
Politecnico di Torino

**INGEGNERIA GESTIONALE (ENGINEERING AND MANAGEMENT)**

# Business Case and Competitor Analysis of Sustainable Submerged Breakwaters and Floating Breakwaters

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# Abstract

## English Version

This study aims to analyse the market potential of an innovative solution like floating breakwaters, comparing it both technologically and in terms of market potential with the currently most widespread solution of fixed breakwaters.

While conducting these studies, a literature review on breakwaters was first carried out. This review includes the types of breakwaters, their advantages and disadvantages, characteristics and use cases, as well as the materials used.

After this section, a detailed analysis of important companies in the breakwater sector has been conducted. These analyses are based on the technological details of the company's products, their locations, the number of projects, and an examination of their financial data. As a result of this analysis, the market's most significant companies have been selected according to their importance/performance scores which indicates their importance in Italian breakwater market, and detailed examinations of these companies have been carried out.

Financial data has been collected from the Bureau Van Dijk Orbis Moody's Database, while also the market growth rate and key financial ratios were examined.

After these, a market analysis related to the breakwater market and marine and port construction market has been conducted. This analysis includes market and industry definition, market size, market segmentation, market trends, Porter's five forces analysis, and SWOT analysis. Finally, the necessary questions have been prepared for the completion of this market analysis with the intention of presenting them to the breakwater producers in order to validate the data collected and the assumptions made.

**Main Keywords:** Business Case, Breakwaters, Breakwater Products, Breakwater Types, Competitor Analysis, Financial Ratios, Market, Market Analysis, Market Segmentations, Market Trends, Porters five Force's Analysis, SWOT Analysis

## Versione Italiana

Lo scopo di questa tesi  è analizzale le potenzialità sul mercato di una soluzione innovativa come i Frangiflutti galleggianti confrontandola sia a livello tecnologico che di potenzialità sul mercato con la soluzione attualmente più diffusa dei Frangiflutti fissi.

Durante la conduzione di questi studi, è stata prima effettuata una revisione della letteratura sui frangiflutti. Questa recensione include i tipi di frangiflutti, i loro vantaggi e svantaggi, le caratteristiche e i casi d'uso, oltre ai materiali impiegati.

Dopo questa sezione, è stata condotta un'analisi dettagliata delle aziende importanti nel settore dei frangiflutti. Queste analisi si basano sui dettagli tecnologici dei prodotti delle aziende, le loro posizioni, il numero di progetti e un esame dei loro dati finanziari. A seguito di questa analisi, le aziende più significative del mercato sono state selezionate in base ai loro livelli di rischio, il che indica la loro importanza nel mercato italiano dei frangiflutti, e sono state effettuate analisi dettagliate di queste aziende.

I dati finanziari sono stati raccolti dal database Bureau Van Dijk Orbis di Moody's, esaminando anche il tasso di crescita del mercato e i principali rapporti finanziari.

Dopo di ciò, è stata condotta un'analisi di mercato relativa al mercato dei frangiflutti e al mercato delle costruzioni marine e portuali. Questa analisi include la definizione di mercato e settore, dimensione del mercato, segmentazione del mercato, tendenze di mercato, analisi delle cinque forze di Porter e analisi SWOT. Infine, sono state preparate le domande necessarie per completare questa analisi di mercato, con l'intento di porle ai produttori di frangiflutti con l'intento di porle ai produttori di frangiflutti in modo da validare i dati raccolti e le assunzioni fatte.

**Parole chiave:** Business Case, Barriere Frangiflutti, Prodotti Frangiflutti, Tipi di Frangiflutti, Analisi della Concorrenza, Rapporti Finanziari, Mercato, Analisi di Mercato, Segmentazioni di Mercato, Tendenze di Mercato, Analisi Le Cinque Forze di Porter, Analisi SWOT.

*To my family:*

*Hafize Funda Dereli & Semih Sertan Dereli*

# FOREWORD

Market analysis and business cases have always been intriguing to me, especially during my master's at Politecnico di Torino, where this interest has grown even more. I would like to thank my professors Giorgi Guiseppe & Sirigu Sergej Antonello for helping me write this thesis; I am also very grateful to Alice Rosiello for guiding me in this work.

I am very grateful to my family; Hafize Funda Dereli & Semih Sertan Dereli and my cousin; Berkutay Binol for always supporting me in my university life. I also want to thank all my friends who have been by my side on this journey for being there when I needed them and for never holding back their support.

Bogachan Dereli

Torino, 2024

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# Introduction

Breakwaters are one of the most important structures in protecting marinas, ports, and offshore areas from waves.

However, there is lack of research on the types and varieties of breakwaters, their technologies, the financial data and growth rates of the companies producing them, as well as the defining and analysing breakwater market.

This study aims to examine the technologies of breakwater products and analyse financial data of the breakwater companies, while also defining and analysing the relevant market.
This chapter will provide an introduction, first explaining the background and context, then discussing the research problem, and finally addressing the significance of the study.

In general, there are three types of breakwaters: floating, submerged, and fixed breakwaters. While each can be used under different conditions and for various purposes, their main characteristic is to protect various structures from waves. Another purpose of use is environmental effects. While breakwaters can harm the environment, they also provide benefits to it. Generally, floating breakwaters are cost-efficient and are used in calmer waters. At the same time, if the water depth is very deep, floating breakwaters are preferred because fixed breakwaters might be too expensive to construct. Fixed breakwaters are more expensive, but they are more robust structures. Submerged breakwaters, being underwater, reduce wave energy and break the waves depending on their design, while also preserving the natural aesthetics among all breakwaters. Additionally, they provide numerous benefits to marine life, which positively impacts tourism activities such as diving, leading to an increase in participation.

In general, studies related to breakwaters mostly focus on the design of breakwaters and their efficiency; however, there is insufficient research discussing profitability of the sector, growth rate of the sector, main players in the sector, and market definitions. This study consolidates information on several breakwater products and the associated manufacturing companies into a single document. This analysis enables firms to pinpoint deficiencies and areas for enhancement, while also identifying their technological strengths and weaknesses.

This report provides valuable information for companies and investors seeking to enter this market.

Chapter 1 defines what breakwaters are and what purposes they serve.

Chapter 2 delves into the details of the types of breakwaters, discussing their characteristics and purposes. The advantages and disadvantages of these types are also highlighted.

In Chapter 3, the operational factors of companies that produce and design floating and fixed breakwaters have been analysed, and a technology feature analysis of their products has been conducted, resulting in the creation of an importance/performance matrix. At the same time, it has been defined why the firms that stand out in the sector have distinguished themselves and what the state-of-the-art features of their products are.

In Chapter 4, the financial data of these firms is analysed as a whole and compared among each other and between different types of breakwaters.

In Chapter 5, the definition of breakwater marketing is provided, segments are identified, negative and positive trends are determined, and both Porter's Five Forces analysis and SWOT analysis are conducted.

In Chapter 6, questions have been prepared and categorized for the completion of the market analysis for breakwater manufacturers.

# 1. Breakwaters

## 1.1 What is a Breakwater?

Breakwaters are built to create a tranquil area for ships and safeguard harbour infrastructure. Additionally, they are occasionally employed to safeguard the port area against the encroachment of littoral drift. Breakwaters are essential for ports exposed to turbulent ocean conditions, as they play a crucial role in facilitating port activities.

Due to the immense force of ocean waves, it is challenging to create structures that can effectively reduce this force. The history of breakwaters can be characterised by significant damage and numerous failures. However, nautical technology has significantly advanced, particularly since 1945, enabling the construction of breakwaters with enhanced stability against waves. (TAKAHASHI, 1996)

A breakwater is a structure located offshore and parallel to the shore. These buildings, composed of rock, concrete, or oyster shell, can either float or be anchored to the ocean floor. They can also be either continuous or divided into segments. Breakwaters can be positioned either as headlands attached to the beach or as submerged sills near the shoreline. Breakwaters facilitate the accumulation of silt in the area between the structure and the shoreline, which can help stabilise wetlands and create a protected environment for the growth of new intertidal marsh habitat. However, this can hinder the transportation of material down the shore, resulting in erosion in the direction of the current and the formation of intertidal marshes that are not suitable for the area, replacing the native sandy beach habitat. (Breakwaters, Headlands, Sills, and Reefs, 2019)
In the figure 1 an example of breakwater can be seen.

**Figure 1** Glace Bay North Breakwater Light *(Jarvis, DGJ_4810 - Glace Bay North Breakwater Light, 2011)*

## 1.2 Purpose of the Breakwaters

It should come as no surprise that the primary function of a breakwater is to offer protection against waves. In addition to providing protection for an approach canal, the protection may also be given for the harbour itself. It is essential to have this kind of protection implemented in order to make the water more peaceful for ships to traverse and moor in. The motion of anchored ships in harbours can be detrimental to the efficiency of cargo handling, particularly for container ships. The activity of waves in approach channels can make navigating more difficult and increase the risk that tugboat workers face with their operations. Additionally, dredging in areas that are exposed to the elements is relatively expensive. Another function that a breakwater can do is to lessen the amount of dredging that is necessary at the entrance to a harbour. The occurrence of this phenomenon can be attributed to either the interruption of the supply of littoral transport to the approach channel or the natural scouring action that occurs within a channel that has been artificially restricted. It is common for breakwaters to also function as quay amenities in areas where there is little to no natural protection. This form of dual utilisation of the breakwater is cost-effective in terms of the surrounding harbour space; nonetheless, it necessitates a distinct kind of breakwater structure. It is probable that a breakwater serves a fourth crucial purpose, which is to direct the currents that are flowing in the canal or along the waterfront. (W.w. Massie, 1986).In the figure 2 an example of an old breakwater can be seen.

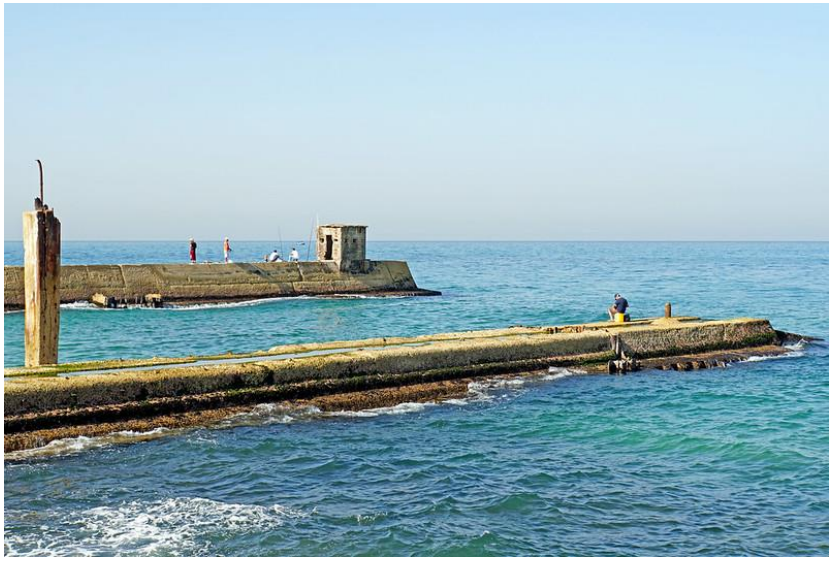


**Figure 2** Old Port Breakwater *(Jarvis, Israel-04557 - Old Port Breakwater, 2017)*

# 2. Types of Breakwaters

The purpose of this chapter is to review and compare the various types of devices and structures available as breakwaters. We can generally divide wave breakers into three categories.

First fixed breakwaters, which are frequently used, are inflexible structures firmly attached to the seabed, typically made of rock or concrete. Second floating breakwaters, however, are buoyant structures that bend in response to wave movement. Lastly, submerged breakwaters are located below the water's surface. The selection of breakwater type is contingent upon various criteria including sea depth, wave climate, environmental considerations, and financial limitations.

## 2.1. Fixed Breakwaters

Fixed breakwaters are constructed to protect harbours, anchorages, and marinas from strong waves and to prevent potential damages. The primary purpose of these solid structures is to serve as a barrier against strong waves before they reach the area that needs protection, and to reduce the energy of the waves.

These fixed breakwaters are generally designed specifically according to the situation and needs. This special situation could be the wave intensity that the protected area is facing. When constructing fixed breakwaters, many materials can be used. These are large rocks or concrete blocks, which are carefully positioned to create a strong and long-lasting structure.

The breakwaters face approaching waves either by reducing their energy through friction and turbulence or by deflecting them back towards the ocean.

When designing these fixed breakwaters, certain factors are considered: water depth, environmental factors, and budget constraints. Engineers aim to create the most environmentally and budget friendly as well as the most effective breakwater, taking these elements into account. In the figure 3 an example of a breakwater construction can be found.

**Figure 3** Breakwater under construction *(Leffmann)*

### 2.1.1 Types of Fixed Breakwaters

#### 2.1.1.1 Rubble Mound Breakwater

A rubble mound is a trapezoidal construction that is flexible, heterogeneous, and consists of artificial armour as a protection cover; the core of the structure is composed of rocks that have been mined. The underlayers prevent the wave energy from being transmitted, while the armour units that are located on the outer layer absorb the majority of the energy. The

most significant benefit of the rubble mound is that its failure does not occur immediately and may be rectified by making additions of stones to the area that has been drained out. More than fifty percent of the breakwaters that have been built all over the world are made of rubble mounds. While designing rubble mound breakwaters, it is important to take into account the hydraulic stability of the structure in relation to wave activities, the design of the structural components, and geotechnical factors. The most prevalent causes of rubble mound failure include hydraulic damage, erosion of subsoil, slope failures, toe erosion, overtopping, liquefaction of subsoil, crest erosion, and leeside damage. Other causes include overtopping and toe erosion. For the purpose of providing support for this section, the failure of the rubble mound breakwater at Ergil fishing port in Turkey as a result of the Kocaeli earthquake in 1999 has been explained. (P. K. Akarsh, 2022)In the figure 4 an example of an ancient breakwater can be found.

**Figure 4** Remains of ancient breakwaters *(Rublle mound breakwater design example, 2024)*

### 2.1.1.2 Vertical Breakwater

Vertical breakwater is created by constructing a vertical wall made of masonry concrete blocks or mass concrete in a uniform and systematic manner. The wall has a vertical face that faces the sea. Vertical breakwater can reflect the incident waves while minimizing wave energy dissipation. Its main purpose is to protect ports and channels from waves, siltation,

and currents; moreover, it also protects from tsunamis. It can be used as berthing facilities. Lastly, it provides access or transportation capability that is double the height of the wave specified in the design. (Raza, 2017) In the figure 5 an example of vertical breakwater can be seen.

**Figure 5** Example of Vertical Breakwater *(Bruce, 2017)*

### 2.1.2 Advantages of Fixed Breakwaters

- Fixed breakwaters reduce wave energy, thus protecting ships and infrastructure from potential damage while also creating a more peaceful environment.
- Fixed breakwaters serve the purpose of preventing erosion by absorbing or reflecting wave energy.
- The physical construction has the potential to become a suitable environment for various marine organisms, including fish, crabs, and algae.

### 2.1.3 Disadvantages of Fixed Breakwaters

- The construction expenses for a fixed breakwater can be high, particularly in deeper water or places with strong currents.
- The construction of a fixed breakwater and its presence in nature can alter the environment, negatively affecting water circulation and the life of marine organisms.
- Once these fixed breakwaters are constructed, it is difficult to make changes or do modifications.

## 2.2 Floating Breakwaters

Floating breakwaters function by dispersing and reflecting a portion of the wave energy. Wave overtopping does not introduce any excess water into the covered region. Floating breakwaters are typically employed as piers in marinas, but they also serve as protective barriers for marinas located in partially sheltered regions. They are particularly well-suited for regions with a significant tidal range, as they closely track the water level. Floating breakwaters are infrequently employed as coastal defence constructions due to their unsuitability for deployment in the open ocean.

Floating breakwaters offer a cost-effective alternative to traditional fixed breakwaters for shielding an area from wave impact. They are efficient in coastal regions with gentle wave conditions (where the significant wave height is not significantly higher than 1 m and the wave periods are 4 s or shorter). (Ruol, Dronkers, & Mangor, 2024)

### 2.2.1 Floating Breakwaters Application

Floating breakwaters have numerous potential uses in safeguarding boat basins, protecting boat ramps, and controlling coastline erosion. Several factors that support the use of floating breakwaters include (Bruce L. McCartney, 1985):

1. In cases when the ground is not strong enough to support breakwaters that are attached to the bottom, floating breakwaters may be the only viable option.

2. In areas where the water depth is 6.1 meters, floating breakwaters are generally more cost-efficient than fixed breakwaters.

3. Water Quality: Floating breakwaters have a minimal effect on water circulation and also have a minimal impact on marine life.

4. Ice Formation: If there is ice formation in the area with breakwaters, floating breakwaters can easily be relocated. Thus, they move to a safe area.

5. Aesthetics: Floating breakwaters have an elegant design and create minimal visual disturbance, especially in areas with large tidal ranges. (Bruce L. McCartney, 1985)

### 2.2.2 Types of Floating Breakwaters

#### 2.2.2.1 Box-type Breakwaters

The prismatic, rectangular box-type floating breakwater, which has been extensively studied in the last century, is considered the simplest type. (Turner, 1980) (Carr, 1950) (Carver, 1979) (Hay, 1966) (Ofuya, 1968)This particular breakwater reduces the intensity of ocean/sea waves mostly by reflecting the waves that are coming towards it. In the figure 6 and figure 7 examples of Box-type breakwaters can be seen.

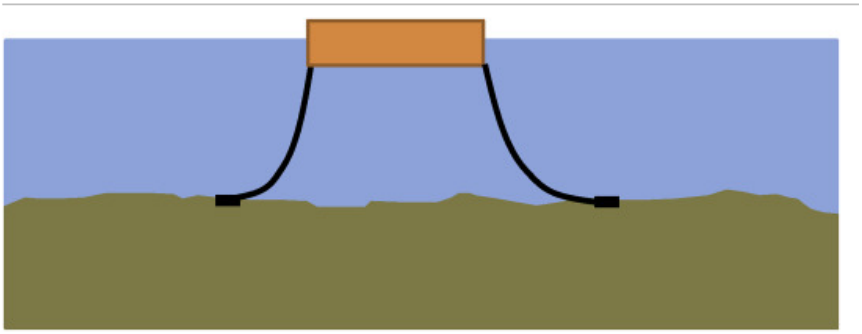


**Figure 6** Box-type breakwater *(Jian Dai, 2018)*

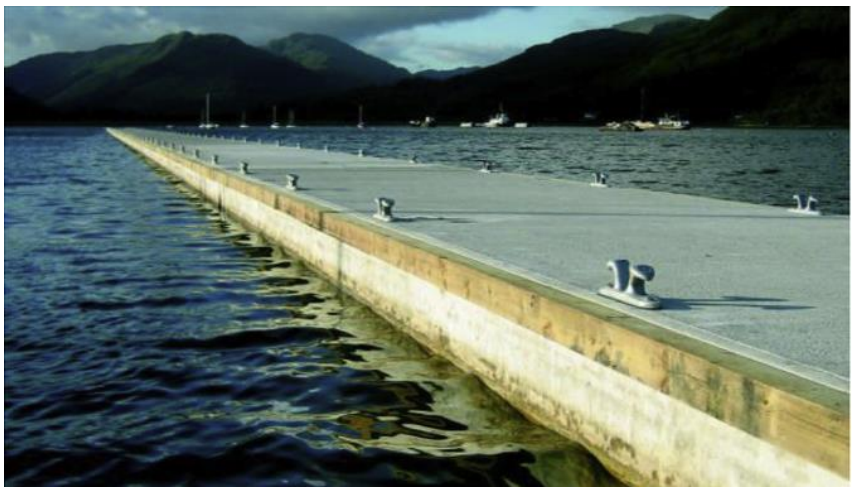


**Figure 7** Box-type breakwater *(Jian Dai, 2018)*

### 2.2.2.2 Pontoon-Type Breakwaters

A common pontoon-type floating breakwater consists of two or more lengthwise pontoons that are typically rigidly attached at intervals or by a deck on top of them, as illustrated in Figure 8. This design is inspired by popular pontoon boat designs. This design is commonly known as double-pontoon, twin-pontoon, and occasionally catamaran-type. In comparison to box-type floating breakwaters, this design enhances inertia and hence stability without significantly increasing the overall mass or material cost. Pontoon-type floating breakwaters mitigate wave energy through wave reflection, similar to a box breakwater. Furthermore, the space between the two floating objects facilitates the dissipation of turbulent energy. (Jian Dai, 2018) In the figure 8 an example of pontoon-type breakwater can be seen.

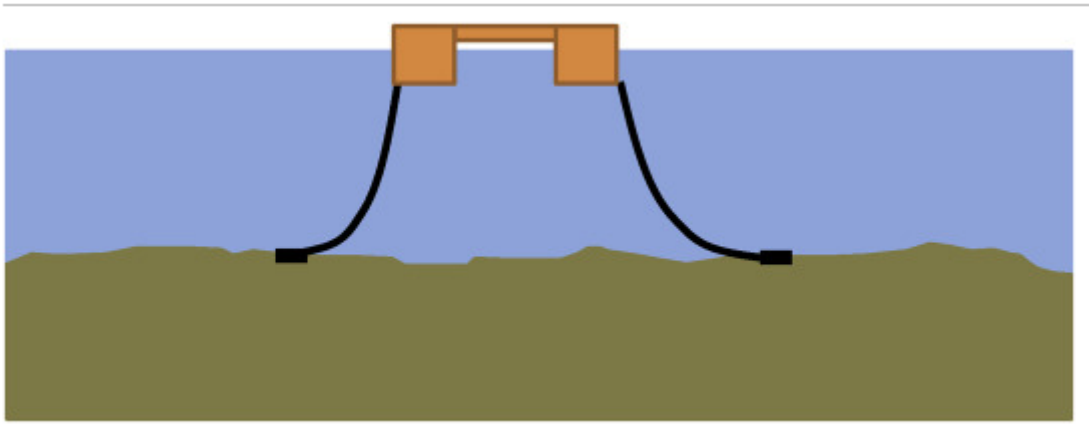


**Figure 8** Pontoon-type breakwaters *(Jian Dai, 2018)*

### 2.2.2.3 Frame-Type Breakwaters

Frame-type floating breakwaters typically consist of a combination of pontoons and frames or truss structures. They weaken waves by reflecting them off pontoons and by causing turbulence and disruption with frames. Contemporary designs typically employ concrete or steel pontoons due to their robustness and long-lasting nature. (Jian Dai, 2018)

### 2.2.2.4 Mat-Type Breakwaters

Among the various types of mats, those made from tires are the most commonly used. They are distinguished by their cost-effectiveness, ease of disassembly, suitability for construction by unskilled labour with minimal tools, lighter anchor weights, less reflection, and enhanced wave energy dissipation. Nevertheless, they are less durable and appropriate solely for mild wave climates with a considerable wave height of less than 0.5 m. Additional variations of mat breakwaters consist of horizontally positioned flexible permeable membranes. Membrane porosity has a role in the dissipation of viscous wave energy. The addition of more mat layers leads to an increase in wave attenuation (Yu Chan Guo, 2023). A wave transmission coefficient, defined as the ratio of transmitted to incident wave height, of less than 0.8 can only be achieved if the membrane width passes half a wavelength. (Ruol, Dronkers, & Mangor, 2024)

## 2.2.3 Advantages of Floating Breakwaters

- At larger water depths they are attractive to apply from economical point.
- Floating breakwaters have advantage of transportability, which enables to change the lay-out of a port easily.
- Floating breakwaters are applicable at poor soil conditions.
- Hardly any interference with sediment transport processes and water circulation.
- Floating breakwaters have multiple functions, such as: mooring facilitation, walkway, or parking facility.

## 2.2.4 Disadvantages of Floating Breakwaters

- Floating breakwaters are providing less protection against waves with comparing other types of breakwaters.
- Sensitive for wave frequencies close to its natural frequency (resonance).
- Floating breakwaters are less effective for longer waves.
- Dynamic response to the incoming waves can result into fatigue problems and heavy mooring forces.
- Floating breakwaters maintenance costs are higher because of the dynamic response.

## 2.3 Submerged Breakwaters

Submerged breakwaters are offshore structures that are constructed parallel to the beach in shallow water. These structures have low crests that are either at or below the water level. The types of breakwaters that are covered by submerged breakwaters include vertical breakwaters, rubble mound breakwaters, semi-circular breakwaters, and geosynthetic breakwaters. (D. Morgan Young, 2011) (Saengsupavanich, 2022) (Ibrahim ‘Izzat Na’im, 2018)They have the potential to enhance port manoeuvring and manage sedimentation by controlling water currents and establishing wave-interference zones. (Eryani, 2019)Their geometric characteristics, such as the crest, front slope, and back slope, have a substantial impact in determining their effectiveness. Recently, submerged breakwaters have grown more common compared to emerging breakwaters . (Ibrahim ‘Izzat Na’im, 2018)The use of submerged breakwaters to prevent coastal erosion is gaining popularity worldwide. However, there is a debate about their effectiveness in protecting beaches and improving the environment (Zanuttigh, 2007). (Hidayat, 2020) (Torres-Freyermuth, 2019)One significant question that remains is whether the environmental implications of submerged breakwaters are thoroughly comprehended. (Saengsupavanich, 2022) (Zanuttigh, 2007) In the figure 9 an illustration of the environmental impact of submerged and emerged breakwaters can be seen.

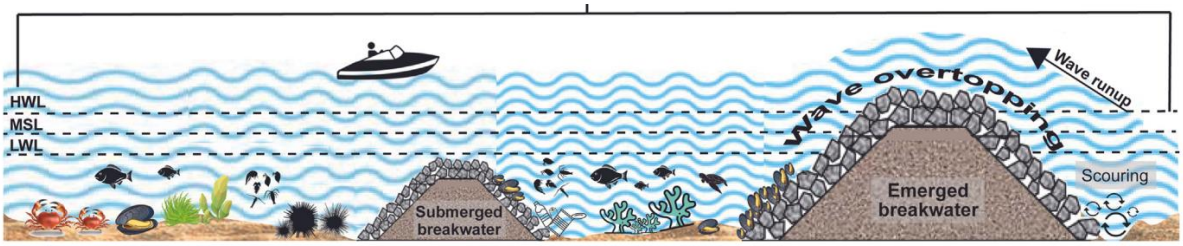



**Figure 9** Environmental impact of submerged and emerged breakwaters. *(Saengsupavanich, 2022)*

### 2.3.1 Types of Submerged Breakwaters

Currently, a wide range of breakwaters have been constructed globally. The design of breakwaters is adaptable, allowing for construction that can be customised to meet specific requirements. Certain breakwaters are built to safeguard the beach against erosion, while others are erected with the same objective but without compromising the aesthetic appeal of the beach. In certain regions of the world. Breakwaters are constructed with the purpose of serving as a means to restore coral reefs. Some individuals are seeking breakwaters made from more cost-effective and environmentally sustainable materials. Furthermore, the design of breakwaters varies due to the distinct parameters of the waves and the condition of the beach in different locations. (Ibrahim 'Izzat Na'im, 2018)

#### 2.3.1.1 Perforated Concrete Block

The use of porous breakwater has been extensively employed to mitigate the wave force impact on the frontal section of vertical wall breakwaters, as initially proposed by (Jarlan, 1961). (Quinn, 1972) These structures have the potential to decrease the amount of concrete used and are environmentally favourable due to the presence of huge pores that can serve as habitats for marine organisms (S. Tamrin, 2014). An important feature of a porous breakwater is that wave energy will dissipate upon impact with the front section of the permeable and porous vertical wall breakwater (Quinn, 1972). Furthermore, the oncoming wave will persistently collide with the pore, resulting in a decrease in wave reflection in front of the breakwater construction. (H. Bergmann, 1998)

#### 2.3.1.2 Sill

A sill is a horizontal rock construction positioned parallel to the shoreline to provide a barrier that allows for the establishment of a marshland behind it. These structures have the ability to safeguard and regulate various habitats and energy levels, so serving as a natural barrier and sanctuary for benthic shallow water animals. (A., 2019) In the figure 10 a stone sill can be seen.

**Figure 10** Stone sill connecting breakwaters with sand fill and marsh implantation on Choptank River, Talbot County, MD, just after construction and 5 years post-construction *(Byrne, 1999)*

### 2.3.2 Reef Balls as Artificial Reefs

Reef balls are artificial units formed like hollow hemispheres. In the figure 11 examples of reef balls can be seen. They are specifically developed to enhance biological growth, restore coral reefs, and serve as structures for coastal protection (United States Patent No. U.S. Patent No. 5,564,369, 1996). The reef ball can either remain in its original location to promote the growth of marine life or it can be harvested and relocated to other environments, such as natural or artificial aquariums. (Reef Balls as Submerged Breakwaters or for Erosion Control, n.d.)

**Figure 11** Example reef balls unit *(Vita, 2016)*

Several varieties of reef balls include regular, layer cake, lobster cake, stalactites, stalagmite, predator exclusion, net deterrent, seagrass, abalone surface, oyster surface, custom sculptures, eternal reefs, and red mangrove planter styles. (Reef Ball Styles, n.d.).In the figure 12 a layer cake style reef ball can be seen.

**Figure 12** Layer cake style *(Vita, 2016)*

### 2.3.2.1 Advantages of Reef Balls

- Reef Balls serve as submerged breakwaters to safeguard the coastline against erosion. The efficacy of a breakwater in reducing wave energy can be quantified by the level of wave energy that passes through the apertures of the Reef Ball structure. As the wave transmission coefficient increases, the wave attenuation decreases. (Buogo Moreno)
- The product is environmentally sustainable as it is constructed using concrete with a pH level comparable to that of natural seawater, facilitating the colonisation and development of various marine organisms. (Buogo Moreno)
- Permeability is a property that prevents the accumulation of water behind a breakwater due to wave overtopping. This accumulation can lead to an elevated water level behind the breakwater, resulting in a rapid flow of water back towards the sea. This flow can erode the areas around the ends of the breakwater and remove sand from the landward side. (Buogo Moreno)

- The economic advantages of using this method include a reduced utilisation of stone material compared to the conventional rock breakwater, as well as lower expenses for quarrying and transporting materials by constructing the structures on site. (Buogo Moreno)
- Reef Balls are engineered to prioritise stability and longevity by concentrating more than half of their weight at the base, close to the sea floor. Reef Balls of all dimensions have demonstrated their ability to remain stationary even in the face of severe tropical storms. Reef Balls maintain stability by incorporating an opening at the top of the structure, which counteracts the lifting force caused by the hydrofoil effect typically observed in dome shapes. This feature generates little whirlpools that further decrease upward forces and deliver abundant nutrients to marine organisms on the reef. Furthermore, due to their expansive foundation and substantial mass, Reef balls can also serve as a deterrent against illicit fishing practices such as trolling. (Buogo Moreno)
- Reef Balls facilitate the process of natural beach replenishment, coastal stabilisation, and the maintenance of artificial beach nourishment. (Buogo Moreno)
- Reef Balls provide a possibility for the growth of ecotourism by promoting activities such as snorkelling and diving. (Buogo Moreno) In the figure 13 divers can be seen with the reef balls.

**Figure 13** Coral Transplants and Propagation (Harris, 2007)

- Reef Balls facilitate the process of natural beach replenishment, stabilise shorelines, and help sustain artificial beach nourishment. (Buogo Moreno)
- The distinctive dome form of the unit, with broader side holes towards the centre of the walls and narrower holes near the surface, generates small whirlpools that effectively minimise upward forces and deliver abundant nutrients to marine life on the reef. (Buogo Moreno)In the figure 14 an example of coral growth on reef ball can be found.

**Figure 14** Coral Growth on Reef Ball after 5 Years in Indonesia (Reef Ball Foundation) *(Harris, 2007)*

- The Reef Ball is constructed using a high-strength and abrasion-resistant concrete, ensuring its durability and longevity. Reef Balls are constructed without the use of iron frameworks, which helps to minimise the deterioration of cement in seawater, resulting in a lifespan of over 500 years. (Buogo Moreno)

### 2.3.3 Advantages of Submerged Breakwaters

They have limited visibility compared to other types of breakwaters which are extends above the water surface.

Submerged breakwaters typically need a smaller amount of materials to construct and building work shorter comparing with other types of breakwaters.

Artificial structures can improve marine ecosystems by offering protection and since they have solid surface variety of living marine species can make them home.

### 2.3.4 Disadvantages of Submerged Breakwaters

Their ability to reduce wave energy decrease as the water depth increases.

Insufficient marking of submerged breakwaters can threaten the safety of boats and ships.

Periodic maintenance may be necessary to ensure optimal performance and prevent the accumulation of silt.

## 2.4 Main Material of Breakwaters

Wave breakers, regardless of type (submerged, floating, fixed), are generally designed with the careful selection of strong materials. The factors that need to be considered should generally be able to withstand strong waves and also be resistant to corrosion. Rock and concrete are generally the primary materials, while wood and steel are materials used during construction.

**Rock:** Rock breakwaters are commonly selected for shallow waters and can be built using either natural or mined rocks. They are affordable and may be readily fixed or maintained. In the figure 15 an example of rubble mound breakwater can be seen.

Advantages: Minimal initial expenses, straightforward to fix, and can be built with readily available resources.

Disadvantages: May not be compatible with high-energy waves, susceptible to erosion, and necessitates frequent maintenance. (Butler Hemp CO, n.d.)

**Figure 15** Rubble Mound Breakwater *(Breakwater Construction, n.d.)*

**Concrete:** Concrete breakwaters are highly favoured for their exceptional durability and adaptability. They can be engineered to endure high-energy waves and can be built in many forms and dimensions. In the figure 16 a breakwater made out from concrete can be seen.

Advantages: Exceptional durability, extended longevity, and remarkable resistance to erosion.

Disadvantages: Substantial initial expenses, necessitates skilled workforce, and susceptible to cracking. (Butler Hemp CO, n.d.)

**Figure 16** Northern Breakwater *(Otrębski)*

**Steel:** Used for structural elements in some types of breakwaters, particularly floating breakwaters. Steel provides strength and flexibility.

**Wood:** Occasionally used in older breakwaters or in specific applications. Wood is less common due to its susceptibility to decay and marine borers.

**Geotextiles:** These synthetic fabrics are sometimes used in conjunction with other materials to provide additional stability and erosion control. In the figure 17 an example of geotextile tubes can be found.

**Figure 17** Geotextile Tubes *(Breakwater Construction, n.d.)*

### 2.4.1 Main Materials for Each Type of Breakwater

**Floating breakwaters:** Floating breakwaters often use steel or concrete pontoons for buoyancy and may use geotextiles for wave attenuation.

**Submerged breakwaters:** Submerged breakwaters may be constructed entirely of rock or may use a combination of rock and concrete.

**Fixed breakwaters:** Fixed breakwaters are typically built using rock, concrete, or a combination of both.

In the table 1 below summary of the properties of different types of breakwaters can be found.

**Table 1** Properties of different types of breakwaters. *(Ahmed K. Elsheikh, 2022)*

| Properties | Floating Breakwaters | Submerged Breakwaters | Fixed Breakwaters |
|---|---|---|---|
| Poor soil conditions | Applicable | Not applicable | Not applicable |
| Higher water depths | Applicable Economic | Applicable Not Economic | Applicable Costly |
| Transportability | Yes | No | No |
| Allow mooring facilities | Yes | No | Sometimes depends on design |
| Aquatic and marine life | Relatively Low Impact | Have long term impacts | Have long term impacts |
| Environmental impacts | Relatively Low Impact | Have short term impacts during construction | Have short term impacts during construction |
| Easy of Construction | Yes | Yes | No |
| Time of construction | Relatively short time | Relatively long time | Long time |
| Scour | No | Occurs at toe of Structure | Can occur at base and sides |
| Cost | Relatively low capital cost | Higher capital cost | High capital cost |
| Adapt to Sea level Rise | Yes | No | No |
| Weight | Light | Heavy | Heavy |
| Effect of resonance | Yes | No | Minimal |
| Fatigue Problems | Yes | No | Yes |

| | | | |
|---|---|---|---|
| Maintenance | High cost | Low cost | Moderate cost |
| Severe Wave Conditions | Not applicable | Applicable | Applicable |
| Aesthetic View | Obstructs sea View | Preserve good view | Obstructs view |
| Efficiency on Shore Protection | Efficient for shore protection when having higher draught | Efficient for shore protection when having higher crest freeboard (closer to water surface) | Efficient for shore protection |

# 3. Breakwater Companies

In the breakwater sector, a detailed study was conducted on various breakwater companies, categorizing them into floating and fixed breakwater firms. The companies' data was gathered from their original websites and their features were collected from product catalogues. The threats these companies pose to their competitors were researched. These threats were made considering the technologies, locations, the number of breakwater projects they have carried out, the number of breakwater models, the number of non-breakwater models, and the countries where they have conducted the most projects. And finally, Excel tables were created using this data. These can be found in the continuation of this section.

## 3.1 Floating Breakwater Companies Comparison

A detailed study covering 15 companies in the breakwater industry was conducted. In this review, the analysis was based on technical, geographical, and operational features. As a result of this detailed examination, it was concluded that Ingemar, Poralu, and Lindley are the most dominant and important companies in Italy. In this review, detailed technical analyses have been taken into account. These are: Width, Height, Weight, and Length. If the operational features need to be mentioned, they are: the number of completed projects, product variety, and the locations where projects were carried out. The units for these measures are weight is tonnes/meter also weight is tonnes, height is meter, width is meter and length is meter.

The technical details of some of the products could not be found because the companies are not public, or they do not want to disclose the details of their products, or because the nature of the products can vary greatly or be designed specifically for certain situations. The data that couldn't be found was left as a "not available (n.a.)" in the tables.

While the competitor analysis was being conducted, importance/performance scores were assigned to 15 key companies, and these scores were assigned as 1, 2, and 3. According to Table 2 and Table 3, factors that are more successful and prominent among companies

compared to others have been assigned an importance/performance score of 3. While 2 points were assigned for the average characteristics of the companies based on these factors, 1 point has been assigned for the characteristics that fall behind those of other companies.

It is important to note that since this analysis was conducted for the Italian market, companies with "focus areas and bases" in Italy received a score of 3, while companies in other parts of Europe received a score of 2, and companies from other continents received a score of 1. At the same time, since the base and focus area are often the same region, the importance/performance scores for these indexes have not been aggregated twice. Only the focus area has been taken into account.

For the number of products index, if the number of breakwater products of the companies is 5 or more, it receives a score of 3; if the number of products is 3 or 4, it receives a score of 2; and if the number of products is 2 or 1, it receives a score of 1.

If the not breakwater number of product indices for firms is 10 or more, it receives a score of 3; if it is 6, 7, or 8, it receives a score of 2; and if it is 5 or less, it receives a score of 1 for importance/performance.

The project index number is as follows: if the total number of breakwater projects of the firms is above 25, it receives a score of 3; if it is between 10 and 24, it receives a score of 2; and if it is below 10, it receives a score of 1 for importance/performance.

In the technology index, while assigning importance/performance scores, the maximum and minimum values of the data have been taken into account.

In Tables 2 and 3, the text or numbers written in red represent a score of 3, while the yellow colour represents a score of 2, and the green colour represents a score of 1. Table 2 contains technical information, while Table 3 contains operational information. In Table 4, the total importance/performance scores of the companies have been calculated, and a competitor performance matrix has been created.

**Table 2** Technical details of floating breakwater products of different companies.

| | width max | width min | weight max | weight min | height max | height min | length max | length min |
|---|---|---|---|---|---|---|---|---|
| Marinetek | 5.3 | 3.3 | 2.62 | 1.29 | 1.8 | 1 | n.a. | n.a. |
| Ingemar | 10 | 3 | n.a. | n.a. | 2.4 | n.a. | 360 | n.a. |
| Bellingham Marine | 4.5 | 4 | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| Sf Marine | 8.25 | 3.25 | 160 | 20 | 3 | 1.8 | 20 | 10 |
| Bellamer | 3.3 | n.a. | 38 | n.a | n.a. | n.a. | 15 | n.a. |
| Martini Alfredo | n.a. | n.a. | 4 | 3 | n.a. | n.a. | n.a. | n.a. |
| Horizon Marina | 10 | 6 | n.a. | n.a. | 2 | 2 | 20 | 20 |
| Goodocks Marine | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| Poralu | 4 | 3 | n.a. | n.a. | n.a. | n.a. | 20 | 12 |
| Lindley | 6 | 3 | 71 | 30 | 1.8 | 1.4 | 20 | 15 |
| Ronautica | 5 | n.a. | n.a. | n.a. | 2.25 | n.a | 20 | n.a. |
| Inland | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| IMFS | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. |
| System Group | 4 | 3 | n.a. | n.a. | 2 | 2 | 20 | 12 |
| Pontech | 5.3 | 3.3 | 65 | 19.5 | 1.8 | 1.8 | 20 | 10 |

**Table 3** Operational factors of floating breakwater companies.

| | # project | focus area | # product | # not product | breakwater base |
|---|---|---|---|---|---|
| **Marinetek** | 16 | Croatia | 5 | 2 | Finland |
| **Ingemar** | 43 | Italy | 5 | 8 | Italy |
| **Bellingham Marine** | 10 | Usa | 1 | 5 | Usa |
| **Sf Marine** | 17 | Usa | 6 | 4 | Sweden |
| **Bellamer** | n.a. | Finland | 1 | 12 | Finland |
| **Martini Alfredo** | n.a. | Italy | 2 | 5 | Italy |
| **Horizon Marina** | 14 | Indonesia | 1 | 8 | China |
| **Goodocks Marine** | n.a. | China | 4 | 1 | China |
| **Poralu** | 31 | France,Italy | 1 | 7 | France |
| **Lindley** | 3 | Portugal | 4 | 11 | Portugal |
| **Ronautica** | 6 | Spain | 1 | 4 | Spain |
| **Inland** | 8 | Ireland | 1 | 11 | Ireland |
| **IMFS** | 7 | Canada | 1 | 6 | Canada |
| **System Group** | n.a. | Italy | 2 | 6 | Italy |
| **Pontech** | 1 | Sweden | 1 | 6 | Sweden |

**Table 4** Competitor Performance Matrix of Breakwater Companies

| **Competitor Performance Matrix** | |
|---|---|
| Marinetek | 7 |
| Ingemar | 11 |
| Bellingham Marine | 5 |
| Sf Marine | 7 |
| Bellamer | 7 |
| Martini Alfredo | 6 |
| Horizon Marina | 6 |
| Goodocks Marine | 5 |
| Poralu | 9 |
| Lindley | 8 |
| Ronautica | 5 |
| Inland | 7 |
| IMFS | 5 |
| System Group | 7 |
| Pontech | 6 |

## 3.2 In-Depth Analysis of Most Important Companies

This chapter provides detailed analysis of the breakwater companies. These companies are Ingemar, Poralu, Lindley, Marinetek, Bellingam Marine, and Martini Alfredo. All of these companies are large and specialized firms in the floating breakwater sector. These companies have been subjected to a detailed evaluation, and as a result, risk profiles have been created.

Firstly, the firm profile is examined, taking into account their country of origin and the scope of their worldwide presence, including the number of countries in which they operate and the continents they work in. This demonstrates their market presence and potential drawbacks in relation to various geopolitical and economic risks.

Secondly, a detailed review was conducted to examine the variety of products, focusing on how many products are breakwater products and how many are non-breakwater products. This also provided data about product variety. This review showed how firmly breakwater companies stand in the market with their breakwater products and demonstrated customer demand.

Thirdly, the breakwater projects they constructed and the number of breakwater projects they carried out were examined. At the same time, also the countries where they carried out their projects were examined. This analysis provided data about the companies' experiences, capabilities, and how much business they are doing in the market, as well as in which continents they are more effective.

Finally, the technology in the breakwater products of these companies were examined. The important features of these technologies, as well as their differences and weaknesses were found.

As a result, this report was used to conduct a detailed risk analysis of the companies and their breakwater models. This report can be used to uncover potential weaknesses of companies and to see their strengths. At the same time, measures can be taken by utilizing these weaknesses.

### 3.2.1 Ingemar

Ingemar is a company established in Italy, specializing in the design and production of floating structures. They have over 40 years of experience in the sector and work internationally. At the same time, they have a diverse project portfolio with expertise particularly in: pontoons, breakwaters, and customized solutions. (Ingemar, n.d.) In figure the 18 logo of Ingemar can be seen.


**Figure 18** Logo of Ingemar *(Ingemar, n.d.)*

#### 3.2.1.1 Important Data's for Risk analysis

**Country Origin:** Italy

**Break Water Product Number:**5

**Break Water Project Number:**43

**Where their projects were carried out:**

- **Europe:**
  - Italy 30 times
  - France
  - Switzerland
  - Slovenia
  - Turkey
  - Montenegro
  - Croatia
  - Greece 4 times
- **Asia (Middle East):**
  - Oman
  - Kuwait
  - Saudi Arabia

**Total Countries:** 10

**Not Break Water Product Number:**8

### 3.2.1.2 Important Information and Features About Ingemar's Breakwaters

Ingemar is conducting product tests in collaboration with the University of Padua. And at the same time, they stand out for having to build longer breakwaters compared to competitors. The floating breakwater they built in La Spezia, which is 360 meters long, is an example of this. And these long structures can be considered state of the art.

## 3.2.2 Poralu

Poralu Marine is one of the leading companies in the marine industry, drawing strength from innovation and an adventurous spirit. They have specialized in aluminum products, anchoring systems, water treatment, and recycled plastic solutions. At the same time, they offer high-quality turnkey projects. (Poralu, n.d.) In figure the 19 logo of Poralu Marine can be seen.

**Figure 19** Logo of Poralu Marine *(Poralu, n.d.)*

### 3.2.2.1 Important Data's for Risk Analysis

**Country Origin:** France

**Break Water Product number:** 1

**Break Water Project Number:** 31

**Where their projects were carried out:**

- **Europe:**
  - France 6 times
  - Italy 8 times
  - United Kingdom
  - Switzerland
  - Spain

- **North America:**
  - Canada 4 times
  - USA 2 times
  - Mexico 2 times
  - Caribbean
  - West Indies
- **Asia:**
  - Thailand
- **Australia:**
  - Australia 2 times

**Total Countries:** 11

**Not Break Water Product number:** 7

### 3.2.2.2 Important Information and Features About Poralu's Breakwaters

Poralu Marine generally designs floating breakwaters for more challenging environmental conditions. For this reason their floating breakwaters are more solid and reliable compared to other companies. Their products have a load capacity of 400kg, and this feature can be considered state of the art.

### 3.2.3 Lindley

The Lindley company was established in 1930 and designs and produces floating solutions for marinas. Their headquarters is in Portugal, and they are recognized as a leader in the Iberian Peninsula (Portugal and Spain) region, also operating in Africa and South America (Lindley, n.d.) In figure the 20 logo of Lindley can be seen.


**Figure 20** Logo of Grupo Lindley *(Lindley, n.d.)*

#### 3.2.3.1 Important Data for Risk Analysis

**Country Origin:** Portugal

**Break Water Product Number:** 4

**Break Water Project Number:** 3

**Where their projects were carried out:**

- **Africa:**
  - Namibia
- **Europe:**
  - Portugal

**Total Countries:** 2

**Not Break Water Product Number:** 11

### 3.2.3.2 Important Information and Features About Lindley's Breakwaters

Lindley's floating breakwaters are made of reinforced concrete with expanded polystyrene which makes their product more durable and has more strength. We can say that this features are their state arts.

## 3.2.4 Marinetek

The Marinetek company is recognized as a leader in premium global marina design and floating solutions. It has a wide product portfolio that includes pontoons, breakwaters, and equipment. Marinetek communicates with customers to design products specifically for them, while also providing maintenance services for the future. This shows extra care for the customers' needs and helps establish a long-term relationship. (Marinetek, n.d.) In figure the 21 logo of Marinetek can be seen.


**Figure 21** Logo of Marinetek *(Marinetek, n.d.)*

### 3.2.4.1 Important Data for Risk Analysis

**Country Origin:** Finland
**Break Water Product number:** 5
**Break Water Project Number:**16

**Where their projects were carried out:**

- **Europe:**
  - Montenegro
  - Croatia 6 times
  - Finland 3 times
  - Norway
  - Sweden
  - Poland
  - Malta
- **North America:**
  - USA

**Total Countries:** 8

**Not Break Water Product number:**2

### 3.2.4.2 Important information and features About Marinetek's Breakwaters

We can say that Marinetek's state of art is combination of the breakwaters' extreme durability, their research-backed optimization for wave attenuation, and the company's unusual level of transparency when it comes to performance data.

## 3.2.5 Bellingham Marine

Bellingham Marine specializes in meeting customer needs with its custom manufacturing floating dock solutions and extensive product range. This company has achieved a streamlined design/build approach, cost-effectiveness, and brand reputation, having been in the industry for decades. (Marine, n.d.) In figure the 22 logo of Bellingham Marine can be seen.


**Figure 22** Logo of Bellingham Marine *(Marine, n.d.)*

### 3.2.5.1 Important Data for Risk Analysis

**Country Origin:** USA

**Break Water Product number:** 1(depends on request)

**Break Water Project Number:** 10

**Where their projects were carried out:**

- **North America:**
  - Canada
  - USA 5 times
- **Oceania:**
  - Australia 3 times
  - New Zealand
- **Asia:**
  - Singapore

**Total Countries:** 5

**Not Break Water Product number:**5

### 3.2.5.2 Important Information and Features About Bellingham Marine's Breakwaters

We can say that their state of the art is basically customization. Their emphasis on heavily customized designs for each specific site stands out. This suggests they might have sophisticated modelling or simulation tools to accurately predict wave attenuation performance under a wide variety of conditions.

## 3.2.6 Martini Alfredo

The company Martini Alfredo Marina is known for its 45 years of experience in the manufacturing and design of floating pontoons and equipment. They hold the record for completing over 2000 installations and prioritize security and technology. (Alfredo, n.d.) In figure the 23 logo of Martini Alfredo can be seen.


**Figure 23** Logo of Martini Alfredo *(Alfredo, n.d.)*

### 3.2.6.1 Important Data's for Risk Analysis

**Country Origin:** Italy

**Break Water Product number:** 2

- Concrete one is only for Italian market
- Thermoplastic one is for whole world

**Break Water Project Number:** Martini Marinas has realised more than 2000 installations in Italy and abroad. (Not 100% valid information)

**Where their projects were carried out:** Works mostly in Italy.

**Not Break Water Product number:** 5

### 3.2.6.2 Important Information and Features About Martini Alfredo's Breakwaters

Using different products for different countries can set Martini Alfredo apart from its competitors. Here we can say that having a variety of products are state of the art.

## 3.3 Fixed Breakwater Projects

Fixed breakwater projects are generally carried out by large construction companies namely "Boscalis" and "Webuild" as examples. Generally, these breakwaters are 300 meters long and weigh 900,000 tons. Some specific projects may exceed these limits, which indicates how extensive and costly these projects are. (webuild, 2022)

An example of a project that exceeds this average is the "Genoa breakwater project," which is still ongoing and being carried out by Webuild. This breakwater was specially designed by engineers to reach a depth of 50 meters while also being 6 kilometers long.This project is much larger than similar projects.It has a diameter of 400 meters, weighs 7 million tons, and more than 1,000 people are working on its construction.The budget for this project is an incredibly high amount of 928 million dollars, and 3 million dollars has been allocated solely for marketing. (webuild, 2022) In the figure 24 a photo of the Genoa breakwater project can be seen.

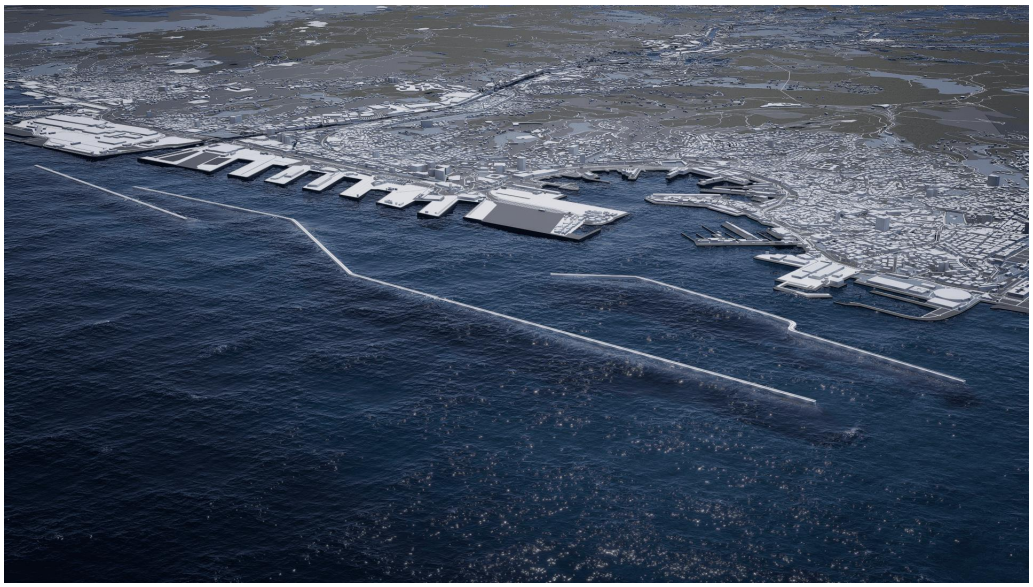


**Figure 24** Genoa New Breakwater *(Group, n.d.)*

## 3.4 Fixed Break Water Firms

The two largest fixed breakwater firms in Europe are "Webuild Group" and "Boskalis". Compared to the companies which operates in floating breakwater sector these two firms, they are both much larger and much more comprehensive. Because fixed wave companies also operate in many other sectors.

In the continuation of this section, there is more detailed information regarding these two companies.

### 3.4.1 Webuild Group

**About:** Webuild is a leading company in the construction sector and a global player.They generally undertake large and diverse projects, including: sustainable mobility (rail, metro, bridges, roads, ports), hydropower (dams, power plants), water (treatment and desalination plants, wastewater management, irrigation dams), and green buildings. (civil and industrial buildings, airports, stadiums, hospitals)**.** (Group, n.d.)

We Build Company has over 120 years of engineering experience and operates on 5 continents. It is one of the leading companies in the Italian market and the global market, with over 87,000 employees and more than 100 different nationalities. (Group, n.d.)

This company operates in Italy and globally, and they also have a passion for excellence in quality and production. At the same time, they are innovative for a sustainable future. (Group, n.d.) In the figure 25 logo of We Build Group can be seen.


**Figure 25** Logo of Webuild (Group, n.d.)

**Business model:** Today, demographic growth and urbanisation, resource scarcity and climate change strongly influence the lives and needs of people, globally. Due to these global challenges, companies and public bodies must rethink their priorities and business models. (Group, n.d.)

Today, demographic growth and urbanization, along with climate change, are changing the lives of many people. For these reasons, We Build group have adjusted their business model. We build the group's business model to be results-oriented, quality-focused, socially and environmentally conscious, and stakeholder-oriented. At the same time, this group's business model helps customers moreover enables them to effectively complete projects of complex infrastructures. (Group, n.d.)

We Build group has achieved 11 sustainable development goals. While doing this, shared value has been created for stakeholders, investors, customers, employees, and suppliers. (Group, n.d.)

**Business Area:** We Build Group has been completed in some of the world's most iconic infrastructure projects for 100 years. While undertaking these projects, they have achieved sustainable development goals and simultaneously met the needs of their clients. (Group, n.d.)

The expertise and projects of We Build Group include railway lines and metros, dams and hydropower plants, hydraulic systems, drinking water, desalination and water treatment plants, airports, motorways, and civil and industrial buildings. (Group, n.d.)

### 3.4.2 Boskalis

**About:** Boskalis is a global leader in its field, specializing in dredging, offshore contracting, and maritime services. Their origins are in the Netherlands, and they have been in operation for 100 years. They are creating new values for Boskalis stakeholders; these values are being generated in the ports, offshore energy, maritime, and inland infrastructure markets. (Boskalis, n.d.)

Boskalis operates on a large scale in expert dredging, offshore transport and installation solutions, as well as maritime services, including towage and salvage industries. As a result, Boskalis provides innovative solutions. (Boskalis, n.d.)

Boskalis has more than 11,000 employees, operates in 90 different countries, and has over 500 vessels and floating solutions. Boskalis provides innovative and sustainable solutions in ports, offshore areas, coastal areas, and delta regions. (Boskalis, n.d.) In the figure 26 logo of Boskalis can be seen.

**Figure 26** Logo of Boskalis *(Boskalis, n.d.)*

**Business Plan:** Boskalis has created a three-year business plan strategy within its corporate structure. The examination of the marketing and business line and the construction of the new Corporate Business Plan has been carried out between the periods of 2022-2024. This plan addresses current developments in the global business environment. Population growth has been observed, and trends have been identified. As a result of these studies, it has been noted that there is a need for cleaner energy, as well as marina and inland infrastructure. It aims to support economic growth and increase world trade. (Boskalis, n.d.)

All medium and long-term developments and trends support Boskalis's business. The increase in population is raising the demand for raw materials, energy, and global trade in coastal areas. Climate change is the most important reason for the transition from fossil energy to renewable energy, and this transition requires significant investments. (Boskalis, n.d.)

# 4. Financials

## 4.1 Financial Comparison of Companies Which Offer Floating and Fixed Breakwater Products

The careful examination of the financial data of companies which offer fixed and floating breakwater products between 2021 and 2023 has shown trends and unique characteristics. Although both types of companies play an active role in port construction, their business models and profits differ significantly from each other.

Companies that do fixed breakwater construction are usually very large construction companies. These construction companies in general do not primarily do breakwater construction. Their primary business is usually bridge construction or other large scale projects. For this reason, when we compare these companies with floating breakwater companies, it is expected that there will be a gap in revenue between them.

Examining the number of employees gives us additional data and information. Large construction companies generally have more employees than companies which offer floating break water products.

All financial data is taken from Bureau Van Dijk Orbis.

After the inferences we mentioned above, when we look at the financial data, we can clearly see that the inferences made are correct.

Graphs and tables were designed in Excel based on the results of these financial data. The revenue comparisons clearly show the significant differences between the two types of companies

Finally, this analysis demonstrates valuable information about unique traits of companies specialising in floating and fixed breakwaters. Although one company focuses on a specific market, the other company superior in generating higher revenue because of its diverse range

of construction projects. In the tables 5 and 6 below, you can find the financial data and employee number of the companies. In Table 7, you can find the average financial data categorized by breakwater type.

**Important note:** The financial data in Table 5, Table 6, and Table 7 represent the total financial figures of the mentioned companies. These data are not just the earnings of these companies from breakwater products or construction. As mentioned in Chapter 4.1, these companies also generate revenue from products that are not breakwaters, and especially the fixed breakwater companies, namely Webuild and Boskalis, have breakwater construction as only a small part of their total operations. All companies described in this section offers breakwater products. This analysis aims to compare the data of companies in the same sector as a whole.

**Table 5** Financial values of companies which offer floating breakwater products 2021-2022-2023.

| Floating Breakwater companies | REVENUE 2021 | ROA 2021 | EBITDA 2021 | %margin 2021 | #employee 2021 |
|---|---|---|---|---|---|
| **Marinetek** | $19,476,207.00 | -1.63% | $86,908.00 | 0.45% | 58 |
| **Ingemar** | $6,418,929.00 | -0.76% | $8,718.00 | 0.14% | 26 |
| **Bellingham Marine** | $14,111,957.00 | 5.68% | $1,418,780.00 | 10.05% | n.a. |
| **Sf Marine** | $11,902,280.00 | -1.76% | $189,531.00 | 1.59% | 54 |
| **Bellamer** | $455,157.00 | 3.50% | $154,492.00 | 33.94% | 2 |
| **Martini Alfredo** | $13,655,582.00 | 2.28% | $428,795.00 | | 29 |
| **Poralu** | $15,235,549.00 | 6.93% | $1,142,911.00 | 7.50% | n,a. |
| **Lindley** | $7,770,072.00 | 7.20% | $429,289.00 | 5.52% | 20 |
| **Ronautica** | $5,705,529.00 | -2.77% | $129,422.00 | 2.27% | 27 |
| **System Group** | $10,233,690.00 | 5.24% | $951,573.00 | 9.30% | 27 |
| **Pontech** | $2,975,404.00 | 11.52% | $130,669.00 | 4.39% | 3 |

| Floating Breakwater companies | REVENUE 2022 | ROA 2022 | EBITDA 2022 | %margin 2022 | # employee 2022 |
|---|---|---|---|---|---|
| **Marinetek** | $16,674,286.00 | -9.90% | -$707,625.00 | -4.24% | 51 |
| **Ingemar** | $8,536,946.00 | 11.40% | $682,387.00 | 7.99% | 26 |
| **Bellingham Marine** | n,a. | n,a. | n,a. | n,a. | n,a. |
| **Sf Marine** | $16,735,204.00 | 3.54% | $838,664.00 | 5.01% | 55 |
| **Bellamer** | $688,658.00 | 2.60% | $103,870.00 | 15.08% | 1 |
| **Martini Alfredo** | $13,857,443.00 | 2.04% | $351,698.00 | 2.54% | 29 |
| **Poralu** | $15,997,118.00 | 6.81% | $1,408,087.00 | 8.80% | 57 |
| **Lindley** | $7,137,683.00 | 8.60% | $428,336.00 | 6.00% | 20 |
| **Ronautica** | $6,073,939.00 | 5.75% | $439,810.00 | 7.24% | 27 |
| **System Group** | $11,147,981.00 | 10.59% | $1,575,140.00 | 14.13% | 25 |
| **Pontech** | $3,088,048.00 | 7.52% | $74,804.00 | 2.42% | 3 |

| Floating Breakwater companies | REVENUE 2023 | ROA 2023 | EBITDA 2023 | %margin 2023 | #employee 2023 |
|---|---|---|---|---|---|
| **Marinetek** | $27,580,375.00 | 1.81% | $1,383,920.00 | 5.02% | 63 |
| **Ingemar** | $8,531,076.00 | 9.27% | $678,431.00 | 7.95% | 25 |
| **Bellingham Marine** | n,a. | n,a. | n,a. | n,a. | n,a. |
| **Sf Marine** | $17,147,567.00 | 2.18% | $1,026,629.00 | 5.99% | 57 |
| **Bellamer** | $459,632.00 | -4.66% | $6,520.00 | 1.42% | 1 |
| **Martini Alfredo** | n,a. | n,a. | n,a. | n,a. | n,a. |
| **Poralu** | $17,983,042.00 | 3.80% | $875,816.00 | 4.87% | n,a. |
| **Lindley** | n,a. | n,a. | n,a. | n,a. | n,a. |
| **Ronautica** | n,a. | n,a. | n,a. | n,a. | n,a. |
| **System Group** | n,a. | n,a. | n,a. | n,a. | n,a. |
| **Pontech** | n,a. | n,a. | n,a. | n,a. | n,a. |

**Table 6** Financial values of companies which offer fixed breakwater products

| Fixed Breakwater Companies | REVENUE 2021 | ROA 2021 | EBITDA 2021 | %margin 2021 | #employee 2021 |
|---|---|---|---|---|---|
| **We Build Group** | $6,552,243,000.00 | -1.17% | $445,619,000.00 | 6.80% | 30798 |
| **Boskalis** | $3,403,693,000.00 | 3.64% | n.a. | n.a. | n.a. |
| **Fixed Breakwater Companies** | **REVENUE 2022** | **ROA 2022** | **EBITDA 2022** | **%margin 2022** | **#employee 2022** |
| **We Build Group** | $8,091,153,000.00 | 0.72% | $582,745,000.00 | 7.20% | 35994 |
| **Boskalis** | $3,904,153,000.00 | 5.31% | n.a. | n.a. | n.a. |
| **Fixed Breakwater Companies** | **REVENUE 2023** | **ROA 2023** | **EBITDA 2023** | **%margin 2023** | **#employee 2023** |
| **We Build Group** | $9,951,256,000.00 | 1.58% | $863,855,000.00 | 8.68% | 37995 |
| **Boskalis** | $4,838,565,000.00 | 13% | n.a. | n.a. | 6608 |

**Table 7** Averaged Financial values for companies which offer breakwater products.

| | 2021 | REVENUE 2021 | EBITDA 2021 | %margin 2021 |
|---|---|---|---|---|
| **Averaged Financials of Floating Breakwater Companies** | | $9,812,759.64 | $461,008.00 | 4.70% |
| **Averaged Financials of Fixed Breakwater Companies** | | $4,977,968,000.00 | $445,619,000.00 | 8.95% |
| | **2022** | **REVENUE 2022** | **EBITDA 2022** | **%margin 2022** |
| **Averaged Financials of Floating Breakwater Companies** | | $9,993,730.60 | $519,517.10 | 5.20% |
| **Averaged Financials of Fixed Breakwater Companies** | | $5,997,653,000.00 | $582,745,000.00 | 9.72% |
| | **2023** | **REVENUE 2023** | **EBITDA 2023** | **%margin 2023** |
| **Averaged Financials of Floating Breakwater Companies** | | $14,340,338.40 | $794,263.20 | 6% |
| **Averaged Financials of Fixed Breakwater Companies** | | $7,394,910,500.00 | $863,855,000.00 | 12% |

## 4.2 Comparing EBITDA and Revenue for Break Water Types

When evaluating the financial performance of companies which offer floating and fixed breakwater products, it is important to consider revenue and EBITDA (Earnings Before Interest, Taxes, Depreciation, and Amortisation) as important indicators. Revenue is the complete income generated from a company's core operations, while EBITDA indicates its operating profitability, excluding non-operational expenses.

Important indicators used when comparing the financial performance of companies are EBITDA and revenue. EBITDA is a financial measure used to evaluate a company's profitability and overall financial performance. The expansion of EBITDA stands for earnings before interest, taxes, depreciation, and amortisation. Investors, analysts, and business owners frequently use it to evaluate operational efficiency and financial stability. EBITDA provides vital insights into a company's ability to create cash flow by concentrating on its core business operations. (Klipfolio, n.d.)

Revenue is the complete amount of money earned by a firm via the sale of its products or services. This financial metric incorporates the total revenue generated by the company, which includes income from the sale of goods, providing of services, or a mix of both. It is important because it allows investors and business owners to evaluate the financial well-being of the organisation. (Klipfolio, n.d.)

Considering that companies which offer fixed breakwaters are large construction firms, it can be anticipated that their EBITDA and revenue figures will be greater than those of companies offer floating breakwaters. In conducting this analysis, the average values of the companies offer floating breakwaters and companies offer fixed breakwaters that were found in the financial data were taken and compared with each other. With this method, it was aimed to compare companies with different types of breakwaters using their average values to find a more accurate result.

During the period of 2021 to 2022, a 2% increase in the revenues of companies offer floating breakwater products has been observed. Companies which offer fixed breakwaters have made a 19% increase.

In the 2022-2023 period, while a 30% growth in revenues was observed for firms offer floating breakwater products, this figure is 17% for firms offer fixed breakwater products.

Between the years 2021 and 2022, the change in EBITDA for firms offer floating breakwater products are 11%, while for firms offer fixed breakwater products, it is 24%. In the years 2022-2023, EBITDA for companies which offer floating breakwaters experienced a 35% increase, while companies which offer fixed breakwaters saw a 33% increase.

Looking at this data, we can say that the companies operating in the floating breakwater sector experienced greater increases in Revenue and EBITDA during the 2022-2023 period compared to the 2021-2022 period, which indicates that demand has risen. In Table 8 and in Table 9, you can see the revenue and EBITDA values of the companies which offer floating and fixed breakwater products.

**Table 8** Averaged Revenue and EBITDA values for companies which offers fixed breakwater products

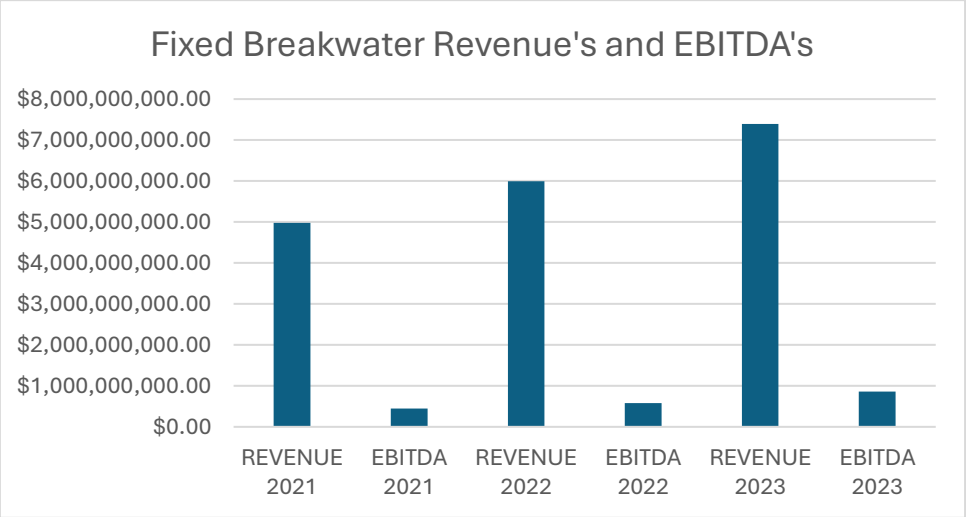
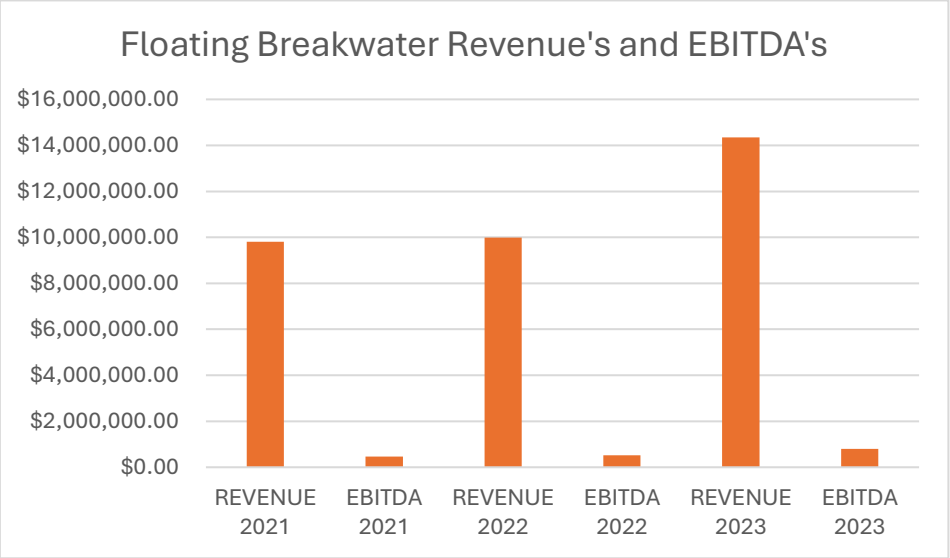


**Table 9** Averaged Revenue and EBITDA values for companies which offer floating breakwater products




## 4.3 Comparing % Margin for Break Water Types

Another important ratio we should consider when comparing companies with fixed and floating breakwater structures is EBITDA/revenue, which is the EBITDA margin.
The EBITDA margin is a performance statistic utilised by investors and analysts to gauge a company's profitability solely from its operations. (Chen, 2023)

Surprisingly, companies that specialise in fixed breakwaters have higher EBITDA margins when compared to those that focus on floating breakwaters. It may appear counterintuitive, as companies in the floating breakwater industry operate in a specialised market, often linked to higher prices and potentially greater profitability. On the other hand, companies which offer fixed breakwater construction enjoy higher margins due to their ability to take advantage of economies of scale, maintain diverse project portfolios, and establish a strong market presence. This allows them to distribute costs across multiple revenue streams.

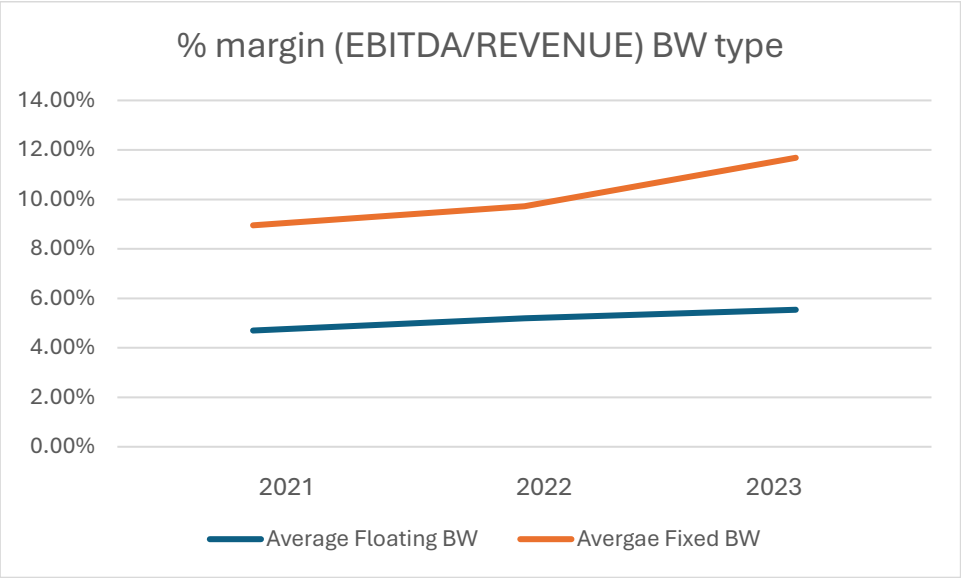
Interestingly, the EBITDA margin of companies offer fixed breakwaters is higher than that of companies offer floating breakwaters. At first glance, this result seems strange because companies offer floating breakwaters can potentially yield higher outputs since they are sold to specialized markets. However, companies which offer fixed breakwaters can spread their

costs due to benefits from "economies of scale" and "diverse project portfolios."

At the same time, EBITDA margins have increased for both types of companies. In the 2021-2022 period, companies offer floating breakwaters showed an increase of 9.63%, while companies offer fixed breakwaters demonstrated an increase of 7.87%. In the 2022-2023 period, companies offer floating breakwaters experienced an increase of 6.14%, while companies which offer fixed breakwaters  had an increase of 16.83%.

In table 10 below you can find EBITDA/revenue data for both type of companies.

**Table 10** EBITDA margin analysis for companies which offer breakwater products



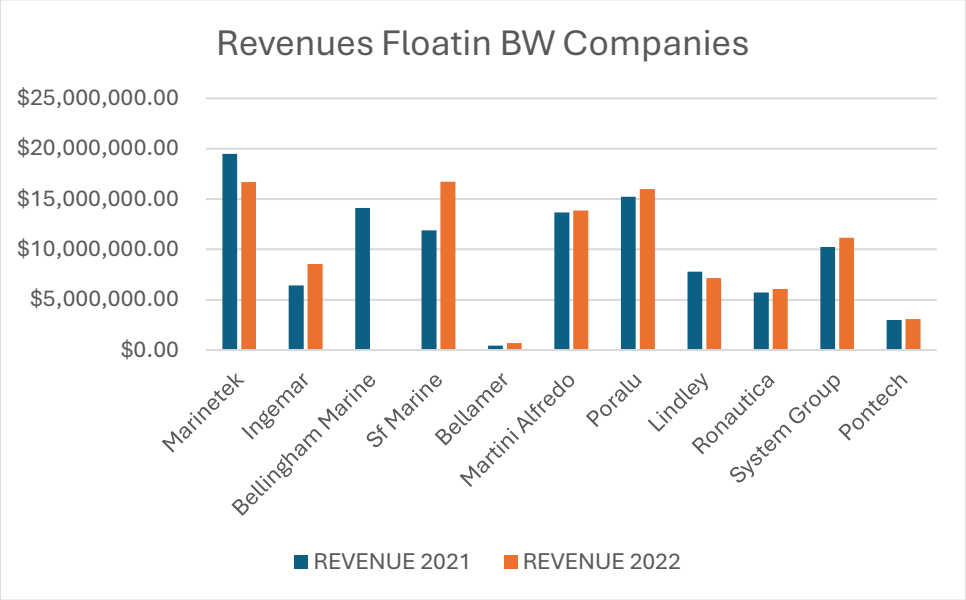

## 4.4 Revenue Analysis for Companies Which Offers Floating Breakwater Products

When comparing the revenues of various floating breakwater offering companies, a certain pattern becomes visible for the 2021-2022 period. In 2021, Marinetek ranked first with a revenue of 19.5 million dollars, while Poralu was in second place with 15.2 million dollars, and Bellingham Marine came in third with 14.1 million dollars.

In 2022, there were some changes in the revenues, with SF Marine achieving a significant increase in its revenues, rising from 11.2 million dollars in 2021 to 16.7 million dollars, marking an increase of approximately 5 million dollars. While some of the remaining companies have experienced slight declines in their revenues, most firms have managed to maintain their revenue levels. These data show that the sector is developing and at least not losing value.

You can find the revenue analysis for companies which offer floating breakwaters in table 11.

**Table 11** Revenue analysis for companies which offer floating breakwater products



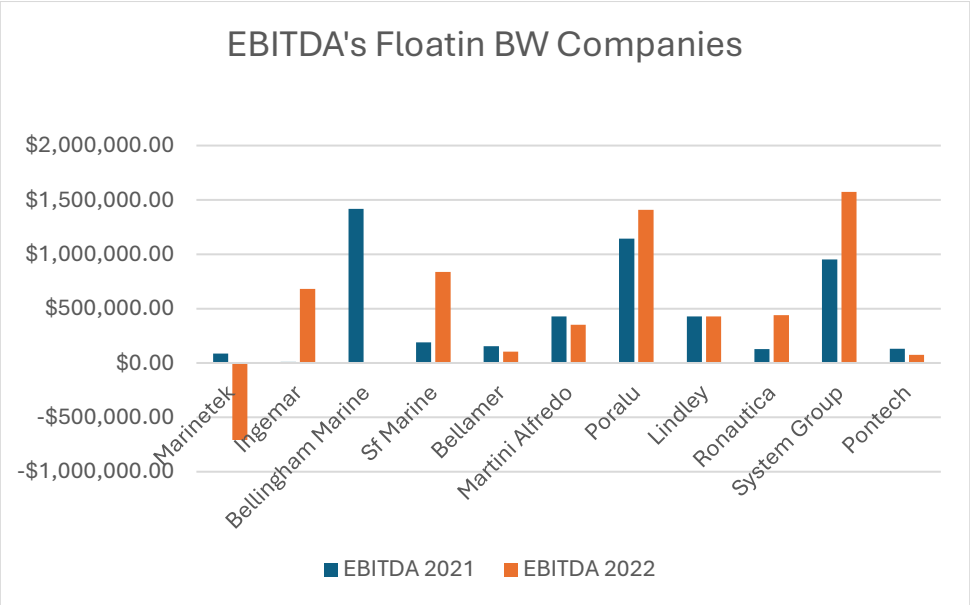
## 4.5 EBITDA Analysis for Companies Which Offer Floating Breakwater Products

When analysing EBITDA, there seems to be a significant increase or decrease in the EBITDA values of companies during the 2021-2022 period. In 2021, Bellingham Marine ranked first with an EBITDA value of 1.4 million dollars, while Poralu came in second with 1.1 million dollars, and System Group ranked third with 900 thousand dollars.

In 2022, the most striking changes increased the System group's EBITDA value to 1.5 million dollars, while SF Marine raised its EBITDA value from 180 thousand dollars to 830 thousand dollars. At the same time, Ingemar has increased its EBITDA value from 8,000 dollars to 682,000 dollars. In contrast, Marinetek experienced a decline from $86,000 EBITDA to -$700,000 in 2022.

You can find the EBITDA analysis for companies which offer floating breakwater products in table 12.

**Table 12** EBITDA analysis for companies which offer floating breakwater products



## 4.6 EBITDA/Revenue Analysis for Companies Which Offer Floating Breakwater Products

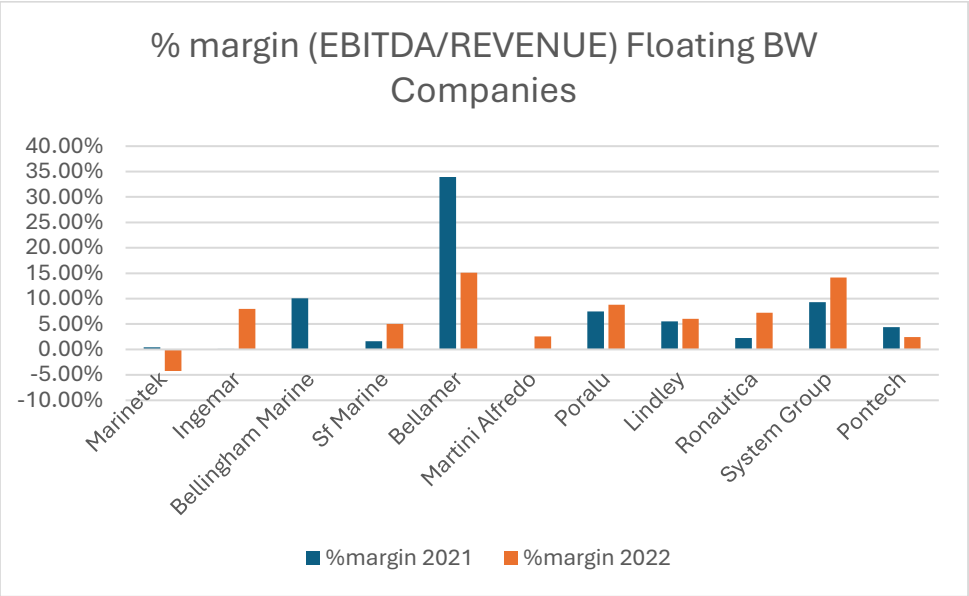
When the EBITDA margin is analysed for companies offer floating breakwaters, it can generally be seen that this margin is low, around 10%.When we compare these values to the average of 5.66% (Resources , n.d.) in the engineering and construction industry, it appears that the values are quite good. You can see that some companies have reached very high values in Table 12. For example, in 2021, Bellamer ranks at the top of the list with a 33% margin, while Bellingham Marine is in second place and System Group is in third place with margins of 10% and 9%, respectively.

In 2022, however, Bellamer's margin value showed a significant decline, dropping to 15%, but it still ranks first on the list and remains above the industry average. In addition, System Group has reached a 12% margin, rising to second place on the list. This value change indicates that there are some unforeseen factors in the floating breakwater sector; for example, the company Marinetek has dropped from a margin of 0.4% to a margin of -4.24%.(Marinetek has negative EBITDA in 2022).

However, when we look at this industry as a whole, if we take the average values of all the companies and calculate the EBITDA margins for the years 2021, 2022, and 2023, we can see that they are respectively 4.70%, 5.20%, and 6%. This indicates that the industry as a whole is on the rise.

In Table 13 you can see EBITDA margin analysis for companies which offer floating breakwaters.

**Table 13** EBITDA margin analysis for companies which offer floating breakwater products




## 4.7 ROA Analysis for Companies Which Offer Floating Breakwater Products

Return on assets is a financial metric that measures the profitability of a corporation by comparing the value of its assets to the profits it generates within a specific time period. (Birken, 2021)

As a result of the ROA analysis, the data of many companies which offer floating breakwater products has undergone changes between the years 2021 and 2022.In 2021, Pontech ranked first with a value of 11.52%, while Lindley was at 7.2% and Poralu at 6.93%.When looking at the ROA values of the companies at the top of the list, they are above the industry average of 4.6% (Return on Assets (ROA) by industry, n.d.). However, when examining the average value of

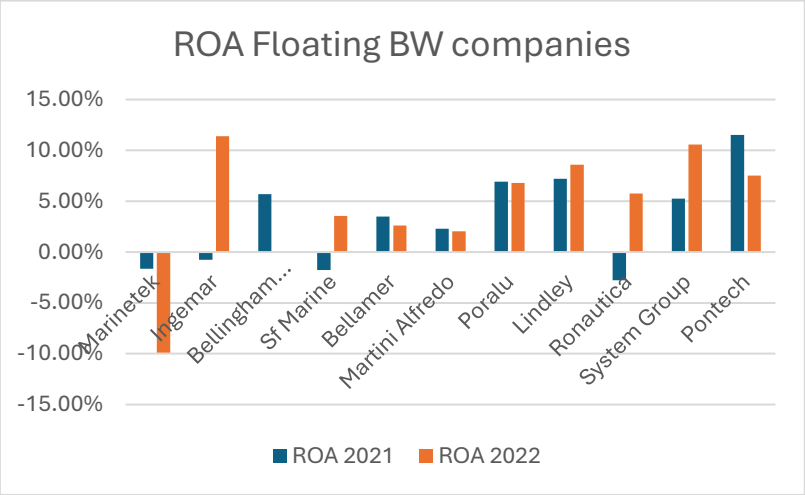
Companies which offer floating breakwaters, it appears to be below this average at 3.22%.

In 2022, the most notable company that changed its ROA value positively is Ingemar. Ingemar had a value of -0.76% in 2021, while in 2022 it rose to 11.4%. At the same time, System Group's ROA value increased to 10.5% in 2022, while Lindley's rose to 8.6%.When

looking at the average of floating breakwater companies in 2022, we can observe that it exceeded the industry average with 4.9%. This statistic shows that companies are improving their ability to generate profit from their assets.

You can find the ROA analysis of companies which offer floating breakwater products in Table 14.

**Table 14** ROA analysis for companies which offer floating breakwater products



# 5 Breakwater Market Analysis

## 5.1 Industry Definition

### 5.1.1 Marine and Port Construction Industry

Marine construction refers to the act of constructing structures either in or near vast quantities of water, typically the ocean. These constructions can be constructed for several functions, including as transportation, energy generation, and recreation. Marine construction often utilises a range of construction materials, with steel and concrete being the primary choices. Marine structures encompass a variety of examples such as ships, offshore platforms, anchors, pipelines, cables, wharves, bridges, tunnels, breakwaters, and docks. (Marine Construction, n.d.)

### 5.1.2 Breakwater Industry

The breakwater industry is primarily focused on the design, construction, and maintenance of breakwaters. Other side activities include bringing the breakwater construction materials to the field and conducting regular checks. The breakwater industry is within the marine and port construction industry, meaning that the marine and port construction industry encompasses the breakwater industry.

## 5.2 Market Definitions

### 5.2.1 Marine and Port Construction Market

According to the report by "The business research company," the definition of the marine and port construction market is: Marine and ports construction involve the construction of structures along a shoreline or shore to protect nearby property from harm and facilitate the loading and unloading of shipping and people from ships. Furthermore, the task involves constructing and restoring harbours and naval facilities, encompassing all the structures within these areas. (Company, n.d.)

### 5.2.3 Breakwater Market

Breakwater market generally includes the construction of breakwater structures or the renovation and maintenance of old breakwaters to protect these areas from waves, primarily at ports and marinas, and sometimes for offshore energy companies. We can also include in market companies that sell the necessary materials for construction and renovation, as well as the firms that transport these materials, and the engineers who work on the design of the buildings. At the same time, the "marine and port construction" market encompasses the "breakwater market."

## 5.3 Market Size

### 5.3.1 Marine and Port Construction Market Size

According to description from their public website of the report (Marine and Ports Construction Market Definition and Segments) by "The business research company," Marine and Port Construction market value and compound annual growth rate (CAGR) is:

In 2023, the market value of 42.58 billion dollars increased to 44.61 billion dollars in 2024, which corresponds to a compound annual growth rate (CAGR) of 4.8%. At the same time, it has been observed that the market value has been consistently increasing in recent years. It is expected that by 2028, the marine and port construction market will reach 51.86 billion dollars with a CAGR growth of 3.8%. (Company, n.d.)

### 5.3.2 Breakwater Market Size

According to the executive summary from their public website of the report (Breakwater Market Insights) by “Verified Market Reports” Breakwaters Market size is:

The market size of Breakwaters was assessed at USD 3 billion in 2023 and is expected to reach USD 5 billion by 2030, with a compound annual growth rate (CAGR) of 6% during the forecast period from 2024 to 2030. (Reports, 2024)

If we consider that the marine and port construction market encompasses the breakwater market, when we divide the market values of these two different reports, we can see that the breakwater market covers 11.74% of the marine and port construction market. The fact that the breakwater market encompasses 11.74% of the marine and port construction market demonstrates how large and simultaneously how important the breakwater market is.

You can see this process in Table 15 below.

**Table 15** percentage of breakwater market in marine and port construction market

| Market Values in Billions | 2023 | Market Type |
|---|---|---|
| The Business Research Company | 42.58 | Marine and Port Construction |
| Verified Market Reports | 5 | Breakwater |
| | 11.74% | |

After that, the compound annual growth rate (CAGR) was calculated for the breakwater market using the financial values of the floating breakwater companies and fixed breakwater companies that was used in Chapter 4. And this value came out to be an average of 6.22% for the companies which was analysed. While the value of CAGR for floating breakwater firms was 4.72%, it was 13.69% for fixed breakwater firms. When the calculated CAGR which is 6.22% was compared with the prepared reports, it turned out to be higher than the value from the marine and construction market report which was 4.8%. While the calculated CAGR is almost the same result with the breakwater market report which was 6%.

You can find this calculation in Table 16 below.

**Table 16** CAGR calculations for breakwater market

| | **Revenues** | | | **CAGR** |
|---|---|---|---|---|
| **Firms** | 2021 | 2022 | 2023 | |
| **Marinetek** | $19,476,207.00 | $16,674,286.00 | $27,580,375.00 | 12.30% |
| **Ingemar** | $6,418,929.00 | $8,536,946.00 | $8,531,076.00 | 9.95% |
| **Sf Marine** | $11,902,280.00 | $16,735,204.00 | $17,147,567.00 | 12.94% |
| **Bellamer** | $455,157.00 | $688,658.00 | $459,632.00 | 0.33% |
| **Martini Alfredo** | $13,655,582.00 | $13,857,443.00 | n,a. | 0.74% |
| **Poralu** | $15,235,549.00 | $15,997,118.00 | $17,983,042.00 | 5.68% |
| **Lindley** | $7,770,072.00 | $7,137,683.00 | n,a. | -4.16% |
| **Ronautica** | $5,705,529.00 | $6,073,939.00 | n,a. | 3.18% |
| **System Group** | $10,233,690.00 | $11,147,981.00 | n,a. | 4.37% |
| **Pontech** | $2,975,404.00 | $3,088,048.00 | n,a. | 1.88% |
| **We Build Group** | $6,552,243,000.00 | $8,091,153,000.00 | $9,951,256,000.00 | 14.95% |
| **Boskalis** | $3,403,693,000.00 | $3,904,153,000.00 | $4,838,565,000.00 | 12.44% |
| | | | Average CAGR for all Breakwater Types | 6.22% |
| | | | Average CAGR for Floating Breakwaters | 4.72% |
| | | | Average CAGR for Fixed Breakwater | 13.69% |

## 5.4 Market Segmentation

In the market segmentation section, our main market is the marine and port construction market, under which the breakwater market, which we are primarily interested in this thesis, is located. The breakwater market have been divided into a total of 4 segments, which are:

1) Breakwater type
2) Geographic
3) Project size
4) Usage purposes.

The details of these classes will be addressed later in this section. In figure 27 you can see general scheme of market segmentation.

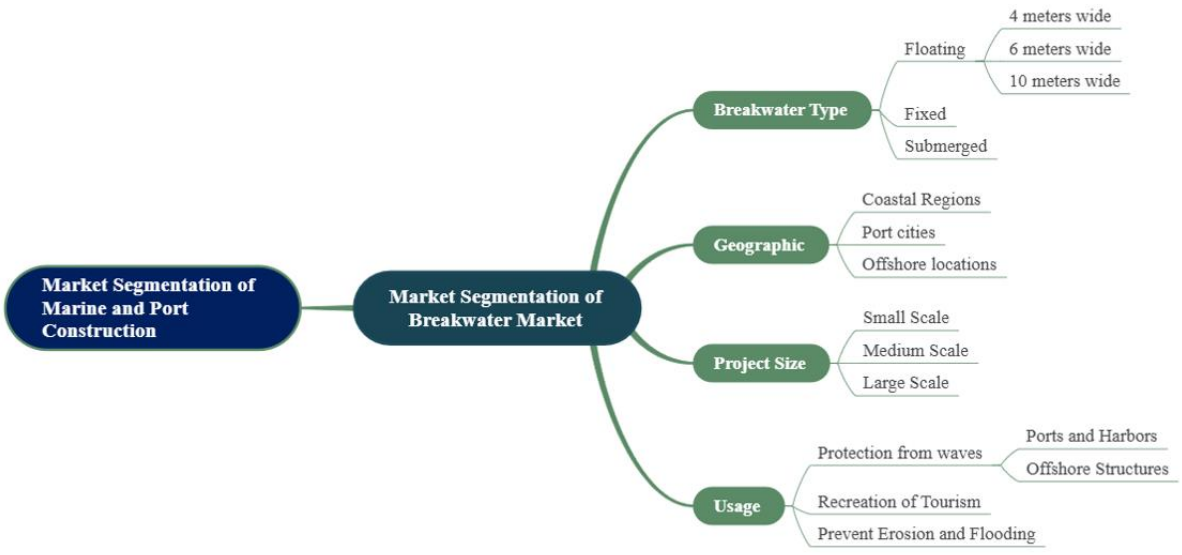



**Figure 27** General Scheme of Market Segmentation

### 5.4.1 Breakwater Type Segment

This segment is related to the types of breakwaters. The main reason for dividing the market into this segment is that, in general, most of the produced breakwater's products are one of these floating, fixed, or submerged types. You can find the details of these types in chapter 2.

#### 5.4.1.1 Floating Breakwater Segment

In floating breakwater segment, the most commonly produced models are those with widths of 3, 6, and 10 meters. You can find the floating breakwater products of various companies in Chapter 3, Table 2.In figure 28 breakwater type segment can be seen .

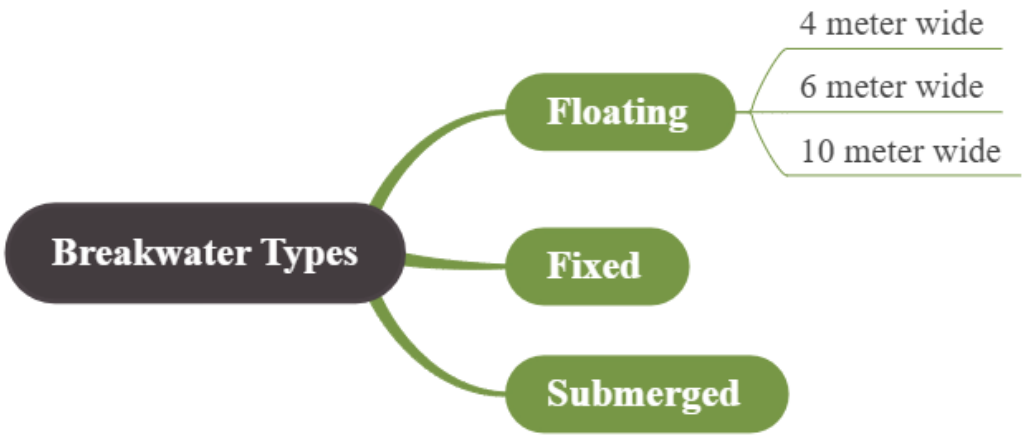



**Figure 28** Breakwater Type Segment

### 5.4.2 Geographic Location Segment

In the geographical location segment, there are "Coastal," "Port Cities," and "Offshore Locations." In coastal areas, breakwaters are generally used to take measures against erosion, while in port cities, they are typically used to protect the ports. Similarly, in offshore areas, they are used to protect that region as well. In figure 29 geographic segment can be seen.

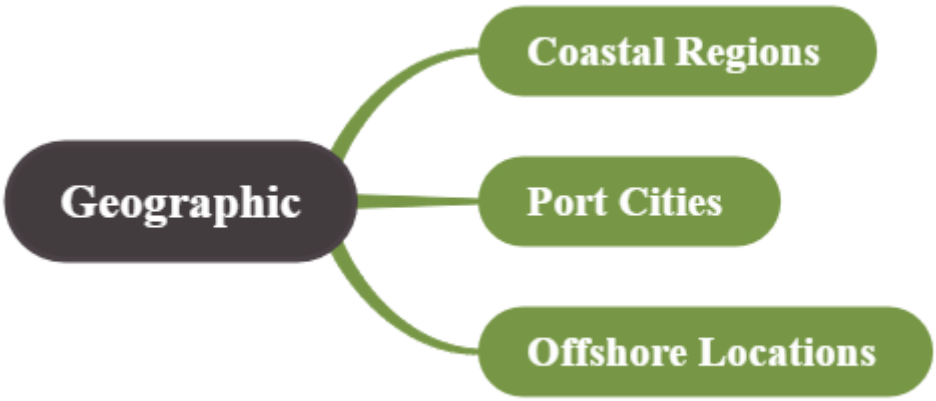



**Figure 29** Geographic Segment

### 5.4.3 Project Size Segment

This segment was divided according to the size of the projects undertaken, and the main reason for doing this is that in the comparison of floating and fixed breakwater companies in Chapter 3, there are significant differences between the sizes and budgets of the projects they carry out. For example, there are significant differences in budget, workforce, and construction time between the "Genova New Breakwater" project carried out by the "Webuild" group and the construction of floating breakwaters. You can find more details in chapter 3. In figure 30 project size segment can be seen.

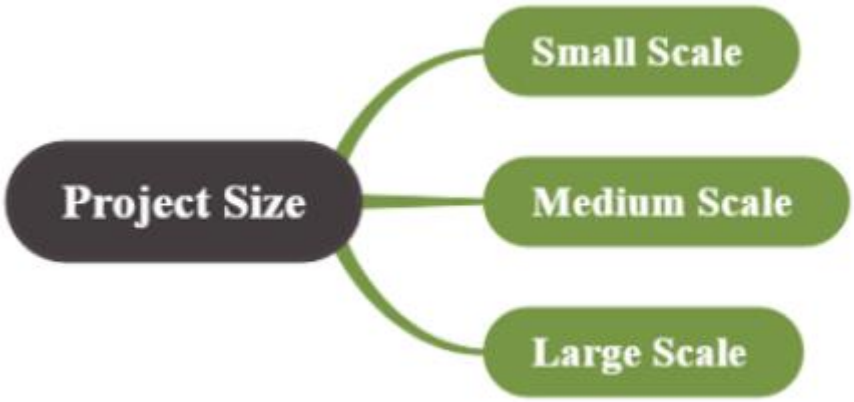



**Figure 30** Project Size Segment

### 5.4.4 Usage of Breakwaters Segment

This segment has been separated according to the applications of breakwaters. The main reason for this is that the purpose of the application and its context, as well as the potential customers are changing, and consequently, the project's budget size and type are also changing according to the application. This segment includes "Protection from Waves," "Recreation of Tourism," and "Prevent Erosion and Flooding. Since the main purpose of breakwater is to protect against waves, it is divided into two categories: "Ports and Harbors" and "Offshore Structures". But the purpose remains the same; only the area they protect is changing. Waves not only prevent erosion, but they can also contribute to tourism; for example, artificial reefs can serve as a foundation for activities like diving. You can find more details in chapter 2. In figure 31 usage segment can be seen.


**Figure 31** Usage Segment

## 5.5 Market Trends

### 5.5.1 Positive Trends

Trends positively affecting the breakwater market.

**The development of technology**: With the advancement of technology, the innovative features of floating wave breakers have been developed, the use of new, more durable materials has begun, and construction methods have become easier, cheaper, and quicker with new technologies.

**Increase in Investments:** Investments in ports are generally on the rise; those making these investments are typically countries that are also firms involved in the construction of new ports and marinas. According to a report by PwC (Jakubowska, 2024), it shows that China and India are investing in port infrastructure. These port investments directly affect the breakwater market.

**Economic Growth:** According to data from the IMF report, countries' GDP is expected to show an increase of 3.2% starting from 2024.This data indirectly contributes to the growth of the breakwater market. We can see this data in the Figure 32 below.

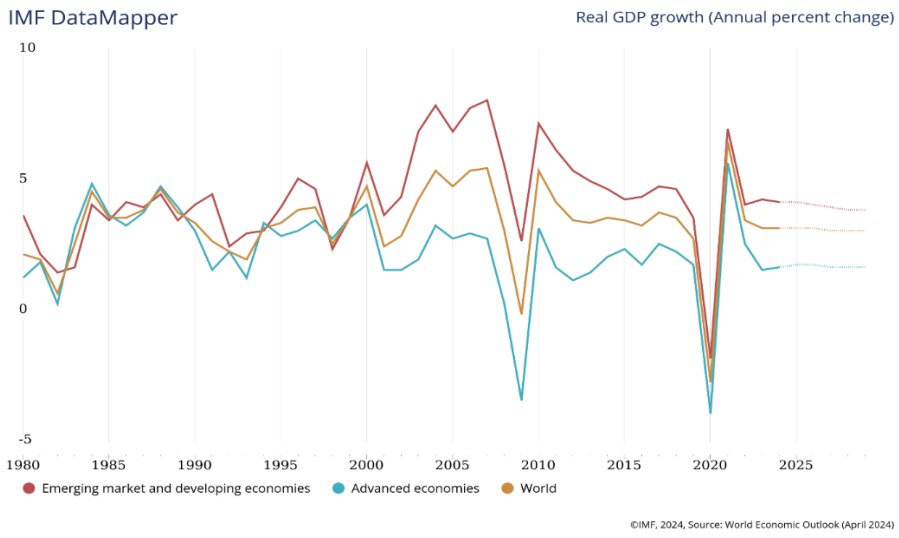



**Figure 32** IMF GDP growth rates (Real GDP growth , n.d.)

**New Ports:** The opening of new ports is a positive indication that the market is growing and will continue to grow, for example, BOSKALIS opens a shore power facility for its vessels in Rotterdam. (Prevljak, 2023)

**The increase in tourism:** According to reports from the European Commission, coastal tourism has been steadily increasing, except for the exceptional case of the COVID-19 pandemic in 2020. The industry experienced significant repercussions as a result of the COVID-19 pandemic in 2020. The beach tourism sector experienced a partial recovery in 2021, however it remained below the level observed before the crisis. The sector's gross value added (GVA) reached €49.9 billion, showing a significant rise of 74% compared to the €28.6 billion recorded in 2020. However, it still represents a contraction of 38% compared to the GVA of €49.9 billion in 2019. (Commission, n.d.)

**Population growth:** When we look at the data on article (Hannah Ritchie, 2023), the annual population growth worldwide corresponds to 0.8%. The increase in population has several direct positive effects, such as the rise in tourism numbers and the need for new ports.

**Support from the government:** Due to the reasons and reports we mentioned in the increase in investment section, support from the government part is also increasing in the same way.

### 5.5.2 Negative Trends

Trends negatively affecting the breakwater market.

**Covid-19:** Just as Covid-19 has negatively impacted many sectors, it has also adversely affected the breakwater market. The reasons for this include a decrease in tourism, delays in construction due to obstacles, and a general negative impact on the economy.

**Alternative Solutions:** Just like every product, there are alternatives for breakwaters as well. Some examples are: groins, jetties and seawalls

**High Construction Costs:** The construction costs of fixed breakwater can be very high; for example, we can refer to the genoa breakwater project, and you can find the details in Chapter 3.

**Maintenance and repair challenges:** In this report, considering the data titled "The effectiveness of coral reefs for coastal hazard risk reduction and adaptation," (Ferrario, 2014) it appears that the maintenance costs of breakwaters are high.

**Climate change:** Climate change exerts substantial pressure on the tourism industry by modifying environmental and socio-economic factors that impact tourist behaviour and the appeal of destinations. (Tanrisever, Pamukçu, & Baydeniz, 2024). Additionally, another negative aspect of climate change is the insufficiency or modification requirement of existing breakwaters due to the rise in sea levels.

## 5.6 Porter’s Five Force Analysis

Michael Porter's groundbreaking 1979 essay in the Harvard corporate Review introduced his influential ideas that have since transformed the area of strategy and continue to have a profound impact on corporate practices and academic thought. A Five Forces study enables organisations to evaluate the appeal of an industry, anticipate the impact of trends on industry rivalry, choose the industries in which a company should compete, and strategize how to position themselves for success. (Competitiveness, n.d.)

In this section, a Porter's Five Forces analysis was conducted for the breakwater market. A total of 5 factors have been used for each force, and scores have been assigned based on these factors, which are 1, 5, and 10. In the case of a high total score, the high porters force is a threat, while the low porters force is not a threat. You can see the results of Porter's Five Forces in Figure 33 below.

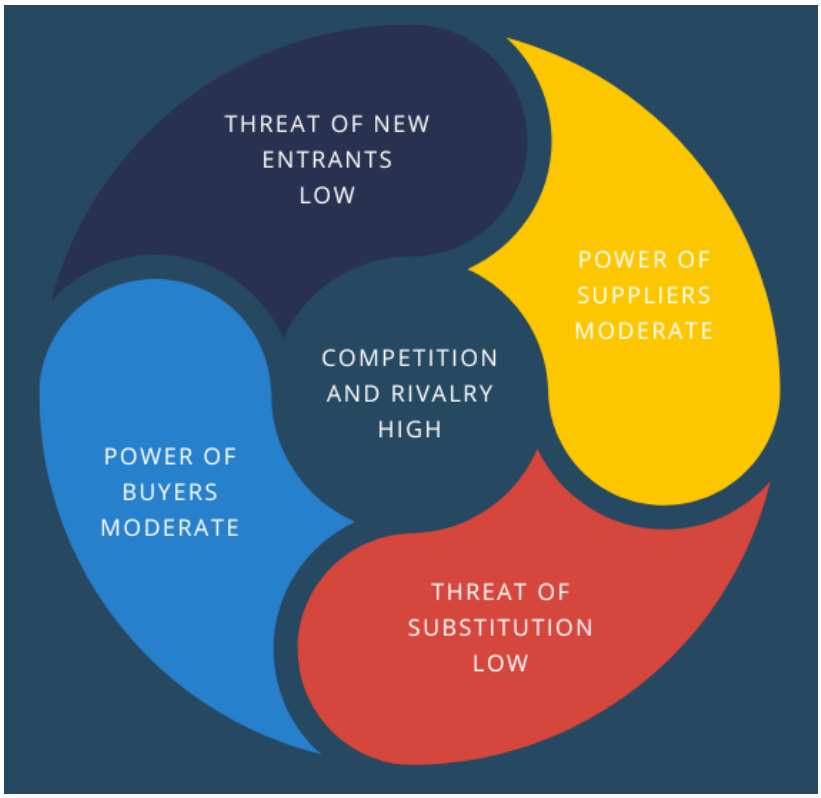



**Figure 33** Porters Five Force Analysis

### 5.6.1 Competition and Rivalry

In the "Competition and Rivalry" section of the Porter's 5 Forces analysis, the result has come out as high. Because most factors have become the high-ranking score, meaning "threat".

**The number of competitors:** There are many players in the breakwater industry and market because there are numerous companies both regionally and internationally. As we can see in Chapter 3 and Table 3, the focus areas of the projects that companies undertake with their base are changing. A score of "10" has been given for this reason.

**Growth Rate:** Considering the CAGR of 6.22% calculated in Table 16, although the breakwater and breakwater construction sector is not growing very rapidly, it has been assigned a score of "5" because it is growing faster than the general construction sector's CAGR of 4.6%.

**Exit Barriers and Fixed Costs:** Exit costs and fixed costs are generally high in the construction sector, just as they are here .A score of "10" has been given for both for this reason.

**Brand Reputation:** When breakwater companies collaborate with governments or large energy companies, it is crucial for them to establish their credibility. which results in a score of "10".

You can see scores in following Table 17.

**Table 17** Porters 5 force Competition and Rivalry

| Competition and Rivalry | Scores |
|---|---|
| The number of competitors: | 10 |
| Growth Rate: | 5 |
| Exit barriers: | 10 |
| Fixed costs: | 10 |
| Brand Reputation: | 10 |
| Overall, Strength: | 45 |

### 5.6.2 Threat of New Entrants

In the "Threat of New Entrants" section of the Porter's 5 Forces analysis, the result has come out as low.

**Economies of Scale:** Just as many construction companies benefit from economies of scale when constructing fixed breakwaters, firms that produce floating breakwaters do not benefit to the same extent. Therefore, a score of 5 was assigned.

**Regulations:** The deliverable outlines the prevalent administrative impediments associated with the implementation of infrastructure projects at several phases, including certification procedures, due diligence, permits, public procurement, tender bidding, contracting, and planning. They frequently engage closely with the previously described intricate hierarchy of the institutional framework and the international nature intrinsic to numerous IWT infrastructure projects. The predominant administrative impediments arise from institutional complexity and procedures that adhere to the established hierarchy specified at the national level of EU Member States. (Seitz, 2023) For this reason, a score of 1 was assigned.

**Switching Costs:** When port construction begins, switching costs can be very high because companies provide multiple services instead of just one. One of these services is breakwater construction, and since they undertake many other projects as well, changing providers becomes difficult, resulting in high switching costs. For this reason, it received a score of 1.

**High Capital Requirement:** As in the construction sector, capital requirements are high; another reason for this is that contracts are not limited to just the breakwater but encompass the entire port. From the report “Impact of Competitive Forces to the Contractors in Sri Lanka: an Industry Analysis Using Porter’s Five Forces” (INDRARATHNE. P.K.G, 2020) proves this hypothesis. For these reasons, it has received a score of 1.

**Regional Focus:** Despite these challenging entry conditions, this work can begin to be carried out in smaller and less developed countries. For this reason, a score of 5 was assigned.

You can see scores in following Table 18.

**Table 18** Porters 5 force Threat of New Entrants

| Threat of New Entrant | Scores |
|---|---|
| Economies of Scale | 5 |
| Regulations | 1 |
| Switching Cost | 1 |
| High Capital Requirements | 1 |
| Regional Focus | 5 |
| Overall, Strength | 13 |

### 5.6.3 Power of Suppliers

In the "Power of Suppliers" section of the Porter's 5 Forces analysis, the result has come out as moderate. The data above has been examined from the report "Impact of Competitive Forces on Contractors in Sri Lanka: an Industry Analysis Using Porter's Five Forces." (INDRARATHNE. P.K.G, 2020) Since the data in this report is applicable to the construction sector, it has been modified specifically for the breakwater construction sector.

**Supplier Product Differentiation:** While the quality of the materials we purchase and use is important, these materials are basic materials, such as rock, wood, and concrete, and their development and customization are limited. That's why a score of 5 was given.

**Number of Suppliers:** The materials used in construction are simple, but since specialized products are used occasionally, the number of suppliers is neither too many nor too few. A score of 5 was given for that reason.

**Switching Cost:** The switching cost was given a score of 5 for the same reasons, as it is proportional to the number of suppliers.

**Proven and Tested Product:** In the construction sector, it is very important for materials to be reliable and to have been previously used with satisfaction. That's why a score of 10 was given.

**Supplier Reputation:** While the reputation of the supplier is important, it is not sufficient on its own; however, suppliers that work with well-known companies have extra credibility. That's why a score of 5 was given.

You can see scores in following Table 19.

**Table 19** Porters 5 force Power of Supplier

| Power of Suppliers | Scores |
|---|---|
| Suppliers Product Differentiation | 5 |
| Number of Suppliers | 5 |
| Switching Cost | 5 |
| Proven and Tested Product | 10 |
| Supplier Reputation | 5 |
| Overall, Strength | 30 |

## 5.6.4 Power of Buyers

In the "Power of Buyers" section of the Porter's 5 Forces analysis, the result has come out as moderate.

**Number of Buyers:** In the breakwater products and construction sector, there are not many buyers; those that do exist are usually governments or prestigious offshore energy companies. This reason gives the recipient extra power and advantage. For this reason, a score of 10 has been given.

**Size of Project:** The size of the project varies greatly depending on the type of breakwaters; while fixed wave breaker projects can be quite large for example the Genoa Breakwater project, (Group, n.d.) comparing fixed breakwater projects with floating breakwaters is comparatively smaller in scale. A score of 5 was given for this reason.

**Buyer Switching Cost:** Buyer switching costs are similarly related to the breakwater type. This amount is higher in fixed breakwaters while it is lower in floating breakwaters; for this reason, a score of 5 was given.

**Availability of Alternative Solutions:** Although there are not many alternatives to breakwaters, there are some options available. You can find the details of this in chapter 5.7.4. A score of 5 has been given for this reason.

**Product standardization and differentiation:** Product standardization and differentiation is more important for floating breakwaters, while it is less significant for fixed breakwaters. You can find the details of this in chapter 2. For this reason, a score of 5 has been given.

You can see scores in following Table 20.

**Table 20** Porters 5 force Power of Buyers

| **Power of Buyers** | **Scores** |
|---|---|
| Number of Buyers | 10 |
| Size of Project | 5 |
| Buyers Switching Cost | 5 |
| Availability of Alternative Solutions | 5 |
| Product standardization and differentiation | 5 |
| Overall, Strength | 30 |

### 5.6.5 Threat of Substitution

In the "Threat of substitution section of the Porter's 5 Forces analysis, the result has come out as low.

**Availability of substitutes:** Although there are not many alternatives to breakwaters, there are a few options available such as groins, jetties and seawalls

You can find the details of this in chapter 5.7.4. A score of 5 has been awarded for this reason.

**Cost effectiveness:** Especially floating breakwaters are given a score of 1 in this factor because they are incredibly cost-efficient.

**Environmental Concerns:** Breakwaters have received a score of 5 for this factor because they have both benefits and drawbacks for the environment. You can find the details of this in chapter 2.

**Customer willingness to go elsewhere:** Due to the lack of alternatives, it received a score of 1.

**Product Similarity:** Especially since fixed breakwaters resemble each other and most of the time products are specifically designed for ports and marinas, this section has received a score of 1. You can find the details of this in chapter 3.

You can see scores in following Table 21.

**Table 21** Porters 5 force for Threat of Substitution

| **Threat of Substitution** | **Scores** |
|---|---|
| Availability of substitutes | 5 |
| Cost effectiveness | 1 |
| Environmental Concerns | 5 |
| Customer willingness to go elsewhere | 1 |
| Products Similarity | 1 |
| Overall, Strength | 13 |

## 5.7 SWOT Analysis

Definition of SWOT analysis is a method employed to ascertain the strengths, weaknesses, opportunities, and threats pertaining to your firm or a particular project. (Raeburn, 2024)

In this section, a SWOT analysis has been conducted related to the breakwater products and market. Three factors have been put for each part. You can see this analysis according to figure 34 below.

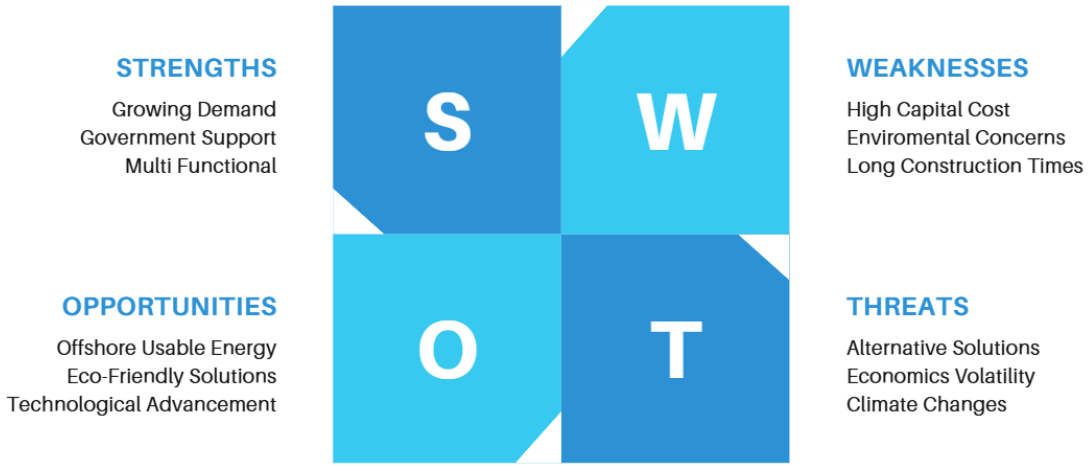



**Figure 34** SWOT Analysis

### 5.7.1 Strengths

**Growing Demand**: As explained in the Porter's Five Forces analysis, demand is generally increasing. The positive factors contributing to this include the growth of the population and GDP, which in turn boosts tourism and increases the need for breakwaters. Some of the negative factors include climate change, rising water levels, and natural disasters.

**Government Support:** In Chapter 5.5.1 the PwC report was mentioned as one of the pieces of evidence for this. Which says countries like India and China investing in marines and ports.

**Multi-functional:** Breakwaters are used for many different purposes besides protecting against waves. Improving marine life, energy production, and providing an environment for diving activities, among others. You can find the details of these objectives in chapter 2.

### 5.7.2 Weaknesses

**High Capital Cost:** Just like in the construction sector, breakwater construction requires a large budget. Especially in fixed breakwater construction, there are projects that can reach up to 1 billion dollars.

**Environmental Concerns:** Breakwaters can cause erosion and flooding; you can find the details in chapter 2.

**Long Construction Times:** Some projects involve a construction process that can take 8-10 years; for example, the Genoa breakwater project started in 2022 and is expected to be completed in 2030.

### 5.7.3 Opportunities

**Offshore Usable Energy:** Breakwaters can be used in energy production. Breakwaters primarily disperse the energy of incoming waves by wave breaking and partially reflect the waves back into the sea. This is achieved through their distinctive geometric design, which enhances their hydraulic efficiency. (Vicinanza, 2020)

**Eco-Friendly Solutions:** Artificial reefs are eco-friendly and provide protection from waves. You can find more detailed explanation chapter 2.

**Technological Advancements:** These are products that are open to development and improvement. These advancements can involve materials, efficiency, cost reduction, and finding new purposes for use.

### 5.7.4 Threats

**Alternative Products:** There are some alternative products for breakwaters, which are: dynamically stable beaches, vertical wave barriers, grooves, and jetties. All these alternatives pose risks to breakwater products and the market. (Lukshin, 2004) (MP, n.d.)

**Economic Volatility:** Wars, pandemics, and natural disasters negatively impact many sectors, including the breakwater market.

**Climate Changes:** Just as climate change negatively affects tourism, it also raises sea levels, which adversely impacts the breakwater market. You can find the details in chapter 5.5.2.

# 6. Key Questions for Suppliers & Management

In this section, there are questions prepared for breakwater product manufacturers and construction companies; these questions are critical for completing the market analysis. These questions are intended to be asked in an interview format and have been divided into a total of 6 categories: Company-Wise, Market Discovery, Market Sizing, Market Conditions, Fixed Breakwaters and Floating Breakwaters. Not every question is appropriate for every company representative; it is necessary to examine the company before asking these questions. For example, it would not be appropriate to ask a company that constructs fixed breakwaters about floating breakwater products.

Unfortunately, no interview has been conducted with these questions, and there is no such data available. For this analysis to be fully completed, further studies on this subject need to be conducted.

## 6.1 Company-Wise

1. Could you briefly describe your company's experience and involvement with breakwaters?

## 6.2 Market Discovery

1. What are the primary factors that drive demand for breakwaters in your experience?
2. In your view, what are the main challenges or barriers companies face when entering new markets for breakwaters?
3. What do you see as the future trends for breakwaters in general?
4. Who are your main competitors in the breakwater market?
5. What factors are most important to your customers when selecting a breakwater (for example cost, durability, environmental impact)?

## 6.3 Market Sizing

1. How would you estimate the current size of the market for breakwaters (for example, regional, global)?
2. What data sources or methodologies do you rely on to assess market size?
3. How large is the market for your type of breakwater in terms of revenue and volume?
4. What is the projected growth rate for this market over the next 5-10 years?
5. In which regions or countries do you see the highest demand for your break waters?
6. Are there emerging markets that show potential for growth?
7. What are the main customer segments for your breakwater's products?

## 6.4 Market Conditions

1. What do you see as the main differentiating factors or competitive advantages among different breakwater providers?
2. How have environmental considerations impacted the market for breakwaters?
3. What pricing models or cost structures are most common in the breakwater market?
4. What regulatory challenges or requirements impact the installation and maintenance of breakwaters?
5. How do economic conditions (for example, recession, inflation) impact your market?
6. What is the average cost of a breakwater project, and how sensitive are your customers to price changes?

## 6.5 Fixed Breakwaters

1. What are the typical design lifespan and maintenance requirements for fixed breakwaters?
2. How have advancements in materials or construction techniques affected the market for fixed breakwaters?
3. What are the main challenges associated with the construction and maintenance of fixed breakwaters?
4. In what environments are fixed breakwaters most effective?

## 6.6 Floating Breakwaters

1. What are the typical design lifespan and maintenance requirements for floating breakwaters?
2. What are the key challenges or considerations in the installation and anchoring of floating breakwaters?
3. What are the key design innovations in floating breakwaters?
4. How do floating breakwaters perform in various sea conditions (for example, calm vs. rough seas)?
5. What are the environmental benefits or drawbacks of using floating breakwaters compared to other types?

# Conclusion

This chapter will conclude this study and will establish the relationship between the key research findings and the purpose of research, answering the research questions. Also, this chapter will discuss the importance and value of this study. At the same time, this chapter will point out the factors that limit the research and how potential new studies can be conducted.

This study aims to do a literature review of breakwaters and their types, also examine the technologies of floating breakwater products, conduct a competitor analysis of companies that produce and manufacture breakwaters, and analyse the breakwater market.

The results of the literature review indicate that different types of breakwaters are used in different situations and conditions. While each type has its own advantages and disadvantages, careful consideration should be given to which one to use under specific conditions and for particular purposes. While floating breakwaters are more cost-effective in deeper waters, the construction of fixed and submerged breakwaters can be quite expensive. At the same time, only floating breakwaters are suitable in poor soil conditions; they are also only portable solutions. Submerged breakwater types, known as artificial reefs, generally have a positive impact on the environment and aquatic life, while the effects of floating breakwaters are minimal, and fixed breakwaters have a negative impact. Fixed breakwaters have a high capital cost, but they also have a long construction period. But, in severe wave conditions, the most effective solution is fixed breakwaters.

The results of the analyses of 15 floating breakwater companies, considering technological and operational factors, show that Ingemar, Poralu, and Lindley are the most dominant firms in the European breakwater market among these 15 companies. The Ingemar company, especially with their 360-meter floating breakwater in La Spezia, stands out when it comes to their work. Meanwhile, the Poralu company is notable for producing floating breakwaters for challenging environments, and their floating breakwaters have a loaf capacity of 400 kg. On the other hand, the Lindley company distinguishes itself through the materials they use, particularly expanded polystyrene.

Boskalis and Webuild Group are companies that construct fixed breakwaters and are among the most dominant and largest firms in the European sector. Webuild Group is actively constructing the Genoa breakwater project, which is a mega breakwater project. Both companies are construction firms, and fixed breakwater construction is one of their areas of expertise.

The analysis of the financial data of floating and fixed breakwater companies between 2021 and 2023 shows that the financial figures of fixed breakwater companies are higher overall because, by nature of the products, fixed breakwaters involve costly and lengthy project timelines, while floating breakwaters are cost-efficient structures. In general, the revenue, ROA, EBITDA, EBITDA margin, and employee numbers of breakwater companies have all increased. The average compound annual growth rates of all those companies are 6.22%.

The breakwater market includes the construction, renovation, and maintenance of breakwaters, as well as the materials needed for this construction and their transportation. The breakwater market is worth 3 billion dollars in 2023 and is projected to grow at a CAGR of 6% according to report from Breakwater Market Insights by “Verified Market Reports”. As a result of the calculations made in this study, the CAGR has been calculated as 6.22%.

As a result of the analyses made in this study, market segmentation has been divided into 4 segments: Breakwater Type, Geographic, Project Size, and Usage.

In this study positive trends affecting the breakwater market have been identified as: Development of technology, increase in investment, Economic growth, New ports, Increase in tourism, Population growth, and support from the government. Negative trends affecting the breakwater market have been identified as: Covid-19, Alternative Solutions, High Construction Costs, Maintenance and Repair Challenges, and Climate Change.

The results of the Porter's 5 Forces analysis are as follows: the threat of new entrants is low, the power of suppliers is moderate, the power of buyers is moderate, the threat of substitution is low, and competition & rivalry is high.

The results of the SWOT analysis show that the strengths are: Growing demand, Government support, and multi-functionality, while the weaknesses are: High capital cost, Environmental concerns, and long construction times. Opportunities include offshore usable energy, eco-friendly solutions, and technological advancement, while threats consist of alternative solutions, economic volatility, and climate change.

Finally, questions that need to be asked to breakwater product manufacturers have been formulated to complete the market analysis; the answers to these questions are critical for the analysis. These questions are divided into a total of 6 categories, which are: Company-wise, Market discovery, Market sizing, Market conditions, Fixed breakwaters, and Floating breakwaters.

With this study, the details of the types of breakwater products, as well as the data of the manufacturing companies, have been gathered in a single work. This study can help companies identify where they are lacking and where they can improve, as well as recognize their technological advantages and disadvantages. At the same time, this study serves as a source of information for entrepreneurs and investors who wish to enter this sector.

In this study, the limits and barriers encountered primarily stem from the lack of information about each company's products, which is due to the nature of breakwaters being produced and customized specifically for the situation. In terms of financial data, most companies are not public, so the data is limited. At the same time, since there is no percentage of revenue and other values coming from breakwaters in the financial data of the companies, the total financial data of the companies has been used. Since there is a time barrier for market questions, this process has been left for further development.

As mentioned before, this thesis work aims to provide a detailed perspective on different types of breakwaters, products, and companies. In order to validate the data collected and analysed, it is necessary to collect more detailed and specific financial data, as well as to complete surveys and interviews.

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