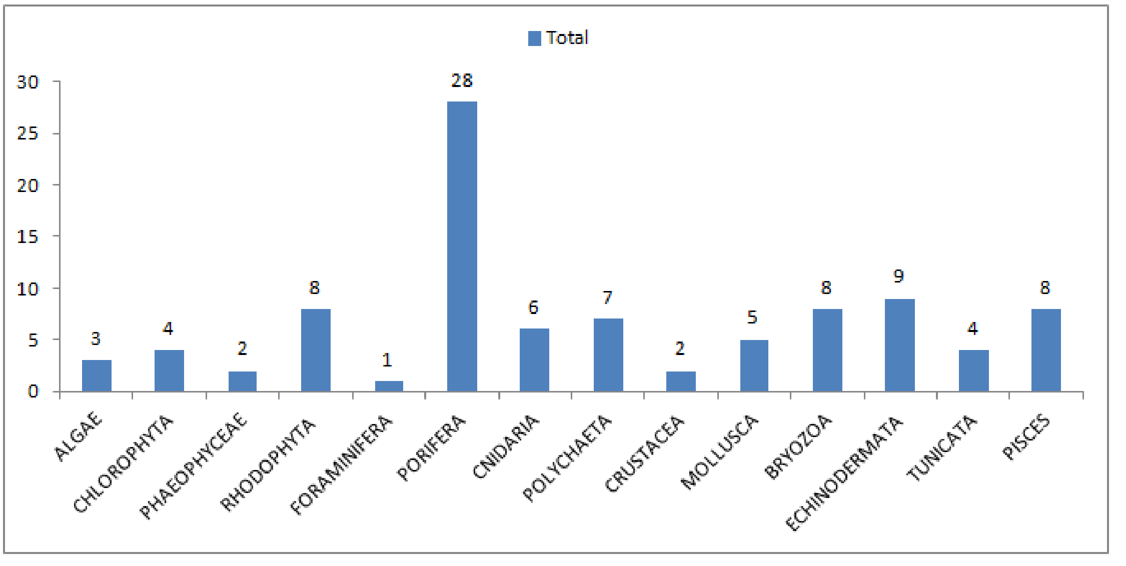


Figure 5. Distribution of total number of species to groups.

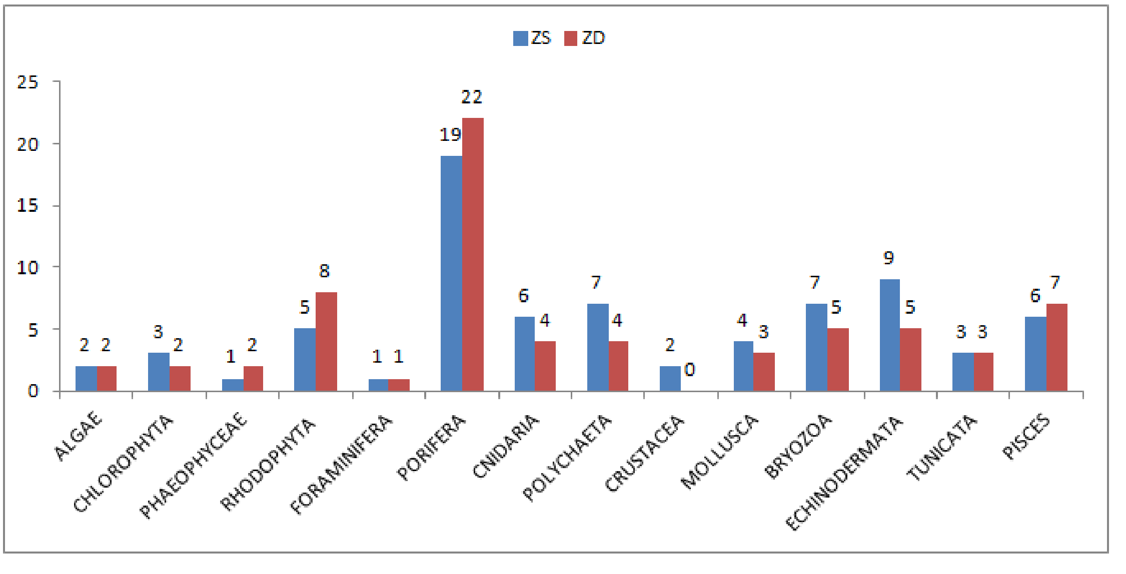


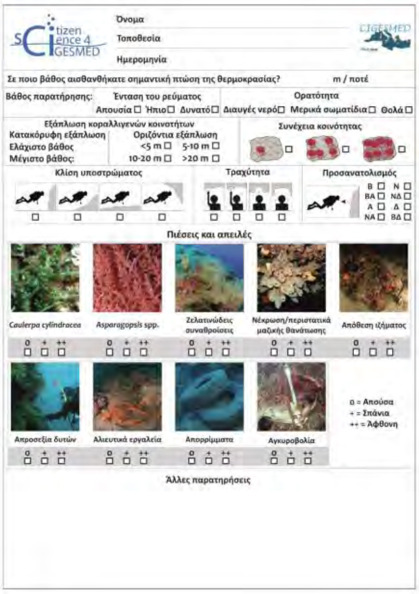
Figure 6. The number of species found in each group and station.

8. CITIZEN SCIENCE ACTIVITIES

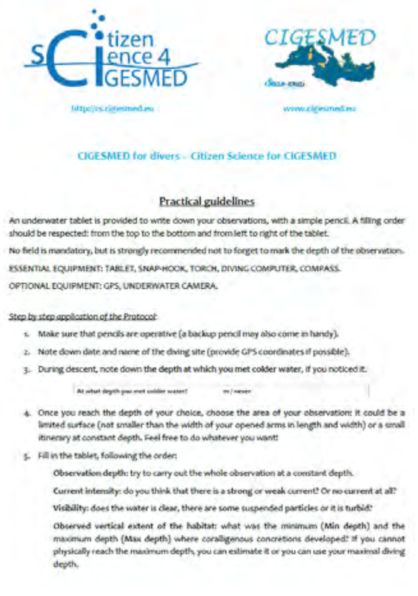
The NMPZ/University of Aegean working group was actively involved in the activities performed in the framework of the Citizen Science WP of CIGESMED project (WP5)

(Citizen Science for CIGESMED). The following activities were carried out by the working group of the NMPZ/ University of Aegean:

a) Participation in the compilation and translation in the Greek language of the underwater slates that will be used by the citizen scientists for the study and monitoring of the coralligenous habitat.



b) Participation in the preparation of the practical guidelines (short and long version) documents and translation in the Greek language.



CIGESMED for divers - Citizen Science for CIGESMED

Practical guidelines

An underwater tablet is provided to write down your observations, with a simple pencil. A filling order should be respected: from the top to the bottom and from left to right of the tablet.

No field is mandatory, but is strongly recommended not to forget to mark the depth of the observation.

ESSENTIAL EQUIPMENT: TABLET, SNAP-HOOK, TORCH, DIVING COMPUTER, COMPASS.

OPTIONAL EQUIPMENT: GPS, UNDERWATER CAMERA.

Step by step application of the Protocol:

1. Make sure that pencils are operative (a backup pencil may also come in handy).
2. Note down date and name of the diving site (provide GPS coordinates if possible).
3. During descent, note down the depth at which you met colder water, if you noticed it.
4. Once you reach the depth of your choice, choose the area of your observation: it could be a limited surface (not smaller than the width of your opened arms in length and width) or a small itinerary at constant depth. Feel free to do whatever you want!
5. Fill in the tablet, following the order:

   Observation depth: try to carry out the whole observation at a constant depth.

   Current intensity: do you think that there is a strong or weak current? Or no current at all?

   Visibility: does the water is clear, there are some suspended particles or it is turbid?

   Observed vertical extent of the habitat: what was the minimum (Min depth) and the maximum depth (Max depth) where coralligenous concretions developed? If you cannot physically reach the maximum depth, you can estimate it or you can use your maximal diving depth.

CIGESMED για Δύτες, Πολίτες Επιστήμονες για το πρόγραμμα παρακολούθησης των κοραλλιγενών οικοτόπων

Τι είναι οι 'κοραλλιγενείς' οικότοποι;

Οι κοραλλιγενείς οικότοποι, αποτελούν ένα ιδιαίτερο υποβρύχιο τοπίο, που απαντά αποκλειστικά στη θάλασσα της Μεσογείου. Αναπτύσσεται πάνω σε σκληρούς βραχώδεις πυθμένες, κυρίως από ενασβεστωμένα ροδοφύκη των τάξεων Corallinales και Peyssonneliales, οι αλλεπάλληλες αποθέσεις των οποίων μπορούν σε βάθος χρόνου να σχηματίσουν πολυδιάστατες υποβρύχιες δομές και υφάλους. Πλήθος άλλων ειδών-βιοκατασκευαστών συμμετέχουν σε αυτή τη βιογενή διεργασία οικοδομώντας (π.χ. γοργονίες, σκληρακτίνια, σπόγγοι, βρυόζωα, πολύχαιτοι) ή αποδομώντας («βιοδιαβρωτές», π.χ. σπόγγοι του γένους Cliona που διατρυπούν, ή αχινοί που θρυμματίζουν το ασβεστώδες υπόστρωμα), αυξάνοντας διαρκώς τη δομική πολυπλοκότητα των κοραλλιγενών σχηματισμών. Ακριβώς λόγω της πολυπλοκότητας τους, οι δομές αυτές αποτελούν σημαντικό καταφύγιο για μεγάλο αριθμό ασπονδύλων (π.χ. καρκινοειδή, εχινόδερμα, μαλάκια, ασκίδια) και ψαριών, γεγονός που τις καθιστά πυρήνες θαλάσσιας βιοποικιλότητας. Κατά κανόνα, οι κοραλλιγενείς οικότοποι χαρακτηρίζονται από υψηλή αισθητική αξία αλλά και υψηλή ευπάθεια λόγω των εξαιρετικά αργών ρυθμών αύξησης των επιμέρους ειδών τους.

Γιατί μελετούμε τους κοραλλιγενείς οικοτόπους;

Οι θαλάσσιοι αυτοί οικότοποι είναι μοναδικοί σε παγκόσμιο επίπεδο και κατατάσσονται μεταξύ των ομορφότερων και πλουσιότερων σε ζωή θαλάσσιων τοπίων που μπορεί κανείς να προσεγγίσει με αυτόνομη κατάδυση. Λόγω της δομικής πολυπλοκότητας που παρουσιάζουν, φιλοξενούν πλήθος ειδών μεγάλης οικολογικής, αισθητικής και εμπορικής αξίας, ορισμένα από τα οποία προστατεύονται από την Εθνική αλλά και τη Διεθνή νομοθεσία. Οι κοραλλιγενείς οικότοποι συχνά απειλούνται από τις ανθρώπινες δραστηριότητες. Η ανεξέλεγκτη αγκυροβολία, η κατάδυση με έλλειψη περιβαλλοντικής ευαισθητοποίησης, η υπεραλίευση και τα απορρίμματα, σε συνδυασμό με την εισβολή αλλόχθονων ειδών και την αύξηση της θερμοκρασίας της θάλασσας (λόγω κλιματικής αλλαγής), αποτελούν τις κυριότερες απειλές που μπορεί να υποβαθμίσουν σημαντικά την κατάσταση των κοραλλιγενών οικοτόπων.

c) Organizing and realizing the testing of CIGESMED citizen science protocol in the field. The aim of this activity was to test the effectiveness of one of the proposed citizen science protocol (i.e. tablet with a specific data form, practical guidelines) that was developed in the framework of CIGESMED project, in the National Marine Park of Zakynthos (NMPZ). To this end, volunteering experienced SCUBA divers (local recreational and/or professional divers, instructors and owners of local diving centres) participated in this study. The citizen science protocol was tested in selected study sites of CIGESMED within the NMPZ, during July and September 2015. Further testing will be also carried out during the summer of 2016. The methodology, results, conclusions and suggestions of this initiative were thoroughly presented in the following interim report (attached to the deliverables of the current reporting period):

Dimitriadis C., Gerovasileiou V., Dailianis T., Sini M., Kalli E., Sourbes L., Arvanitidis C., Koutsoubas D. 2015. Testing CIGESMED citizen science protocol in the field: assessment and results. CIGESMED project internal report, NMPZ, Zakynthos, Greece. 10p.

d) Participation in the testing of the webpage of Citizen Scientists for CIGESMED.

9. PROGRESS OF REALIZED ACTIONS

The progress of the activities that the Management Agency of the National Marine Park of Zakynthos carried out in relation to CIGESMED work packages is provided in the following table.

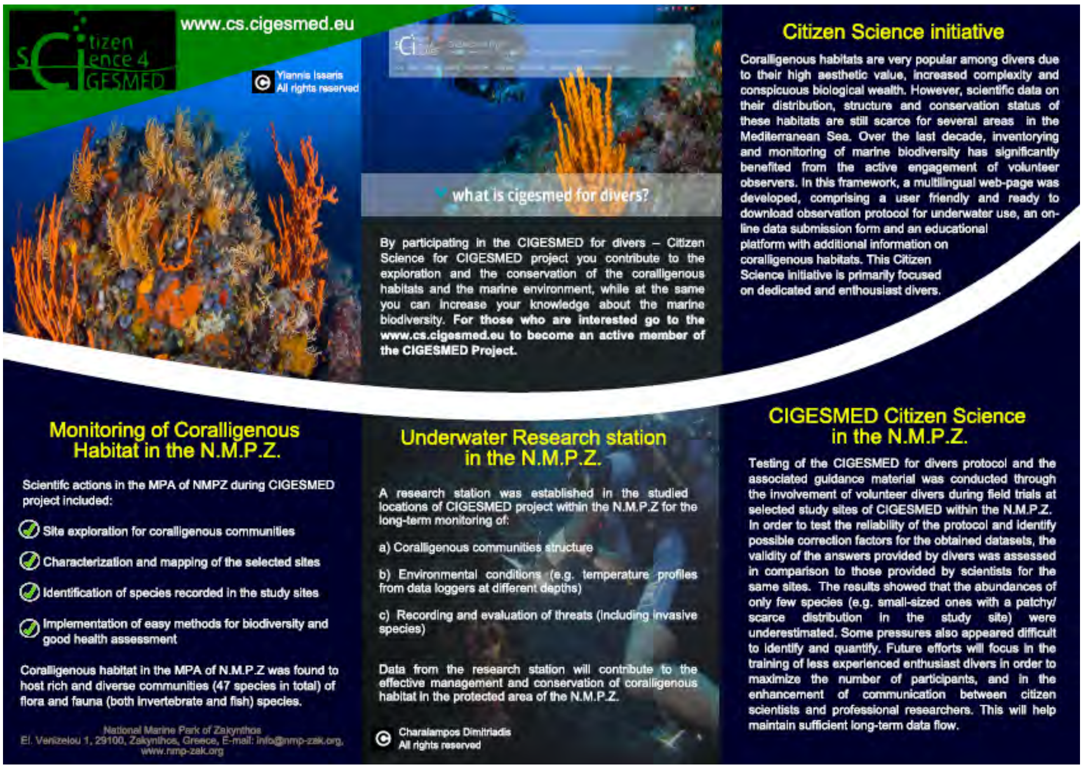
NMPZ Activities	CIGESMED WP's	NMPZ PROGRESS
Activity 1 *Coralligenous assessment and monitoring*	**WP2** - *Coralligenous assessment and threats in the different basins* **WP3** - *Indicators' development and test*	**Completed** (field work, testing and implementation of protocols, data gathering, processing and analysis)
Activity 2 *Management tools*	**WP4** - *Innovative monitoring tools* **WP6** - *Data management, mapping and assimilation tools*	**Completed** (establishment of research station for the long term monitoring of coralligenous habitat, data management and assimilation tools)
Activity 3 *Participatory process-Promotion - Public awareness activities*	**WP5** - *Citizen science network implementation* **WP7** - *Outreach, dissemination and stakeholder engagement*	**Completed** (involvement in CS network implementation, involvement in the development of the CS protocols and informational material, implementation and evaluation/testing of CS protocol in the NMPZ with divers, production of educational/promotional leaflet, engagement of stakeholders, communication of CIGESMED actions to other NetWorks)

9. FINAL GENERAL ASSEMBLY 2016

The members of NMPZ/University of Aegean working group Koutsoubas D. and Sini M. will participate to the final general assembly of CIGESMED project which will be held from 27 to 29 of June 2016 at Marseille, France.

Supplementary material

Dissemination – Promotional leaflet



Internal Report: ***Testing CIGESMED citizen science protocol in the field: assessment and results***

TESTING OF THE CIGESMED CITIZEN SCIENCE PROTOCOL IN THE FIELD: ASSESSMENT AND RESULTS

Internal Report

Authors:
Dimitriadis C. [1], Gerovasileiou V. [1,3], Dailianis T. [3], Sini M. [1,2], Kalli E. [1], Sourbes L. [1], Arvanitidis C. [3]., Koutsoubas D. [1,2]

[1]NATIONAL MARINE PARK OF ZAKYNTHOS
HTTP://www.nmp-zak.org

[2]DEPT. OF MARINE SCIENCES, UNIVERSITY OF AEGEAN

HTTP://www.mar.aegean.gr

[3]Hellenic Centre for Marine Research, Heraklion, Crete

HTTP://www.hcmr.gr/

Front page photos: C. Dimitriadis

1. INTRODUCTION

The aim of this study was to test the effectiveness of one of the proposed citizen science protocol (i.e. tablet with a specific data form) that was developed in the framework of CIGESMED project, in the National Marine Park of Zakynthos (NMPZ). To this end, 9 volunteering experienced SCUBA divers (local recreational and/or professional divers, instructors and owners of local diving centres) participated in this study. The citizen science protocol was tested in selected study sites of CIGESMED within the NMPZ, during July and September 2015 according to the following steps:

Preparatory Actions

- ✓ Identification of participating divers
- ✓ Providing the guidelines of the protocol to the divers for reading (and evaluation)

Field Work

- ✓ Implementation of the protocol with divers at specified locations (marked with labels) in selected study sites of CIGESMED within the NMPZ. At this particular locations a survey was initially conducted by expert scientists in order to fill in the CIGESMED protocol few days before the field trials with the divers. The answers provided by the experts were used to verify the validity of the ones provided by the divers.
- ✓ Divers were accompanied during their dives by scientific personnel of the NMPZ in order to collect information about the implementation of the protocol underwater.
- ✓ Interviews with the divers were conducted after their dive so as to gather their comments about the implementation of the protocol.

Data analysis

- ✓ Data were analyzed in order to evaluate the validity of the answers provided by the divers in comparison to those provided by the scientists.
- ✓ The abovementioned comparisons were made at the smallest spatial scale possible (marked locations of a 2x2 m surface within the study site) and were then aggregated to site level.
- ✓ Divers success rate in the identification of species and threats was calculated based on presence/absence data (true/false answers).
- ✓ Divers success rate in the quantification of abundance classes of both species and threats, as well as the intensity of each threat, were also evaluated.
- ✓ Ranking of species and threats according to identification and abundance quantification success was also conducted so as to assist in the improvement of the protocol and the final selection of species and threats.

2. METHODS

2.1 Field work with divers

Field work took place in "Mavros Kavos" area which is located at the SW part of Zakynthos Island (37.647284 N, 20.845715 E), close to the westernmost boundaries of NMPZ. The selected area corresponds to the study site "SC-1" of CIGESMED project (Figure 1).

For the needs of the citizen science protocol testing we used the permanent transect line that was established at a depth range of 15-20 m for the needs of the project. Volunteering divers were assigned to follow the protocol at different segments of the transect line. Each segment had been previously marked with a permanent identification tag (Figure 2) and therefore each diver worked upon a 2 x 2 m observation unit across the transect with the tag marking its center. Each diver took note of the ID number of the location of the unit they worked upon, in order to precisely correlate the observations of the volunteers with the ones previously recorded by the expert scientists. Overall, participants' observations were implemented at 6 distinct areas along the transect line.

Figure 1: Map of the study area in Zakynthos Island (A) showing the research sites of CIGESMED project in NMPZ (B). The study site CS-1 was used for the needs of citizen science protocol trials.

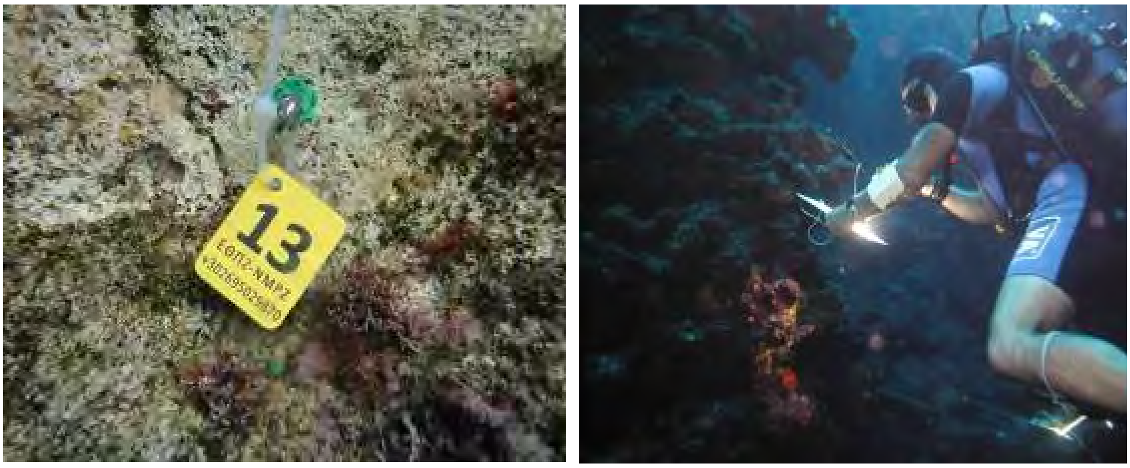


Figure 2: Permanent tag marking the observation unit along the transect line at the study site (left) and diver filling in the observation form during the testing procedure (right).

2.2 Data analysis

Data concerning the threats and the species section of the protocol were discriminated to the following categories (according to the observations previously recorded by expert scientists) in order to identify trends in the variability of answers provided by volunteering divers:

a) Species/threats which are absent from the study area (including all testing sites) although they are included in the protocol. In this case a false answer implies a misidentification of the target species/threat (i.e. the target species/threat is actually not present and it is falsely recorded as such). In other words, the diver is confusing the target species/threat with something else.

b) Species/threats which are present at the sampling location. In this case a false answer implies the inefficiency of the participant in observing the target species/threat which is *a priori* known to occur in the observation area. In other words, the diver fails to spot the target species/threat.

c) Species/threats with a patchy distribution across the testing sites. In this case a false answer implies the combination of misidentification and/or inefficiency to detect the target species/threat.

Analysis was based on both presence/absence (lower level of complexity that the divers have to deal with) and abundance estimation data (higher level of complexity that the divers have to deal with). The use of presence/absence data served as the basis to understand the level at which the divers can provide reliable information about the occurrence of species (simplest level of information). On the other hand, the use of abundance estimation data provides evidence about the robustness in the use of quantitative data (abundance estimation) for the study of coralligenous formations (higher level of information).

With respect to presence/absence data analysis, we checked if the observation of the diver at each particular observation unit was correct (true) or mistaken (false) in comparison to the data provided by the expert scientists at each tagged location. Consequently, the frequency of occurrence of true and false answers for each species or threat was calculated and converted to % success score (percentage of correct answers) regarding the total studied area.

Regarding the abundance estimation analysis we developed a distance-based method which calculates how close the estimation provided by the divers is to the one provided by the experts. Moreover, this method allows for the identification of the degree of over- or underestimation of abundance levels obtained by the divers.

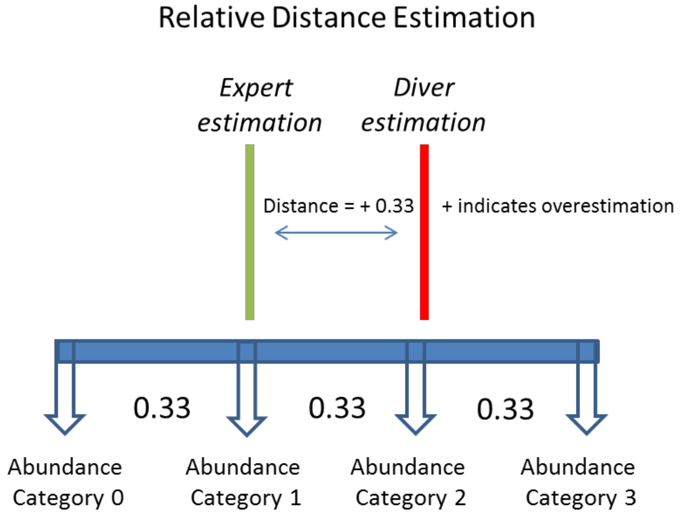


Figure 3: Rationale of the abundance estimation analysis that was developed in the present study.

According to this method we calculated the relative distance between the abundance category provided by the expert and the one provided by the volunteering diver (Figure 3). Expert estimation is the reference point for the calculation of the distance. If the participant's estimation falls to the right of the estimation of the expert (positive sign) then overestimation occurs. If the participant's estimation takes a lower value than that of the expert then underestimation occurs (negative sign). In this respect, the relative distance measures can take values from 0 (100% success score) to 1 (0% success score) with distance intervals of 0.33. The relative distance was calculated for each diver and species/threat and then we calculated the mean distance for the total sample (all divers for each species/threat) and converted it to success percentage. Calculations were performed only for the cases of correctly identified species (information provided by the presence/absence data analysis). For species/threats that were consistently absent in the study area (as it was reported by the expert scientists) we did not perform abundance estimation analysis.

With regard to the species section of the protocol, an additional discrimination of species was employed according to their mobility status. Hence, for both presence/absence and abundance estimation data two groups were formulated: a) mobile and b) sessile species. Mobile species are variable in space and time (e.g. fish species) and therefore the comparison between surveys which are conducted at different days may lead to different results. In this respect, since surveys by expert scientists did not occur simultaneously with those of the citizen scientists, direct comparisons between the obtained results should be handled and interpreted with caution. On the other hand, sessile species provide a safer base for such comparisons, especially since the surveys of expert scientists and citizen scientists were separated by just a few months' interval at greatest.

3. RESULTS & CONCLUSIONS

3.1. Threats

3.1.1. Presence-Absence frequencies

Analysis of the presence – absence data (true and false answers of the divers) is presented for each threat in the graphs of the Appendix while the main results are summarized in Table 1. In short, for the case of the threats that were absent from the total study area (as it was indicated by the experts) fishing gears, litter and anchoring received a 100% success score. Hence, a high level of reliability in the use of these threats in the protocol was detected. With respect to *Asparagopsis* spp. and *Womersleyella setacea*, a success score of 88.89% was found, therefore suggesting that divers mostly manage to understand that these species were absent from the study site. Mucilaginous aggregates received a success score of 88.89% whereas 11.11% of the participants did not answer this question. A considerably lower success rate was evidenced for the cases of *Caulerpa cylindracea* and sedimentation, thus indicating that almost half of the divers confused these threats with something else (these threats were absent while divers thought they were present). For the case of sedimentation it was quite clear that divers were not familiar with this term and further clarification may be needed in the guidelines of the protocol. Divers' recklessness marks and necrosis/mortality events received the lowest recorded success score further suggesting that these threats were largely misidentified by the divers. Hence additional information should again be included in the guidelines.

Table 5: Rank of threats with respect to the success score that each threat received based on presence/absence data (NA = no answer)

Rank of threats that were absent	Success score	NA %
Fishing gears	100	
Litter	100	
Anchoring	100	
Asparagopsis spp.	88	
Womersleyella setacea	88	
Mucilaginous aggregates	88	11
Caulerpa cylindracea	55	
Sedimentation	55	11
Rank of threats that were present or exhibited patchy distribution	**Success score**	**NA %**
Divers recklessness marks	33	11
Necrosis/Mortality events	11	22

3.1.2 Intensity of threats (abundance estimate)

Given that divers mainly failed to identify 'Divers recklessness marks' and 'Necrosis/Mortality events' (see presence - absence data section), a low success rate in abundance estimation was also identified (underestimation pattern) for these threats.

Table 2: Rank of threats with respect to the success score that each threat received based on abundance estimation data

Rank of threats that were present or exhibited patchy distribution	Success score (%)	Trend
Divers recklessness marks	68	Underestimation
Necrosis/Mortality events	35	Underestimation

3.1.3 Concluding remarks for the threat section of the protocol

Our results suggested that some threats of the protocol (*Caulerpa cylindracea*, sedimentation, divers recklessness, and necrosis/mortality events) were rather problematic both in identifying them and estimating their intensity. Hence, further measures should be taken for their accurate quantitative and qualitative assessment (e.g. further instructions in the guidelines, detailed briefing before the dive) or their presence in the protocol should be reconsidered. However, it should be taken into consideration that some of these threats were absent from the study site or had a very low intensity that could presumably only be identified by experts. It would be interesting to evaluate the success score of citizen scientists in areas with a notable presence of such threats.

3.2. Species

3.2.1. Sessile species

3.2.1.1 Presence-Absence frequencies

Leptogorgia sarmentosa and shark eggs received a success score of 100%, a result which implies that divers manage to understand their absence in the study area. In very few cases (1 occassion) divers reported the presence of *Eunicella cavolini*, *E. singularis* and *Corallium rubrum* despite the fact that these species were not present. However, the success score for the former species was rather high (88.89%), indicating that, as a general trend, divers avoided falsely reporting these species as present. *Paramuricea clavata* and *Savalia savaglia* received a success score of 77.78% since 2 out of the 9 divers erroneously indicated this species as present.

Table 3: Rank of sessile species with respect to the success score that each species received based on presence/absence data.

Rank of species that were absent	Success score%
Leptogorgia sarmentosa	100
Shark eggs	100
Eunicella cavolini	88
Eunicella singularis	88
Corallium rubrum	88
Paramuricea clavata	77
Savalia savaglia	77
Rank of species that were present or exhibited patchy distribution	**Success score%**
Calcareous red algae	88
Agelas oroides	88
Myriapora truncata	88
Scleractinians	55
Peyssonnelia spp.	55
Axinella spp.	44
Cliona spp.	33
Other bryozoans	11

Calcareous red algae, *Agelas oroides* and *Myriapora truncata* received a relatively high success score (88.89%) and thus it was evidenced that the majority of divers correctly identified these species. A moderate success rate was evidenced in the identification of Scleractinians, *Peyssonnelia* spp. and *Axinella* spp. as a result of divers' inefficiency in locating them. Divers largely failed to identify *Cliona* spp. and "Other bryozoans" since these species received the lowest recorded success score (33.33% and 11.11%, respectively).

3.2.1.2 Abundance estimates

In the case of species correctly identified by the divers, a general trend for underestimation in species abundance was detected. In this respect, the lowest success score regarding abundance estimation was recorded for "Other bryozoans", *Myriapora truncata* and *Peyssonnelia* spp. For the cases of Scleractinians, *Axinella* spp. and *Cliona* spp., abundance estimation by the divers was slightly diverging from the estimation provided by the expert scientists. A moderate success rate in abundance estimation was detected for *Agelas oroides* and Calcareous red algae.

Table 4: Rank of species with respect to the success score that each species received based on abundance estimation data

Rank of species that were present or exhibited patchy distribution	Success score %	Trend
Scleractinians	85	Underestimation
Axinella spp.	81	Underestimation
Cliona spp.	78	Underestimation
Agelas oroides	74	Underestimation
Calcareous red algae	66	Underestimation
Peyssonnelia spp.	52	Underestimation
Myriapora truncata	44	Underestimation
Other bryozoans	0	Underestimation

3.2.1.3 Concluding remarks for the sessile species included in the protocol

Participating divers generally managed to avoid falsely recording species that were actually absent in the study area. On the other hand, half of them failed to identify small-sized taxa with a patchy/scarce distribution in the study site, such as Scleractinians, *Peyssonnelia* spp. and *Axinella* spp. The lowest identification success ratewas recorded for *Cliona* spp. and “Other bryozoans”. The presentation of these taxa in the protocol should probably be reconsidered. Further optical clues forthe identification of these species should be provided to the divers through the website and the guidelines of the protocol (e.g. photos, distinctive features/colors/shapes and striking characteristics that will help divers identify the species, provide similar species and highlight the differences with the targeted ones). Finally, the success in the estimation of species abundance by the divers varied considerably depending on the species with a general trend for underestimation. Top-rated species according to success score in abundance estimation (i.e. Scleractinians and *Axinella* spp.) were the ones that received a low identification success score. On the other hand, species that exhibited a high success in their identification (e.g. *Myriapora truncata*), presented at the same time a low success in abundance estimation. Finally, several species presented low success both in their identification and abundance estimation (e.g. *Peyssonnelia* spp.). Therefore, future effort for the improvement of the protocol should primarily focus in helping divers correctly identify the species and provide reliable information about their occurrence (simplest level of information) rather than effectively estimating their abundance (higher level of information).

3.2.2. Mobile species

Divers managed to avoid falsely reporting species that were acually absent in the study area. However, a success score of 66% was recorded for the case of *Anthias anthias* since some divers confused this species with *Apogon imberbis*. Hence, the guidelines of the protocol should highlight the conspicuous morphological features that are discriminative for each species. However the inclusion of *Anthias anthias* in the protocol basically aimed to the verification of the habitat type (flag species of coralligenous communities) and not the species *per se*. The cardinal fish *Apogon imberbis* is typical of cavities, fissures and caves, which are commonly found in coralligenous seascapes as well.

The success score for the mobile species that are known to occur in the study area was quite low (ranged from 11 to 44%). However this fact should not be solely interpreted as participants’ failure to identify these species (which are quite striking and well known among divers) but can also be attributed to species mobility (i.e. they were present when the expert scientist surveyed the study area but not so during the volunteers’ survey).

Table 5: Rank of mobile species with respect to the success score that each species received based on presence/absence data.

Rank of species that were absent	Success score%	NA %
Homarus gammarus	100	
Palinurus elephas	100	
Anthias anthias	66	
Rank of species that were present or exhibited patchy distribution	**Success score%**	**NA %**
Scorpaena spp.	44	
Epinephelus marginatus	33	
Scyllarides latus	22	
Centrostephanus longispinus	11	11
Other sea urchins	11	

4. Notes from interviews with divers

Comments by the participating divers:

• Guidelines of the protocol are too "scientific" and text too lengthy (comment of 9 out of the 10 divers); most participants actually never reached the end of the document.
• There was a question regarding what exactly should be noted in the protocol: "Do I fill in exactly what I observe during this dive or I am writing down also the species or the threats that I have observed during previous dives at the same location? That question was justified by the fact that most of the participants are visiting the testing site very frequently. (Comment of 2 out of the 10 divers)
• Make images on the tablet larger, cropped to the species of interest (comment of 1 out of the 10 divers)

Comments by the scientific supervisor following and observing the divers during the surveys:
• Some participants omitted filling up some fields during the dive; however, they did so post-dive for information that could easily be recalled from memory.
• A torch and compass are –required; artificial light restores the natural coloring of organisms thus making them more easily recognizable and similar to the photos of the protocol, while without a compass the identification of the orientation of the site is impossible)
• Participants found it difficult to fill in the information about the rugosity and orientation of the sampling site; this could be resolved by providing more thorough guidelines during the pre-dive briefing and stressing the importance of specific required pieces of equipment. .
• Most of them neglected to fill in water temperature data at different depths during their ascent. This information though is not essential and can be easily obtained at the surface by downloading the dive profile from a participant's dive computer.
The actual time needed to fill-in the protocol (not the duration of the whole dive but the exact time participants spend to fill in the data form) ranged between 15 to 20 minutes.This possibly implies some constraints to the maximum depth the divers can implement the protocol at, since 20 minutes spent at the 30-35 m zone is dangerously close or exceeds no-decompression safety limits.