ANALYSIS OF THE CONDITIONS FOR BUILDING FLEXIBLE UNDERWATER REEF

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Abstract: The artificial reef is a man-made underwater structure, typically designed to stimulate marine life in areas with relatively uninhabited bottom, to control erosion, to block access to ships or improve surfing. Many underwater reefs are built from rigid constructions, such as oil platforms, old ships or gravel, building materials and others.

Designed by scientists from the Technical University of Varna was developed flexible underwater reef composed of concrete anchors, ropes, ropes and floats collectors that evolve in the structure of the underwater reefs. The flexible underwater reef is designed to withstand all external influences and implements water purification. The tests for 5 years show that the reef is storm resistant. It is located above the bottom, which does not allow Rapana destroy mussels. The flexible underwater reef is additionally secured with special traps for Rapana. Mussels in the process of growing periodically fall from the reef and accumulate close to the construction thus forming another bio - reef.

The article analyzes the conditions for development, sustainability and amortization of underwater reef. There are analyzed the living conditions of mussels on the underwater reef.

Keywords: *underwater reef, mussels, biofilter, biodiversity, habitat, installation, Vromos bay, Bulgarian Black Sea coast*

Introduction

The marine underwater reef is a unique natural biofilter designed for bio - melioration of coastal waters, increasing the quantity and biodiversity of hydrobionts, mostly active biofilters and improving the environmental status of the marine environment.

The pilot investigations were carried out in "Vromos" bay, situated between Nos Atiya and Nos Akin, part of the coastal waters of Chernomorets town, Sozopol municipality, Bulgaria (fig.1). Chernomorets town is located 8 km north of Sozopol town and 24 km southeast of Burgas town, on the south coast of Burgas Bay.

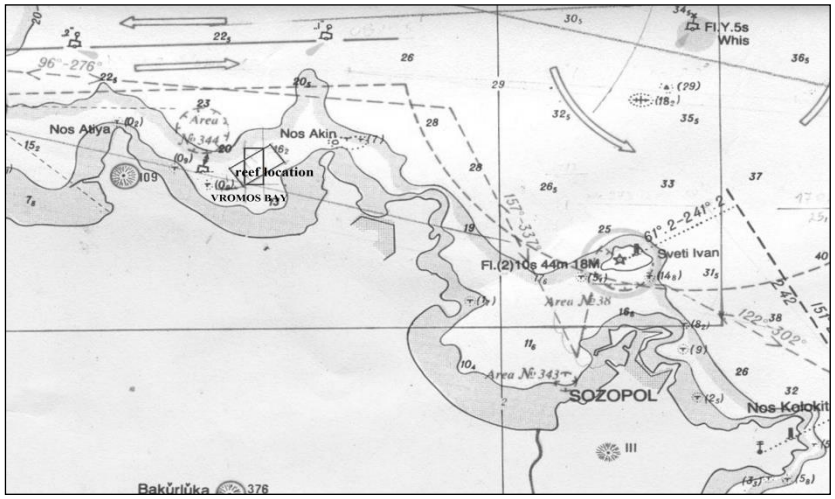

Fig. 1. Map of **"**Vromos" bay including the selected area for the elaboration of the artificial reef,

The underwater reef is a versatile volumetric figure situated on an area ~ 400 acres. The expected positive effect is due to storm resistant construction with easily interchangeable components and the provided favorable conditions where hydrobionts are in an active physiological phase.

1. Analysis of the conditions for the construction of flexible underwater reef

The high anthropogenic pressure on the Bulgarian Black Sea coast, combined with low intensity exchange of water masses and lack of strong currents obstruct the natural conditions of existence of marine and coastal ecosystems, violate water quality and threaten human health. The lower biological diversity and higher sensitivity of the Black Sea biocoenoses towards the unfavorable environmental conditions require special attention to the conservation of marine resources and their exploitation and demand for effective solutions to protect and restore marine ecosystems.

One of the possible solutions to restrict the negative effect of marine resources exploitation is the creation of protected zones, using artificial habitats such as floating reefs, aiming to implant a diversity of benthic communities with powerful biofilter capacity [4, 5, 9]

Dominant inhabitants on the reefs surfaces are usually the mussels, which are one of the most powerful biofilters. One mussel filteres about 3 - 3,5 liters seawater per hour, and only one ton of mussels filters more than 1200 m^3 of water per day. [6]

As a result of the realization of the construction in Vromos bay were created favorable conditions for the distribution of mussels, which in turn is a prerequisite for enhancing biodiversity in this region and increasing the productivity of the water area. Moreover the conditions for fish feeding were improved, creating new areas and niches favorable for survival and protection from predators. On the other hand purification of the marine waters from domestic wastewaters and urban runoff was achieved, leading to improvement of the ecological status. At present Chernomorets wastewaters are discharged into the Vromos bay by sewerage system without purification [7, 8].

With the deployment of the underwater reef in Vromos bay "good ecological status" of marine water was achieved, which is in compliance with the main objective of the EU Water Framework Directive (WFD 2000/60) [3] and the River Basin Management Plan of the Black Sea River Basin Region [2]

The construction of the artificial reef in the Vromos bay was agreed with the Navy, the Ministry of Environment and Water and Ministry of Transport, Information Technology and Communications in order to avoid complications concerning navigation.

Vromos bay was selected as experimental aquatory for elaboration of the artificial reef due to the following reasons:

- Favorable hydrological, hydrographic, meteorological and hydrodynamic conditions, due to the storm protection of the bay by Nos Akin;
- Untreated domestic wastewaters of Chernomorets town, discharged by sewerage system, which is a prerequisite for organic and nutrients contamination, enabling the growth of mussels and development of mussels fields;
- "Moderate" ecological status of the water body (ID BG2BS000C011) during the period of the investigation according to the assessment of the Black Sea River Basin Directorate [1]
- Not officially designated as bathing area, which made the deployment of the artificial

reef legally possible in terms of authorization.

2. Underwater reef main characteristics

The existing bottom reefs, consisting usually of submerged structures, old ships, concrete elements and others have a good storm resistibility, but their disadvantage is that mussels are attached only on the surface but most of them are buried by silt and sand, which substantially reduces the usability of the constructions. Besides, within the time various deposits of silt, wastes from feeding, shells of dead mussels etc. are accumulated over the hydrobionts which significantly reduces their viability and filtering capacity.

The artificial reef was installed in the sea as volume complex (reef belt) of affordable and non-toxic materials in bulk form; characterized with long term durability and reliable thermal stability. The main modules did not sink into the primer, the substract part were easily removed and replaced in the water after several periods of exposure and were protected against invasion of Rapana. The reefs modules were easily mounted and dismounted under the water in order to be relocated - if necessary.

The proposed technology of construction and exploitation of the underwater reef was in compliance with the basic requirements concerning design of artificial reefs in the Bulgarian Black Sea coast and fit the natural conditions of the marine environment.

To prevent possible negative consequences when performing assembly activities the recommended period of performance was in line with the hydrometeorological conditions of the region and the conditions of vitality of hydrobionts.

The underwater reef is a versatile volumetric figure situated on an area ~ 400 acres. The scheme of the flexible reef is shown in figure 1. The reefs' construction included special flexible elements: anchors made of concrete (1) - 3,5 - 4 t each, (2) basic line, (3) triangular collectors - 3 - 4 m in length. Floats (4) were attached to the upper part of the triangular collectors and traps for Rapana (5) were mounted to the lower part. The lines were placed at a distance of 7 - 10 meters and could increase in length indefinitely. The distance between anchors was not more than 50 m to avoid congestion of the main lines. The anchors were made by deepening in the base in order to be used the effect of "suction" towards the bottom.

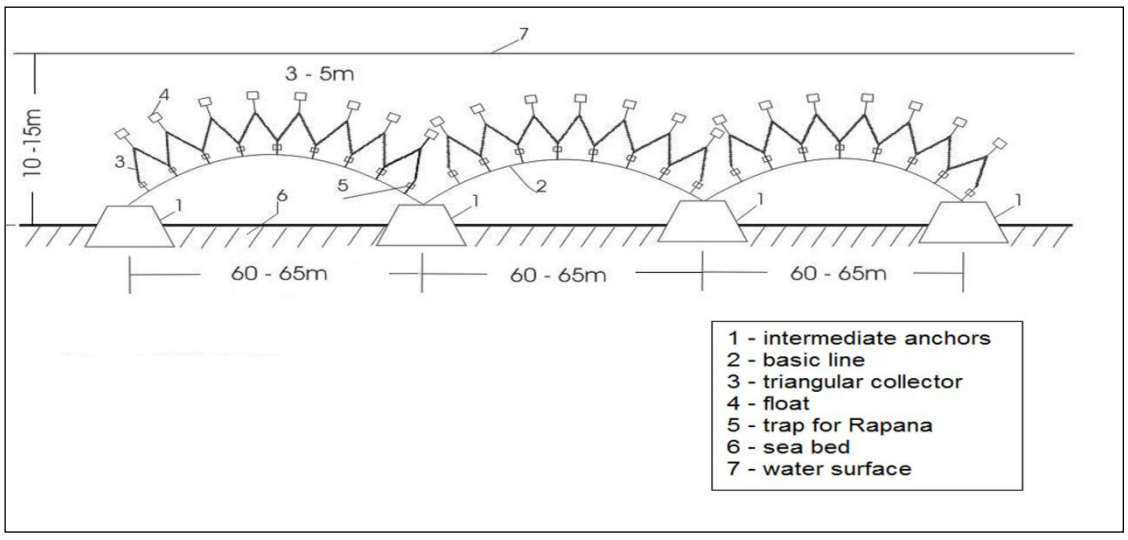

Fig. 1. Schematic diagram of one segment from the main line of the artificial habitat

Schematic diagram of part of the reefs field is shown in figure 2. The main elements could be deployed in all directions.

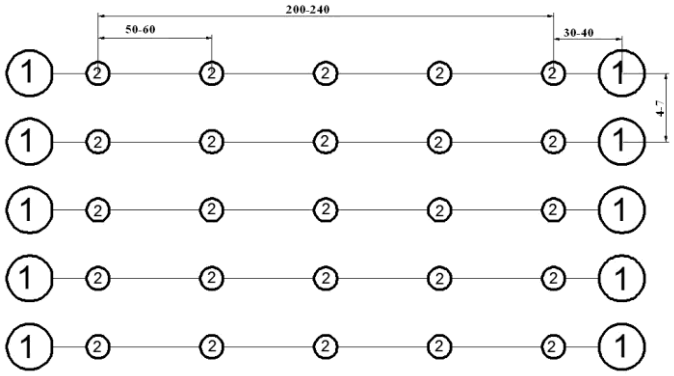

Fig. 2. Scheme of the field
1 – concrete elements- 5 t/each
2 – concrete elements – 3,5 t/each

3. Construction of the underwater reef

The main processes related to the construction of the artificial reef included the following steps:

- Preliminary preparation of the basic elements of design - ropes, anchors, collectors for attachment of mussels, Rapana traps, floats;
- Assembling the basic elements of construction and transportation with vessel to the place of immersion;
- Positioning and installation of the construction in the selected area by boats, cranes and skilled divers
- Marking the area of the reef location with luminous buoys, following the requrements of IALA;
- Periodic maintenance of the facility.

The construction of the reef didn't require any modifications of the existing road infrastructure, because the existing road and port infrastructure was used.

The methodology for installation and operation activities can be summarized as follows:

- Preliminary analysis of the physico - chemical, biochemical and bacteriological indices of seawater;
- Preliminary analysis of the hydrodynamic processes in the selected water area in order to be determined the optimal design of the underwater reef;
- Selection of the most appropriate materials for construction of the artificial underwater reef;
- Design of the artificial reef;
- Installation of the reef;
- Marking on the marine navigational charts after deployment of the construction;
- Periodic underwater visual monitoring for the integrity of the construction;
- Periodic underwater monitoring regarding the increase of the natural species population in the area of the construction;
- Maintenance of the constuction and cleaning the structure from fouling;

- Regular physico - chemical, biochemical and bacteriological monitoring of the water quality in the marine area.

Based on the investigation it was found that for 10 months the size of the mussels occupying the construction of the underwater reef in the Vromos bay reached 62 mm. The fouling of the ropes by mussels reached a diameter of 50 cm, which in some cases caused lying on the bottom of some parts of the triangular collectors (fig.3).

Fig. 3. Underwater photos of mussels occupancy on some elements of the reef construction 10 months after the positioning in "Vromos" bay

Over time, much of adhering mussels reached lethal and fell to the bottom. The accumulation of the dead mussels formed new bio - reef below the line, which was prerequisites for fouling with algae and increasing the biodiversity around the reef.

4. Problems related to the construction and exploitation of the reef

One of the main problems during the construction of the reef was the positioning of vessels in the necessary directions.

1. The crane, used to submerge the anchors that weigh 4,5 to 5 tons was situated on vessel with large dimensions. The lines with buoys were deployed by two boats. In case of windy weather the lines were shifted and couldn't be accurately positioned.
2. After the submerge some of the buoys were floating on the water surface which required additional anchor with lower weight to be immersed in the middle between the two anchors
3. Serious problems occured with fishermen who placed the networks near the reef. When pulling the nets the construction was damaged.
4. There were problems with anglers entering the location of the reef for fish. They launched anchors or tried to be anchored to the signal buoys.
5. Too often the signal indications were stolen which guarding is practically impossible without constant personal availability.

6. Mitigation measures

The main purpose of the construction of artificial underwater reef is to create suitable conditions for recovery of demersal and pelagic communities, combined with appropriate development of black mussels, aiming to improve the ecological status of the selected marine area.

In order to avoid any significant negative impacts on the status of the marine environment the following mitigation measures were taken:

- The main elements of the facility were made of durable and thermos - resistant, non - toxic materials;
- The assembly of the main elements of the facility were carried out outside the experimental aquatory;
- Bearing in mind that the assembly of the main elements was carried out far from the selected area, the final installation of the underwater reef caused only short - term impact and created minimal discomfort of the marine ecosystems;
- The volumetric structure of the facility allowed only a small part of the items (anchors) to be attached to the bottom, suggesting lower impact on the benthic communities, unlike many similar structures entirely lying on the bottom.
- In order to prevent rapid growth of Rapana population (which is the main predator of mussels) traps for Rapana were provided to the facility, which facilitate the natural increase of the biodiversity in the aquatic environment.

Conclusion

Design and technology of flexible underwater reef was developed, which main objective was to increase the biodiversity in areas with limited opportunities for habitation.

The reef was made of durable and thermo - resistant, non - toxic materials.

The investigation showed that the reef was storm - resistant and durable.

It was found that for 10 months the size of the mussels occupying the construction of the underwater reef reached 62 mm.

Periodically mussels fell to the bottom and formed bio reef that was overgrown with algae which created suitable conditions for hydrobionts.

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