BENTHIC ASSEMBLAGES ON CONCRETE ARTIFICIAL REEFS IN THE NORTHERN ADRIATIC SEA: COMPARISON BETWEEN TECNOREEF® PYRAMIDS AND CUBIC BUNDLES OF TUBES

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Abstract
Benthic assemblages colonising two typologies of concrete artificial reefs (Tecnoreef® pyramids and cubic bundles of tubes), characterised by different shape and material, were investigated three years after their deployment offshore to Po River Delta (northern Adriatic Sea). On both reef types large areas were covered by fine sediments, assemblages where characterised by reef building polychaetes and zoantharian. Assemblages differed among reefs but not between reef typologies, both in term of species abundance and cover percentage.
Keywords: Adriatic Sea, Artificial Reefs, Fouling, Po Delta, Zoobenthos

Introduction
Artificial reefs are manmade structures deployed on sea bottoms with the main aims: protecting and increasing biotic resources by preventing trawling, supporting sessile filter feeders, which can colonise the hard substrata and exploit water column resources, providing nourishment and refuges for motile species, attracting bentho-nectonic fishes ([1], [2]). Sessile and motile species colonise artificial reefs according to complex ecological processes affected by seasonal larval supply, water circulation, turbidity and nutrients, depths, orientation and material of the substrata ([3], [4], [5], [6], [7], [8]). The macrobenthic assemblages colonising two types of concrete artificial reefs modules, Tecnoreef® pyramids and cubic bundles of tubes differing in shape and concrete type, were investigated 3 years after their deployment in the northern Adriatic Sea.

Material and methods
The investigated artificial reefs were deployed in autumn 2006 on muddy bottom 2 nautical miles offshore of Scardovari (Po River Delta, northern Adriatic Sea, 44° 54' N 12° 33' E) at 13-14 m in depth, close to a long-line mussel farm. Reefs included a few dozen of Tecnoreef® pyramids (2 and 3 floors, 1.8 and 2.4 m height), made by 'sea-friendly' certified reinforced concrete manufactured using only natural components without synthetic additives, and cubic bundles of tubes, made by common building reinforced concrete tubes laid on a concrete slab (1.8 m height). The macrobenthic assemblages were investigated during the summer 2009 by means of destructive (scraping off 20x20 cm by hammer and chisel) and digital photographic (17x23 cm) sampling. Four reefs per typology were randomly chosen. For each reefs, 4 destructive and 8 photographic samples were collected. Species were identified to the lowest possible taxonomic level and their abundance was estimated as number of individuals per sample and/or covers percentage estimation, excluding from the pictures dark and blurred zones or portions covered by motile organisms. On pictures percentage cover of sediment was also estimated. Differences between reefs and reef typologies were assessed by uni- and multivariate permutational analysis of variance (PERMANOVA, [9]).

Results
The vertical surfaces of all the reefs were mainly covered by muddy sediments (mean percent cover 57%). Overall, 58 invertebrate taxa were identified in the destructive samples. The most abundant sessile taxa were the reef builder polychaetes (*Sabellaria spinulosa*, *Pomatoceros triqueter* and *Serpula vermicularis*), the zoantharians *Epizoanthus* sp. and the bivalve *Anomia ephippium*. In particular, *Sabellaria spinulosa* colonies, with up to 51 ind. dm^{-2} (means 16.1±5.3 ind. dm^{-2} ± e.s.), built thin crusts of fused tubes from mud, send or shell fragments. Motile fauna was dominated by the muddy tube building amphipod *Corophium acherusicum* and the fossorial polychaetes *Polydora ciliata*. Assemblage structures significantly differed between single structures but not between reef typology (i.e. shape and concrete types), both in term of species abundance and cover percentage. Similar patterns were observed in the distribution of the most abundant species.

Discussion
Both destructive and photographic samplings were able to assess the dissimilarity among single reefs and between reef typologies. No differences in density and/or diversity of the assemblages were detected between Tecnoreef® pyramids support and cubic bundles of tubes. Bio-construction processes on artificial reefs, mainly supported by calcareous algae, is generally favoured under good light conditions and low sedimentation rate ([7]). Here, under high sedimentation rate and reduced lighting conditions, *Sabellaria spinulosa*, with its sand-muddy agglomerates seem to play a relevant bio-construction and strengthening role.

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References
1 - Bohnsack J.A., Sutherland D.L., 1985. Artificial reef research: a review with recommendations for future priorities. *Bulletin of Marine Science* 37: 11-39.
2 - Baine M.S.P., 2001. Artificial reefs: a review of their design, application, management and performance. *Ocean & Coastal Management* 44: 241-259.
3 - Ardizzone G.D., Gravina M.F., Belluscio A., 1989. Temporal development of epibenthic communities on artificial reefs in the central Mediterranean Sea. *Bulletin of Marine Science* 44: 592-608.
4 - Turner S.J., Todd C.D., 1993. The early development of epifaunal assemblages on artificial substrata at two intertidal sites on an exposed rocky shore in St Andrews Bay, NE Scotland. *Journal of Experimental Marine Biology and Ecology* 166: 251-272.
5 - Rodriguez S.R., Ojeda F.P., Inestrosa N.C., 1993. Settlement of benthic marine-invertebrates. *Marine Ecology-Progress Series* 97: 193-207.
6 - Relini G., Zamboni N., Tixi F., Torchia G., 1994. Patterns of sessile macrobenthos community development on an artificial reef in the Gulf of Genoa (Northwestern Mediterranean). *Bulletin of Marine Science* 55: 745-771.
7 - Riggio S., Badalamenti F, D'Anna G., 2000. Artificial reefs in Sicily: an overview. In: Jensen A.C., Collins K.J., Lockwood A.P.M. (eds) Artificial reefs in European Seas. Kluwer Academic Publishers, Dordrecht, pp. 65-73.
8 - Nicoletti L., Marzialetti S., Paganelli D., Ardizzone G.D., 2007. Long-term changes in a benthic assemblage associated with artificial reefs. *Hydrobiologia* 580: 233-240.
9 - Anderson M.J., ter Braak C.J.F., 2003. Permutation tests for multi-factorial analysis of variance. *Journal of Statistical Computation and Simulation* 73: 85-113.