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ARTIFICIAL REEFS IN THE SPANISH COASTAL ZONE

Marta C. Gómez-Buckley and Ricardo J. Haroun

ABSTRACT

The Multi-annual Guidance Program (MAGP; 1987–1991) on artificial reefs was first undertaken by the Spanish government under the supervision of the European Economic Community. With this program, the Spanish government attempted to unify artificial reef construction criteria (i.e., materials, design, place selection, etc.), as well as ensure proper scientific assessment for all future artificial reefs to be established in the Spanish coastal zone. Before the 1987–1991 program, isolated artificial reef projects were developed along the Spanish shore by different institutions. Very few of these artificial reefs were assessed through base-line surveys before or impacts after their implementation. During the MAGP, 35 artificial reefs were constructed. The main goals of this Program were: 1) Protection of over-exploited coastal areas from trawl fisheries; 2) Development of diversified habitats to enhance biological production; and 3) To promote artisanal fishing in the surrounding areas. A brief description of the MAGP for 1992–1996 is also given.

The Spanish coastal regions have been severely affected by two general environmental problems in recent times: over-exploitation of resources and pollution. In the late 1970's and early 1980's, artificial reef technology was develop Worldwide to try to manage and mitigate these types of problems. In Japan, artificial reef technology has been utilized mainly for commercial fishery exploitation, and in the United States for recreational fishery enhancement (Stone et al., 1991). In Spain, the construction of artificial reefs was conceived to be a possible solution for over-exploitation of near-shore fishery resources. During the early history of artificial reef construction, a few of the first projects used disposal of discarded materials, such as tires, car bodies, etc., to create reef structures. Artificial reef construction techniques and designs were poorly developed in Spain until 1987, when a more serious approach was jointly undertaken by federal, regional, and local governments.

A Multi-annual Guidance Program (MAGP; 1987–1991) on artificial reefs, was carried out by the Spanish Government under the supervision of the European Economic Community (EEC). This program attempted to unify criteria (i.e., materials, design, place selection, etc.) for all the future artificial reefs to be established in the Spanish coastal zone. The main goals of this Program were: 1) Protection of over-exploited coastal areas from trawl fisheries; 2) Development of diversified habitats to enhance biological production; and 3) To promote artisanal fishing in the surrounding areas. The conditions and characteristics of the coastal areas determined the artificial reef designs required to meet the protection, restoration and production objectives.

The Spanish Ministry of Agriculture, Fisheries and Food (MAPA), identified three major areas in the Spanish coastal zone for the MAGP: Cantabric-Galician; South Atlantic and Mediterranean; and the Canary Islands (Fig. 1). This partitioning was made more for common objectives than for geographical characteristics. In the Mediterranean the main aim is to prevent illegal trawl fisheries, while more emphasis is given to restoration and production aspects in the other two areas (MAPA, 1986).

EARLY ARTIFICIAL REEF CONSTRUCTION

The first artificial reef covering approximately 1,000 m^2, was constructed in 1979 off the shore of Barcelona. Although small in scale, it was also the first in

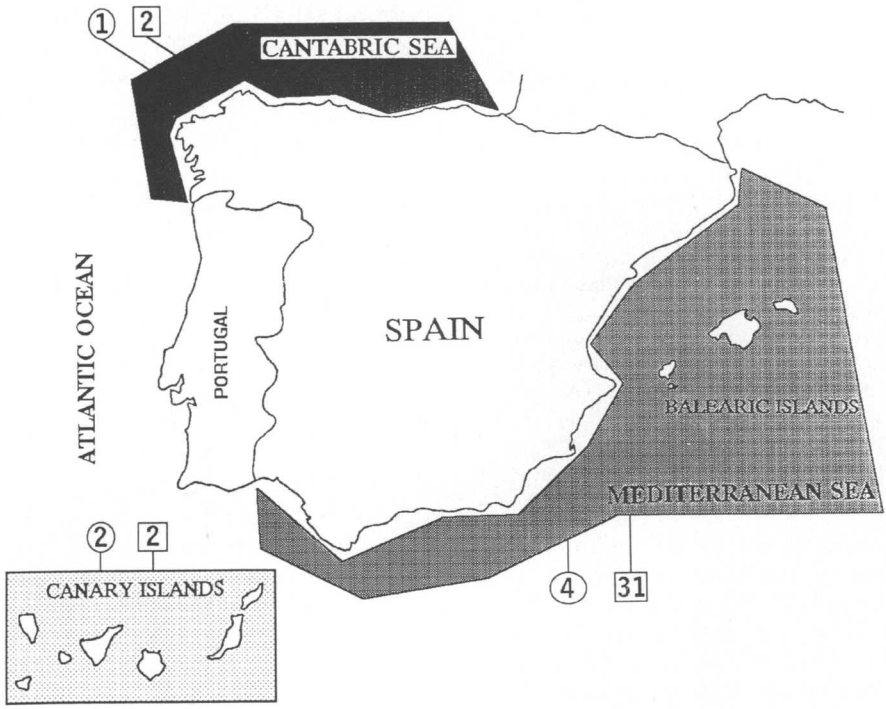

Figure 1. Number of artificial reefs built before (circles) and during (squares) the 1987–1991 MAGP, in the Cantabric-Galician area (dark colored), the South Atlantic and Mediterranean area (medium colored), and the Canary Islands area (light colored).

which several materials (concrete blocks, ceramic pieces, Fiber-cement and car bodies) were tested (Table 1). A scientific assessment of the area was undertaken before the reef was deployed (Anonymous, 1981), but none was conducted after the construction.

The funding for all seven artificial reef projects was limited to, in most cases, just the costs of placement of materials. The majority of these projects used materials of opportunity deployed by voluntary workers. As a result of these budgetary limitations, only one preliminary study of a site was done, and only two projects were assessed after the construction of the reefs (Table 1). A detailed study was carried out in the Cantabric-Galician area after reef construction (MAPA, 1986), and in the Canary Islands, a short study was developed after the construction (Castillo et al., 1988). The remainder of the artificial reefs have either failed to have an assessment, or the results have not been published.

Current Artificial Reef Construction

From 1987 to 1991, the construction of artificial reefs in Spain was done in accordance with the MAGP and the (EEC) Regulation 4028/86. The EEC Regulation advises that the criteria for selection of sites and materials, as well as deployment plans for the artificial reef modules, should be dictated by the federal government of each country. In Spain, the Federal government through the MAPA manages the artificial reef program. Regional governments are the starting point of this process. According to the budgets established for each year, both federal

Table 1. General data of the artificial reef construction in Spain, grouped in three periods: 1979–1986, 1987–1991, and 1992–1996 (data incomplete for 1992–1996)

Period of construction	Total reefs	Pre-construc. assessment	Post-construc. assessment	Material use	Artif. reef area (sq. m)	Depth (m)	Objectives	Investment (U.S.$)†
1979–1986	7	1	2	Materials of opportunity (mainly)	30–1,000	10–42	Reycling, protection	Unknown
1987–1991	35	35	35	F.C.M.*	4,000–250,000	10–40	restoration, protec. production and recreation	10,467,000
1992–1996	78 (planned)	—	—	Wooden vessel bodies and F.C.M.*	—	—	restoration, protec. production and recreation	43,730,000 (planned)

* Fabricated concrete modules.
† Rate of exchange peseta-U.S.$ based on average 1991 market values.

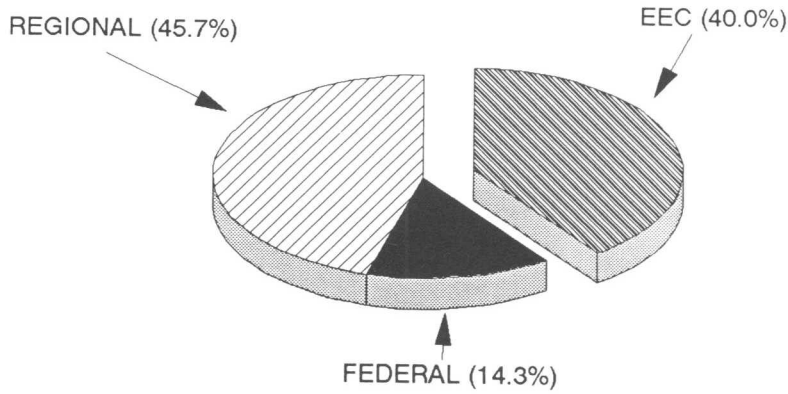

Figure 2. Percentages of funding by federal government, regional governments and the European Economic Community, for all artificial reefs (35) built during the 1987–1991 MAGP.

and regional governments determine the artificial reef policy for each region for each 5-year period.

As a result of the MAGP, all governmental agencies expect that future demand for artificial reefs will be generated from the public, specifically fishermen co-operatives. Other local agencies or private enterprises may also be interested in artificial reef construction to enhance marine resources, to increase public awareness of the need to protect coastal areas, or for recreational fishery purposes.

Funding for all artificial reefs planned and built during the MAGP was supplied either by the EEC or the federal and regional governments. Of the total of 35 reefs, 14 were funded with EEC grants, while the remainder were financed exclusively by the federal and regional governments (Fig. 2; MAPA, 1991).

The complex funding process for an artificial reef project is compiled in the Official Bulletin of Spain (REAL DECRETO 222/1991) and the EEC Regulation. Each of the projects that applied for EEC funding and were approved, received

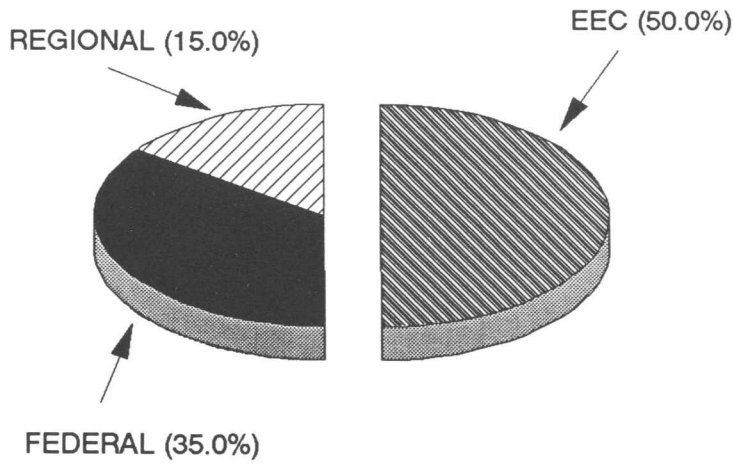

Figure 3. Distribution of funding for each of the 14 artificial reef projects approved by the European Economic Community during the 1987–1991 MAGP.

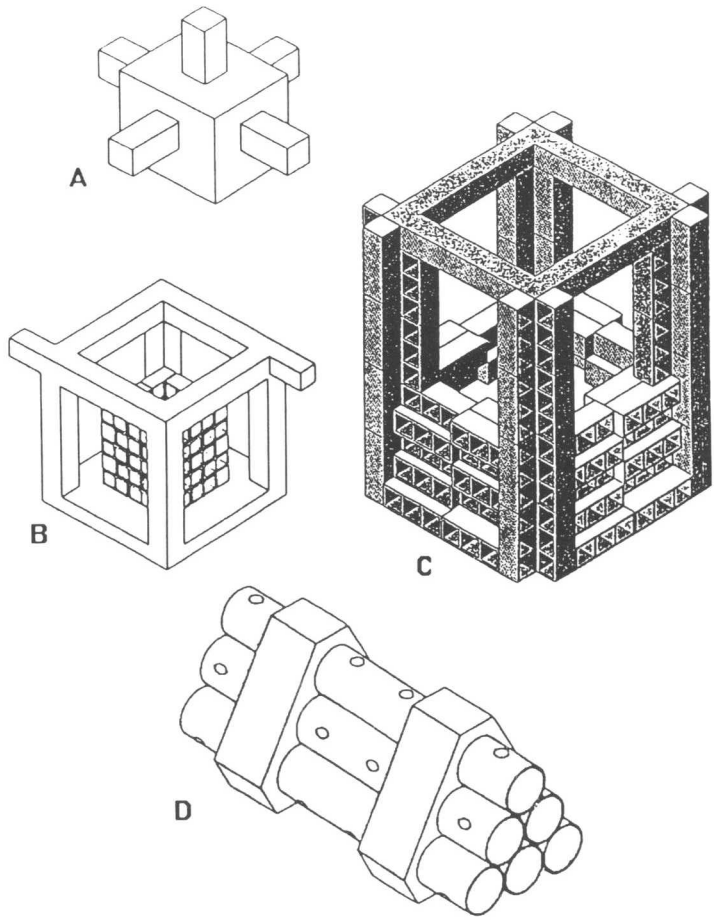

Figure 4. Some of the fabricated concrete blocks used in the construction of reefs in Spain. Anti-trawling structures (A) have a relative weight/volume ratio higher than the restoration and production modules (B, C and D).

50% of the total budgeted for the reef from the EEC. The remaining costs were financed by the federal government (35%) and regional governments (15%; Fig. 3). This percentage covered during the MAGP by regional governments exclusively, may be financed in future programs by other public sources, such as fishermen cooperatives and local organizations or agencies (MAPA, 1986).

The total investment expected for the MAGP was US$ 22,500,000. According to recent data from the federal government (MAPA, 1991), the actual amount expended was US$ 10,467,000 (Table 1), with a mean cost per reef of US$ 299,000. From a total of 45 reefs planned, 35 were actually built. These figures, which are lower than expected, are apparently related to the 1987–1991 MAGP being the beginning of the spanish government policy on artificial reefs.

The materials and structures stipulated to meet the MAGP objectives were fabricated concrete modules. Some of these structures are shown in Figure 4. There are two groups of modules: the ones designed exclusively to stop illegal trawl fisheries (Fig. 4A), and those designed for restoration and production of biological resources (Fig. 4B, C and D). The first group consists of heavy blocks

Figure 5. Group of fishes (Serranidae and Mullidae) gathering around a concrete module (design C in Fig. 4) of an artificial reef in the Mediterranean (northeast shore of Spain), 1 year after construction in 1987.

with sharp and acute projections so that trawl nets which became tangled on these modules would be severely damaged (size approximately 1 m^3, 2–3.5 mt). The second group consists of designs with numerous hollow spaces on the surfaces of the modules (size range 16–30 m^3, 6–16 mt; Goutayer, 1988; Ojeda, 1990; TASA, 1991), apparently to facilitate increased biological production.

Discussion and Conclusions

Until 1987, artificial reefs in Spain were approached mainly as a way to dispose of solid waste materials and, as a collateral benefit, to enhance artisanal fisheries and prevent illegal trawling. The established guidelines in the MAGP (1987–1991) mandated the use of fabricated concrete structures as the sole material used in the reef construction. Other restrictions imposed by this program were that artificial reef projects financed with either EEC or other public funds must 1) be scientifically assessed for stability of the modules and biological development during at least 3 years after the deposition of the reef, and 2) preclude all fishing activity on the surroundings of the artificial reef during these 3 years.

A proposal for the second MAGP (1992–1996) was presented to the EEC in Brussels (Belgium) by the Spanish government. The EEC approved this Program in December, 1991. The summary of this program included an overview of the previous period (1987–1991) and listed the objectives, distribution, and funding for the artificial reef projects during a next 5 years (MAPA, 1991). There are two significant differences from the previous MAGP; the creation of marine sanctu-

aries, and the use of duly prepared wooden fishing vessels as artificial reefs. The artificial reefs built with fabricated concrete structures will be the only projects funded by the EEC or the Spanish governments (federal, regional or local agencies). The discontinued use of one of the artificial reef modules (Fig. 4D) during the second MAGP, is another difference with respect to the first MAGP. This module design used asbestos as one of its constituent materials, the toxicity of this substance resulted in the modules not being recommended for deployment.

The 1992–1996 MAGP should develop a better understanding and coordination between the different organizations involved (federal, regional and local governments, agencies, and universities charged with the scientific assessment of the reefs, etc.). This will lead to a more efficient process of construction and installation of artificial reefs. During the 1987–1991 MAGP, some of the planned reefs were delayed or not constructed due to a lack of coordination between the administrations involved.

Despite all of the problems, the encouraging results of the 1987–1991 MAGP are being corroborated by data from scientific assessments that are now being revealed. In some cases, such as the Calafell artificial reef (North-east Mediterranean shore; Fig. 5) installed in 1987, fishermen are reporting better catches than before the artificial reef was developed (J. Goutayer, Tecnología Ambiental Sociedad Anónima, pers. comm.) when the area was exposed to an over exploitation of resources. This and many other reefs built during the 1987–1991 MAGP are positive examples for which results are now being verified by scientific publications (J. Goutayer, Tecnología Ambiental Sociedad Anónima, pers. comm.; Moreno et al., 1994; Bayle-Sempere et al., 1994; Haroun et al., 1994; Guillén et al., 1994). This assessment work will serve as a baseline for future artificial reef programs in the waters of Spain.

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ADDRESS: *(M.C.G-B.) School of Fisheries WH-10, 121-A Fisheries Center, University of Washington, Seattle, Washington 98195; USA; (R.J.H.) Departamento de Biología, Facultad de Ciencias del Mar, Universidad de Las Palmas de Gran Canaria, 35017 Las Palmas (Canary Islands) Spain.*