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Review Article

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Ecological Notes on Macrozoobenthic Amphipoda Populations, Recruited on Artificial Anti-Trawiling Barriers, In the North-West Sardinia (Italy), by the Means Of Scuba Diving

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ABSTRACT
This work is a part of a broader environmental monitoring project conducted by the Institute for Environmental Protection and Research (ISPRA) within the laying of submarine cables between the Lazio and Sardinia (Italy). Due to anthropogenic damage observed along these cables artificial anti-trawling barriers (tripods) were located on the seafloor in order to safeguard the electrical connection from potential illicit activities while simultaneously promoting the protection of existing ecosystems. Over the years, anti-trawling tripods have proven effective in reducing the impact of bottom trawling and promoting marine biodiversity. However, their success largely depends on their ability to attract and support colonization by marine species (process known as recruitmen). Our work then focuses on observing recruitment on anti-trawling barriers to evaluate the colonization of artificial substrates introduced into the marine environment. In particular, the research involved the identification of amphipod species one of the most diversified and fascinating groups of crustaceans inhabiting marine waters and can serve as a partial descriptor of the community, providing a tool to assess the current state of the ecosystem.

Keywords: Scuba Diving, Ecological Notes, Marine Environment, Ecosystem

Introduction

The marine environment is a dynamic and complex ecosystem that plays a crucial role in the ecological balance of our planet. However, it is constantly threatened by several anthropogenic activities, including bottom trawling, which can have a significant impact on benthic habitats and the species that inhabit them. This context frames the present work, which is part of a broader environmental monitoring project conducted by the Institute for Environmental Protection and Research (Ispra) within the SAPEI Project: "New 500 kV Direct Current Submarine Connection SAPEI" (Sardinia - Italian Peninsula), implemented by Terna S.p.A.. This connection is composed of two power cables 420 km long, that cross Tyrrhenian Sea until the maximum depth of 1640 meters, two electrode cables (the anode and cathode) and three landing points: Fiume Santo and Punta Tramontana in Sardinia and Nettuno in Latium region. During inspections conducted along the cables laied in Sardinian side, damage due to anthropogenic actions, likely illegal bottom trawling activities, was observed. To safeguard the connection from potential illicit activities while simultaneously promoting the protection of existing ecosystems, artificial anti-trawling barriers (tripods) were located close Fiume Santo and Punta Tramontana landing points. These submerged artificial structures were analysed annually to assess potential changes in the marine area where they were positioned (Figure 1,2).

Over the years, anti-trawling tripods have proven effective in reducing the impact of bottom trawling and promoting marine biodiversity. However, their success largely depends on their

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ability to attract and support colonization by marine species. This colonization process, known as "*recruitment*," is crucial for the restoration of marine habitats and the establishment of resilient marine communities.

Figure 1: Example of anti-trawl tripod module. Sizing of a single tripod

Figure 2: Marine stretch affected by the laying of marine cables

Our study focuses on observing recruitment on anti-trawling barriers to evaluate the colonization of artificial substrates introduced into the marine environment. In particular, the research involved the identification of amphipod species present in samples collected from eight selected stations. Amphipods emerge as one of the most diversified and fascinating groups of crustaceans inhabiting marine waters and can serve as a partial descriptor of the community, providing a tool to assess the current state of the ecosystem. [1-6]

Sampling Strategy

The colonization of the artificial substrates released into the marine environment was analysed through direct and indirect methods, during the various phases of succession of the reef population as indicated by the FAO guidelines for the monitoring of artificial reefs in the Mediterranean Sea. In consideration of the different types of substrates and environments in which the reefs were paced, the sampling plan envisages the study of the population in two bathymetric bands: superficial/photophilous, between 10 and 15 m, and deep/sciaphilous, between 20 and 30 m. For each band, an artificial barrier was chosen, selected on the basis of its representativeness of the average environmental conditions of the area in which it was positioned. Two stations for direct study and two for indirect study were established in each barrier, for a total of 4 stations in the Punta Tramontana site (PT) and 4 in Fiume Santo site (FS). The underwater activities were performed by an ISPRA's diving researcher supported by technical diving operators from a company contracted for this activity. In each station, the ISPRA researcher took steps to collect the biological samples by manual grating of all the material adhering to the surface of the reef, then collected using a compressed air sorbona operated by an other technical diver. [7, 8]. (Figure: 3, 4, 5, 6; Table 1).

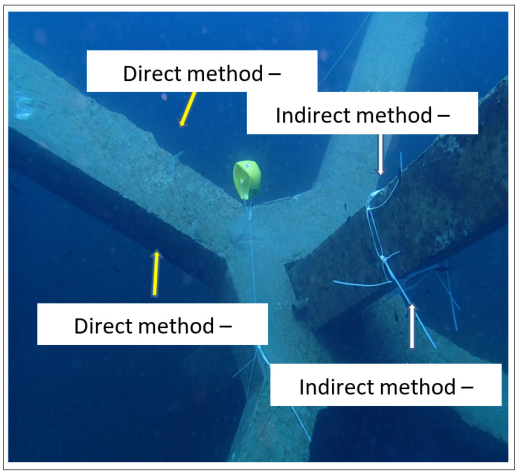

Figure 3: Direct and indirect sampling points performed by scuba diving

Figure 4: Sample collection for direct study by grating and sorbone

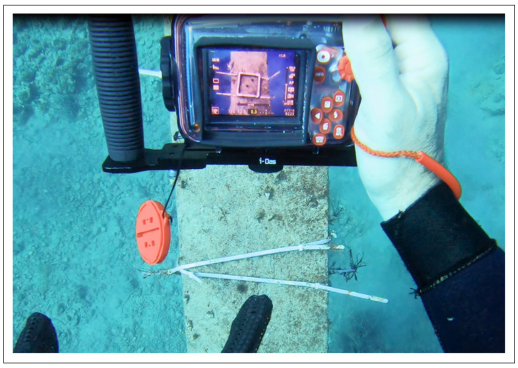

Figure 5: Collection of images of the surfaces included in the frames installed for indirect sampling

Table 1: Type, location and depht of the sampled stations

	Fascia	Stazione	Codice	Latit. Gg°mm'ss"	Longit Gg°mm'ss"	Prof. m
Metodo Indiretto	Superficiale	Orizzontale	2F_UP	40°52'45,49"	08°37'14,72"	12
		Verticale	2F_DW	40°52'45,49"	08°37'14,72"	12
	profonda	Orizzontale	18F_UP	40°52'42,26"	08°36'38,59"	22
		Verticale	18F_DW	40°52'42,26"	08°36'38,59"	22
Metodo Diretto	Superficiale	Orizzontale	2F_UP	40°52'45,49"	08°37'14,59"	12
		Verticale	2F_DW	40°52'45,49"	08°37'14,59"	12
	profoncla	Orizzontale	18F_UP	40°52'42,26"	08°36'38,59"	22
		Verticale	18F_DW	40°52'42,26"	08°36'38,59"	22

Figure 6: Sampling site with operator equipped with compressed air sorbone used for the collection of organisms.

Samples Analyses and Statistical Data Elaboration

All samples were stored in 80% denatured alcohol solution. Qualitative and quantitative analysis of macrozoobenthic communities has been carried out in the laboratory. All individuals were classified and taxonomically recognized, down to the lowest possible taxonomic level, i.e. the species. Amphipoda were all separated from all other taxa.

The structure of the Amphipoda community was assessed by considering both species and individual organisms to characterize the biocenotic traits of the study area. Subsequently, we subjected the collected data to statistical analysis to gain deeper insights into the population structure and to detect any spatial and temporal variations. Various structural parameters and ecological indices were employed: Total abundance N, Total species richness S,* the Shannon-Wiener Specific Diversity Index H'; Pielou index J.

Abundance data underwent analysis using advanced multivariate statistical methods. A multivariate assessment was carried out based on quantitative matrices featuring "taxa x stations". This involved the application of non-metric Multidimensional Scaling (nMDS) and Cluster analysis utilizing the average linkage algorithm. These analyses relied on the Bray-Curtis similarity index and were conducted using Primer 6.1.6 software [9-11]

Results and Discussion

Amphipods emerge as one of the most diversified and fascinating groups of crustaceans inhabiting marine waters and can serve as a partial descriptor of the community, providing a tool to assess the current state of the ecosystem. The data obtained by the sample analysed confirm findings from similar studies conducted in other coastal areas and highlight the challenges in predicting the processes and timing of colonization by macrobenthic organisms. The data obtained indicate a well-established state of colonization of the anti-trawl barriers, progressing towards a climax stage. The vagile fauna primarily consists of small-sized organisms that inhabit the algal mats. Changes in the abundance and composition of amphipod species over time on the artificial reef provide valuable and essential insights into the ecology of these species and their intra/interspecific relationships. [12-14] (Figure 7, 8, 9, 10, 11, 12, 13, 14, 15).

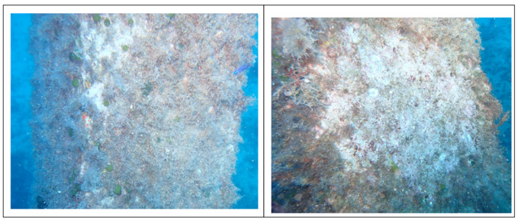

Figure 7: Detail of the surface of the 18F barrier before and after the scratching operations

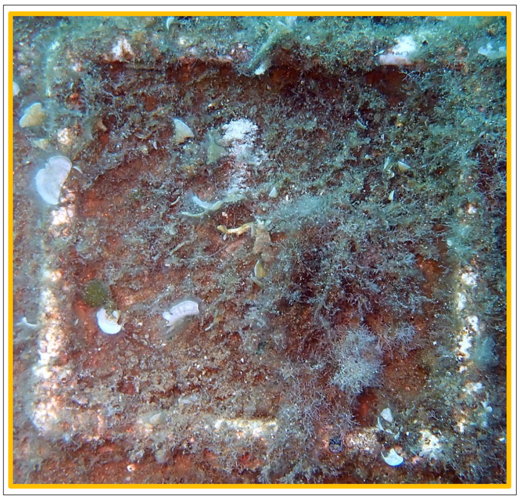

Figure 8: Barrier 2F, station 2F_UP, surface for indirect study of colonization by macrobenthic organisms

Figure 9: Barrier 2F, station 2F_DW sub horizontal, surface for indirect study of colonization by macrobenthic organisms

Figure 10: Barrier 18F, station 18F_UP, surface for **indirect** study of colonization by macrobenthic organisms

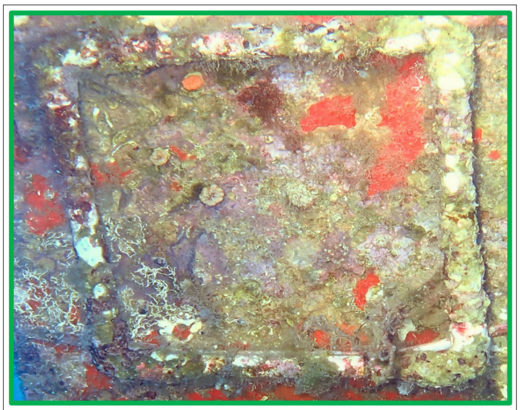

Figure 11: Barrier 18F, station 18F_DW sub vertical, surface for indirect study of colonization by macrozoobenthic organisms

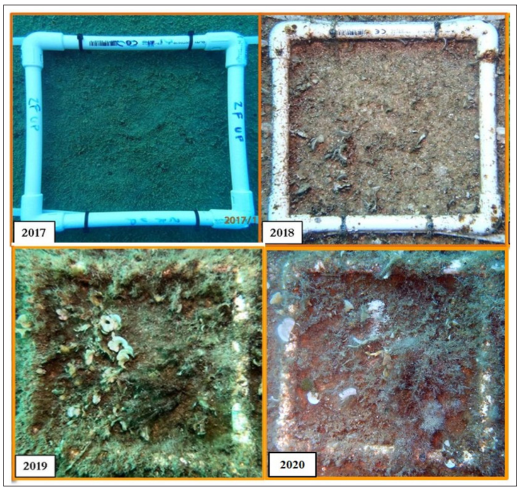

Figure 12: Comparison of the population photographed in station 2F_UP in November 2017, July 2018, September 2019 and September 2020

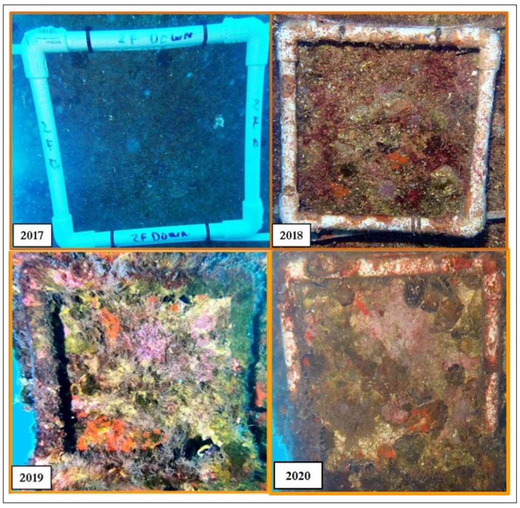

Figure 13: Comparison of the population photographed in station 2F_DW in November 2017, July 2018 and September 2019

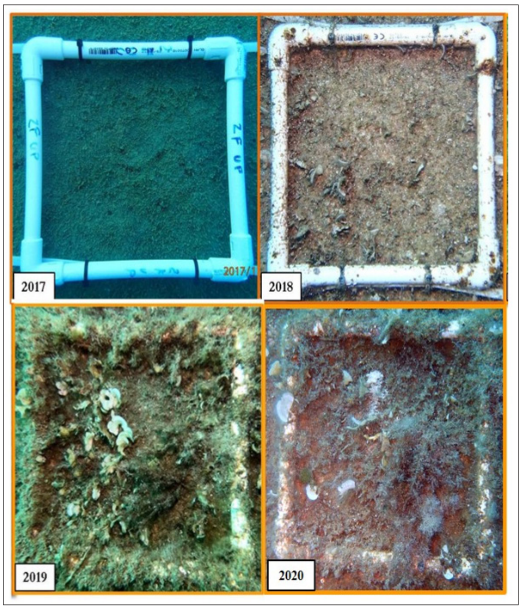

Figure 14: Comparison of the population photographed in station 18F_UP in November 2017, July

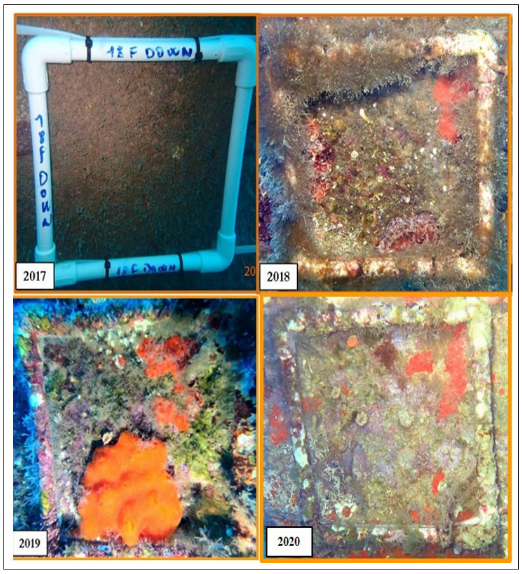

Figure 15: Comparison of the population photographed in station 18F_DW in November 2017, July 2018, September 2019 and September 2020

Conclusions

This work has confirmed what has already been demonstrated by similar studies regarding the utility of anti-trawl barriers as artificial habitats, attracting a wide range of organisms, from small invertebrates to fish, and therefore have positive effects on fish repopulation and biodiversity. Tripods were indeed introduced as invasive structures designed to prevent the passage of trawl fishing gear on the seafloor, thus protecting the habitats and species living there. Monitoring activities remain highly relevant because the evolution of the colonizing population needs to be studied and evaluated over time] (Figure 16, 17, 18, 19, 20, 21).

Figure 16: Macrozoobenthos samples

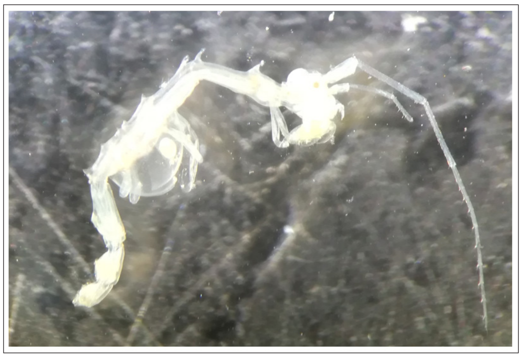

Figure 17: Caprella achantifera - Ecology: algal or hard substrates in shallow water, 1-10m difficult to see and survey for the small size, easily however, they can be found on the wetsuit at the end of the dive.

Figure 18: Lysianassa caesaria - Ecology: algal or hard substrates in shallow water, also on soft-bottom, difficult to see and survey for the small size.

Figure 19: Liropus elongatus - Ecology: algal or hard substrates in shallow water, also on soft-bottom, difficult to see and survey for the small size, easily however, they can be found on the wetsuit at the end of the dive

Figure 20: Microdeutopus obtusatu - Ecology: algal or hard substrates in shallow water, also on soft-bottom, difficult to see and survey for the small size

Figure 21: Cressa cristata - Ecology: algal or hard substrates in shallow water, also on soft-bottom, difficult to see and survey for the small size

Aknowlegment

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