BENTHIC RESPONSE TO THERMAL DISTURBANCE: PROJECT CONCEPT AND PRELIMINARY RESULTS

Lampa M., Manolaki S. M., Chatzivasileiou D., Dimitriou P. D. and Karakassis I.

Department of Biology, Marine Ecology Laboratory, University of Crete, mlampa98@gmail.com

Abstract

One of the most important outcomes of climate change with potentially significant ecological and economic consequences is the increase in seawater temperature. In this context, areas in the coast where warm discharges (i.e. industrial cooling water) are discharged in the sea inducing a mild and temporal change in water temperature, may be considered as an experimental simulation of climatic change. This study aims at assessing the effect of water temperature increase in macrofaunal community structure, ecological status as well as sediment environmental variables at four different locations where warm water emerges in the sea from industrial pipelines. Four locations were chosen, with three sampling stations each (Near the emerging point, Far 50 meters away and Control 1km upstream). The results indicate that there is one-degree ^{o}C water and sediment temperature increase in the Near stations. Based on the preliminary results presented here, there is an observable effect on sediment environmental variables but the Ecological Status based on the BQI_Family index does not differ between Near and Control stations.

Keywords: Benthos, Marine Ecology, Climate Change.

1. Introduction

The rapid response of benthic macroinvertebrates to environmental changes, such as raise of water temperature, has led to several studies examining the response of community structure and diversity patterns. Survey data over the past century suggest that there have been significant spatial changes in the distribution of intertidal organisms when sea temperatures have risen by as much as 1º C patterns (Xu *et al.*, 2020). Climate warming, over decades, has been suggested to modify the composition of resident organisms by promoting the spread of species from warm temperature areas. Change in temperature could affect mortality, reproduction, spawning, embryotic and gonad development of benthic species, modifying the community structure of benthic species. Furthermore, this change may also alter population dynamics at temporal and spatial scale and switch the geographical distribution of benthic communities which may induce species extinction as well as loss of diversity and ecosystem functionality (Birchenough *et al.*, 2011). Raise in water temperature caused by climate change could potentially increase the pressure on soft bottom benthic communities by reducing dissolved oxygen -increasing hypoxia, reducing the ability of benthic fauna to cope with large quantities of organic waste (Tett *et al.*, 2013).

The findings of this study will be used to assess the effects of thermal wastes on benthic communities. Furthermore, they will provide helpful information for monitoring marine ecosystems in view of the upcoming changes due to global warming. They will also result in a better understanding of the effects of climate change in coastal ecosystems, especially considering the oligotrophic conditions of the eastern Mediterranean, as well as the establishment of alien species in new areas.

2. Material and Methods

As a method of simulating scenarios of climate change, four areas were chosen, in which warm water discharge points are located. The warm water is used as a means of cooling heat exchangers of thermoelectric factories or industries and in the end emerges from pipelines and disperses to the sea. The temperature of the emerging water is reasonably higher than that of the sea and as it disperses it creates a zone of increased temperature which gradually decreases around the discharge point or pipeline.

In total, four locations were sampled in March 2022 two thermoelectric power plants at Ammoudara Beach and Atherinolakkos in Crete island and two oil. In Crete at, and two refineries oil companies, Oil Company 1 (OC1) and Oil company 2 (OC2) in Saronikos gulf. First of all, an accurate mapping of the exact location of the pipelines was created using satellite images extracted from Google Earth© and a set of three sampling stations at each location was determined. The sampling stations were codenamed: Station Near as close as possible to the water exit point, Far 50m away from the exit point and Control at least 1000m away upstream in a location with similar depth and sediment type. The sampling took place with the research vessel "Philia" in the context of the BENTHERM program funded by the RePhil project. At first, a video recording from the sediment at each location was captured with an underwater ROV, which possesses a real-time temperature sensor which was used to record sea bottom water temperature. Then, from each sampling station three replicated sediment samples were collected by using a Smith-McIntyre grab sampler ($0.1m^2$). Temperature (T) was measured in the 1 cm of the sediment, while redox potential (Eh) and hydrogen sulfide (H_2S), were measured in every 1 cm of the first 5 cm of the by means of a UNISENSE© Field-Microprofiler. Furthermore, samples were taken for granulometry from the upper 5cm and organic matter content from three layers (0-1, 1-3, 3-5 cm) and measured using the Loss of Ignition protocol (Loh et al., 2008). Macrofauna samples were sieved consecutively over a 1mm and a 0.5mm sieve, the retained materials were, fixed with Formalin solution (4%) and stored for sorting and taxonomic identification. The biotic index BQI_Family (Dimitriou *et al.*, 2012) was used to assess the Ecological Status (ES) of Near and Control stations.

3. Results

Habitat description based on CTD data, ROV videos and depth measurement (Table 1) showed that all locations had different environmental characteristics. However, based on the real-time ROV temperature sensor it was found that the water temperature at the sites close to the warm water effluent points was 1-2 ºC higher than that at the respective control sites. This was also confirmed from the temperature measurements of the Field Micro-profiler measured at the sediment corers (Table 1).

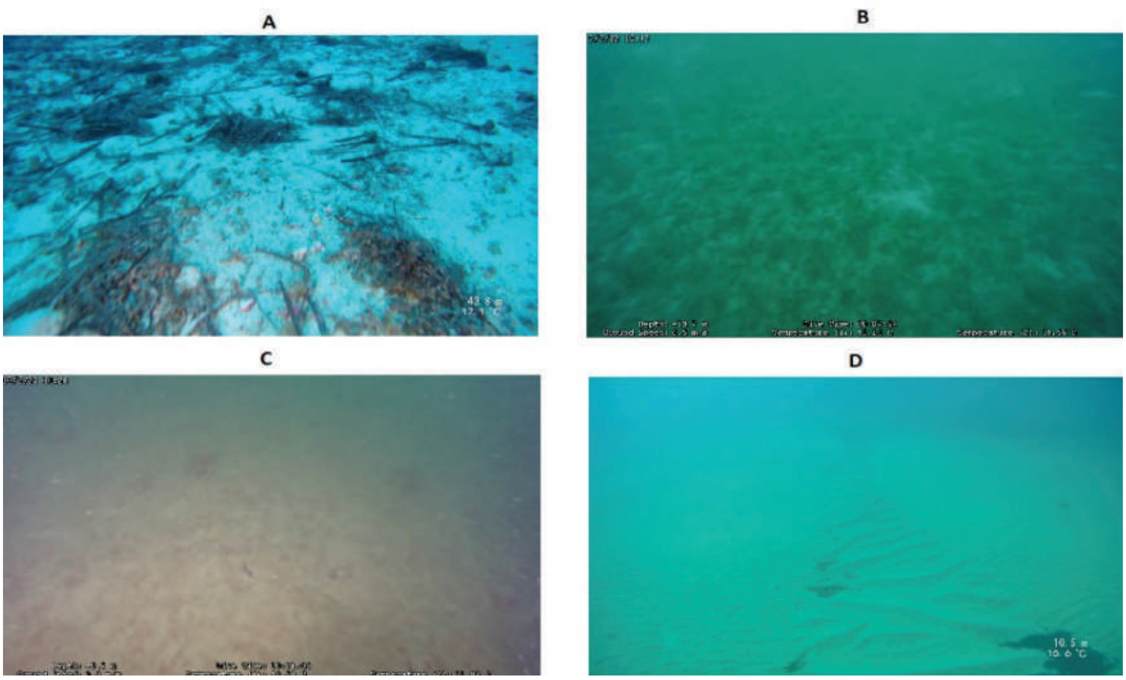

Fig. 1: Photographic images of the sediments taken using a camera on the underwater ROV near the warm effluents discharge points at locations: A) Atherinolakkos, B) Oil Company 1 (OC1), C) Oil Company 2 (OC2) and D) Ammoudara.

Table 1. Values of environmental variables and Ecological Status at each sampling station.

Station	Average Depth (m)	Habitat description	Average Water Temperature (C)	Average Sediment Temperature (C)	Ecological Status BQI_ Family
Ammoudara_near	5	Sand with no vegetation	16.6	16.3 ± 0.3	Moderate
Ammoudara_far	10	Sand with no vegetation	15.5	15.7 ± 0.3	-
Ammoudara_control	7.5	Sand with no vegetation	15.5	15.1 ± 0.2	Moderate
Atherinolakkos_ near	28.7	Sand with decaying vegetation	18	16.7 ± 0.2	Good
Atherinolakkos_far	37.4	Sand with decaying vegetation	17.1	16.3 ± 0.3	-
Atherinolakkos_ control	34.9	Sand with decaying vegetation	17.1	14.6 ± 0.2	Good
OC1_near	19.4	Sand covered with green algae	15.7	14.8 ± 0.3	Moderate
OC1_far	17.2	Sand covered with green algae	14.6	14 ± 0	-
OC1_control	24.2	Sand covered with green algae	14.6	13.8 ± 0.3	Good
OC2_near	7.4	Mud mixed with biogenic detritus	13	11.3 ± 0.6	Good
OC2_far	11.8	Mud mixed with biogenic detritus	11.6	10.7 ± 0.6	-
OC2_control	8.9	Mud mixed with biogenic detritus	11.6	9.7 ± 0.6	Good

In all cases the water and sediment temperature was around 1° C higher in the Near sampling locations compared to the control. The ES classification was Good in most cases. Sediment vertical redox profiles are presented in Figure 2 for all locations. No H_2S was detected in all sampling stations.

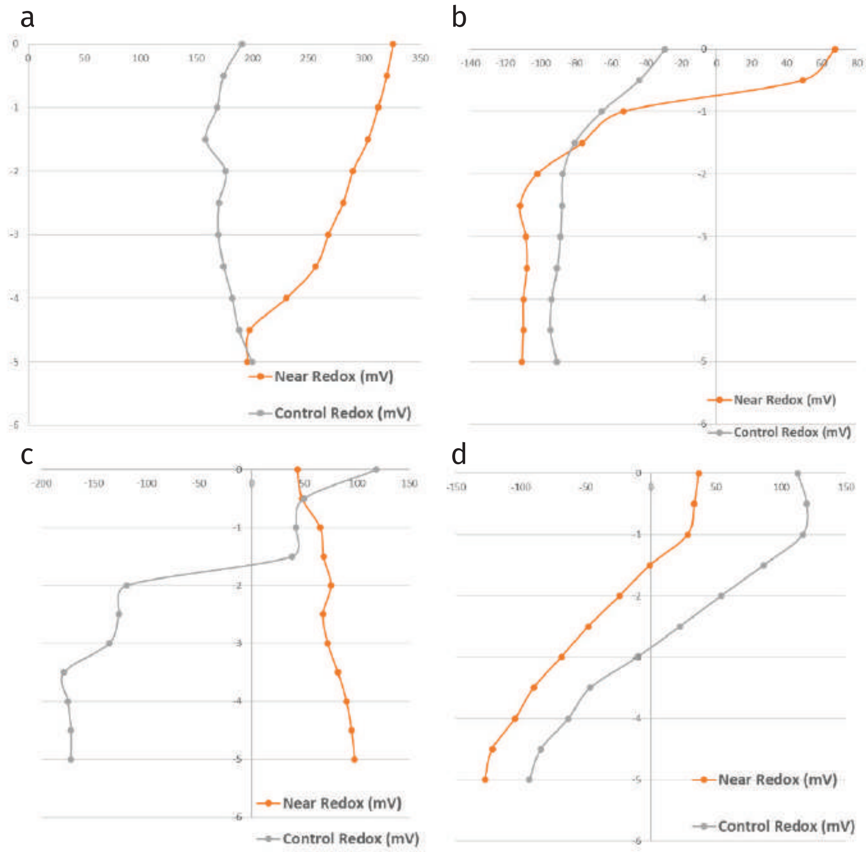

Fig. 2: Ventral profiles of sediment redox-potential at locations: a) Ammoudara, b) Oil Company 2, c) Atherinolakkos and d) Oil Company 1.

From the Redox vertical profiles it can be concluded that the locations with electric power plants have similar patterns with the Near station having higher Eh values. In the OC stations the opposite pattern is observed with the Near stations having lower Eh values after the 1 cm of the sediment.

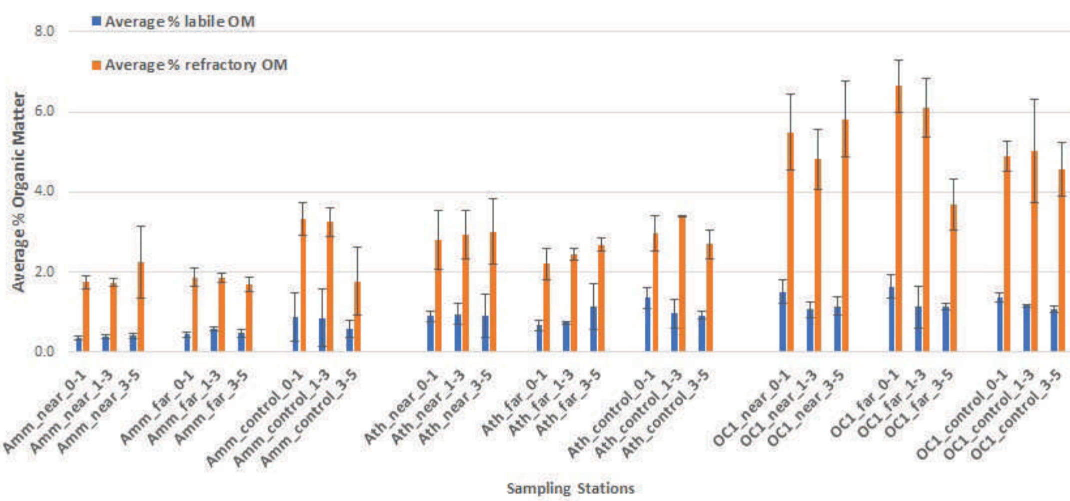

Fig. 3: Average (±SD) of labile organic matter (%) and refractory organic matter (%) in each sampling station of Ammoudara, Atherinolakkos and Oil Company (OC1).

The sampling stations in Crete had lower labile and refractory OM content compared to OC1 in Saronikos. Additionally, both in Ammoudara and Atherinolakkos the Control stations had higher OM content in the 0-1 layer of the sediment (ANOVA $p<0.05$), as opposed to the lower layers where no differences were observed (ANOVA $p>0.05$). In OC1 no significant differences were observed ($p>0.05$). OC2 OM data are not presented since the analysis of the samples is still ongoing, as is the case with macrofaunal community data (Fig 4).

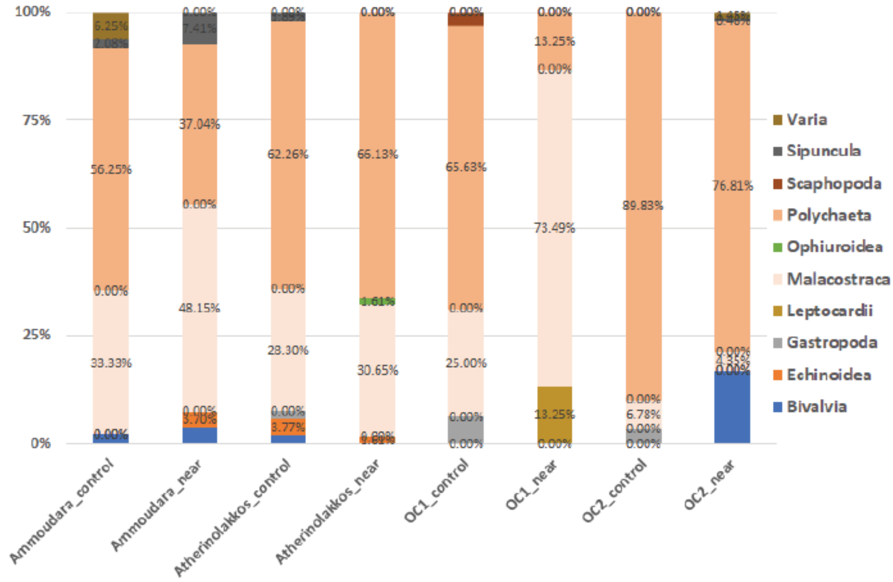

Fig. 4: Abundance percentage of macrofaunal classes in each sampling station.

4. Discussion/Conclusion

Based on the preliminary results presented here it can be concluded that:

the geochemical variables determined so far indicate that there is more variability between sites than between control and impact stations within each site (Fig. 2, Fig. 3)

There are some observable differences between environmental variables of the near and control stations but the effects are statistical significant only in a few cases, mainly in the stations in Crete. With the data available so far this cannot be attributed to the increased temperature.

The collection of macrofaunal specimens for the sediments in the close vicinity of the warm effluents discharge points has shown that the benthic communities are comprised of a large number of individuals, belonging to various families. Furthermore, with the exception of OC1, the ES classification of the Control and Near station was identical.

5. Acknowledgements

We would like to thank the captain and the crew of the RV Philia for assisting with the sampling. This project is part of the Hellenic Research Fleet - Reconstruction of the Research Vessel PHILIA, which is funded by the Operational Program (OP) “Competitiveness Entrepreneurship and Innovation” (NSRF) for the period 2014-2020 and co-financed by the European Regional Development Fund (ERDF)

6. References

Birchenough, S.N.R., Degraer, S., Reiss, H., Borja, A., Braeckman, U. *et al.,* 2011. Responses of marine benthos to climate change. ICES status report on climate change in the North Atlantic. *ICES Cooperative Research Report,* 123-146.

Dimitriou, P.D., Apostolaki, E.T., Papageorgiou, N., Reizopoulou, S., Simboura, N. *et al.,* 2012. Meta-analysis of a large data set with Water Framework Directive indicators and calibration of a Benthic Quality Index at the family level. *Ecological Indicators*, 20, 101-107.

Loh, P.S., Miller, A.E.J., Reeves, A.D., Harvey, S.M., Overnell, J. *et al.,* 2008. Assessing the biodegradability of terrestrially-derived organic matter in Scottish sea loch sediments. *Hydrology and Earth System Sciences*, 12 (3), 811-823.

Pearson, T.H., Rosenberg, R., 1978. Macrobenthic succession in relation to organic enrichment and pollution of the marine environment. *Oceanography and Marine Biology: An Annual Review,* 16, 229-311.

Tett, P., Gowen, R.J., Painting, S.J., Elliott, M., Forster, R. *et al.,* 2013. M. Framework for understanding marine ecosystem health. *Marine Ecology Progress Series*, 494, 1-27

Xu, K., Wang, R., Guo, W., Yu, Z., Sun, R. *et al.,* 2020. Factors affecting community structures of benthic macroinvertebrates and microorganisms in Yellow River Delta wetlands: Seasons, habitats, and interactions of organisms. *Ecohydrology and Hydrobiology*, 20 (4), 570-583.