

An artificial reef is to some extent a "memory" of the environment, where the benthic community is an effective storer of information and converter of energy (BOMBACE, 1989). Data from the fishing yields obtained in proximity of artificial substrata have been taken into account mainly from the economic or applicative point of view, whereas their utilization as a reliable descriptor of the reef system has been neglected. In this note data, obtained from the monitoring of the fishing yields of 3 artificial reefs, are analysed in order to verify the possibility to utilize informations from catch data to assess the degree of maturity and efficiency of a manmade reef.

Methods

Three artificial reefs (AM, TR, TE) were deployed in the Gulf of Castellammare on a sandy bottom at distance of ca. 6 Km from each other. Further details and descriptions are reported in RIGGIO, 1990. Fishing samples were performed monthly for a year using a trammel net (height 3 m, inner mesh size 54 mm) at 6 stations (depth 18-20 m) : 3 over the reefs and 3 (CAM, CTR, CTE) in a nearby control site. CAM and CTR were located on sandy bottom at a distance of about 1 Km far from the respective artificial reefs, whereas CTE was situated at a distance of ca. 0.5Km close to *P. oceanica* meadows on a mixed bottom of hard and soft substrata. Samplings, carried out during the night for a mean fishing time of 12h, were started in each reef after 4 years from their deployment. Data from the catches were standardized to a fishnet 500 m long and the average values of the numbers and weights of the individuals in each station were calculated in order to compare data of a site to the others. The following indexes referring to each station for both total and benthic-nektobenthic taxa were calculated: species richness of Margalef (d'), Shannon-Weaver diversity index (H'), and Pielou's evenness index (J'). Factorial Correspondence Analysis (FCA) was performed on a quantitative 6x60 station/species correlation matrix (BENZECRI, 1982) not inclusive of rare species. Axes significance was evaluated using the tables of LEBART (1975). Taxa were included in four groups according to their higher or lower affinity for the substratum and/or biocoenosis (Fig. 1).

Results

Eighty-eight taxa were identified. The highest values of d' and H' were recorded in close proximity of the reefs, whereas the values in the control sites were lower (Tab. 1). On the contrary, the evenness (J') of the control sites was nearly equal to those calculated on the reefs.

The first three axes of the FCA are significant (P < 0.001), accounting for as much as 90% of the total variance. The model puts into evidence a parabolic distribution of the stations along a steep gradient from soft (left side of Fig. 1) to natural hard substrata (right side of Fig. 1).

Table 1 - Community structure indexes (d' richness, H' diversity, J' evenness) calculated separately for total and benthic-nektobenthic species at each site.

AREA	AM	CAM	TR	CTR	TE	CTE
No. catch operations	16	17	19	22	11	11
d' TOTAL SPECIES	7.30	4.44	5.88	5.51	5.44	4.36
H'	2.44	2.14	2.91	2.72	2.76	2.44
J'	0.60	0.60	0.77	0.75	0.72	0.68
BENT.-NEK.-BENT. SPECIES						
d'	6.23	3.84	5.22	4.31	5.16	3.70
H'	2.95	2.72	2.82	2.59	2.59	2.25
J'	0.77	0.82	0.77	0.77	0.68	0.65

AM, TR, TE = artificial reefs; CAM, CTR, CTE = control sites

This pattern is typical of those environmental situations heavily conditioned by a polarizing factor represented in our case by the first axis. The second axis is related to the first one by a squared relationship and represents an intensity factor. No sensible differences can be shown between each artificial reef and its control site.

Discussion

Although the trammel net is highly selective, the fauna sampled with this gear is well representative of the species composition of the nektonic community (D'ANNA *et al.*, in press).

One might expect the artificial reefs to develop a peculiar community of nektonic species, related to the nature, the shape and orientation of the artificial substrata, and more or less independent on a recruitment from neighbouring areas.

On the contrary careful examination of the catch composition focuses on the reefs as individual units whose fish communities are strictly related to the natural populations living in the area. In fact, although the higher values of d' and H' in the reef areas highlight a greater variety and complexity of the environment from the point of view of biotic diversity, no valuable change in the structure of the natural population living in the area is evident.

Conclusions

Manmade reefs - as far as a critical volume is attained - should be viewed as breakups in the environmental continuum, that locally increase the biotic diversity by recruitment of few new taxa (D'ANNA *et al.*, in press; BADALAMENTI *et al.*, in press), which do not alter the overall community structure. Their ultimate result is a magnification of the dominant features of the surrounding seabed, that is the major source of biological information. Detailed knowledge of preexisting communities in natural areas, often neglected in the reef plans, is the necessary prerequisite to a rational deployment of reefs. This view can give a new insight and practical directions in the promotion and future planning of artificial marine habitats.

REFERENCES

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Résumé

On a étudié la colonisation des blocs de cendres de charbon provenant des centrales thermoélectriques en comparaison avec des blocs de béton. Les meilleurs résultats ont été obtenus avec les blocs de cendres qu'on pense utiliser pour la construction des récifs artificiels.

The construction of artificial habitats by sinking residual or purpose-built bodies on sea bottoms makes it necessary to ascertain whether they are compatible with marine ecosystems and in compliance with environmental protection laws of the country concerned.

ENEL - The Italian Electricity Board - has started a research program with the aim of monitoring the use of coal ash derived from its thermoelectric power plants as a component of blocks for artificial habitats whose construction is planned along the Italian coast line (SAMPAOLO and RELINI, 1991).

After preliminary laboratory tests were completed, an experimental installation was designed and constructed in the area of the Torrevaldaliga power plant (80 Km NW of Rome).

Two reef models - each made by assembling pyramids of 225 20x20x20 cm blocks - were submerged in two tanks (10x2x1,5 m) with running sea water (water flow: 3-5 cm/s).

The ash blocks were composed to 52.1 % of fly ash, 26.1 % of bottom ash, 5.2 % of hydrated lime and 16.6 % of water, while concrete blocks were made of pozzuolanic cement, sand and gravel. The main aims of this study are to obtain data about the behaviour of such materials and the interaction between the blocks and marine organisms, in particular the macrobenthos.

The observations were made at 3, 6, 9, 12, 15, 18, 21 and 24 months starting from 4 April 1990. At the moment of the examination the 6 sides of each cubes were photographed and described separately. Settlement was assessed by means of cover indices and the wet weight of the biological material scraped off each side. Subsequently the dry and ash weights were determined.

During the course of the observations the settlement on the ash blocks proved greater in quantity and better in quality than that in concrete. On ash blocks 60 species were found, compared to 50 on concrete. In particular on the ash blocks Algae together with the Serpulids are dominant components during the whole cycle of observations; on the other hand Corallinaceae and Spirorbids reach a maximum in 9-month associations, and then fall in the year long associations. Sponges, Gasteropods and Bivalves are always represented in low numbers, while Ascidians, which show a reasonable settlement on substrata immersed for 3 months, (3 M June '90), decrease to sporadic presences as the length of the period of immersion increases. Always present, however, are the colonies of encrusting Bryozoans with less marked seasonal fluctuations than the non-encrusting Bryozoans.

As already mentioned, on the concrete blocks, the associations are reduced and Algae, Corallinaceae, Serpulids and Spirorbids are the dominant components; Sponges are less represented than on the ash blocks; Gasteropods and Bivalves settle in small quantities, while the settlement of encrusting Bryozoans is greater especially on the half-year blocks. The colonies of the non-encrusting Bryozoans are particularly evident on the three-month blocks where Ascidians are missing although they are abundant on the corresponding ash substrate. The biomasses confirm the qualitative and quantitative differences expressed in the cover indices between the association which settle on the ash blocks and those on the concrete cubes.

Moreover, the increase in fouling with the increase of length of the period of immersion is much more evident and gradual for the ash blocks than for concrete, at least up to 15 months of immersion.

During the 24 months of observations, it was found that the accumulation of fouling (total wet weight), was greater on the ash-based substrata for all period of immersion except on the blocks exposed for 21 months, where there was an inversion. Furthermore, still considering the average weight values of all the blocks under examination, an increase in the accumulation of biomass was found up to 15 months, than a considerable reduction up to 21 months - a phenomenon due more to environmental factors than to the materials under examination.

At 18 months (Sept. '91), the biomass values are lower than those found at 12 months (Mar. '91), and even the value at 21 months (Dec. '91) is similar to that found on the substrata after 3 months' immersion (June '90). Such quantitative reductions could be seen in relation to a reduction in the presence of Algae and to a Summer crisis (high temperature in August) with the consequent high mortality affecting also a proportion of the animal component.

On substrata immersed for 24 months there is a definite recovery in the biomass values; these reach values close to those obtained after the first year of study.

In conclusion, ash-based materials seem to be more suitable for the settlement of the macrobenthos. Since other studies have shown only a slight release of polluting metals and a weak bioaccumulation, these materials can be used for the construction of artificial reefs.

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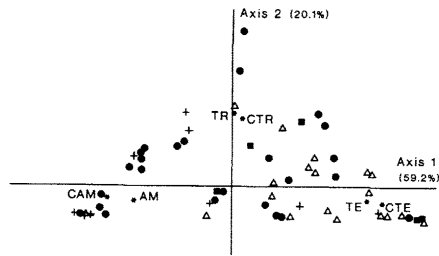


Fig. 1 - Ordination of stations and species derived from FCA
 ● Sandy bottom species ▲ Rocky bottom species
 + Pelagic species ■ Seagrass species
 neighbourhood areas.