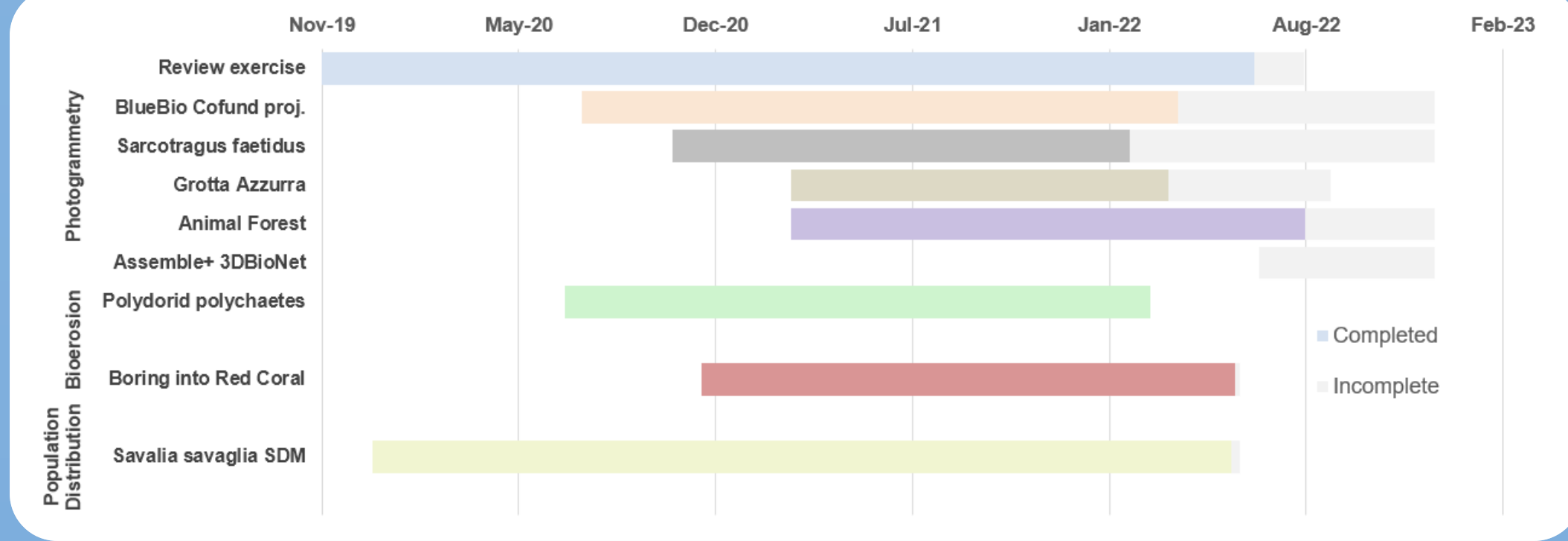


## INNOVATIVE METHODOLOGICAL APPROACHES FOR BENTHIC COMMUNITIES ASSESSMENT

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Over the past decades, thanks to the development of technology and computing power, new techniques raised allowing the scientific community to capture in a more complete and realistic way biological processes at a wide range of scales. Within the framework of this PhD research, different ecological scales will be approached by a three-dimensional perspective through the coupling of innovative and traditional methodologies. The link among all these different working packages? The application of methods that allow to capture the structural complexity present from a 3D point of view, one of the main factors driving biotic interactions, and influencing on the functioning and resilience of whole ecosystems.

Project Timeline



### Bioerosive assessments

Hydrobiologia  
https://doi.org/10.1007/s10750-022-04839-3

PRIMARY RESEARCH PAPER

#### Bioerosion features of boring polydorida polychaetes in the North Adriatic Sea

Considering the role that bioerosion plays in the marine habitat and the scanty knowledge of this phenomenon in the Mediterranean Sea. The aim of the study is to describe and quantify the bioerosive activity performed by pioneer organisms during the first stages of bioerosion in carbonatic substrate from the North Adriatic Sea.

Method

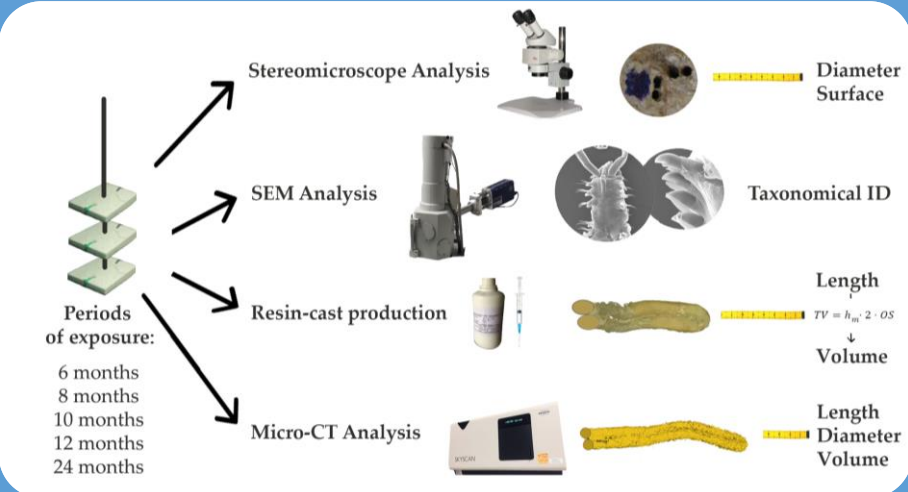


Fig.1 Flow diagram of the study case.

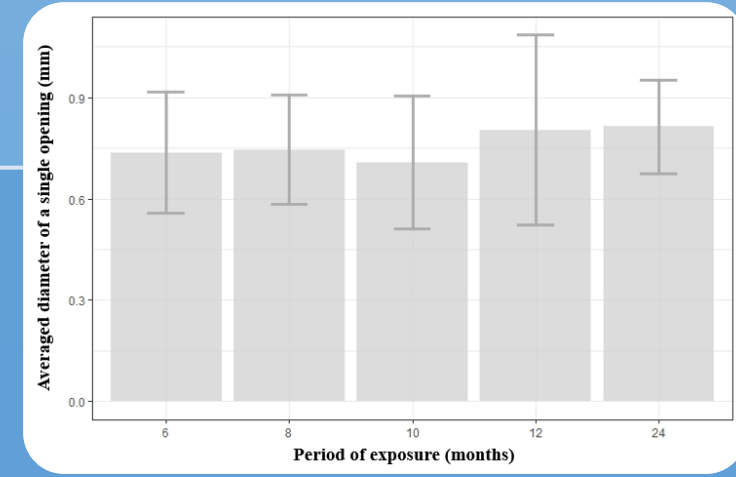


Fig.2 Ø Excavation patterns along the period of exposure

- No differences among length or Ø of traces through time
- Differences among densities
- Estimated erosion rates:  $0.053 \text{ g cm}^{-2} \text{ year}^{-1}$

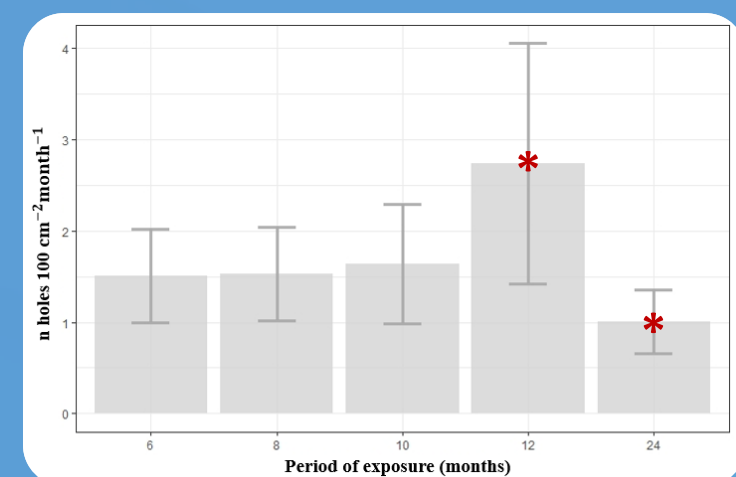


Fig.3 Perforation density per period of exposure

Journal of Marine Science and Engineering

Article Under Review

#### A 3D innovative approach supporting the description of boring sponges of the precious red coral *Corallium rubrum*.

To identify and describe the erosive patterns of the boring community present into the red coral scleraxis, SEM analysis and micro-CT were coupled to do so. The spicule component and the erosion patterns of each sponge species were described, estimating the eroded volumes and obtaining in the process three-dimensional digital casts.

#### Remarks

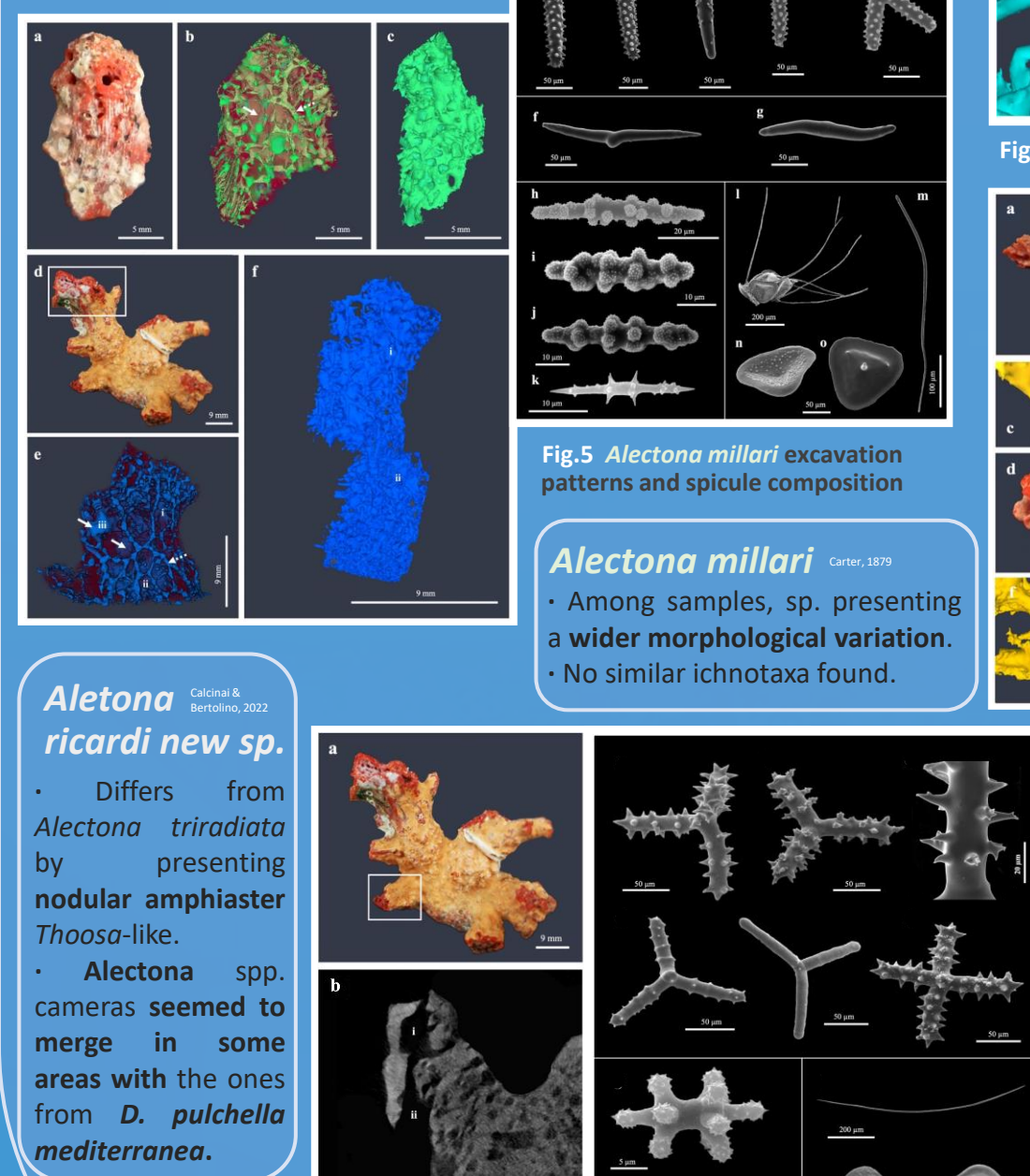


Fig.4 *Dotona pulchella mediterranea* excavation patterns and spicule composition

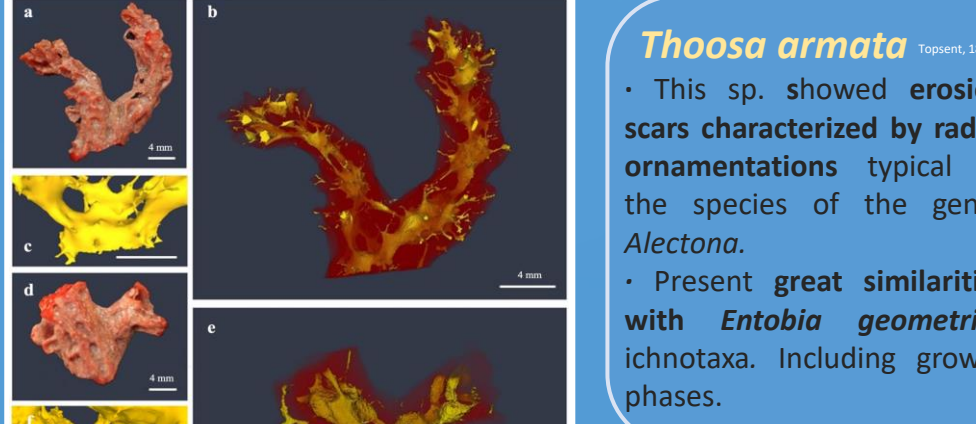


Fig.5 *Alectona millari* excavation patterns and spicule composition

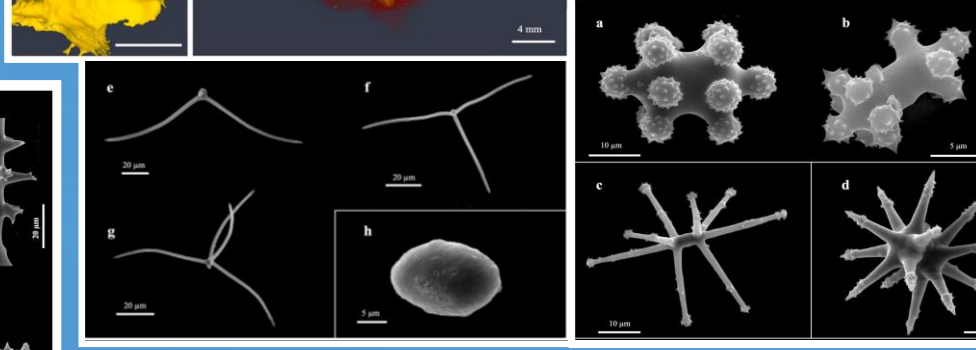


Fig.6 *Alectona ricardi* excavation patterns and spicule composition

Table S1. Summary of metrics extracted by micro-CT analysis from the eroded traces of each of the boring sponges found excavating the red coral samples.

Species	Sample	Length (mm)	Length pap. (mm)	Ø Channels (mm)	Length Interm. (mm)	Caal (mm)
<i>Alectona ricardi</i>	CT1	0.13	0.13	0.13	0.13	0.13
	CT2	0.13	0.13	0.13	0.13	0.13
<i>Thoaosa armata</i>	CT3	0.13	0.13	0.13	0.13	0.13
	CT4	0.13	0.13	0.13	0.13	0.13
<i>Dotona pulchella mediterranea</i>	CT5	0.13	0.13	0.13	0.13	0.13
	CT6	0.13	0.13	0.13	0.13	0.13

Fig.7 *Thoaosa armata* excavation patterns and spicule composition

#### PhD Curricular publications

- Pulido Mantas, T., Pola, L., Cerrano, C., Gambi, M. C., & Calcina, B. (2022). Bioerosion features of boring polydorida polychaetes in the North Adriatic Sea. *Hydrobiologia*, 849(8), 1969-1980.
- Rossi, P., Ponti, M., Righi, S., Castagnetti, C., Simolini, R., Mancini, F., Agrafiotis, Panagiotis, Bassani, L., Bruno, F., Cerrano, C., Cignoni, P., Corsini, M., Drap, P., Dubbini, M., Garrabou, J., Gori, A., Gracias, N., Ledoux, J.-B., Linares, C., Pulido Mantas, T., Menna, F., Nocerino, E., Palma, M., Pavoni, G., Ridolfi, A., Rossi, S., Skarlatos, D., Treibitz, T., Turicchia, E., Yuval, M. & Capra, A. (2021) Needs and gaps in optical underwater technologies and methods for the investigation of marine animal forest 3D-structural complexity. *Frontiers in Marine Science*, 8, 171.
- Minor revisions: Pulido Mantas, T., Varotti, C., Roveta, C., Palma, M., Innocenti, Giusti, M., Benabdi, M., Trainito, E., Macic, V., Gambi, M. C., Cerrano, C. (2022). Mediterranean shelters for the Gold Coral: an assessment of potential Mediterranean distribution of *Savalia savaglia*, a rare parasitic species. *Marine Environmental Research*.
- Under review: Pulido Mantas, T., Bavestrello, G., Bertolino, M., Cerrano, C., Pica, D., Roveta, C., Calcina, B. A 3D innovative approach supporting the description of boring sponges of the precious red coral *Corallium rubrum*. *Marine Sciences and Engineering*.
- Extra-PhD Curricular publications
- Bienwirth, J., Pulido Mantas, T., Villechanoux, J., & Cerrano, C. (2022). Restoration of Marine Sponges—What Can We Learn from over a Century of Experimental Cultivation?. *Water*, 14(7), 1055.
- Villechanoux, J., Bienwirth, J., Pulido Mantas, T., & Cerrano, C. (2022). Testing Transplantation Techniques for the Red Coral *Corallium rubrum*. *Water*, 14(7), 1071.
- Alghan, A., Cerrano, C., Luzzi, G., Calcina, B., Puce, S., Pulido Mantas, T., Roveta, C., Di Camillo, C.G. (2020) Main Anthropogenic Impacts on Benthic Macrofauna of Sandy Beaches: A Review. *Journal of Marine Science and Engineering*, 8, 405.
- Roveta, C., Annibaldi, A., Afghan, A., Calcina, B., Di Camillo, C.G., Gregorin, C., Illuminati, S., Pulido Mantas, T., Truzzi, C., Puce, S. (2021) Biomonitoring of toxic elements: the unexplored role of marine sessile taxa. *Applied Sciences*, 11, 508.
- Roveta, C., Annibaldi, A., Calcina, B., Girolametti, F., Illuminati, S., Pulido Mantas, T., Truzzi, C., Puce, S. (2022). Distribution of mercury inside the Mediterranean sponge *Chondrosia reniformis*: A study case from the Tuscan Archipelago National Park (Tyrrhenian Sea). *Journal of Sea Research*, 102, 206.
- Roveta, C., Annibaldi, A., Vagnoni, F., Pulido Mantas, T., Domenichelli, F., Gridelli, S., Puce, S. (2020). Short-term effects of environmental factors on the asexual reproduction of *Aurelia* sp. *polyps*. *Chemistry and Ecology*, 36(5), 486-492.
- Roveta, C., Marrocco, T., Calcina, B., Pulido Mantas, T., Pica, D., Valisano, L., Puce, S. (2022). Unravelling the sponge diversity of the Tuscan Archipelago National Park (Tyrrhenian Sea, Italy). *The European Zoological Journal*, 89(1), 317-330.
- Roveta, C., Pica, D., Calcina, B., Girolametti, F., Truzzi, C., Illuminati, S., Pulido Mantas, T., Truzzi, C., Puce, S. (2020). Hg Levels in Marine Porifera of Montecristo and Giglio Islands (Tuscan Archipelago, Italy). *Applied Sciences*, 10(12), 4342.
- Roveta, C., Marrocco, T., Pica, D., Pulido Mantas, T., Rindi, F., Musco, L., Puce, S. (2022). The effect of substrate and depth on hydroid assemblages: a comparison between two islands of the Tuscan Archipelago (Tyrrhenian Sea). *Marine Biodiversity*, 52(1), 1-20.

### Photogrammetric approaches

To fully understand the processes occurring in a three-dimensional world, it is necessary to analyse it from a three-dimensional perspective.

#### Review: Photogrammetry, from the land to the sea beyond.

- Identify the application of photogrammetric approaches with survey purposes through history.
- Paying special attention to the environment surveyed, the aim of the study, scientific discipline and the coupling of other methods.

Criteria

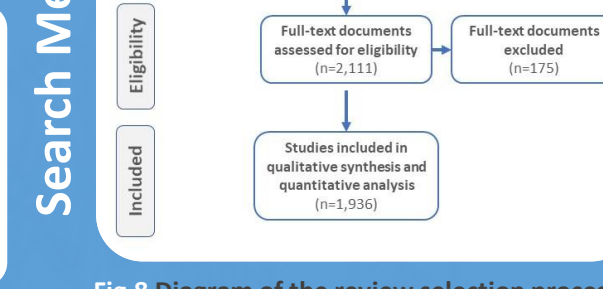


Fig.8 Diagram of the review selection process

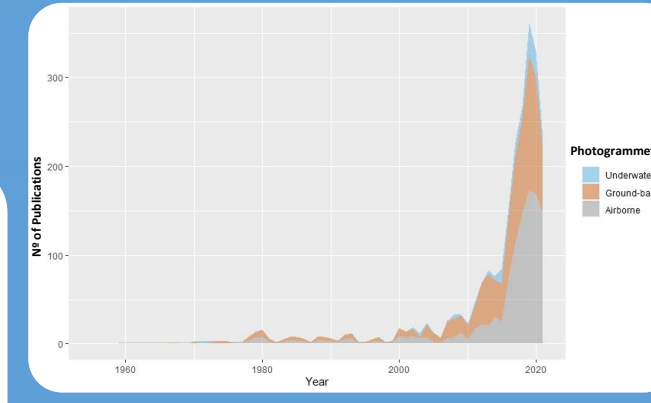


Fig.9 Photogrammetry-type trends through history

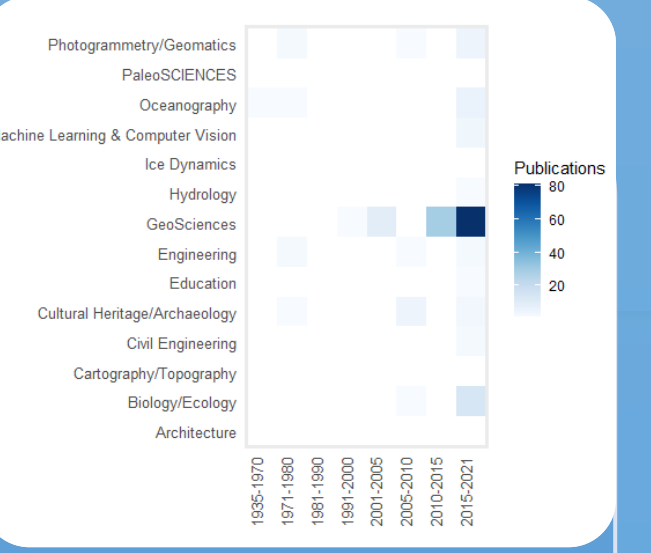


Fig.11 Photogrammetry survey applications per Scientific Discipline.

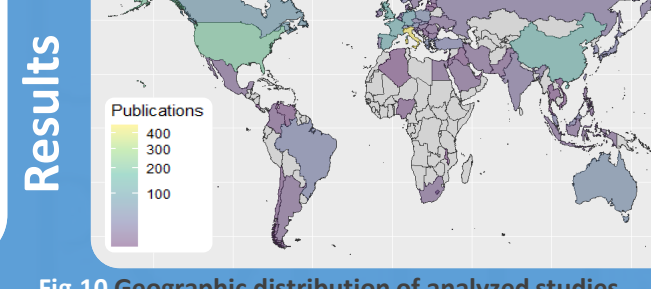


Fig.10 Geographic distribution of analyzed studies

Further developments of the technique are expected along the next decades. Specially by its coupling of with emergent approaches as Machine Learning and Multispectral Imagery.

### Single organism level

#### Assessing growth and biomass

Assess the average growth rates of a population (n=20) of *S. foetidus* present in Portofino MPA and estimate biomass production through the development of an index.

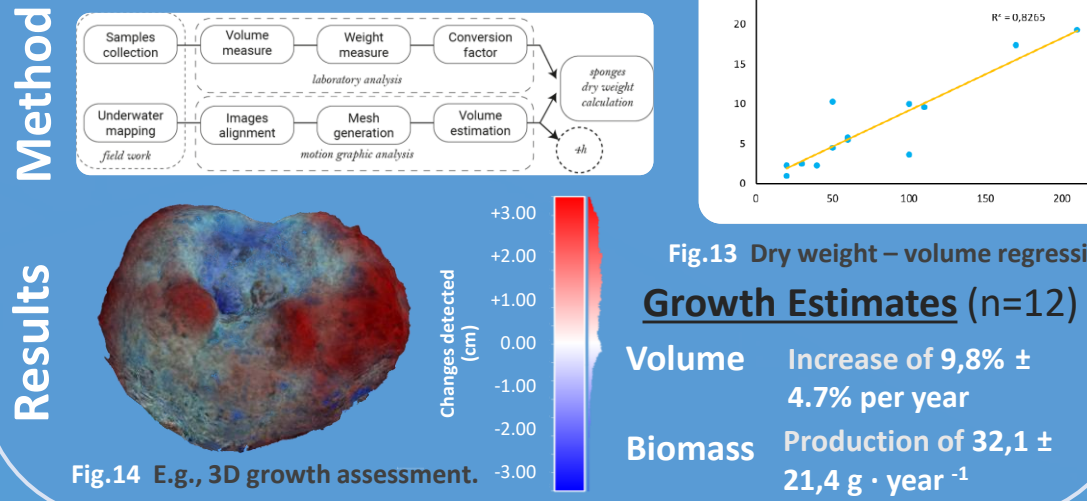


Fig.13 Dry weight - volume regression.

Growth Estimates (n=12)

Volume Increase of  $9.8\% \pm 4.7\%$  per year

Biomass Production of  $32.1 \pm 21.4 \text{ g} \cdot \text{year}^{-1}$

Fig.14 E.g., 3D growth assessment.

### Developing and Monitoring sustainable mariculture techniques for Marine Sponges

Identify sustainable approaches to cultivate two sponge species of biotechnological interest. To do so, growth of sponge explants together with regeneration of the donor is being monitored by SfM-Photogrammetry.

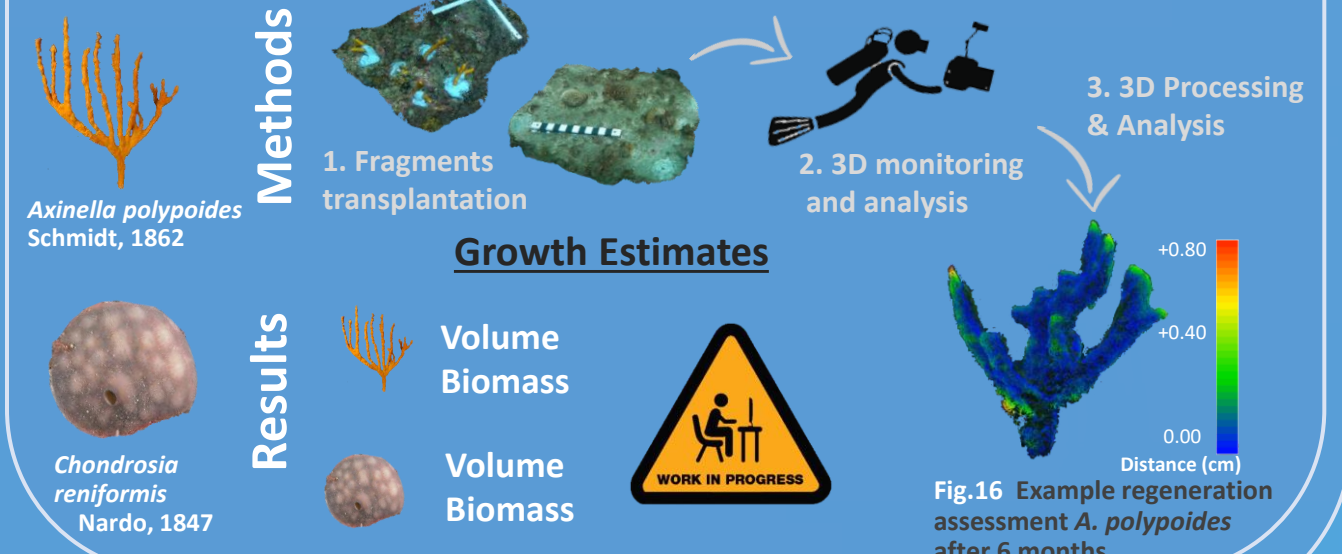


Fig.15 Example regeneration assessment *A. polyoides* after 6 months.

### Population level

#### Assessing the animal forests' health by 3D photogrammetry

Provide a new perspective to assess animal forest effect by means of underwater optical survey. Investigating structural complexity at different spatial scales

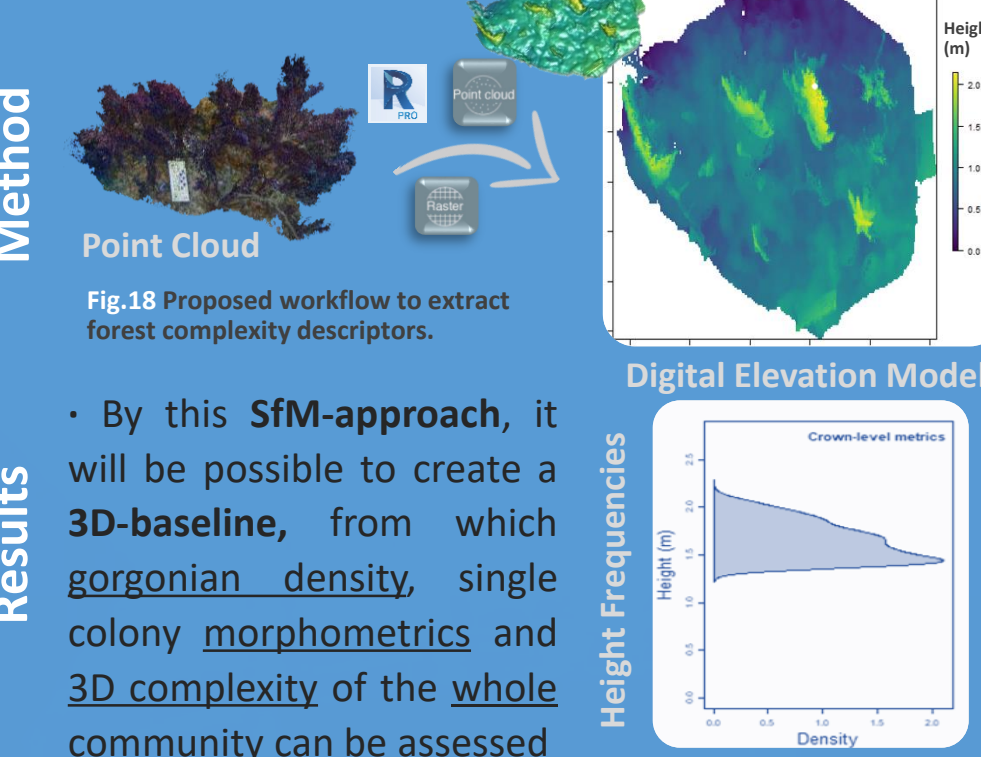


Fig.17 Gorgonian forest height frequency

### Ecosystem level

#### 3D mapping of Grotta Azzurra marine cave, the importance of establishing a baseline.

Produce a complete 3D reconstruction of the Grotta Azzurra (Ancona) as a baseline to identify future climate and human-induced changes on the composition of the cave's sessile community. Identify spatial gradients on the benthic community, paying special attention to sponges, tunicates, and their gradients towards the inner part of the cave.

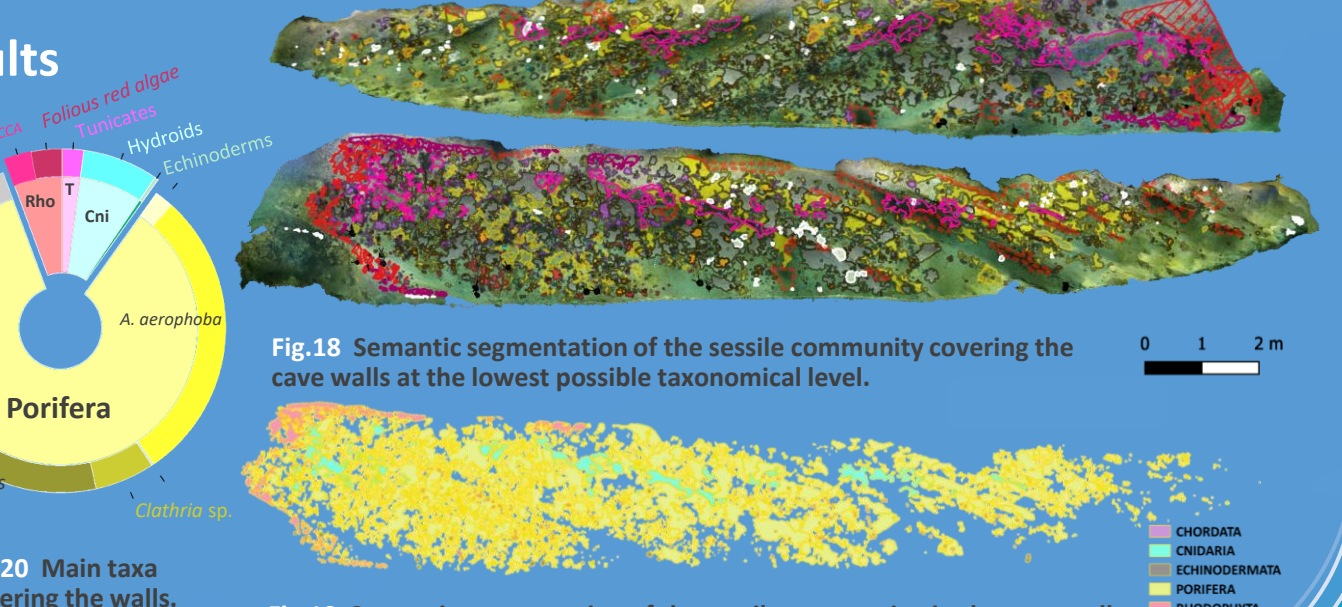


Fig.18 Semantic segmentation of the sessile community covering the cave walls at the lowest possible taxonomical level.

Fig.19 Semantic segmentation of the sessile community in the cave walls at Phylum level.

#### Scientific Outreach

- Collaboration in the development of Photogrammetry protocol included in the Monitoring Climate-related responses in Mediterranean Marine Protected Areas and beyond (MPA Engage, Interreg Project)
- Development of the Conservation Diver Course (ReefAlert Network).
- Progetto di valorizzazione del patrimonio naturale sommerso di Punta Manara (ReefAlert Network).

