

PHD COURSE IN LIFE AND ENVIRONMENTAL SCIENCES

Report Form for PhD student annual evaluation (XXXVII and XXXVIII cycles)

Name of PhD student: Agnese Riccardi

Title of PhD research: Valorization of Marine Biodiversity to Engage Local Communities in the Design of Tailored Conservation Measures

Name of PhD supervisor: Carlo Cerrano

Research lab name: Zoology Lab

Cycle:

XXXVI

XXXVII

PhD Curriculum::

Marine biology and ecology

Biomolecular Sciences

Civil and environmental protection

DISVA instrumentation labs/infrastructure eventually involved in the project:

Actea Mobile Laboratory

Advanced Instrumentation lab

Aquarium

MassSpec lab

MaSBiC

Simulation/informatics lab

Other. Please, indicate:

ABSTRACT

Marine habitats are rapidly degrading under multiple stressors [1]. Climate change is strongly impacting the Mediterranean Sea [2] and further degradation of marine biodiversity and ecosystem functions is expected to increase [3]. This project aims to design *ad hoc* strategies i) to raise awareness about climate change's effects on marine biodiversity, ii) to drive politicians and society in smoother acceptance of conservation measures and iii) to engage communities in their implementation. Citizen Science (CS) and Ocean Literacy (OL) programs are developed and addressed to different stakeholders (all grades' schools, artisanal fishermen, diving centers and volunteers) to reach the project's goals. We get to 503 students (Marche Region, Italy) involving them in *in-and-outdoor* activities and evaluating the impact through quali-quantitative pre-post surveys. 40 *vis-a-vis* interviews were addressed to Ancona Municipality's citizens, conducted and transcribed in order to create a more specific online survey to be disseminated widely and homogeneously. To collect large spatial and temporal scale data on Heterobranchia as indicators of climate change's effects, a CS monitoring protocol was disseminated in the Mediterranean Basin and Web Ecological Knowledge (WEB) methodology was used to extract data both from the *iNaturalist* platform (from where we recorded 1,363 observations uploaded by 106 volunteers) and from the Facebook page "*Nudibranchi del Mediterraneo*" (with approximately 200 observations recorded). A focus along Monte Conero Coast is also taking place with

underwater visual census: 37 scientific dives in 7 different dive sites took place from September 2021 to July 2023 and 735 Heterobranchia specimens were observed. Local Ecological Knowledge (LEK) standardized protocol procedure was adopted to reconstruct ecology historical changes, interviewing 48 fishermen from 3 Mediterranean Seas (Sicily, North Adriatic and North Tyrrhenian Seas) and collecting their perceptions about the abundance trends of 122 species mentioned. Pilot study 3, Pantelleria Island, allowed us to involve local community in designing and implementing the conservation project PANTHER.

Part 1. Scientific case of the PhD Research

- BACKGROUND

Ocean Literacy (OL) has been defined as the “understanding of the ocean’s influence on you and your influence on the ocean [4]. An ocean-literate person i) understands the Essential Principles and Fundamental Concepts about the Ocean, ii) can communicate about the ocean in a meaningful way and iii) is able to make informed and responsible decisions regarding the ocean and its resources. In 2017, the UN proclaimed the Decade of Marine Sciences for Sustainable Development (2021-2030), concurrently with the 2030 Agenda, to reverse the decline in ocean health and improve its conservation status. The OL is considered crucial to both the Decade [5] and 2030 Agenda goals [6]. Based on this framework, marine scientists and educators developed the “Mediterranean Sea Literacy” (MSL) guide adapted to the specificities of the Mediterranean region. The MSL guide, comprising 7 principles and 43 concepts adapted to the specificities of the Mediterranean Sea, is expected to raise awareness and create a Mediterranean-Sea-literate society [7].

The training and engagement of citizens develop a population of final users with a better attitude towards scientific knowledge and enhanced awareness of the nature of the science itself [8]. Citizen Science (CS) programs are considered stepping stones in the nurturing of a new generation of ocean-literate citizens [9]. As well as having citizens' OL goals, CS programs also have scientific and policy goals [10]. CS is particularly effective at addressing ecological questions at large spatial and temporal scales that cannot be covered by a small team of investigators [11] and can provide crucial baseline information on the effects of global change and for identifying locations in good or bad environmental health [12].

Ongoing climate change is rapidly altering underwater communities, sometimes causing local extinctions or alterations in normal life cycles, and very often the disappearance of a species goes completely unnoticed. Sea slugs seem to be good indicators of regional climate shift [13; 14] basically for the three following reasons:

- - these organisms have evolved several defensive strategies involving aposematic coloration, making their liveries vivid and detectable to humans (useful to scuba macro-photographers);
- - most of them appear to have a stenoecious diet and mainly target sessile organisms such as cnidarians and sponges, which are very sensitive to climate change;
- - Short life cycle, larval growth and development.

Their specialization in feeding might impact species survival under a warming scenario, since the local extinction of a preferred prey could cause a reduction in feeding efficiency, providing too little energy to support the expected higher metabolic rate [15]. Although many other factors (e.g. nutritional state, body size, population density) affect the reproductive output of a given nudibranch species [16], temperature increase during nudibranch’s embryonic development has been proved to cause deleterious effects on embryo’s survival and hatching success [17] In the present research, several parameters will be evaluated with laboratory culture, in order to highlight the temperature effect on i) adult feeding and survival ii) spawning frequency, iii) embryonic development time and survival. The Reef Check Italia ETS project, “Nudibranchs and other sea slugs in the Mediterranean and the Black Sea”, is one of the projects settled worldwide and focused on the monitoring of Heterobranchia, it represents an important CS tool to collect large-scale data on this delicate group of organisms concerning their distribution and diet preferences.

Besides people who voluntarily participate in marine conservation or monitoring programs (CS), there are millions of people who contribute unintentionally to marine science by publishing information about the distribution of marine species on the World Wide Web (WWW), sharing videos and pictures on social media

pages [18]. All the ecological information contained in the WWW and exploitable for scientific purposes are termed Web Ecological Knowledge (WEK). In a recent work, Krželj et al. [19], confirm that WEK, still scarcely exploited, represents a consistent source of scientific information that is accessible and continuously updated.

In the framework of community engagement in climate change detection, “Local Ecological Knowledge” (LEK) has emerged as an alternative approach to collect information on species presence/abundance when historical data are lacking [20; 21]. However, up to now, the use of LEK in the Mediterranean Sea has been limited to collecting information and describing trends in fish diversity and abundance [22], and discarding commercially important fish species in the bottom trawl fishery [23; 24]. Here we apply LEK also to examine the temporal change of habitat-forming invertebrates and other important taxa. This approach can be expanded to other Mediterranean Sea regions to reconstruct the change of this heavily exploited sea.

- SCIENTIFIC AIMS

1. *Can OL and proper awareness of local sea, drive society towards a smoother acceptance of conservation measures?*
2. *Can the Heterobranchia group be an effective taxa to design CS projects and a good proxy of climate change's effect on benthic communities?*
3. *Can local historical ecology affect the design of effective conservation strategies?*

- WORKPLAN AND RESEARCH ACTIVITIES

WP 1. Objective. Define knowledge and gaps in society's awareness about the Essential Principles of Ocean Literacy in order to define tailored communication/engagement strategies.

Methods

Middle and High Schools (11-18 y.o.):

- Activities proposed: Lectures, Laboratory with macrofauna samples, Workshop on Marine Protected Areas and stakeholders' engagement, MAC-Emerso beach monitoring protocol.
- Evaluation methods: quali-quantitative questionnaires, using Google Moduli online form, addressed to school students before and after their participation in several in-and-out-door activities.
 - International Ocean Literacy Survey (IOLS) to evaluate technical knowledge about the 7 Ocean Literacy Essential Principles.
 - Engagement survey to explore the other dimensions of Ocean Literacy (Attitude, Behaviour, Activism, Communication and Emotional Connections)



First ages schools (3-10 y.o.)

- Activities proposed: in-class activities, MAC-Emerso beach monitoring protocol and beach clean-ups.
- Evaluation methods:
 - Ocean Literacy Survey for Primary Schools: quali-quantitative hand-written questionnaire addressed to school students before and after their participation in several in-and-out-door activities.
 - Drawings to survey children's perception of the local marine environment and the impact of the activities proposed. Kids (3-5 y.o.) were asked to draw the beach and the sea.



General citizens: vis-a-vis interviews addressed to local citizens of legal age, conducted randomly in different districts of Ancona Municipality. The survey is based on a quali-quantitative method (both open-ended and closed-ended questions). The interview contains 19 questions. It is divided into five sections:

- A: Subject's demographic profile
- B: Subject-Sea relationship
- C: Subject's perception of local sea state of health and biodiversity
- D: Subject's perception/knowledge about the Marine Protected Areas
- E: Subject's availability to be involved and/or committed to respecting and safeguarding the marine environment.

Each interviewee was asked to read and sign the 'consent document' regarding the purpose and conditions of the research for ethics and privacy issues before starting. All interviews were recorded using a Philips VoiceTracer DVT2810 audio recorder. The recordings are being transcribed. Subsequently, we will proceed to transfer the data into an Excel matrix which will be used to define the online questionnaire to be distributed to a greater number of people in the Municipality of Ancona.

Expected/Obtained Results.

Middle and High Schools (11-18 y.o.) and First ages schools (3-10 y.o.)

The project reached 8 schools (from nursery to high school) in 3 provinces (AN, AP, PU) of the Marche Region, with a total of 32 teachers and 503 students involved.

Questionnaires and draws are being analyzed. We expect to prove that Ocean Education in schools with in-and-outdoor activities can increase knowledge of the local marine environment and biodiversity and raise awareness about the threats affecting ecosystems.

General citizens

40 interviews were conducted, currently in the transcription phase. The response rate for this method approach is usually the highest, but it will be costly in terms of time. For this reason, the results of these first interviews will be used to create an *ad-hoc* online questionnaire to be disseminated widely and homogeneously to citizens of Ancona Municipality.

We expect to prove that citizens are not fully aware of the local marine environment and biodiversity and the threats that are affecting ecosystems. Results could help in the design of communication and engagement strategies in order to facilitate understanding of conservation measures.

WP 2. Objective. Collect data on the Heterobranchia's spatial and temporal distribution, life cycle and trophy, will help understand how they are influenced by climate change.

Methods.

Citizen Science: CS monitoring protocol focused on Heterobranchia's in the Mediterranean basin. A detailed guide presentation has been created and shared on the social media channels of Reef Check ETS (<https://www.reefcheckmed.org/italiano/reef-check-med/nudibranchi/>) and Marine Zoology Laboratory. It is used to train volunteers on how to collect the data and upload them into the iNaturalist platforms. To expand the network, it will be translated into two more languages (English and Spanish). Data are being extracted from the platform using the WEK (*Web Ecological Knowledge*) approach, which is being used also to collect data from the Facebook page "Nudibranchi del Mediterraneo" (<https://www.facebook.com/groups/184708685727400/>).

The WEK method allows researchers to acquire data on

- online source
- observation and publication dates
- user id
- site coordinates
- species
- abundance
- habitat
- primary and secondary substrates
- water temperature and depth
- oviposition and reproduction behaviors, egg mass presence,

from websites or social networks uploaded by underwater photographers who share their observations. The first post published on the Facebook pages dates back to 06/08/2023 and from that date we proceeded retrospectively to the publication date of 11/29/2022.

Visual Census: this method is helping us to focus on the Riviera del Conero area. Data collection is standardized at 60 minutes per dive and includes information on:

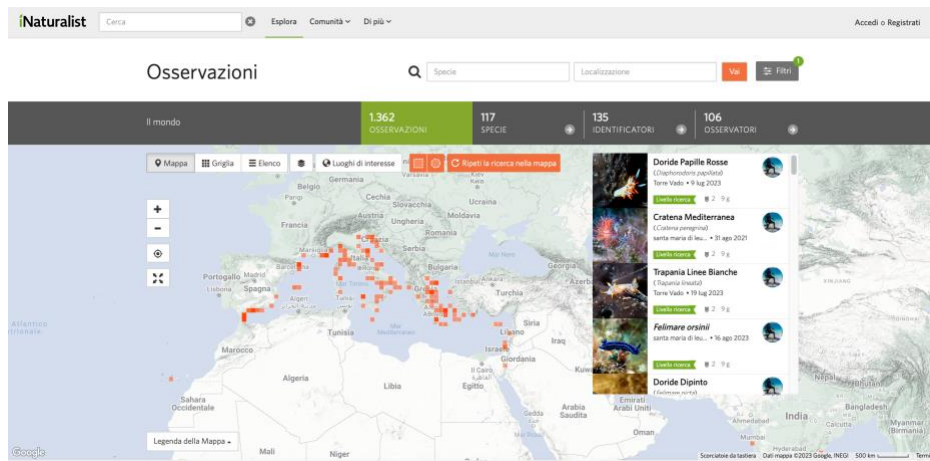
- site coordinates
- species
- abundances
- water temperature and depth
- habitat
- primary and secondary substrates
- oviposition and reproduction behaviors, egg mass presence.

Aquarium experiments: Heterobranchia's life cycle experiments are planned in collaboration with Aula del Mar of Universidad de Granada, Spain. Currently, a thesis student is there working on the predator-prey relationship, on how the presence of *Dysidea* sp sponge (prey) influences the embryonic development of the *Felimare* genus.

Expected/Obtained Results.

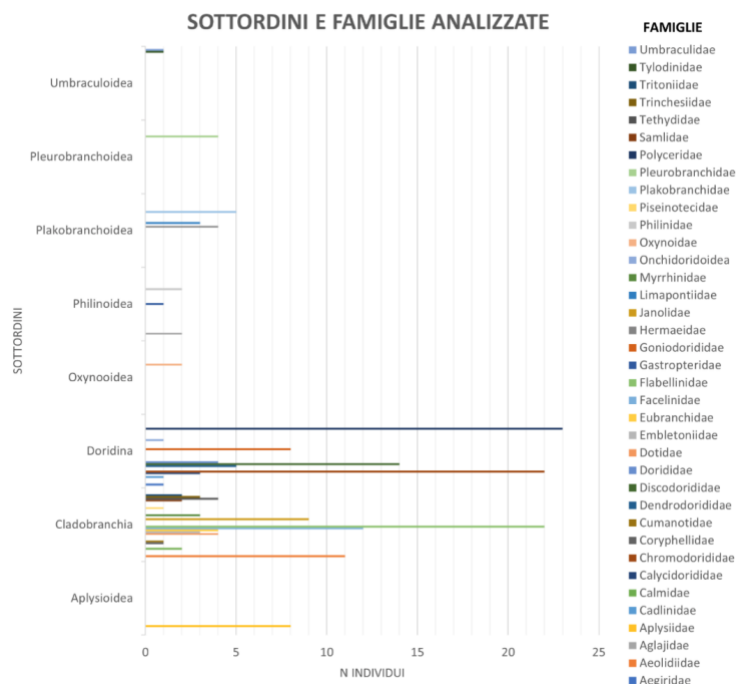
Citizen Science

From the *iNaturalist* platform we can count 1.363 observations uploaded by 106 volunteers in the Mediterranean basin. 135 identifiers checked the uploads to validate the recognition of the observed species.



Among these, 37 observations were carried out along the Conero Riviera with 21 species recorded by 4 volunteers.

Approximately 200 observations were recorded from the Facebook page “Nudibranchi del Mediterraneo”. Most of the observations occurred in Italy (95) and Spain (79), followed by Croatia (17), France (4), one observation in Slovenia, some (4) missing data (/). Of the 214 individuals identified, the taxonomic distribution was also analyzed: the most frequent suborders are those of Doridina and Cladobranchia, both belonging to the order Nudibranchia. The most represented family appears to be the Polyceridae (23 specimens), which contains genus such as Tambja, followed by the families Chromodoridae (22 specimens), with the predominant genus Felimare, and Flabellinidae (22 specimens), with Flabellina as the representative genus.



More specific analyses are still in progress. We expect that the monitoring extended over time will allow us to reconstruct a large-scale and temporal baseline of information on the Heterobranchia group (spatial and temporal distribution, life cycle, trophic). This will help us to understand if and how Heterobranchia group can be an effective taxa to design CS projects and a good proxy of climate change's effect on benthic communities.

Engaging the local community (diving centers, local and tourist divers) with Citizen Science (CS) approaches could raise awareness about climate change's effects on marine habitats and ensure that any protective measures will be understood and well accepted.

Visual Census: The monitoring took place throughout 37 scientific dives in 7 different dive sites along Monte Conero Coast (Passetto, Cala Davanzali, Relitto Nicole, Due Sorelle, Secca dell’Ospedale, Sassi Neri, Scoglio della Vela), from 4,4 to 12,4 meters depth. The dives took place from September 2021 to July 2023 and 735 Heterobranchia specimens were observed. More specific analyses are still in progress.

Aquarium experiments: The experiments are in the planning phase and the first samplings of sponges and nudibranchs of interest are taking place. We expect to demonstrate that the presence of the sponge in the tank positively affects the embryonic development of the nudibranch which would use the aquifer system of the sponges. This would demonstrate a great negative influence of climate change on nudibranchs as the sponge on which it feeds is very sensitive to the heating of the water.

WP 3. Objective. Reconstruct historical changes in local marine habitat and biodiversity.

Methods.

Local Ecological Knowledge (LEK): The interviews were based on a standardized protocol procedure (LEK-1: exploring Local Ecological Knowledge to reconstruct historical changes) officially adopted as part of the MPA-Engage Interreg Project protocols. The investigation’s goal is to track historical trends of species that changed the most in their abundances or remained stable over time. Each interviewee was asked the following question: “Do you know any species which increased or appeared in your fishing area? “. It is noticeable how all respondents started by answering that "Everything decreased..." and then described the situation in more detail. Respondents were asked to provide a qualitative ranking of the abundance of these taxa through time, on an annual basis, according to 6 different grades: 0 = ABSENT; 1 = RARE (once in a year); 2 = OCCASIONAL (sometimes in a year); 3 = COMMON (regularly in a year); 4 = ABUNDANT (regular in captures and abundant); 5 = DOMINANT (always in captures and with great abundance). At the end of the interview, each recorded taxa was assigned to one of these trend factors: DECREASING (D); FLUCTUANT (F); STABLE (S); INCREASING (I).

The species named by the fishermen were proven with the help of Egidio Trainito's Atlas of Mediterranean Flora & Fauna. Only after listening to the interviewee's descriptions, the same tool was provided for any other species recognition.

Expected/Obtained Results.

Local Ecological Knowledge (LEK) investigations were conducted to reconstruct biodiversity’s historical changes. Study cases in Italy:

1. Pantelleria Island (Sicilia-SIC/TUN section);
2. Alassio-Imperia (Liguria-TYR section);

3. Ancona (Marche-ADR section).

A total of 48 interviews were carried out between May 2022 and February 2023. The study was addressed to local recreational and professional fishermen and divers, all between 30 and 80 years old.

Study case 1 SIC/TUN

A total of 12 interviews were carried out. The study was addressed to local recreational and professional fishermen and divers, all between 40 and 80 years old.

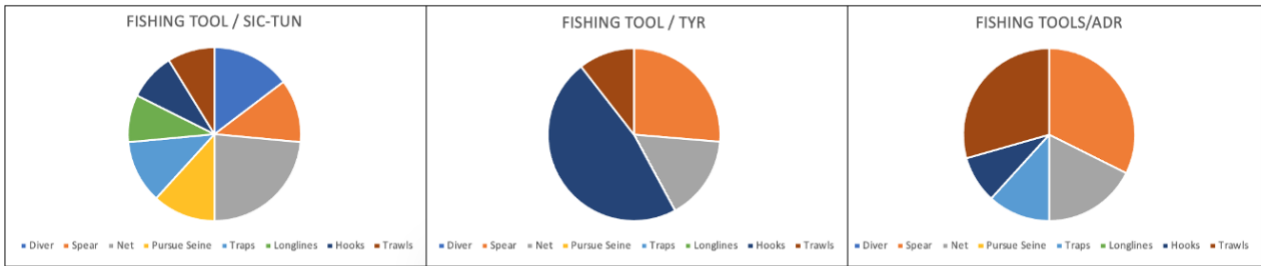
Species abundance information about 47 species belonging to 5 different phyla has been collected: Mollusca (3), Echinodermata (1), Arthropoda (4), Annelida (1) and Chordata (38). Regarding the Osteichthyes, the data collected considering the species abundance perceived by each respondent shows a general decrease (40%), 34% of species show fluctuating trends and 21% increasing trends over time. For each species, we averaged the abundances perceived by the respondents and then constructed historical trends, dividing them into the trend factors (D, F, S, I) and calculating their percentages. 20 species show decreasing trend over time starting from 1970 to today. A strong decline in the general abundance seems to have occurred in the early 2000s. The fluctuant species within the Osteichthyes taxon are 5 in total. *Anguilla anguilla* has been sighted only in Cala Gadir over time. 5 species appear to have remained stable over time. Among them, there is *Scorpaena scrofa* which seems not to be decreased unlike *Scorpaena porcus* which has shown a steep decline over the years. All the remaining phyla (Mollusca, Echinodermata, Arthropoda, Annelida) were considered together and show circa the same trends as Osteichthyes with a high percentage of decreased taxa (45%), a 33% of increased one and fluctuant remain percentage of 22%. No stable taxa were perceived by respondents over time. By averaging the abundance of each species, no stable or fluctuant species appear, instead 67% of them are decreasing and the remainder (33%) are increasing. *Paracentrotus lividus* and *Palinurus elephas* show the widest shift in abundance (from factor 5 to factor 1) over the years, although gradual, compared to *Homarus gammarus* which lost more than 2 factors of abundance in a very few years (1993-1995). There was also confirmed the presence of 12 species belonging to both Cnidaria and Porifera phyla, which show a general decreasing trend (considering fishermen's perception of what they found in the nets over the years). *Pinna nobilis*, *Monachus monachus*, *Posidonia oceanica* meadows and macroalgae forests belonging to the Sargassaceae family are perceived to be present (it's possible that the *Pinna nobilis* is confused with the *P. rudis*; more details are required) but heavily affected by the years likely by trawling and anchoring but also climate change should be considered as an option. The alien algae *Caulerpa cylindracea* is also present from the first meter's depth.

Study case 2 ADR

A total of 24 interviews were carried out. The study was addressed to local recreational and professional fishermen and divers, all between 36 and 77 years old. A total of 47 species belonging to 6 phyla (Arthropoda, Chordata, Cnidaria, Echinodermata, Mollusca and Anellida) were mentioned. Statistical analyses are in progress.

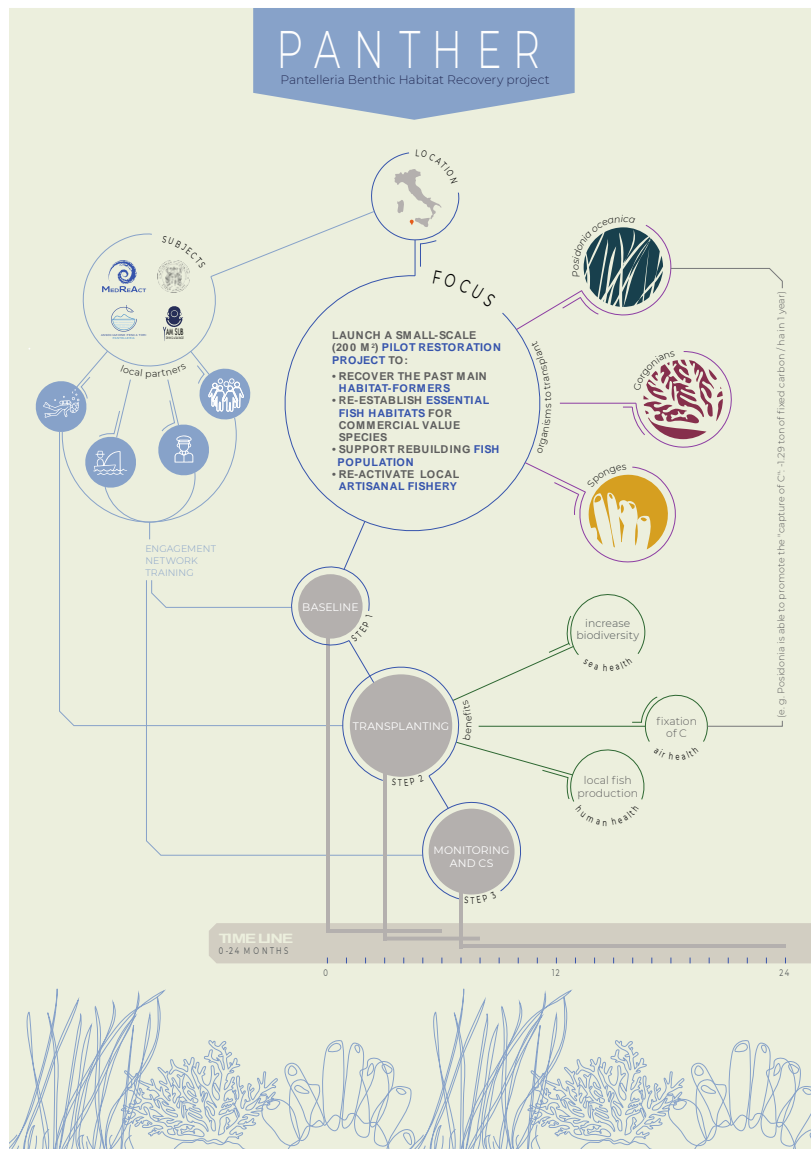
Study case 3 TYR

A total of 11 interviews were carried out. The study was addressed to local recreational and professional fishermen and divers, all between 30 and 65 years old. A total of 28 species belonging to 3 phyla (Chordata, Echinodermata and Mollusca) were mentioned. Statistical analyses are in progress.



Having a framework as clear as possible about local ecosystems could allow the implementation of tailored conservation and restoration actions in the marine environment, in order to recover the healthy state and avoid the loss of small-scale fisheries, allowing the development of sustainable and healthy practices.

The Pantelleria's Island case represents our pilot study since the information collected and the network created with local fishermen and divers allowed us to create a conservation project and apply for funding. The recently started project is named PANTHER (Pantelleria Benthic Habitat Recovery), financed by Pure Ocean Fund and coordinated by me with the support of Prof. Carlo Cerrano and three partners: MedReAct Foundation, Yam Sub srls and Associazione Pescatori di Pantelleria. Here is the graphical abstract of the project:



PANTHER perfectly fits with the strategies for achieving objective 14 of the UN 2030 Agenda for Sustainable Development and the PNRR lines, in particular Investment 3.5 of Measure 3 of the M2C4: "Restoration and protection of the seabed and marine habitats". The project involves scientific underwater dives to survey benthic communities and restore *Posidonia oceanica* meadow, place gorgonians and sponges' colonies which we know have been part of that ecosystem in the past.

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Part 2. PhD student information on the overall year activity (courses/seminars/schools, mobility periods, participation to conferences)

List of attended courses/seminars/schools

1. 7 June 2023 Online - English **Masterclass on Ocean Education** by IOC-UNESCO
2. 8/12 May 2023 in Naples, Italy – **Course PRIMER Version 7 with PERMANOVA+** by Primer-e
3. 12/14 December 2022 in Venice, Italy – **IOC-UNESCO Winter School “Ocean Literacy & Collaboration”**, in the framework of the EU4Ocean Coalition and the UN Decade of Ocean Science for Sustainable Development (2021-2030)
4. 26 June/3 July 2022 in Siena, Italy – **Cortona Week School**
5. October 2021 - **Course “Digital communication and storytelling”** with Alessandro Baricco at FMTS Group

List of periods spent abroad

1. 18/25 June 2023 – Universidad de Granada

List of conferences/workshops attended and of contributions eventually presented

Scheduled participation with a presentation at the **Ocean Decade Conference 2024** in Barcelona (10/12 April)

1. 19/22 September 2023 in Palermo, Italy- Poster at **UZI Congress of the Italian Zoological Union** - 'Unravelling the sea slugs fauna from an extremely variable environment, the 'Passetto' rocky tide pools (North Adriatic Sea)'
2. 20 June 2023 in Motril, España - Presentation at the **Estrategia Andaluza de Economía Azul Sostenible Panel** - 'Marine and coastal biodiversity, natural wealth of the seabed and blue biotechnology'
3. 9/11 January 2023 in Ghent, Belgium - Short presentation at the **International Conference on Ocean Education and Training – Ocean Literacy in a Changing Blue Planet** - 'Sandy beaches and rocky pools: linkage lands to the sea in coastal cities'
4. 18 November 2022 in Ferrara, Italy - Attendee at the **Co-planning Workshop with the Blue Economy actors of the Adriatic Sea - Fisheries management and governance Panel**
5. 28 October 2022 in Latina, Italy - Speaker at **PescaInForma project's frame (MIPAAF and Confsal Pesca)** - *Sea Sentinels: fostering dialogue between fishers and researchers*
6. 8 November 2021 in Ferrara, Italy – Attendee at Sealogy (The Blue Economy European Exhibition) **All Sessions: a new approach for a sustainable blue economy.**
7. 20 November 2021 in Ferrara, Italy - Attendee at Sealogy (The Blue Economy European Exhibition) **Adriareef: sfruttamento innovativo delle scogliere adriatiche per rafforzare la blue economy.**
8. 19 November 2021 in Ferrara, Italy- Attendee at Sealogy (The Blue Economy European Exhibition) **PNRR: Ripristino E Tutela Dei Fondali E Degli Habitat Marini Per Un'economia Blu Sostenibile.**
9. 19 November 2021 in Ferrara, Italy - Attendee at Sealogy (The Blue Economy European Exhibition) **II Mare Del Futuro: Ricerca, Innovazione E Sostenibilità.**

Part 3. PhD student information on publications

If not yet published, please indicate the publication status (submitted, accepted, in preparation...)

List of publications on international journals

- J1. A. Riccardi, A. Colletti, R. Virgili & C. Cerrano (2022) Diversity and behavior of sea slugs (Heterobranchia) in the rocky tide pools of Conero Riviera (western Adriatic Sea), *The European Zoological Journal*, 89:1, 856-869, [DOI: 10.1080/24750263.2022.2095047](https://doi.org/10.1080/24750263.2022.2095047)
- J2. Di Camillo, CG., Roveta, C., Pulido Mantas, T., Gravili, C., Cerrano, C., Calcinai B, Coppari, M., Gregorin, C., Marrocco, T., Riccardi, A., Puce, S. (2023). Guests or pests? Eirenid hydroids living on the soft tissue of bivalves. *Rev Aquac.* 2023; 1-15. [DOI:10.1111/raq.12823](https://doi.org/10.1111/raq.12823)
- J3. Pulido Mantas, T.; Roveta, C.; Calcinai, B.; di Camillo, C.G.; Gambardella, C.; Gregorin, C.; Coppari, M.; Marrocco, T.; Puce, S.; Riccardi, A.; Cerrano, C. (2023) Photogrammetry, from the Land to the Sea and Beyond: A Unifying Approach to Study Terrestrial and Marine Environments. *J. Mar. Sci. Eng.* , 11, 759. [DOI: 10.3390/jmse11040759](https://doi.org/10.3390/jmse11040759)

[Date]

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