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RESEARCH ARTICLE

Expanding the biogeographical range of the seagrass *Posidonia oceanica*: the discovery of meadows at Yer Island, the Sea of Marmara, Türkiye

Rıdvan Kaan Gürses[1*], Orhun Hisli[2], Nisan Aydaş[3], Nehir Eryılmaz[4], Sare Sena Türk[3], Zeynep Gülenç[1]

ORCID IDs: R.K.G. 0000-0001-5951-2308; O.H. 0000- 0002-9102-4125; N.A. 0009-0001-9811-8829; N.E. 0009-0001-5574-431X; S.S.T. 0000-0002-6822-8621; Z.G. 0009-0000-7879-3934

[1] Turkish Marine Research Foundation (TUDAV), P.O. Box: 10, Beykoz, Istanbul, TÜRKİYE
[2] Institute of Graduate Studies in Sciences, İstanbul University, 34116, Fatih, Istanbul, TÜRKİYE
[3] Faculty of Aquatic Sciences, Istanbul University, Onaltı Mart Şehitleri Cad. No: 2, 34134, Fatih, Istanbul, TÜRKİYE
[4] Department of Biological Sciences, Middle East Technical University, Dumlupınar Blv. No: 1 Üniversiteler Mah. 06800 Çankaya, Ankara, TÜRKİYE

***Corresponding author:** ridvankaangurses@gmail.com

Abstract

Posidonia oceanica is a key ecosystem engineer in the Mediterranean, playing a crucial role in maintaining biodiversity, enhancing habitat complexity, stabilising coastal environments, and contributing to carbon sequestration. The present study reports the discovery and spatial delineation of a previously unrecorded *P. oceanica* population on the coast of Yer Island, which is relatively smaller than other Marmara Islands. Through detailed georeferenced mapping and spatial analysis, we identified 37 discrete seagrass patches, covering a total area of 0.64 ha. These findings extend the known biogeographical range of *P. oceanica* and highlight the need for further research and conservation measures to protect these vulnerable habitats from ongoing anthropogenic impacts.

Keywords: *Posidonia oceanica*, Sea of Marmara, Yer Island, biogeographical range, seagrass meadow

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Introduction

Ecosystems are intricate and dynamic systems shaped by complex interactions

between organisms and their physical environment. While all species contribute to ecological processes, certain key organisms function as ecosystem engineers, fundamentally influencing habitat structure and ecosystem dynamics. Among these, *Posidonia oceanica* (Linnaeus) Delile is one of the most ecologically significant species in the Mediterranean (Boudouresque *et al.* 2012; Personnic *et al.* 2014). This seagrass forms extensive meadows that provide critical ecosystem services, including by serving as a habitat and nursery for numerous marine species, stabilising coastal sediments, improving water transparency by trapping suspended particles, sand production, and regulating nutrient cycling (Boudouresque *et al.* 2016; De Falco *et al.* 2017; Scemama *et al.* 2024; Addamo *et al.* 2025). Additionally, *P. oceanica* plays a crucial role in carbon sequestration, making it a key component in mitigating climate change impacts on marine environments (Mateo *et al.* 1997; Monnier *et al.* 2020).

The critical role of these seagrass meadow systems in marine ecosystems is increasingly recognised; however, their rapid decline is primarily driven by anthropogenic pressures, particularly declining water quality and coastal development. In addition to the indirect effects of the aforementioned anthropogenic activities contributing to these alarming losses, direct physical disturbances such as dredging, various fishing practices, anchoring, exert significant destructive impacts on these seagrass meadows (Francour *et al.* 1999; Milazzo *et al*. 2004; Lloret *et al.* 2008; La Manna *et al.* 2015). Extensive research has documented the loss (Kastler and Michaeliss 1999; Talesca *et al*. 2015), recovery, and stability (Barillé *et al*. 2010; Guillén *et al*. 2013; de los Santos *et al.* 2019; Boudouresque *et al.* 2021) of *P. oceanica* and other seagrass meadows (*Zostera marina* Linnaeus, 1753, *Z. noltei* Hornemann, 1832, and *Cymodocea nodosa* (Ucria) Ascherson, 1870) across the Mediterranean coastline. Nevertheless, a general decline has been reported for *P. oceanica*, an endemic Mediterranean species, with estimates suggesting a loss of between 13 – 50% of its areal extent since 1960 (Marbà *et al*. 2014; Telesca *et al.* 2015; de los Santos *et al*. 2019; Boudouresque *et al.* 2009, 2021). The above-mentined anthropogenic activities not only disrupt the structural integrity of *P. oceanica* beds but also hinder their capacity for natural recovery, exacerbating their decline across the Mediterranean. The first step in safeguarding these ecologically vital meadows is to accurately determine their distribution. This approach enables the development of targeted conservation strategies tailored to their specific locations, rather than broad, generalised protection plans.

The challenges faced by *P. oceanica* are not confined solely to the Mediterranean Sea but also extend to the species' northernmost distribution limit in the Sea of Marmara, where similar ecological pressures are observed (Tortonese and Demir 1960). Recent efforts have resulted in the creation of detailed biogeographical maps of *P. oceanica* deposits in the vicinity of Paşalimanı Island and the Kapıdağ Peninsula in the Sea of Marmara (Gönülal *et al*. 2023). The present study reports the discovery and spatial delineation of a previously unrecorded *P. oceanica*

population around Yer Island, a relatively small island located in close proximity to Paşalimanı Island. Through comprehensive georeferenced mapping and spatial analysis, we have identified new seagrass beds and quantified their extent. This finding significantly contributes to the expanding knowledge of *P. oceanica* distribution within the Sea of Marmara and highlights the necessity for focused conservation measures to safeguard these fragile habitats. In light of mounting anthropogenic pressures on marine ecosystems, the identification and ongoing monitoring of these seagrass meadows are essential for evaluating their resilience and ensuring their long-term ecological sustainability.

Materials and Methods

Study area

The Sea of Marmara, formed during the Holocene, serves as a critical connection between the Mediterranean and the Black Sea via the Çanakkale and İstanbul Straits. This relatively young sea functions as both a migration corridor and a biological barrier for certain species (Öztürk and Öztürk 1996). Although endemic to the Mediterranean, *P. oceanica* reaches the northernmost limit of its distribution in the Sea of Marmara. However, its persistence within this biological boundary remains an ecological enigma.

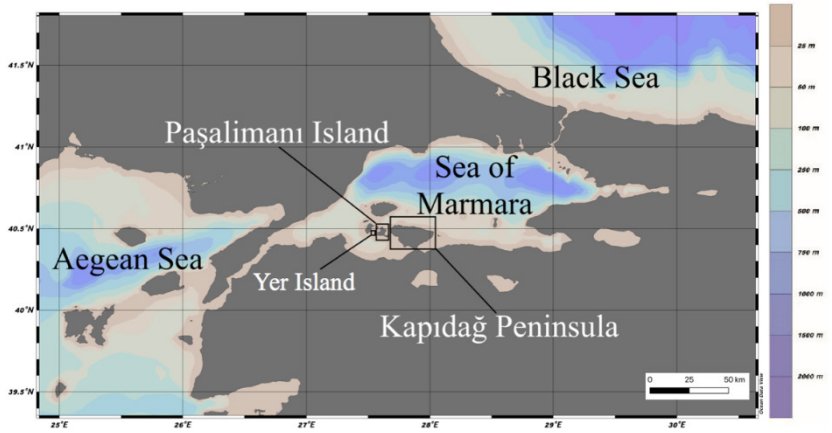

Figure 1. The locations of Yer Island, where this study was conducted, along with the previously studied Paşalimanı Island and Kapıdağ Peninsula (Gönülal *et al*. 2023) in the Sea of Marmara

Building upon previous efforts to document *P. oceanica* in the region, a recent study by Gönülal *et al*. (2023) aimed to map and quantify its coverage around Paşalimanı Island (40°28'32.70"N, 27°37'08.94"E) and the Kapıdağ Peninsula (40°28'26.98"N, 27°41'20.71"E). As research efforts in the region intensified, aerial imagery revealed a potentially significant site on Yer Island (40°28'05.08"N, 27°33'51.40"E), warranting further investigation. Subsequent *in-*

situ observations confirmed the presence of *P. oceanica* at this location. The geographical position of Yer Island, with a coastline of approximately 2.2 km and a total area of 13 ha, is comparatively smaller than the other islands in the region, within the Sea of Marmara, where this study was conducted (Figure 1).

Field survey

The study was conducted aboard the R/V TÜDAV Maru, a research vessel operated by the Turkish Marine Research Foundation, in July 2024. A combination of manta towing, remotely operated vehicle (ROV) surveys, as well as skin and scuba diving (Miller *et al*. 2019), was employed to investigate the study area. The island's coastline was systematically surveyed from the surface using a manta tow, during which the coordinates of locations where *P. oceanica* was recorded.

Mapping

Posidonia oceanica meadows identified during the survey were measured *in situ* using the scuba technique, recording both the long and short axes of the beds. These measurements were subsequently compared with underwater observations obtained using Google Earth © software (version 7.3.6.10201), which integrates data from Copernicus, Landsat, and Airbus; the results were found to be consistent. The corresponding polygons were then transferred to QGIS (QGIS 2023 3.32 Lima) for area calculations and mapping. To ensure data standardization, all spatial information processed in QGIS (QGIS.org 2023) was refined using ESRI software (Environmental Systems Research Institute, http://www.esri.com). Additionally, coastline mapping was supported by data coverage from OpenStreetMap (2025) contributors.

Results and Discussion

The presence of *P. oceanica* meadows in Paşalimanı Island and the Kapıdağ Peninsula has been documented for some time (Ergör 1990; Yüksek and Okuş 2004; Cirik *et al*. 2006, 2010; Meinesz *et al*. 2009; Cirik and Akçalı 2013; Taşkın 2016; Taşkın *et al*. 2019; ÇŞİDB, TÜBİTAK-MAM 2021; Gönülal *et al*. 2023). A recent study by Gönülal *et al*. (2023) reported and mapped a total of 26,537 ha of *P. oceanica* meadows within these two regions. In the present study, the presence of *P. oceanica* on Yer Island (Figure 2), located 0.86 km from Paşalimanı Island, was identified through aerial image analysis and confirmed via *in situ* observations (Figure 3).

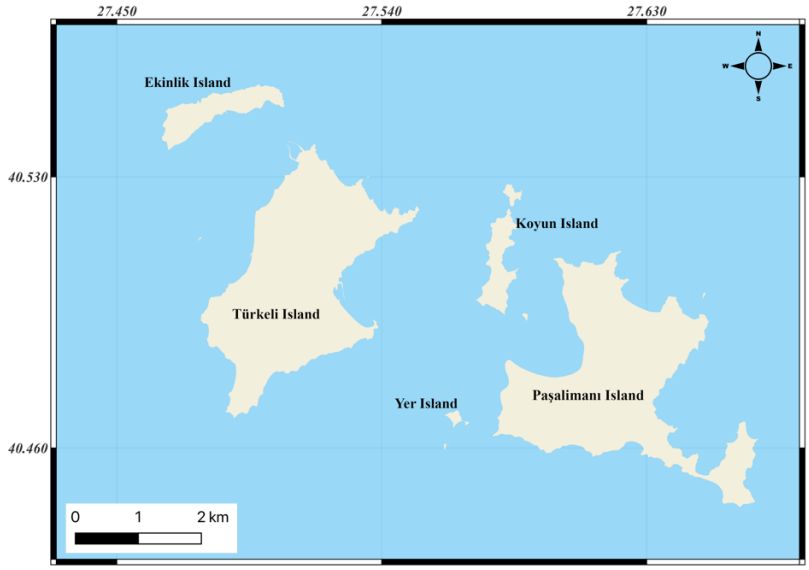

Figure 2. The geographical position of Yer Island in relation to the other Marmara Islands, including Türkeli, Ekinlik, Koyun, and Paşalimanı Yer Island is situated just 0.86 km from Paşalimanı Island, where the presence of *Posidonia oceanica* meadows has been previously documented.

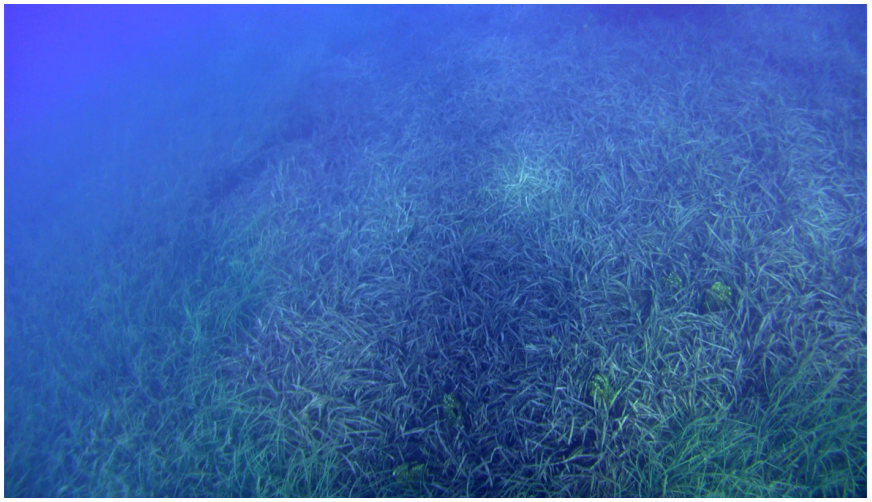

Figure 3. *Posidonia oceanica* meadows identified along the shores of Yer Island in the Sea of Marmara. The image depicts the largest meadow beds recorded in the region, covering an area of 3,131 m².

The distribution of *P. oceanica* meadows on Yer Island (a photogrammetric representation of the area is provided in Figure 4) was restricted to its southeastern

coastline, with no observed presence in other areas around the island. A total of 37 discrete seagrass beds were recorded, with the largest covering 3,130.58 m² and the smallest 2.08 m². The cumulative area of these beds was calculated as 0.648 ha. As previously mentioned and illustrated, *P. oceanica* meadows are exclusively located in the southwestern part of Yer Island (Figure 4). Additionally, seagrass species belonging to the genus *Zostera* were observed. *Zostera* species were found both adjacent to *P. oceanica* meadows and in patches along different shores of the island. The spatially confined distribution and close proximity of these beds suggest that they may have fragmented from larger meadows over time, leading to their current patchy structure (Figure 5).

Figure 4. Mapping of *Posidonia oceanica* meadows along the southwestern coast of Yer Island, highlighting the presence of 37 discrete seagrass patches.

The total area covered by *P. oceanica* meadows in the Sea of Marmara was calculated based on figures reported in earlier studies, as mapping and coverage surveys began two decades ago, leading to relatively low estimates. Akçalı *et al*. (2019) reported that *P. oceanica* covers a total area of 14,486 ha along the entire Turkish coastline, with 1,339 ha in the Sea of Marmara. Building upon the area data presented in the recent study by Gönülal *et al*. (2023) this research serves to update the known distribution of *P. oceanica* in the Sea of Marmara. Although the area along the coast of Yer Island is not extensive, it highlights the necessity for further research on this topic. Additionally, greater efforts should be made to protect the mapped areas, particularly through the installation of buoys, and to raise public awareness about their importance. Furthermore, data on the flowering and fruiting of *P. oceanica* in the Sea of Marmara remain sparse. In conclusion, while this study provides essential baseline data for the field, further

investigations are required to develop effective conservation measures for *P. oceanica*. Although the Sea of Marmara is a well-studied region, it continues to reveal unexpected findings in its lesser-explored areas, as demonstrated in the present study. This highlights the importance of ongoing scientific investigation. Furthermore, the presence of *P. oceanica* exclusively in specific areas—both in the Narlı Peninsula and around Paşalimanı and Yer Islands—remains an unresolved mystery. The reasons behind its restricted distribution, particularly its confinement to only certain parts of these islands, continue to warrant further investigation.

Figure 5. Patchy distribution of *Posidonia oceanica* seagrass meadows on Yer Island

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Posidonia oceanica deniz çayırlarının biyocoğrafik yayılım alanının genişletilmesi: Marmara Denizi, Yer Adası'nda çayırların keşfi, Türkiye

Öz

Posidonia oceanica (L.) Delile, Akdeniz'de önemli bir ekosistem mühendisi olup biyoçeşitliliğin korunması, habitat karmaşıklığının artırılması, kıyı ortamlarının stabilizasyonu ve karbon sekestrasyonuna katkı sağlama gibi kritik ekolojik roller üstlenmektedir. Bu çalışma, Marmara Adaları'na kıyasla daha küçük bir alan kaplayan Yer Adası kıyılarında daha önce kaydedilmemiş bir *P. oceanica* popülasyonunun keşfini ve mekânsal tanımlamasını rapor etmektedir. Ayrıntılı coğrafi referanslı haritalama ve mekânsal analizler sonucunda, toplam 0,64 hektarlık bir alanı kapsayan 37 ayrı deniz çayırı öbeği tespit edilmiştir. Elde edilen bulgular, *P. oceanica*'nın bilinen biyocoğrafik yayılımını genişletmekte olup, bu hassas habitatların devam eden antropojenik etkilerden korunması için daha fazla araştırma ve koruma tedbirlerinin gerekliliğini vurgulamaktadır

Anahtar kelimeler: *Posidonia oceanica*, Marmara Denizi, Yer Adası, biyocoğrafik yayılım, deniz çayırları

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