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A monitoring framework for Marine Protected Areas based on deep-learning images processing

Sergio Sierra, Elena Prado, Alberto Abad-Uribarren, Augusto Rodríguez-Basalo, Pilar Ríos, Javier Cristobo, Rubén Ramo, Cristina Rodríguez-Cabello, Larissa Modica, Francisco Sánchez and Adolfo Cobo

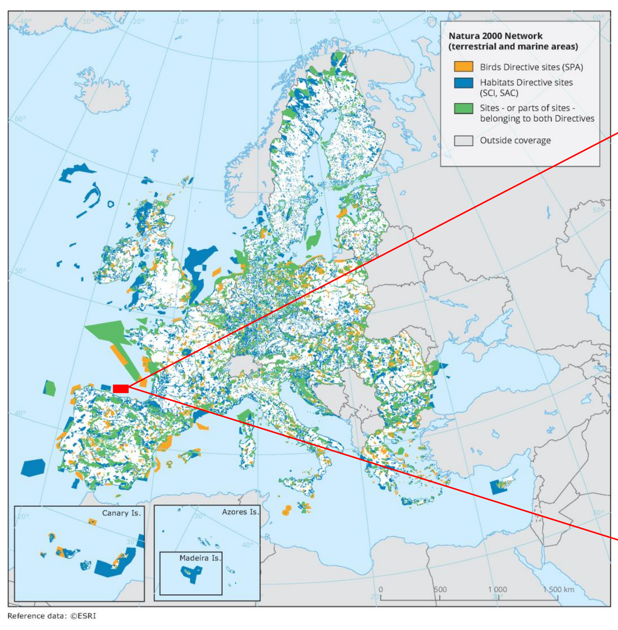
COMPLUTIG · Universidad de Alcalá · CSIC · UC Universidad de Cantabria

elena.prado@ieo.csic.es

Intro & objective

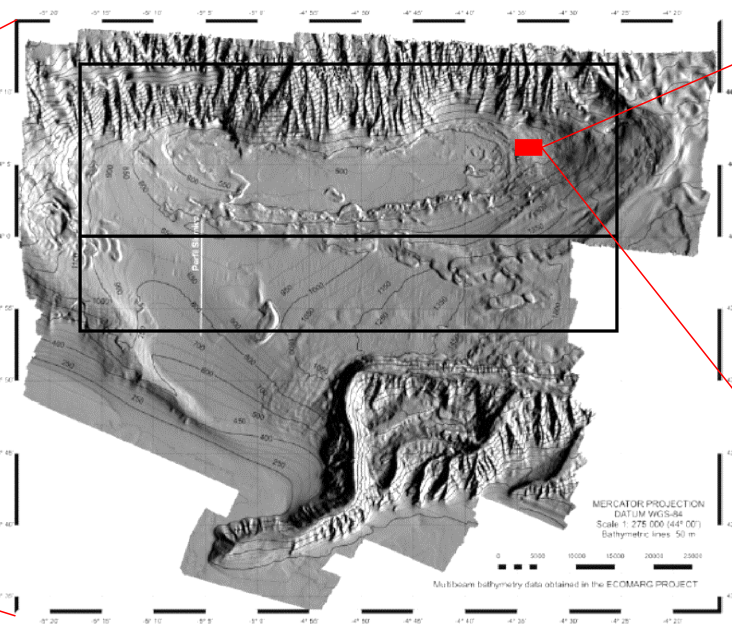
Natura 2000 Network

Exponential increase in marine protected areas over recent years. It is necessary to develop efficient and quantitative environmental assessment methodologies that support management decision-making.



El Cachucho Marine Protected Area

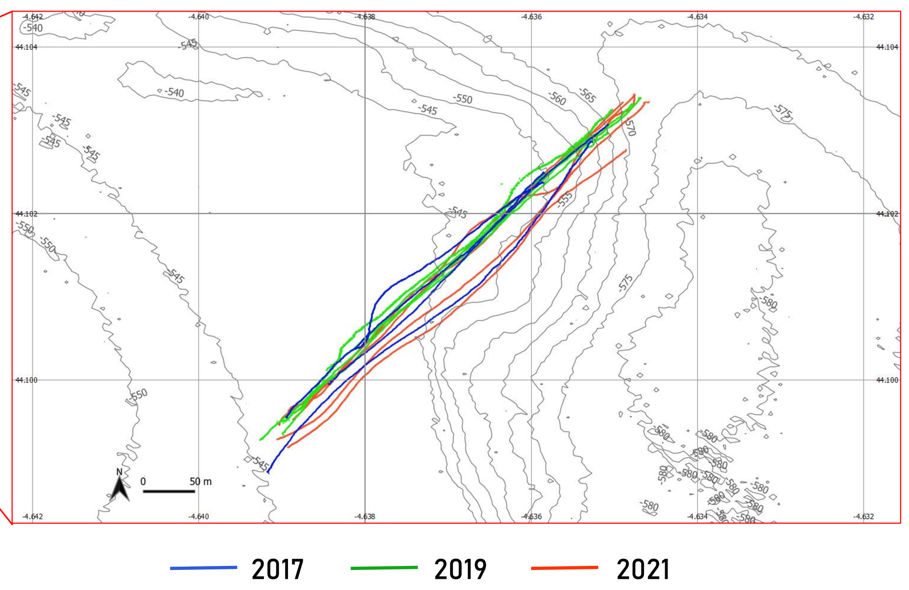
First deep-sea MPA in Spain. It has a management plan with the obligation to monitor the state of conservation of the Natura 2000 Network habitats (EU Habitat Directive).



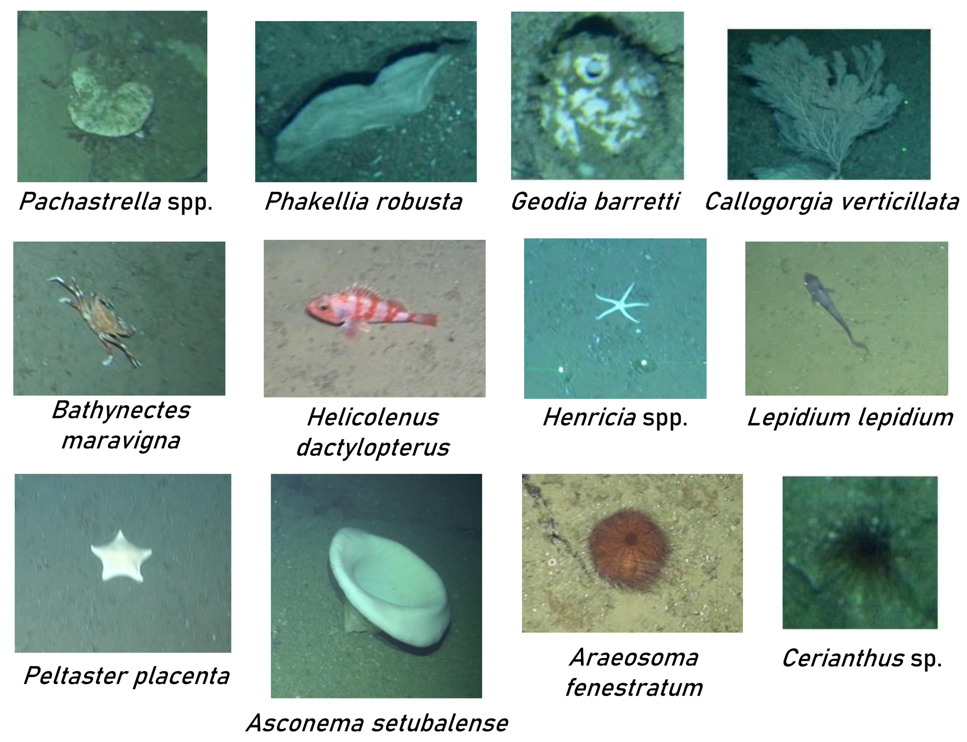
Objetive

Assess habitat 1170 Reefs using multi-temporal ROTV image data and species density

Video transect in a fix location survey station in the years 2017, 2019 and 2021. Site with a presence of representative 1170 reefs habitat.



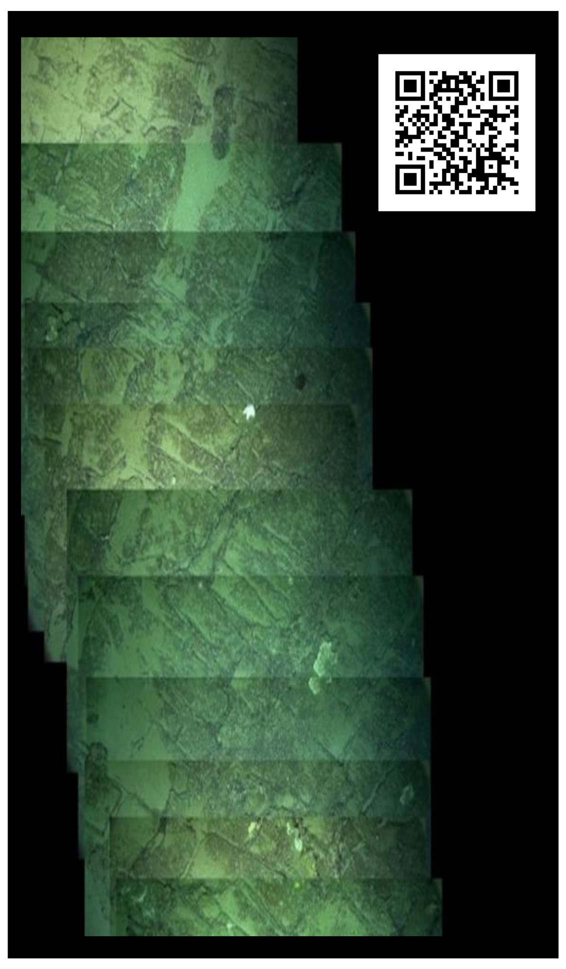
Species selected as indicators of 1170 Reef habitat evolution in the site.



How?

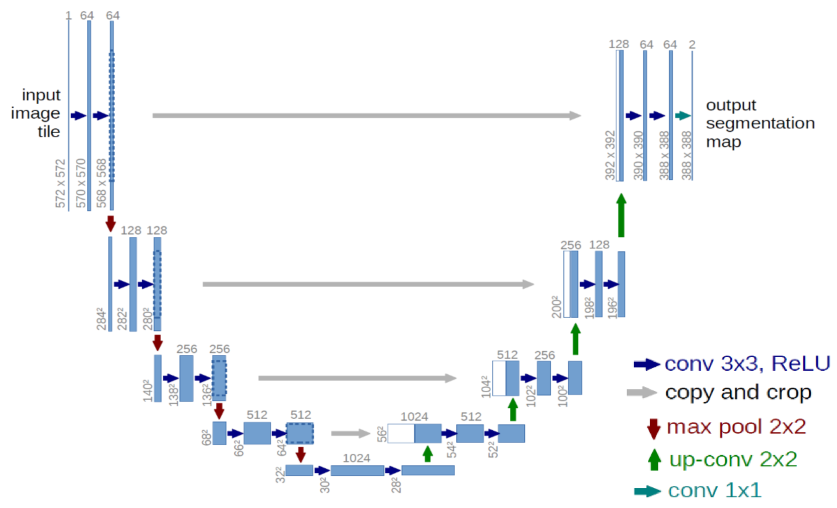
SIFT: Video Mosaic generation

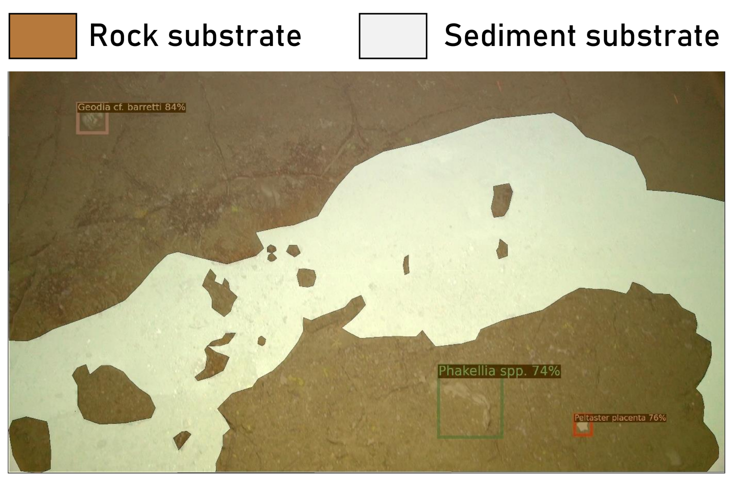
Scale-Invariant Feature Transform (SIFT) algorithm is based on the identification and matching of invariant key points.



Semantic Segmentation: Seafloor type

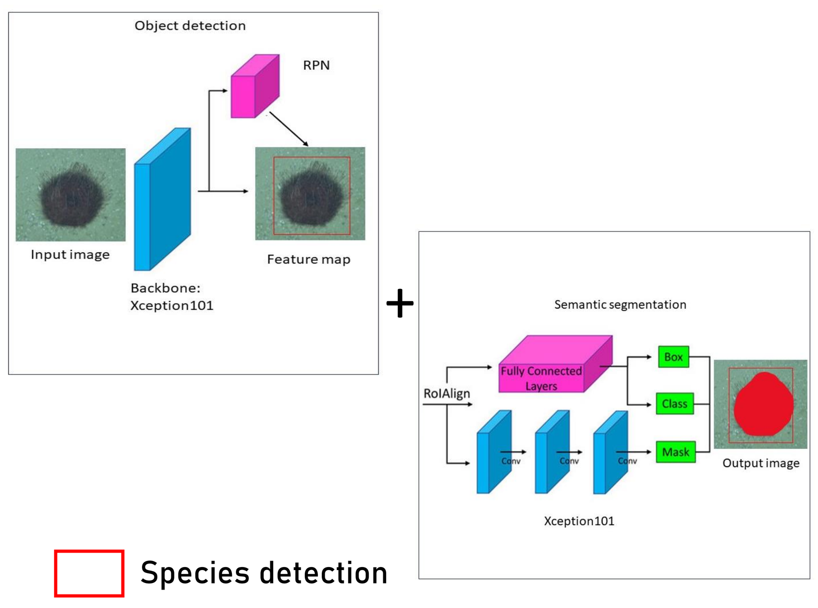
Based on Unet convolutional neural network architecture to evaluate rock/sediment substrate of the study area.

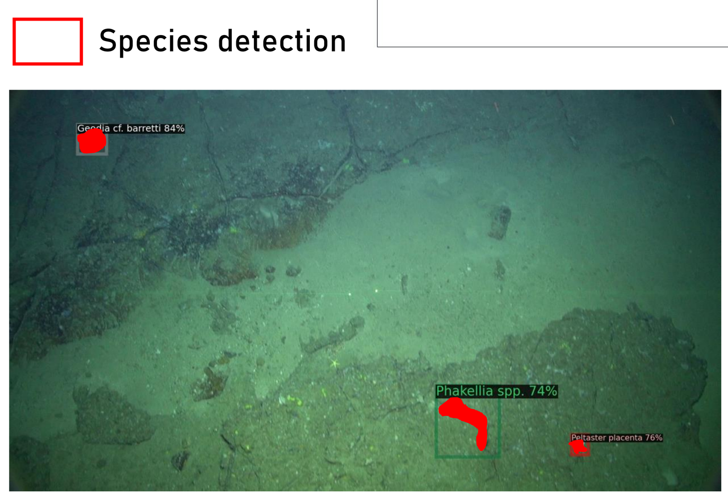




Instance segmentation: Species

Object detection (image annotation) is based on Detectron2: Mask RCNN + Xception101.





Metrics

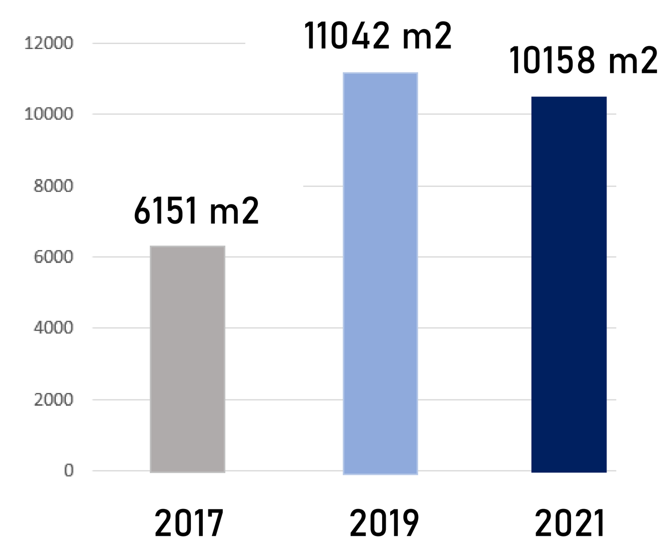
Precision, Recall and F1 Score show adequate values to detect species.

	Precision	Recall	F1Score
Araeosoma fenestratum	0.71	0.86	0.77
Bathynectes maravigna	0.85	0.93	0.89
Phakellia spp.	0.69	0.58	0.63
Lepidium lepidium	0.79	0.7	0.74
Asconema setubalense	0.81	0.88	0.84
Callogorgia verticillata	0.82	0.82	0.82
Pachastrella spp.	0.62	0.73	0.67
Geodia barretti	1.0	0.72	0.84
Peltaster placenta	0.73	0.91	0.81
Ceriathus spp.	0.58	0.68	0.63
Henricia spp.	0.93	1.0	0.96
Helicolenus dactylopterus	1.0	1.0	1.0
Mean	0.79	0.82	0.8

Results

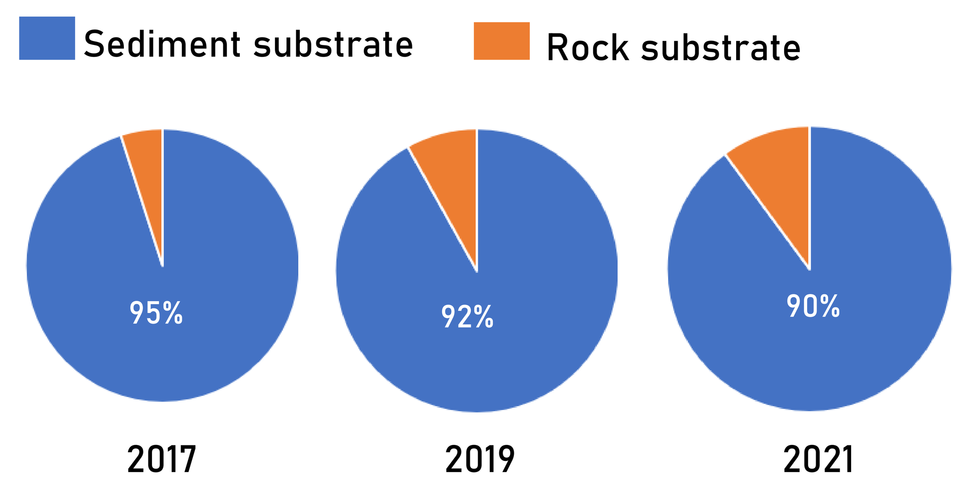
Image Surface Area (m2)

The surface area covered by the images is approximately similar in all years.

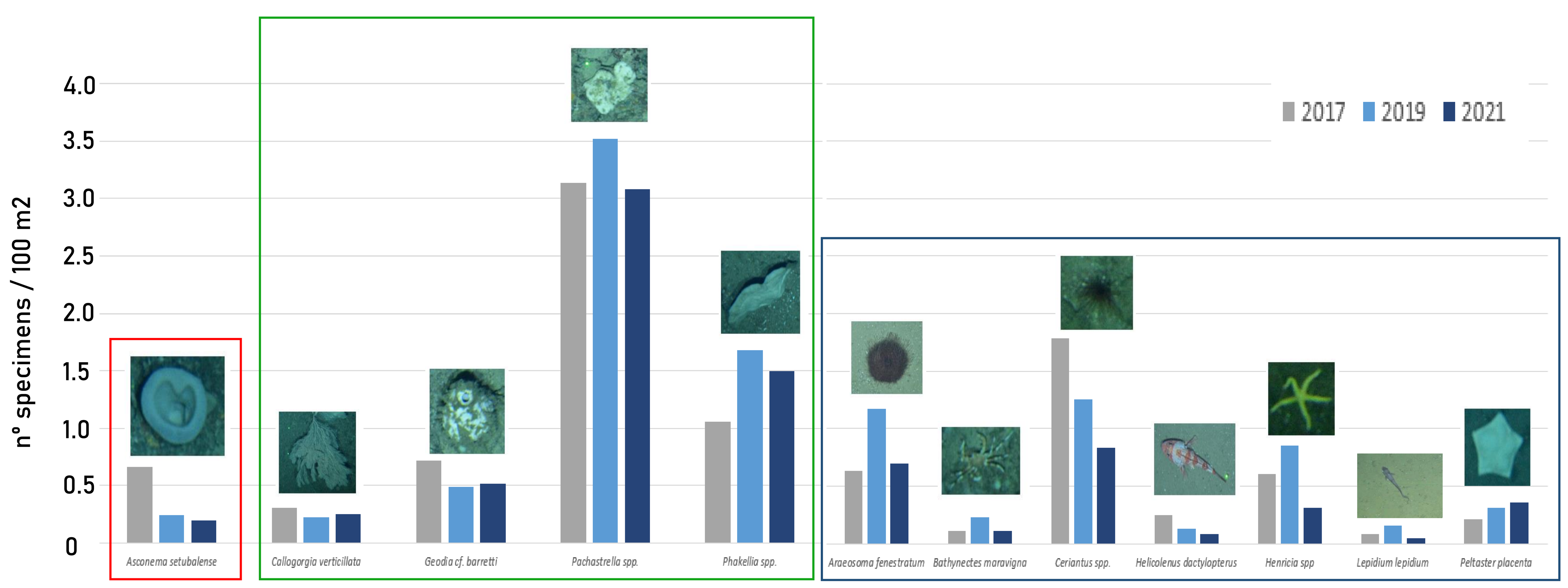


Substrate Seafloor Type (%)

The type of substrate determines the associated species. The percentage of rock substrate covered by the images is constant throughout the time series.



Species Density evolution (2017-2021)



Asconema setubalense

Significant decline of one of the most characteristic and vulnerable species in the area. Event that could be detected in Prado et al., 2019 (https://www.frontiersin.org/articles/10.3389/fmars.2021.612613/full).

Other sessile species

The rest of the sessile species (sponges and corals) do not show clear trends and seem to remain stable throughout the time series. The small differences can be explained by the high fractionation of this type of habitat.

Mobile species

Sampling with ROV vehicles at specific times is not the best sampling methodology to estimate the density of mobile species. The recording of this type of species in the images may vary depending on the time of year, time of day and the life cycles of each of them.

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