THE EXPLORATION OF THE COASTS OF PERINTHOS: WHAT DOES THE MULTIBEAM BATHYMETRY SURVEY TELL US?

Beril Karadöller, Caner İmren, Zeynep Koçel-Erdem

Abstract: The ancient city of Perinthos (Marmaraereglisi/Tekirdag/Istanbul), where researched with a systematic multidisciplinary archaeological project were initiated by the Ministry of Culture and Tourism in 2021, has the potential to accommodate both marine and land-based multidiscipline studies in a comprehensive approach. To investigate the traces of archaeological remains, an integrated geophysical survey was designed. As part of the project, a comprehensive multi-beam bathymetry study was carried out in the city's offshore zones, while geophysical studies were carried out on land. The bathymetry study aims to model and investigate the detailed seafloor morphology of the coast of the Perinthos. The seafloor morphology modelled using high-precision data gave us a unique opportunity to investigate the mysteries of the ancient city of Perinthos. Multi-beam bathymetry data in over 1000 hectare acquired with 400 and 700 kHz central frequency sensors. Throughout the data processing procedure, the ¨International Hydrographic Organization Standards for Hydrographic Survey¨ were adhered to. Finally, morphological imagery of the seafloor was obtained. The resolution of these images, varies between 10 cm and 1 meter depending on the depth. This study is a significant contribution to the high-resolution identification of ancient cultural heritage through the multi-beam bathymetry in marine archaeological sites.

Keywords: Multi-Beam Bathymetry, Perinthos, Marine Archaeogeophysics, Thrace Capital

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Introduction

Archaeological excavations carried out for the exploration and discovery of historical artifacts hidden under the ground require a very meticulous process and take a considerable amount of time. Knowing the location and structure of buried objects not only accelerates archaeological studies but also provides the opportunity to make reliable conclusions about these objects even before excavation. In this sense, it is valuable to utilize the power of geophysics, which sheds light on archaeological studies and provides guiding results. Land-based geophysical methods used in archaeological sites have become popular today. However, there is a need for more case studies, especially for the study of marine archaeological sites. The ancient city of Perinthos has the potential to accommodate both marine and land-based studies in a comprehensive approach.

In 2022, to investigate the traces of archaeological remains in the archaeological site, an integrated geophysical survey was designed. As part of the project, a comprehensive multi-beam bathymetry study was carried out in the city's offshore zones, while geophysical studies were carried out on land. The bathymetry study aims to model and investigate the detailed seafloor morphology of the coast of the Perinthos. Accordingly, this study will be able to detect ancient remains on the seabed. It is also envisaged that the high-resolution multi-beam bathymetry study will reveal the route to the harbor, which was used as the naval base of the ancient city. All the information obtained and the surface models derived from this information will shed light on the diving studies to be carried out at sea.

Historical Background

The ancient city of Perinthos on the coast of the northern Propontis (Marmara Sea), located in the Marmaraereğlisi district of Tekirdağ province, is undoubtedly one of the most important Thracian settlements (Figure 1). It is an important harbor settlement, and the capital of the Thracian Province during the Roman period. It has been continuously inhabited from antiquity to the present-day.

Figure 1 – Overview of Perinthos.

Being inhabited since prehistoric times, being declared the capital of the Thracian Province during the reign of Emperor Claudius in 46 AD, being in the focus of the attention of Roman emperors such as Hadrian and Septimius Severus, its convenient harbors, being located at the beginning of important road networks of the Roman Period such as Via Egnatia and Via Militaris (Via Diagonalis) and the unique opportunities provided by its geography have made the city stand out in many respects [12].

The city, which was renamed Herakleia in 286 AD during the reign of Emperor Diocletian as a reference to both Heracles, who was accepted as a ktistes and had essential cult in the city, and his ruling partner Maximianus Heraclius, consists of the acropolis, the lower city (today's modern settlement), necropolis areas and two large harbors, east and west (Figure 2). Except for the acropolis, which covers a huge area (approximately 1.5 km in length and 500 m in width) and where the buildings are mostly buried, most of the ancient city is under the Marmaraereğlisi district. The city, which has seen many remarkable periods, events, invasions, and destruction throughout history, has been under the influence of prehistoric communities, Thracian, Greek, Persian, Roman, and Byzantine cultures, and has been severely damaged by Avar and Bulgarian raids and many earthquakes [5] after the Late Antique Period.

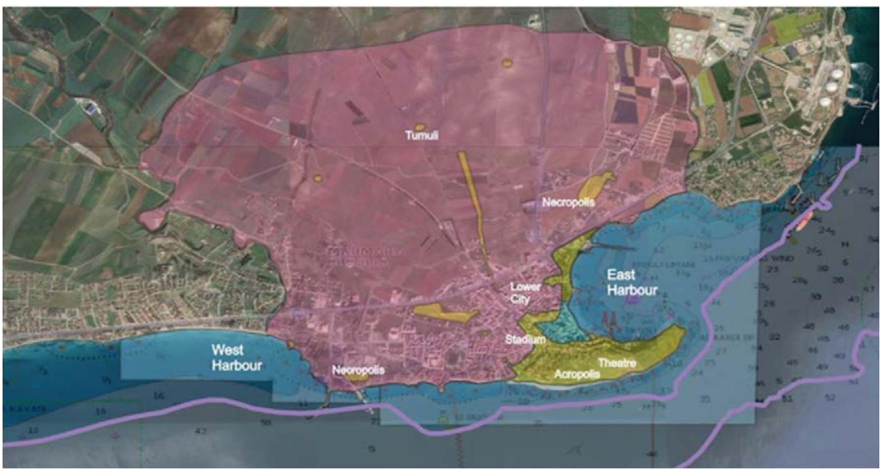

Figure 2 – Overview of Perinthos, main elements of the city.

Although Perinthos is accepted in ancient sources and scientific literature that it was founded by Samos colonists around 600 BC [12], several Prehistoric Age finds in the form of ceramics and stone tools recovered during the excavations started in the acropolis of the city in 2021 have made it possible to trace the settlement to much earlier periods [9]. The city became quite magnificent during the Roman period and became an important episcopal center during the Christian era.

Archaeological Investigations

Although the Perinthos has been mentioned many times in different aspects by ancient writers, no long-term scientific excavations have been carried out so far, except for the short-term research and soundings of Dr. Nuşin Asgari in the 1980s and the rescue excavations carried out by the Tekirdağ Archaeology Museum [1][2][3][4]. Partially surviving buildings and parts of buildings from the ancient city: The parts belonging to the land and sea walls surrounding the city from the west and north, the theater, the stadium, the basilica, the wall fragments of the Late Antique Period buildings on the Acropolis, the large vaults that could be the substructure of a monumental building, the necropolis areas and the breakwater remains of the harbor to the east of the city. The modern neighborhoods and houses located on the northern slope of the acropolis, overlooking the lower city, are positioned in a way to follows the ancient plan scheme and street patterns. On the walls of the houses, it can be seen that there are many reused materials such as inscriptions and architectural fragments. In addition, Rahmi Özcan Boulevard, the main street of the district, should be the main street of the ancient city extending from the lower city to the Acropolis. Other remains of the ancient city structures include architectural fragments, inscribed bases and tombs from various periods exhibited in the Municipality Park (Open Air Museum), and in front of the Municipality Building, as well as numerous artifacts preserved in the Tekirdağ Archaeology Museum.

The first investigations at the settlement were carried out by Cyriacus of Ancona in 1444. Various Western explorers and researchers who visited the city in the last century published several publications, mainly on honor inscriptions and some architectural and plastic works [12]. The first scientific studies that yielded significant results on the archaeological potential of the ancient city were carried out by the Istanbul Archaeological Museums. During the 1980s, Dr. Nuşin Asgari, topographer Adnan Şakar, and the Tekirdag Museum prepared a topographical plan of the city, made soundings in the stadion structure, and examined various points of the settlement and the tumuli in the north [1][2][3][4]. The most comprehensive research on the city so far is the study initiated by Prof. Dr. M. H. Sayar within the scope of a doctoral study and later published as a monograph, which sheds a great deal of light on both the history and cultural assets of the city and the history of the region in the light of Greek and Latin inscriptions [12]. In addition to this monograph, the publication of the Kapıkale Basilica in the lower city, which was excavated by the Tekirdağ Museum between 1992-2010, provides valuable information on the Late Antiquity of the city [11].

The new period of excavations in the ancient city was started in 2021 by Mimar Sinan Fine Arts University with the official permission of the Presidential Decree of the Republic of Turkey and the General Directorate of Cultural Heritage and Museums of the Ministry of Culture and Tourism. In this part of the acropolis facing the western harbor, fortifications (western walls) encircle the hill from the west, almost as a retaining wall. The walls of the polygonal tower of the fortification wall were uncovered during the excavation at the western end (Figure 3). However, it was found that the area, in general, had deteriorated considerably in the 6th century and onwards, and many courtyard spaces and workshops, which were organized for different needs, were found against the tower wall.

Figure 3 – Western excavations, walls of the tower.

Figure 4 – The largest theater in Eastern Thrace.

In the 2022 excavation season, the excavation of the theater, an important public building of the ancient city, was also started. Measuring approximately 140 x1 10 m, it can be compared with the great theaters of Anatolia and is the largest theater known in eastern Thrace (Figure 4). The Greek theater-type building, which is located on a hillside overlooking the Propontis landscape, is quite magnificent even though the cavea seating rows are not in place today. In the 4 trenches opened at the intersection of the cavea and the orchestra within the scope of the excavation, a very dense fill flowing from the upper levels was encountered, some fragments belonging to the seating rows started to be unearthed (for more information see [9][10].

Multi-Beam Bathymetry Survey

Multi-beam bathymetry is a method for measuring the depth of the seabed. It uses high-frequency sound waves sent from the sea surface to the seabed in a beam. This method quickly scans large areas of the seafloor, providing detailed information about the seafloor morphology. The temporal depths obtained in the collected bathymetry data are converted into depth information using the water column velocity. One of the most crucial aspects of bathymetry is the position of each ray reflected from the seafloor. To accurately determine the position of each reflected sound wave, we used GNSS (Global Navigation Satellite System) receivers mounted on the ship. These receivers provide precise geographical location information for the collected data.

Throughout the study [6], we utilized a boat, an unmanned surface vehicle, a bathymetry sensor, a sound velocity profiler, and GNSS receivers (Figure 5). To ensure the precision and achieve sub-centimeter accuracy of the data, we used a post-processed kinematic system. Initially, we established a local GNSS station (base) to obtain highly accurate position and elevation data, which communicated

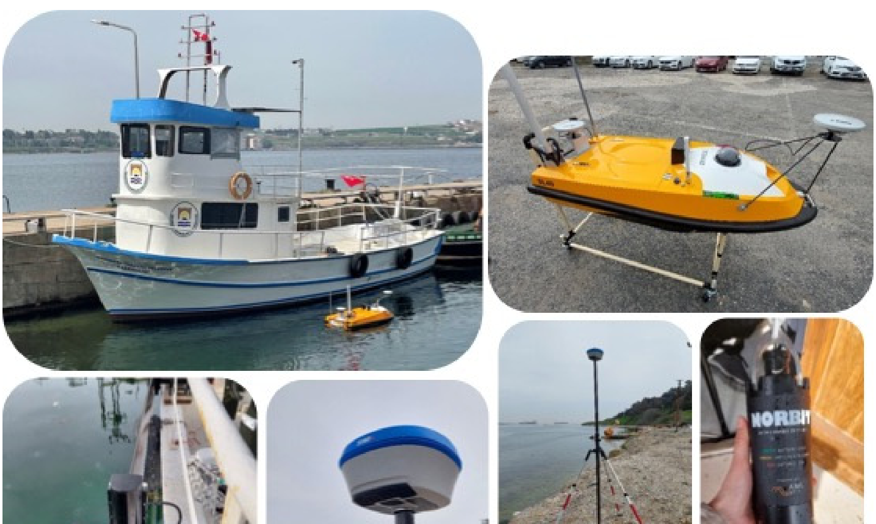

Figure 5 – Multi-Beam Bathymetry Equipment.

with both local stations in the region and the antennas mounted on the surface vehicle. Additionally, we conducted daily sea level measurements and static measurements at the base point.

The bathymetry study was performed in two phases: shallow and deep areas. The data collection area has varying depths, and the coasts contain rocky areas. For this reason, to collect data from very shallow areas where the boat cannot reach, we used an unmanned surface vehicle (USV). The bathymetry sensor was mounted on the boat in areas deeper than 5 meters and on the USV in areas shallower than 5 meters. Calibration was performed after each installation of the bathymetry sensor on the surface vehicles. A 400 kHz signal was used as standard during data collection, and a 700 kHz signal was used for more detailed mapping of some detected objects. 1024 beams were sent to the seabed and the ping rate was taken care not to go above 20 Hz. The swath angle, the angle between the most distant beams, was variably adjusted between 120 and 160 degrees during the study to account for changes in seafloor depth. Wider angles were used in shallow areas to maintain data resolution, while the angle was narrowed in deeper areas. In rocky areas posing risks, the bathymetric sensor was digitally rotated to port or starboard to see obstacles from a greater distance.

Since the water is a non-homogeneous medium, the speed of sound varies with depth due to changes in temperature, pressure, and salinity conditions. To determine the variation of sound velocity with depth in the water column, we used a Sound Velocity Profiler (SVP). The detected velocities are used to convert temporal depths in the bathymetry data into metric depths. For this reason, we conducted relevant sound velocity measurements at specific intervals in the area. The vessel remained motionless during this process to ensure sending the device as perpendicular as possible to the seabed.

In the course of the study, we collected bathymetric data for over 1000 hectares of marine area around the ancient city of Perinthos (Figure 6) [6][7][8]. The seabed depth in the collected data varied from 40 cm to 100 meters. The data was processed using "Qimera" software, starting with positional corrections known as "patch" tests, using the calibration data obtained during data collection. It is used for roll, pitch and heading corrections (Figure 7). These corrections aimed to eliminate mismatches between profiles caused by the vessel's motion. Following that, required corrections for water velocity were applied. Both automatic and manual corrections were also made to the data to remove effects such as schools of fish and scatterings. Throughout the process, the International Hydrographic Organization Standards for Hydrographic Studies were adhered to.

As a result of a multi-beam bathymetry survey, which was launched to explore the high-resolution seafloor morphology off the coast of Perinthos, morphological imagery of the seafloor was obtained. The resolution of these images varies between 10 cm and 1 meter depending on the depth. Thereby, the anomalies on the seafloor were detected through changes in the sea bottom morphology, and both natural formations and archaeological remains were observed [7][8].

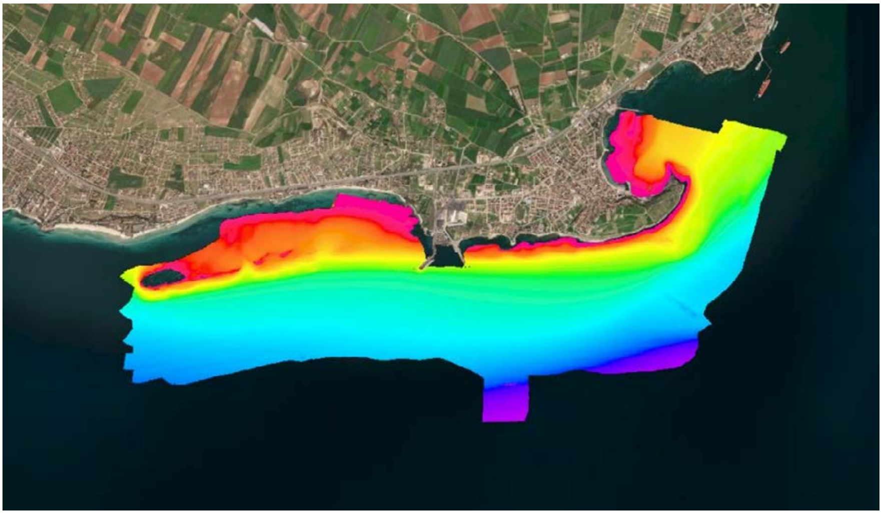

Figure 6 –Collected Data by Multi-Beam Bathymetry (Colors indicate the depths).

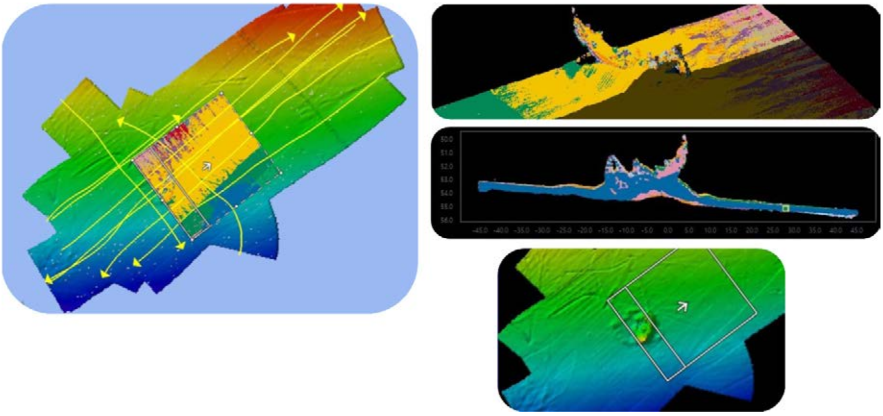

Figure 7 – Exemplary image for Multi-Beam Bathymetry Data Processing on Qimera.

Results, Conclusion and Discussion

As part of the study, an area of more than 1000 hectares was surveyed and started to be modelled with precision. Thanks to this work, unburied objects of different depths and different sizes on the seabed are detected. One of the most remarkable discoveries in the region is a shipwreck found 1500 meters off the coast of the city at a depth of about 60 meters (see Figure 7). Further studies on this shipwreck are ongoing. As a preliminary finding, it can be concluded that the shipwreck, which looks structurally different from modern boats, has a length of 25 meters and a width of 10 meters.

Another finding is a cylindrical trench with a maximum elevation difference of 5 meters from its surroundings and a width of approximately 200 meters. This trench structure is in harmony with the area that is thought to have been a harbor during the Roman Period due to its location and extension. It is likely a natural formation and may have functioned as an entrance through which people of that period passed to access the navy bay in the form of a lagoon. This situation is also handled meticulously.

Surrounding the breakwater in the eastern harbor, which was submerged by the sea level rise, various bathymetric anomalies were observed. A dive in the eastern harbor, where the anomalies observed, revealed for the first time the remains of a wall adjacent to the breakwater at a perpendicular angle. The large number of amphora fragments observed in front of this wall suggests that this area must have functioned as a dock.

The present study demonstrates the significance of using high-resolution multi-beam bathymetry to identify ancient cultural heritage in marine archaeological sites. It is essential to use geophysical methods to explore the archaeological city of Perinthos. Furthermore, a detailed examination of the marine part is crucial in addition to the studies conducted on the land parts of the ancient city.

We believe that conducting a sonar survey in addition to this study will be beneficial for detecting and visualizing archaeological remains on the seafloor. It is also critical to detect large objects such as shipwrecks, which are buried under the seafloor and cannot be seen by diving or bathymetry survey, especially considering sedimentation in marine environments. For this purpose, the study should be further supported by geophysical methods such as sub-bottom profiling methods, which allows the investigation of several meters below the seafloor.

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