

## Mapping of *Posidonia oceanica* (L.) Delile Meadows Using Geographic Information Systems: A case study in Ufakdere - Kaş (Mediterranean Sea)

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### Abstract

*Posidonia oceanica* (Linnaeus) Delile 1813 is an endemic and the most widespread seagrass species of the Mediterranean Sea. Seagrass meadows are one of the most productive ecosystems on Earth, providing habitat to numerous organisms. Therefore, mapping of seagrass meadows is of crucial importance for conservation and coastal management purposes. Here we present an integrated geographic information system approach with SCUBA diving, providing a cost effective method to monitor seagrass beds at shallow coastal habitats. In this case study *P. oceanica* meadows were mapped in Ufakdere region of Kaş (Antalya) coastal area between April – September 2015. A total of 25000 m<sup>2</sup> were screened to create seagrass coverage maps. Results indicate that *P. oceanica* meadows cover 21200 m<sup>2</sup> and we estimated that 520 m<sup>2</sup> of this area is highly damaged. This integrated approach provided one of the most detailed small-scale *Posidonia* mapping in Turkey and this time and cost effective methodology can be applied to any seagrass meadow with great ease to increase our knowledge on this important habitat.

**Keywords:** *Posidonia oceanica*, GIS, Mapping, Scientific diving

### Introduction

*Posidonia oceanica* L. (Delile) (Pasqualini et al., 1998), is an endemic sea grass species of the Mediterranean Sea. It is abundant in Turkey's Aegean and Mediterranean coast all throughout the infra-littoral zone. *P. oceanica* distributions can be observed at temperature range from 11° to 29°C and at a depth from 0 to 40 m (Cirik et al., 2006). It is known to be sensitive to increase in salinity and can exist at a salinity range from 33 to 40‰ (Fernández-Torquemada and Sánchez-Lizaso, 2005). *P. oceanica* meadows play an important role in global carbon cycle by enriching the oxygen content in coastal waters through photosynthesis utilising the daylight (Bay, 1984). Its leaves serve as a natural filter, settle coarse grains of sand and catch solid materials in the water column. Thus, they provide water clarification by reducing the turbidity. *P. oceanica*, fixes the sandy sea bottom with the help of its horizontal rhizomes

and acts as a barrier against the coastal erosion, severe wave movements and current; it stabilizes the coastal line. *P. oceanica*, is sensitive to changes in water quality. Rhizomes can adsorb radioactive materials, synthetic chemicals and or heavy metals so that as a result of this ability, they can be used as biological indicators for monitoring the quality of coastal waters (Pergent-Martini, 1998).

Sea grass meadows, which have an important role in coastal systems (Hemminga and Duarte, 2000), is under threat due to pressure from the increasing population (Short and Echeveria, 1996).

*P. oceanica*, is exposed to direct physical effect by illegal trawling (Ardizzone and Pelusi, 1984), and indirectly by the sedimentation resulting from harbor and breakwater construction, boat anchorage or soil erosion. Furthermore, potential effects of the global climate change such as sea

water temperature increases (Mayot et al., 2005), carbon dioxide level increases, reduction of pH levels and acidification, impacts the photosynthesis of meadows, hence affects reproduction and development.

*P. oceanica* meadows are declining at alarming rate due to pollution, climate change, alien species invasion and human activities (Montefalcone, 2009, Telesca et al., 2015). Therefore, *P. oceanica* is listed in Red List of Threatened Species by the International Union for Conservation of Nature (IUCN). Moreover, it is under protection by Barcelona Convention, Bern Convention, European Union Habitat Directive and many other countries' national legislations.

GIS, together with remote sensing and mapping, is crucial for scientist and decision makers in understanding and management of marine environment (Kapetsky and Aguilar-Manjarrez, 2007). This competence is essential, especially in biodiversity studies, where research needs to be replicated at regular intervals and whose characteristics are to be monitored over time. Nowadays, in most of the modeling studies, GIS integration is required) which is a powerful and effective tool used by several multi-disciplinary scientists to produce rapid, economic, reliable and accurate results (Sertel and Şeker, 2013).

Although seagrass studies are abundant all over the world, studies are scarce in coasts of Turkey. Majority of reported work focuses on species assemblages with in the meadows (Okuş et al., 2006a-b, Okuş, et al., 2007; Meriç et al., 2016a-

b) rather than information on the biology and ecology of meadows. The most significant contribution on *P. oceanica* distribution and *P. oceanica* meadows as a habitat is the proceedings of the "First National Workshop on *Posidonia oceanica* on the coasts of Turkey" (Aktan and Aysel, 2013).

The aim of the present study was to map *P. oceanica* meadows using an integrated geographic information systems approach in order to understand current human impacts and establish a baseline study and methodology to monitor the future changes.

## Materials and Methods

### Study Area

The study was carried out in a shallow sublittoral zone in Ufakdere Cove, located in the southwestern Mediterranean coast of Turkey (Figure 1). Study area is part of the Kas-Kekova Specially Protected Area (SPA) which is one of the most biologically rich marine ecosystems in Turkey.

Substrate consists of sandy bottom between depths of 20 and 30 m and mix substrate of sand and rocky bottom at shallower depths (0 - 18 m) in inner parts of Ufakdere Cove. There is a high flow freshwater input, which is known as "Altug Cave", at a depth of 11 m at the eastern end of Coban Cape. Majority of the meadows are found between 18 and 30 m. Inner part of the cove ends with a pebble beach, with a muddy sandy substrate due to a creek discharging to the bay.



Fig.1. Study area

### Data collection and processing

Small buoys attached to lead weights were used as georeferenced points to validate satellite images and coordinates for in-situ observations. In total 16 markers were submerged and fixed to the bottom at pre-determined intervals starting from 2 m depth. GPS coordinates were recorded at surface for each marker. Following the

marking procedure, scientific divers continuously performed dives in transects, and recorded the meadows from the same distance to the bottom by using a 2 m long string and weight, attached under the camera system and barely touching the bottom while filming. All gathered information on the distribution and coverage of *P. oceanica* meadows were integrated in ArcGIS platform (Figure 2).



Fig. 2. Markers and study plan

### Results

The distribution of *P. oceanica* from the shore (~ 1 m) to 26 m is observed in the Ufakdere area. The Posidonia distribution below the rocky shore region is transformed into a massive, single piece meadow, with severely damaged clusters particularly in the mid-coastal area, where the anchoring activity is intense. There is regional sedimentation on the leaves at the shallow area, in close proximity to the mouth of the creek, and in summer, when the temperatures are extremely hot, a recession in the facies to deeper parts is noticed, indicating that water temperature negatively affects the facies in the shallow region.

The data obtained from the dives and the distribution data extracted from the satellite images were superimposed on the Esri ArcGIS program. The damaged area is mapped in detail.

The results showed that satellite images provided high accuracy information up to 20 meters' depth. The water temperature was 27 °C throughout the study area where the average annual sea water temperature is 21 °C. The dominant stress on the *P. oceanica* meadows in the region was anchoring. The red line in Figure 3 indicates the area of heavy anchor damage. Particularly, the damage due to the heavy use of the region by daily boat tours possess a significant threat. Damage concentrating in the middle block of facies is threatening to separate the one piece facies into two.

Significant loss of seagrass beds were observed particularly at shallow section and anchorage area. As a summary our observations revealed in approximately 21200 m<sup>2</sup> of meadow area, of which an estimated 520 m<sup>2</sup> is highly damaged (Figure 3).

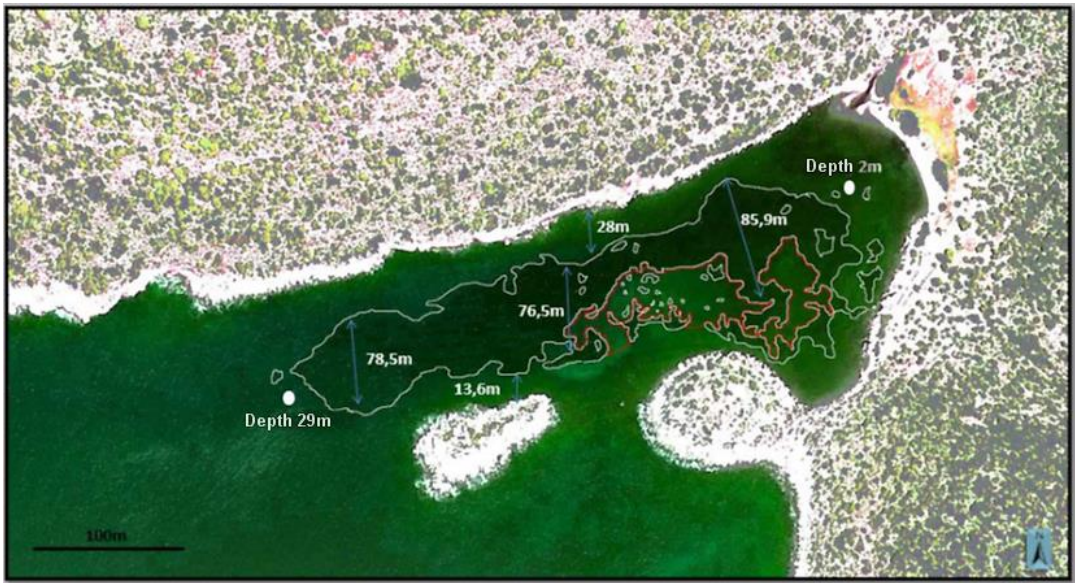


Fig. 3. Distribution of *P. oceanica* in Ufakdere-Kaş (Mediterranean Sea)

### Discussion and Conclusion

This study provides the baseline data for the distribution of *P. oceanica* meadows in Ufakdere region. *Posidonia oceanica* is seen only in the Beş Adalar and the Ufakdere sites in Kaş Kekova Marine Reserve. In general, the rocky bottom structure in the region and high sedimentation rates due to foraminifera depositions considerably limits habitat for the development and expansion of *P. oceanica* (Yokeş, 2009). The integrated satellite imaginary and in-situ observations approach proved to be a practical and low cost method to monitor sea grass meadows in low turbidity environments. A similar study applied in larger scale at the turbid Marmaris Bay confined utilization of satellite data to much shallower depths and showed higher importance of SCUBA surveys (Yüksek et al., 2015). However the information derived was still of great importance.

Habitat mapping is very important for transferring scientific information to decision makers and local users. Evolution of habitats in a certain time would show the progress in the region of interest (Di Maida et al., 2011, Borfecchia et al., 2013, Fornes et al., 2006). The adaptability of this integrated approach will enable us to build a long-term datasets to further manage the protection zone. There are several

long-term studies on distribution and health status of *P. oceanica* meadows in the Mediterranean Sea (Ardizzone et al., 2006), providing valuable information man and climate induced changes in these important ecosystems.

SCUBA dives showed significant damage of the facies by anchoring. The immediate need for designated and managed anchorage zones were declared in other studies along the Aegean and Mediterranean coasts of Turkey (Okudan et al., 2015; Francour et al., 1999; Montefalcone et al., 2008). We propose placement of buoys attached to semi elastic ropes rather than chains and daily tour boats would be obliged to use and maintain these buoys.

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