Project funded by the EUROPEAN UNION

Common borders. Common solutions.

Artificial Reefs in the Black Sea
Training Reference Book

CROSS BORDER COOPERATION

European Union

The European Union is a unique economic and political partnership between 27 European countries. In 1957, the signature of the Treaties of Rome marked the will of the six founding countries to create a common economic space. Since then, first the Community and then the European Union has continued to enlarge and welcome new countries as members. The Union has developed into a huge single market with the euro as its common currency.

What began as a purely economic union has evolved into an organization spanning all areas, from development aid to environmental policy. Thanks to the abolition of border controls between EU countries, it is now possible for people to travel freely within most of the EU. It has also become much easier to live and work in another EU country.

The five main institutions of the European Union are the European Parliament, the Council of Ministers, the European Commission, the Court of Justice and the Court of Auditors.

The European Union is a major player in international cooperation and development aid. It is also the world's largest humanitarian aid donor. The primary aim of the EU's own development policy, agreed in November 2000, is the eradication of poverty.

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BLACK SEA AND ITS ENVIRONMENTAL PROBLEMS

The Black Sea is well isolated geographically ecologically and biologically and it is a typical example of a semi-enclosed, intercontinental sea. It is an Eurasian sea, whose waters, from the west and the north are washing the coasts of the European countries (Bulgaria, Romania, Ukraine and Russia) and, from the south and the east the countries of Asia (Turkey and Georgia).

The drainage basin of the Black Sea exceeds 2,300 million km² and, entirely or partly, covers the territory of 22 countries in Europe and Asia – 6 already named riparian countries and 16 countries of Central and Eastern Europe. Their contribution to the catchment area of the Black Sea is quite different. In this territory are located huge agricultural areas, large industrial centres, and dozens of large cities including many state capitals. More than 300 large and small rivers flow directly into the sea from the catchment basin of the Black Sea.


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The Black Sea, as any other marine basin, has its ecological problems related to human activities and because it is almost isolated from the World Ocean, these problems are more acute than those in open marginal seas having a free water exchange with the ocean:

- massive pre-fertilization of Black Sea with nitrogen and phosphorus compounds known as “anthropogenic euthrofication*”
- disposal of unsufficient purified wastewaters
- degradation of bottom algal communities
- oxygen deficiency in near-bottom water layers
- unmanaged overfishing and bottom trawling
- distribution of invasive species;
- lack of information and economic difficulties.

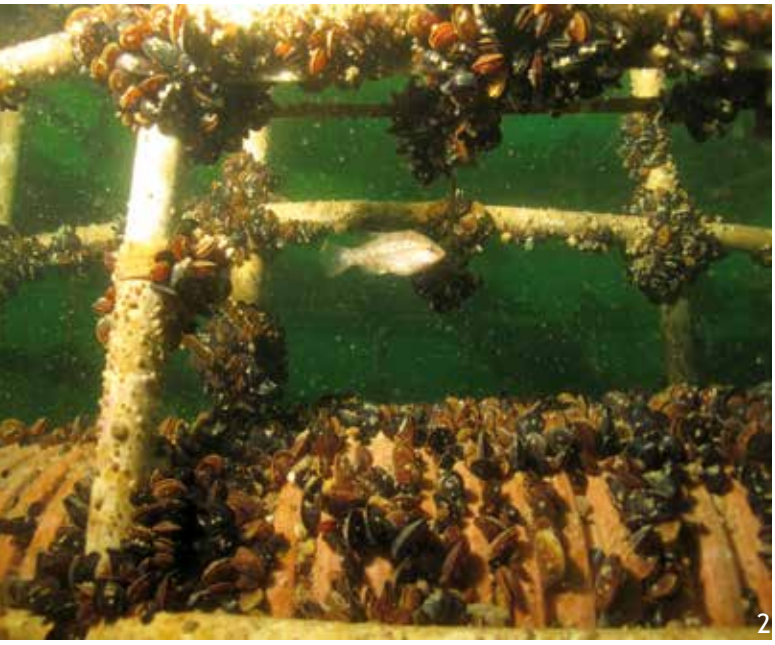
**EUTROPHICATION*

Eutrophication is when the water becomes enriched with nutrients. This causes a problem in marine habitats due to the algal blooms:

- Fertilisers used in farming, run-off into water causing an increase in nutrient levels. Large quantities of nutrients run-off into the marine environment from wastewater from the settlements.
- This causes phytoplankton to grow and reproduce more rapidly, resulting in algal blooms.This bloom of algae disrupts normal ecosystem functioning and causes many problems.
- The algae may use up all the oxygen in the water, leaving none for other marine life. This results in the death of many aquatic organisms such as fish, molusc and crustacean, which need the oxygen in the water to live.
- Mass bloom of algae may also block sunlight from photosynthetic marine plants under the water surface.
- Some algae even produce toxins that are harmful to higher forms of life.

ARTIFICIAL REEFS

Artificial reefs are often defined as any human-made structure or equipment deliberately placed in marine environment where that structure does not exist under natural circumstances. Artificial reefs are used as a tool to improve the state of aquatic ecosystems and evironment. Deploying artificial constructions in support of fishing and aquaculturing was widely used for a long time, but now other applications are also developed like: restoration of marine environment, sustainable management of natural resources, scientific experiments as well as tourist attraction.



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**ARTIFICIAL REEF*

The following definition has been adopted to promote a common understanding of the term, and to serve as standard definition. The definition has been derived from the interational legislation and related guidelines:

"An artificial reef is a submerged (or partly exposed to tides) structure deliberately placed on the seabed to mimic some functions of a natural reef, such as protecting, regenerating, concentrating and/or enhancing populations of living marine resources. This includes the protection and regeneration of habitats. It will serve as habitat that functions as part of the natural ecosystem while doing "no harm".

The term excludes artificial islands, cables, pipelines, platforms, mooring, and structures for coastal defence (e.g. breakwaters, dikes, etc.) which are primarily constructed for other purposes, as well as the Fish Aggregation Devices (FADs) employed to merely attract fish in certain fishing areas.

Objectives of Artificial Reefs:

Artificial reefs are used in coastal waters worldwide for many applications, e.g.:

- protecting sensitive habitats from fishing activities;
- restoring depleted habitats;
- mitigating habitat loss;
- enhancing biodiversity;
- improving populations of aquatic organisms by providing shelter for juvenile and mature individuals as well as for adults during delicate life stages (e.g., moulting season for crustaceans);
- providing new substrates for algae and mollusc culture;
- enhancing professional and recreational fisheries;
- creating suitable areas for diving;
- providing a mean to manage coastal activities and reduce conflicts;
- research and educational activities;
- creating potential networks of Marine Protected Areas to manage the life cycles of fish and connectivity.

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Use of Artificial Reefs and Expected Impacts on the Marine Environment

In the first case the aims are short-term while for the purpose of the improvement and management of the environment it is expected that reefs resemble the natural structures, to progress and stay unchanged long enough to fulfill their function. Investigations in the Mediterranean shows that 5 years is a sufficient period of time for developing a stable community, excluding the case when the environments are of olygotrophic character. Using artificial reefs for improving ecological state of marine environment such as for example, using filtrations for coping with the consequences of local eutrophication events caused by diffuse sources and leading to intensive local phytoplankton blooms and reduces water quality is a relatively new application.

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Mediterranean Mussel Aquacultures in the Black Sea and Bulgaria

The only filter feeding invertebrate of commercial interest in the Bulgarian part of the Black Sea that is currently cultured and harvested is the Mediterranean mussel *Mytilus galloprovincialis*. The first attempts to develop aquacultures for these mussels were carried out in the early 1970s. The most suitable seasons for larval settling, growth rates, rates of biomass production and seasonal yields were established. The density of the population should be also actively managed. Currently, the Mediterranean mussel aquaculturing has a successful story in Bulgaria (around 43 active mussel farms). However, investigations on their effect on the coastal ecosystems are still lacking.

Site Evaluation for Artificial Reef Deployment

From the environmental point of view, the proper location of an artificial reef is essential to optimize its ecological features and can strongly influence the expected effects from its establishment. Physical and chemical variables including sediment type, depth/bathymetry, currents, waves, sedimentation rate, water turbidity, salinity, nutrients as well as ecological features should be taken into account in the identification of the artificial reef location. The stability of a reef is also related to its structural characteristics (i.e., weight, density and design of modules). On muddy bottoms, strong currents and wave action can cause sediment movement leading to sinking and scouring, with consequences leading to the destruction or displacement of the artificial structures. Proximity of the deployment site to sources of pollution may lead to accumulation of contaminant in the organisms inhabiting the artificial reef. In general, artificial reefs should not be deployed on rocky substrates, existing biogenic reefs or inside sea grass meadows unless the reef is not realized to restore an existing damaged habitat. In general, prior to artificial reef deployment, the different users of the area and potential stakeholders of the reef should be adequately informed on the reef project and their viewpoints should be considered in the selection of the reef site.

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Materials

First of all, the materials should be inert to avoid pollution and bioaccumulation of contaminants in the environment and in the aquatic organisms. The choice of the material should also consider the resistance to the chemical and physical forces in constant action in the marine waters, the time-life, and the suitability for colonization by benthic communities. A wide range of natural and man-made materials have been used in artificial reef construction. Natural materials include rocks, shells and wood, the latter being less durable over time due to the action of burrowing organisms. Rocks can be scattered on the seabed or deployed in chaotic piles or assembled inside frames made of steel, iron, plastic or wood. Concrete, iron, steel, and plastic are the most often used artificial materials worldwide. Fiberglass, coal ash by-products, ceramic, and ferro-cement have been also utilised. These materials facilitate the pre-fabrication of specifically designed modules prior to water transport to the deployment site.


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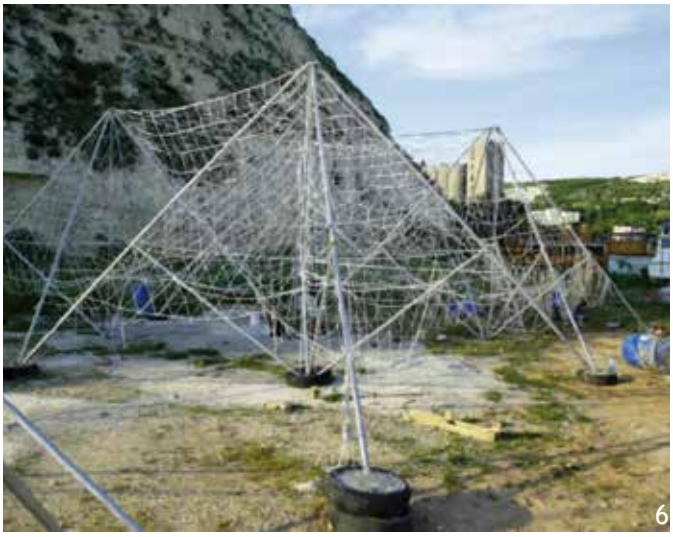
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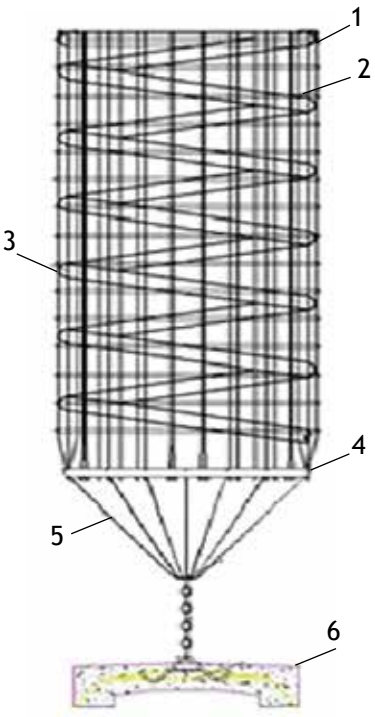
Design of Vertical Floating Artificial Reef

The vertical reef, used by the REEFS Project is a cylindrical floating structure built of polypropylene pipes and attached to the bottom with a concrete anchor. The corresponding available free surface per square meter of bottom provided by the artificial reef is 15.8 m2, which is significantly higher than other popular types of artificial reefs and mussel aquaculture devices used in the Black Sea.

Two types of vertical serpentine mussel reef modules are used: -shallow water type 7 m from the sea botom, and deep water type 12 m from the sea botom.

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Legend

1. PP Pipe Ø 20
2. PP Pipe Ø 25
3. PP Corrugated pipe / Floater
4. PP Ring Ø 90
5. Stainless spokes
6. Concrete anchor
7. Safety signalization - buoy (see Pic. 11)

Filtering and Metabolic Activity of Reef Communities of Mediterranean mussel *Mytilus galloprovincialis*

The mussel bioceoenosis that colonized the studied reefs in the summer of 2015 has a substantial local influence on the processes in the water column surrounding them. The theoretical estimations of the metabolic activity of these mussels show that a single shallow water type reef can remove over 12,5 kg of nitrogen from the marine environment during the course of its complete development (~2 summer seasons). In theory,

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over 4000 reefs of this type will be necessary for the removal of the total amounts of nitrogen released in the marine environment by local sources of pollution. This estimation is a good indication of the applicability of these systems as a means for mitigation of eutrophication stress in the coastal marine environment, as well as of the severity and cost of this problem.

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Impact on Ichtiofauna

The artificial reefs create a suitable environment for some of the typical fish species in the area. An increase in species diversity and numbers was noted during the period of the study. This increase was mostly due to the development of the Mytilus biocoenosis on the reef surface, which created a food sources and suitable microhabitats and spawning areas for benthic fish species, as well as for pelagic migratory species with commercial values such as the Black Sea horse mackerel (Trachurus mediterraneus ponticus). The long-term effects of the development of the artificial reef ecosystem requires a continuation of the surveys.

THE LEGISLATION ON ARTIFICIAL REEFS IN BLACK SEA REGION

The laws of the Black Sea countries differ both by the content of specific rules and by the name of individual acts; by the authorities, which appear competent on artificial reefs subject and by the way of implementation of these standards.

International Agreements

Universal and Regional Agreements

An important component of the national framework is the number of international agreements to which the Black Sea countries are parties. Some of the main universal international agreements are mentioned hereunder:

Maritime law agreements: Convention on the Prevention of Marine Pollution by Dumping Wastes and Other Matter, London, 1972, as amended with Protocol of 1996 to Convention on the Prevention of Marine Pollution by Dumping Wastes and Other Matter; etc.;

Special environmental agreements: Aarhus Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters, Aarhus, 1998; Convention on the Conservation of European Wildlife and Natural Habitats, Bern,1979; Convention on the Conservation of Migratory Species of Wild Animals, (CMS), Bonn, 1979; Convention on Environmental Impact Assessment in a Transboundary Context, Espoo, 1991; etc.;

Natural/Cultural heritage agreements: Convention on the Protection of the Underwater Cultural Heritage, 2001; etc.;

Regional seas agreements: Convention for the Protection of the Black Sea Against Pollution, Bucharest, 1992; Protocol for protection of biological and landscape diversity in the Black Sea to the Convention for the Protection of the Black Sea against Pollution, signed on 14 June 2002.


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European Union Law

EU law counts that two of the countries (Bulgaria and Romania) are already members of the European Union and one more country (Turkey) is in the process of applying for EU membership. Many acts can be mentioned in this field, mostly related to the implementation of policies for fisheries and ecology and in particular the problems of integrated marine and coastal zone management. In general there are two groups of acts related to artificial reefs in the EU law:

1) Acts mainly related to the problems of fisheries and aquaculture in general terms with the problems of the Common Agricultural Policy;

2) Acts related to environmental issues including the problems associated to biodiversity/NATURA 2000, Water and the specific problems of the marine environment.

ECONOMIC PERFORMANCE OF ARTIFICIAL REEFS IN THE BLACK SEA

Preliminary results from the Evaluation the economic performance of artificial reefs in the Black sea indicate that the direct provisioning services of Mediterranean mussel aquaculture on vertical artificial reefs in the Black Sea could return the investments in the reef module in about 5 years. The indirect provisioning, as well as supporting and cultural ESS of reefs would provide additional economic value to the coastal ecosystems and local communities.

The World Bank envisages that by year 2050 global food production will have to increase by 50% to satisfy the growing demand of the swelling world population. Aquacultures will have to play a key role in the future global food security: the baseline scenario predicts that by 2030 they will provide over 60% of the world consumption of fresh and seawater products, or around 10% of the animal proteins. Aquaculture production had an average annual growth of 8% in the last three decades thus being one of the fastest growing industries in the world. Marine mollusks are especially promising in this respect: they feed by filtering their environment; moreover, they have a very high utilization rate of the living space, producing up to 20 tons of edible product per hectare, compared to 1.1 tons for pigs and 1.2 tons for chicken. During their growth phase mollusks do not generate, but absorb nitrous and phosphorus emissions: 27 and 29 kg per ton protein, respectively.

The benefits of artificial reefs reveal themselves in two main aspects. Firstly, they contribute to the food security thanks to the aquaculture and/or their positive effects on the fish stocks. They create employment and the local communities generate incomes. On the other hand, they may be used as a tool for improving the quality of the coastal ecosystems. This on its part promises further benefits for the tourism and fishing industry and for the general quality of life in the coastal zones. The need for public financing for constructing artificial reefs in the Black Sea, so as the numerous vested interests along the coastline.

ECOSYSTEM SERVICES OF ARTIFICIAL REEFS IN THE BLACK SEA

A basic systematization of the ecosystem services (ESS) provided by artificial reefs in the Black Sea is attempted here below.

I. Provisioning ESS

- Food (aquaculture) – measured in monetary and nutritional terms;
- Employment (income) from aquaculture;
- Additional catch for artisanal fishery;
- Additional catch for sport fishery.

II. Supporting ESS

- Purification of seawater: higher transparency of the water column;
- Fixation of the excessive phosphorus and nitrogen in the nutrient cycle and prevention of eutrophication;
- Assisting the recovery of mature ecosystems with high biodiversity;
- An obstacle to bottom trawling, recovery of the benthos.

III. Cultural ESS

- Sites for diving tourism;
- Preservation of the archeological and cultural heritage on the sea bottom (impeding the bottom trawling);
- Healthier ecosystems: higher quality of life for local people and higher customers' satisfaction in mass tourism;
- Educational sites for students and research objects for scholars.

Each of the abovementioned 12 basic ESS may be endowed with a monetary value, even if with different precision.

Evaluating Ecosystem Services of Vertical Floating Modules of Artificial Reefs in the Black Sea

The revenue of aquaculture produced on artificial reefs depends on three variables: quantity produced sale prices and costs (constant and variable). The annual production is determined by the specific life cycle of the Mediterranean mussel in the Black Sea. The growth rate of *Mytilus galloprovincialis* varies in accordance to the water temperature, available nutrients and many other environmental factors. According to most authors the Black Sea mussels reach a marketable size of 50-60 mm during the two warm (spring and summer) seasons.

Musselsproduction costs are not negligible. The initial investment per vertical module is 4 500 EUR (2 200 EUR for the shallow water module), not including installation and transportation costs.

The artificial reefs should be intermittently monitored and repaired by divers. Gathering of aquaculture will also have to be executed by diving specialists, and there are assumptions that this is the most critical part of the business plan.


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The economic perspectives for producing aquaculture with the sustainable technology of vertical artificial reefs in the Black Sea are excellent. Still the business environment in this region indicates that factors that determine the market success are far from being only economic.

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REEFS Project

Research and Restoration of the Essential Filters of the Sea (REEFS) is a pilot project focused on the scientific research of environmental impact of the artificial reefs in the area of Black sea countries.

REEFS Project is a joint cross-border initiative of five partners from the riparian countries – Bulgaria (Bulgarian Biodiversity Foundation), Ukraine (Institute of Marine Biology of the National Academy of Science of Ukraine), Romania (Mare Nostrum NGO), Georgia (Ilia State University) and Turkey (Karadeniz Technical University).

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