

## *Дискусии*

### STATIONARY ECOLOGICAL COMPLEX

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The article describes a hybrid marine structure, a stationary ecological complex composed of an artificial reef, mussel farms, and an artificial island. Its numerous advantages over existing structures are highlighted, and it is anticipated that experiments will confirm that it is the most affordable, effective, and profitable marine facility created, solving a number of current problems simultaneously.

**Keywords:** artificial reef, mussel farm, artificial island, carbonate beach generation, carbon dioxide removal.

### СТАЦИОНАРЕН ЕКОЛОГИЧЕН КОМПЛЕКС

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**Резюме:** Стационарният екологичен комплекс (СЕК) представлява морско хидротехническо съоръжение, изградено от изкуствен риф (ИР), ферми за миди (ФМ) и изкуствен остров (ИО) по начин, улесняващ тяхната експлоатация. Очаква се при оптимални условия от него да се получават годишно минимум 40 t миди. При обединението на четири СЕК в по-голяма квадратна структура и използването на плаващ кран ще се получат 160 t миди (печалбата на всеки собственик ще възлиза на 60 000 лв.). Особено внимание заслужават получените от тях 80 t черупки (неразтворим  $\text{CaCO}_3$ ), от които 35.2 t представляват безплатно абсорбиран от мидите и обезвреден  $\text{CO}_2$  под формата на

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карбонатни наноси за биогенно плажообразуване. Експериментите ще дадат по-точна информация за улова на риба, миди и рапани от съоръжението.

**Ключови думи:** изкуствен риф, ферма за миди, изкуствен остров, образуване на карбонатни плажове, обезвреждане на CO<sub>2</sub>.

Over the last four decades, the Bulgarian Black Sea coastal zone and shelf have experienced a significant natural (“bio-geoecological”) catastrophe resulting from the inability of our marine science to solve marine problems (Parlichev, Stoykov. 2014; Parlichev, 2016). We would like to remind of the catastrophe because there has been complete silence on the subject, ostensibly to avoid responsibility. Our primary aim is to emphasize the need for experimentation and the deployment of methods and structures to overcome the catastrophe. The first, already patented result (Parlichev, Parlichev, 2022) is presented here in a synthesized form, highlighting its most important advantages and benefits. This is particularly important, as no similar structures have been developed in Europe thus far (Kalinov et al., 2020). The proposed structures are designed according to the bioengineering method developed by the authors. The stationary ecological complex (SEC) is a marine hydraulic facility composed of an artificial reef (AR), one to four mussel farms (MF), and an artificial island (AI) (Fig. 1). The artificial reef (Parlichev, Parlichev, 2023, Fig. 3) consists of a square vertical prism, built from four vertical beams at its corners, standing on square, prismatic, hollow bases, and connected in the lower, middle, and upper parts by three sets of horizontal beams. The artificial reef itself is located between the middle and upper beams, with floors made of horizontal and vertical perforated panels, forming square compartments.

The extensions of the upper horizontal beams serve to attach the mussel farms around the artificial reef. The artificial reef can support one to three mobile mussel farms, and most commonly, the artificial island, which rises above the water level – a square horizontal platform above four vertical beams at its corners. As a rule, for stability in the coastal zone and for convenience during operation, four interconnected SEC (a square), consisting of an artificial reef, a mussel farm, and an artificial island, are installed. A top view (Fig. 2) shows only the surface of the four islands, each with 16 square meters of horizontal area, on which a total of 64 evenly distributed small square openings can be seen, allowing for fishing in the four artificial reefs below them. The artificial islands are located several meters above the water surface and remain unreachable even by the highest waves (for Varna Bay, those are 6–8 m (Rozhdevstvenski, 1978; Georgiev, 2000), i.e., artificial reefs should be 4.5 m above sea level). The artificial island can be mounted directly on the artificial reef, where hydrodynamic conditions do not allow mussel farms between them. In almost all cases, however, the first mussel farm, the one around the artificial reef, is also possible. With it, the SEC can also be installed in shallow waters at a depth of 8 meters.

The SEC is primarily designed for use in the Bulgarian Black Sea coastal zone, specifically at a depth of 0–30 meters, which is commonly known as the underwater coastal slope. The simplest type is an artificial reef with a mussel farm around it and an artificial island, while the most complex is an artificial reef with up to four mussel farms and an artificial island. The first one can be used almost everywhere in shallow waters, the second one – in relatively quiet and protected areas such as the bottoms

of bays (e.g., the resort complexes of Albena, Golden Sands, Sunny Beach, etc.), and the intermediate cases will depend on specific conditions.

To understand the function and significance of SEC, we will highlight the most important advantages and benefits of using this complex in the coastal zone, which is the most productive region of the country.

- The comparatively lower cost of the SEC is evident. If built and used separately, the artificial reefs, mussel farms, and artificial islands would be much more expensive and less efficient. By combining the artificial reef, mussel farm, and artificial island in a SEC, the mussel farm and artificial island are supported by the artificial reef, and fishing is possible both within and around the artificial reef and mussel farm structures. Simultaneously, the artificial reef and mussel farm act as food depots for fish, increasing their population and concentrating it in and around these structures, resulting in an inexhaustible source of fish, mussels, and Rapa whelks – a phenomenon known as the “synergistic effect”.

- Each SEC provides opportunities for sport fishing, mussel harvesting, spearfishing, and ecological Rapa whelk collection by divers, as the whelks thrive under the artificial reef and mussel farm.

- The Mytilidae family species, including the Black Sea mussel (*Mytilus galloprovincialis*), are cosmopolites (Gaitán-Espitia et al., 2016) and form the basis of marine aquaculture, with increasing production worldwide (FAO, 2022). These facts, combined with the use of proven technologies such as artificial reefs, mussel farms, and detached breakwaters to develop the SEC, ensure the scalability of applying the bioengineering approach to marine and coastal conservation worldwide.

- Mussels are the most intensive filter feeders, resulting in clearer waters off the shores of our seaside resorts.

- Most probably, the deployment of the first SECs is expected to begin off the shores of the largest Bulgarian seaside resorts, primarily because those resorts can afford to purchase them and will also benefit economically and recreationally from their installation, which will result in turning those resorts into world-famous tourist destinations, at least for a certain period of time.

- SEC features a large number of collectors, particularly those with three or four mussel farms, which require rapid thinning performed using a floating crane and a team of 4–5 divers and 20–30 workers within a single working day. By consistently using workers for the thinning process, SEC provides a solution to unemployment among the unskilled labor force on the Bulgarian Black Sea coast.

- Mussel harvesting through mechanized floating cranes will be required if the annual harvest from each SEC is at least 40 tons of mussels. At a market price of 2 BGN/kg, this would result in an annual income of 80,000 BGN and a net profit of 60,000 BGN per owner.

- Collecting the mussels from a single SEC using a floating crane would take approximately 2–3 hours, so it is necessary to connect four SECs into a quadruple structure (Fig. 2). This approach will increase the stability of the SEC several-fold and will enable the efficient use of a floating crane, divers, and thinning workers for a single working day. The cost for these services is estimated at 20,000 BGN per owner.

- Consider the potential profit of 60,000 BGN – each of the four owners gets to receive this income without having lost almost any time, effort, resources, labor,

materials, electricity, etc. The sea and the mussels work continuously throughout the year, resulting in a potentially profitable profession of a SEC owner. With sufficient funding for four SECs, the total annual mussel harvest could reach 160 tons, resulting in a gross profit of 240,000 BGN.

- 160 tons of mussels contain 80 tons of mussel shells (insoluble  $\text{CaCO}_3$ ), which in turn result from the free absorption of 35.2 tons of  $\text{CO}_2$  through the water from the air, i.e., \$42,240 is saved, which some foreign companies have to pay for extracting and disposing of the same amount of  $\text{CO}_2$  (Parlichev, 2018). So far, it remains unclear how much  $\text{CO}_2$  is transformed into  $\text{CaCO}_3$  in the shells of the Rapa whelks under and around the SEC, as well as on the walls of the AR.

- Let us also consider the following facts: the fight against global warming, which is currently the most challenging and costly effort undertaken by nations worldwide, can be transformed into one of the most lucrative economic activities. Free capital can be attracted to that sector, resulting in increased and accurately reported efforts and contributions by individual countries in the battle for human survival. Something that all international treaties and agreements have failed to achieve to date.

- The artificial reef and mussel farm act as hard substrates, food depots, and concentrators for mussels and fish, while the artificial reef acts as refuges, shelters, spawning grounds, and sources of larvae, micro-, meso-, and macrobionts, but the potential to increase fish productivity and the income from fisheries remains uncertain without proper experimentation. Nevertheless, it is likely that the benefits to fisheries will be comparable to those obtained by harvesting mussels. The difference is that the beneficiaries will not only be the owners of the SEC structures but also amateur fishermen, who will have the opportunity to participate in recreational fishing activities and potentially increase their income.

Though it's not possible to cover the extensive advantages and benefits of SEC, which directly affect the material and spiritual spheres of society, it is only logical to wait for SECs' verification and evaluation following initial trials. However, it is essential to remind certain ministries and departments of their obligations, which they traditionally may not recognize as their own. For instance, have the Ministries of Culture and Tourism considered the potential transformation of the natural and cultural heritage site of Cape Kaliakra into a hazardous sea stack, which could become unsafe for visitors within the next fifty years? These ministries are also obliged, together with the Ministry of Environment and Water, to insist before the Ministry of Regional Development and Public Works on the immediate protection of its eastern cliff from the sea. The Ministry of Regional Development and Public Works has hardly thought about why "Geozashtita" Ltd. – Varna allowed the destruction of the wonderful restaurant at Cape Galata and did not protect the Trakata coast, and instead of a beach, a useless and threatening 8-kilometer-long dike between Albena and Balchik was created. The Ministry of Environment and Water has numerous reasons to consult the marine science community in Varna regarding the bio-geoecological catastrophe along the Bulgarian Black Sea coast. However, the Ministry would not receive answers because the marine science community currently lacks a clear action plan, resists external input, and is not held accountable for the damage caused to the coastal area.

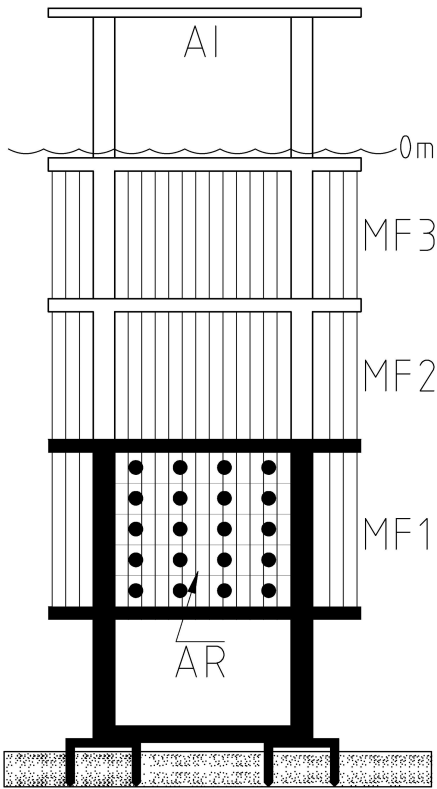


Fig. 1. Schematic of the arrangement of the mussel farms, artificial reef, and artificial island in the stationary ecological complex

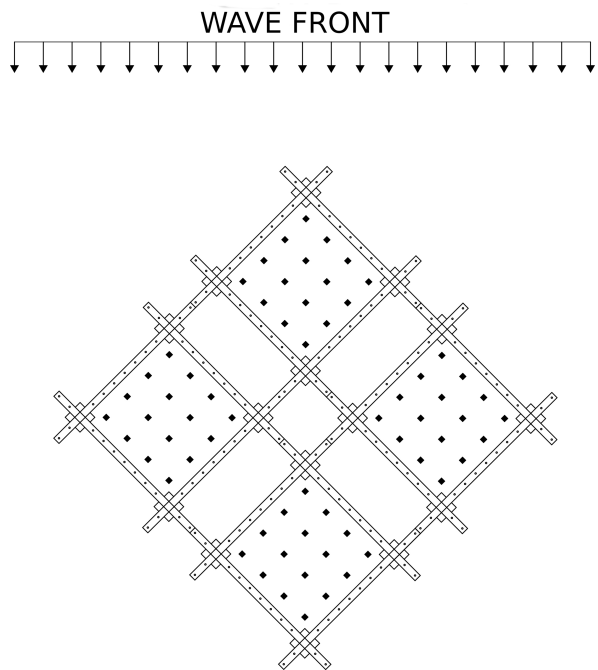


Fig. 2. General view of the quadrangle of four artificial islands – top view

## CONCLUSIONS AND RECOMMENDATIONS

1. We propose the implementation of Stationary Ecological Complexes (SEC), which can concentrate and retain tens of thousands of tons of mussels and fish inside and around themselves, facilitating their catch and delivery to the shore using floating cranes in the shortest time possible.

2. SECs will transform mussel harvesting into a lucrative and environmentally friendly activity, promising to attract free capital towards this sector in the near future, minimizing the time, effort, money, materials, and electricity spent to obtain the product.

3. Considering that 50% of the mussel's weight is shell made up of insoluble  $\text{CaCO}_3$ , which is derived from the free absorption and neutralization of  $\text{CO}_2$  from the water and air by the mussels, mussel farming through SECs may prove to be one of the most effective methods to combat climate change. This necessitates their immediate and widespread implementation in the marine business.

4. The method of reducing  $\text{CO}_2$  through mussels allows for an accurate accounting of the true results of combating climate change, which has so far been the most losing, sabotaged, and ineffective activity by almost all nations, despite annual congresses and conferences, agreements, and treaties aimed at limiting its adverse effects.

5. SECs (and future facilities of this type) have the potential to provide numerous benefits and functions that can increase their effectiveness depending on the speed and extent of their deployment. For example, they will implement a successful and cost-free detached, segmented, direct, and indirect coastal protection system (with tombolos—carbonate beaches), which can stop the landslides and coastal slumps, increase marine life in the coastal zone and the shelf, increase the percentage of higher-quality and cheaper seafood products in the human diet, thus reducing the more expensive and lower-quality livestock products (the livestock being known to emit as much  $\text{CH}_4$  and  $\text{CO}_2$  as transportation), generate new employment for maintaining the SEC, harvesting, processing, and marketing seafood, and many other useful functions.

6. The listed and so far overlooked (pending experiments) benefits of SEC implementation will be made possible by the rapid and fundamental reorganization and reorientation of marine science in Varna towards solving the problems of the sea and maritime economy and tourism, because in its current form, marine science has most definitely proven its complete scientific and practical helplessness, causing immense losses to the economies of the coastal provinces.

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