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Mediterranean Tapeweed *Posidonia oceanica* (L.) Delile, an Endangered Seagrass Species

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THE MOST plentiful and important seagrass in the Mediterranean Sea is *Posidonia oceanica* L. (Delile) because of its ability to create a three-dimensional habitat with high biodiversity and to build the "matte"(a terrace of interlaced rhizomes and roots trapping sediment). This matte highly influences coast features in terms of wave attenuation and shoreline stabilization. In addition, *P. oceanica* meadows, which could extend along the coast, from the shoreline until 40m depth, are directly exposed to anthropic pressure coming from the coastal zones and it is particularly sensitive to the environmental conditions. In the last decades, human activities in coastal areas impacted sedimentary processes severely affecting *P. oceanica* meadows with consequent seagrass loss. This review aims to shed light on the importance of this plant, the extent of its dangerous status, and to urge the international community and governments to try to protect it in all possible ways, especially in Egypt.

Keywords: Endangered species, Endemic species, Mediterranean Sea, *Posidonia*.

Introduction

Seagrasses are submerged flowering plants (in the class Monocotyledoneae) that form massive meadows, which flowering and forming sunken seedlings. They represent one of the richest and most important coastal habitats in the ocean, supporting a range of keystone and ecologically important marine species from all trophic levels (Orth et al., 2006). Seagrass beds are among the most productive and complex oceanic ecosystems (McRoy & McMillan, 1977). They have high primary productivity and are a basis of many marine food webs through direct herbivory and the detrital cycle, both within the seagrass beds and as wrack which washes ashore (Hemminga & Duarte, 2000). They provide nutrients (N and P) and organic carbon to other parts of the oceans, including the deep sea, and contribute significantly to carbon sequestration (Duarte et al., 2005). *Posidonia oceanica* represents one of the chief and plentiful seagrasses in the Mediterranean Sea, where it forms broad meadows from the surface down to 40m water depth, covering approximately 25,000– 50,000km^2 (Pasqualini et al.,1998) and providing highly valuable ecosystem services (Green & Short, 2003).

Seagrass distribution has declined worldwide over recent decades as a consequence of changes in environmental coastal water conditions (Larkum et al., 1989). Anthropogenic stress on the Mediterranean coastal zone has increased quickly during the second half of the 20th century, as the number of peoples doubled between 1970 and 2000 (Benoit & Comeau, 2005). Therefore, the Mediterranean coastal zone is suffering strong alteration: 40% of the Mediterranean coast had

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been built over by 2000, coastal aquaculture has grown really and nitrate concentration in the western Mediterranean has amplified by 0.5 percent per year between 1975 and 1995 (Benoit & Comeau, 2005). This increasing human stress has driven the worsening of the Mediterranean coast as revealed by, among other indications, eutrophication, decrease in water clarity, erosion, and losses of coastal environments and biodiversity. *Posidonia* meadows act as sensitive recipients as well as indicators of these impacts (Martínez-Crego et al., 2008).

Posidonia oceanica decline as a result of human interference is widespread (Ardizzone & Pelusi, 1984; Marbà et al., 2014a). Moreover, it has been suggested that a restricted genetic flow in this species resulting from the majority of asexual modes of reproduction may have contributed to the increasing degeneration of *P. oceanica* (Capiomont et al., 1996). In recent years, some studies have demonstrated that the reproduction of *Posidonia oceanica* seems to be more frequent than previously thought (Balestri et al., 2017).

Posidonia oceanica, an overview

Species of the genus *Posidonia* are the only members of the seagrass family Posidoniaceae and are considered to rank among the earliest marine angiosperms (Den Hartog, 2006). *P. oceanica* is formed by a rhizome, prostrate or erected, with sheaths attached to it and a leafy shoot at the apex (Fig. 1). It is a monoecious species with hermaphroditic and male flowers arranged in a terminal spike composed of three-four flowered spikelet. The production of flowers and fruits is considered episodic (Caye & Meinesz, 1984). The reproductive period naturally starts in September–October in shallow stands, and in November in deep stands; fruit development takes approximately 4 months (Buia & Mazzella, 1991). The developed floating fruit consists of a single seed that lacks a thick-wall coat. The seed is negatively buoyant and lacks dormancy, germinating within a few days following fruit release (Caye & Meinesz, 1984).

Posidonia shoots constitute dense meadows between the surface and at 40 m depth (Procaccini et al., 2003). The rhizome growth rate is very small, between 1.0 and 7.0cm/year on average (Caye, 1982). It is a large, long-living but very slow-growing species and takes a long time to recolonize areas from where it has been removed, although there is some evidence that it has recolonized sites where it has been protected (Pergent et al., 2016). *P. oceanica* is exceptional in that it is arguably one of the longest-lived species, with individual shoots living up to 50 years and clones aged several millennia (Arnaud-Haond et al., 2012), and ranks among the slowest growing (1–6cm per year) plants (Marbà & Duarte, 1998).

Fig. 1. *Posidonia oceanica*. A. Herbarium sheet of specimen collected from Sea shore of Sidi Barani, Northwest coast of Egypt. B. Dried parts in herbal shop at Marsa Matrouh City, Egypt (as folk medicine) [Original photos taken by S. Heneidy in 2019 (author)]

The primary production from *P. oceanica* is rich in cellulose, lignin and phenolic compounds (Piovetti et al., 1984). The average biomass of *Posidonia oceanica* is 501gm DW/m² aboveground and 1611gm DW/m² belowground (Duarte & Chiscano, 1999). Higher values have been measured: up to 1640 and 5500gm DW/m² for leaves and rhizomes, respectively. It drops in relation to depth (Mazzella & Ott, 1984; Pergent et al., 1995; Pergent et al., 1997). Definitely no other marine multicellular photosynthetic organism key species achieves such high total biomass. No other marine ecosystem, except mangroves, offerings such high vegetative biomass. This is owing to the storage of the biomass for a long period of time in the "matte". High biomass and storage are attributes usually associated with continental forest ecosystems In addition to the seagrass biomass, *P. oceanica* leaves and rhizomes harbor autotrophic epiphytes, belonging to Chlorobionta, Rhodobionta, and Stramenopiles; their average biomass ranges between 160 and 420gm DW/m² (Boudouresque et al., 2006).

The primary production of *P. oceanica* ranges between 400 and 2500gm DW/m²/y and decreases with depth. Autotrophic epiphytes as well give to the primary production: up to 500-900gm DW/m²/y. It is the sum of these two compartments, the seagrass and its epiphytes, with values ranging from 2000 to 3000gm DW/m²/y, which can approach the highest values of net primary production observed in the terrestrial realm. However, it is worth that such very high values only concern shallow water meadows (Boudouresque et al., 2006). Elhaweet et al. (2011) observed that *P. oceanica* grows on sandy and/or rocky substrates, its biomass (gm DW/m²) varied between sites and with depth at different sampling sites collected from Sallum Gulf. It varied from the highest of 1679.46 to the lowest of 916.5 (gm DW/m²).

Ecological and economic importance of Posidonia oceanica

Posidonia oceanica plays a main ecological, deposited and economic role in littoral ecosystems (Costanza et al., 1997). These seagrass meadows produce huge quantities of organic matter (leaves, epiphytes), which organize the basis of the food web both within and outside the ecosystem. This production is also exported to other ecosystems, where it is the main source of food (Pergent et al., 1995). Among their many functions, *Posidonia oceanica* meadows play a part in stabilizing sea beds, breaking swells and waves, and encouraging the deposit of sedimentary particles (Boudouresque et al., 2006). De Falco et al. (2000) demonstrate that gradients in sediment texture and composition can be related to meadow distribution and areal coverage. They suggest that this involves the mechanical trapping of fine particles by the plants, enhanced mud deposition due to dampening of wave action in the meadows, and the admixture of bioclastic residues connected to increased production by epiphytes and invertebrates. They also, recorded that the mass of fine sediment which would be re-suspended in the wake of meadow destruction was estimated at 30-90 X 10^3 tonnes km², an amount which could significantly affect water quality and ecosystem stability.

For centuries, the rhizomes of *P. oceanica* form mats which increase into reefs that help to set up sediment and mediate the motion of waves, thus clarifying water turbidity and defending beaches from erosion (Pergent et al., 2016). *P. oceanica* can also affect the seafloor topography through the accretion of rhizomes and roots in the sediments, thus exerting additional engineering influences on flow and sedimentation patterns (Gutiérrez et al., 2011). *Posidonia* leaves, which can be over 2 meters high and up to 20mm wide, also form compact and resistant structures, debris (berms), which accumulate on the beaches and provide very effective protection against coastal erosion (Pergent et al., 2016). In addition, *P. oceanica* environments have a substantial role as a carbon sink, absorbing carbon dioxide, loading carbon at an average rate of 83gm C/m²/year, and serving to lessen the effects of climate change (Vassallo et al., 2013).

Because of its ecological importance and vulnerability to a variety of anthropogenic influences, including pollution, turbidity, and sedimentation (Ardizzone & Pelusi, 1984; Peirano & Bianchi, 1995), there is increasing interest in using this species as an 'indicator' of the health of Mediterranean coastal systems (Pergent et al., 1995). In several countries, marine water-quality programs, including those concerning environmental impact, have recently included the evaluation of ecological status and/or trends of *P. oceanica* meadows, along with traditional water-analysis parameters (Boudouresque et al., 1990).

The importance of the seagrass *P. oceanica* in the marine ecosystem is well- ascertained in many studies (Gillanders, 2006; Ruiz et al., 2009). It is an important primary producer in the coastal waters, providing shelter and food to marine fauna, and habitat for epiphytes. Papers dealing with chemical studies investigating the secondary metabolism of *P. oceanica* are limited. Previous studies (Viso et al., 1993) on the rhizomes shown lipid components like fatty acids and alkanes in few quantities with respect to the aerial part and in varied distribution depending on the geographic sample. Among phenolic compounds, p-hydroxybenzoic acid and vanillic acid are the lone molecules conveyed from the rhizomes (Cariello et al., 1979). Heglmeier & Zidorn (2010) have published a comprehensive review on secondary metabolites of *P. oceanica* relating lipids (as sterols and fatty acids), phenols as simple derivatives, phenyl-methane, -ethane and -propane compounds as well as phenylpropanoic acid esters, flavonols, and chalcones. They also stated the importance of further studies on the secondary metabolites from *P. oceanica* and other sea grasses with special regard to classes of compounds never detected. Chemical analysis of the secondary metabolites of *P. oceanica* rhizomes carried out by Bitam et al. (2012), led to the identification of several compounds. In particular, two neolignans, co-occurring with related metabolites formerly defined from the plant kingdom, have been isolated and characterized by spectroscopic methods.

During the life cycle of *P. oceanica*, the leaves detach from their stems and accumulate on the coasts, producing a deposit that is harmful to the quality of the beaches and whose removal creates significant expenses to the local authorities. A recent study by Benito-González et al. (2019) showed that extracts of *P. oceanica* waste biomass had a curiously high antioxidant ability, which was not only related to phenolic compounds but also to the existence of proteins and polysaccharides. They also show that some extracts inhibited the growth of several foodborne fungi. These results show the possibility of *P. oceanica* waste biomass for the manufacture of bioactive extracts. Complete optimization of the processes to maximize extraction yields and bioactivity of the extracts is suggested to be carried out in the future.

Posidonia oceanica, threats and conservation

At the global level, this Mediterranean endemic species is listed as Least Concern in Red List of Threatened Species of the International Union for the Conservation of Nature (IUCN, 2015). The suspected stable populations in part of its range and the present conservation actions together with the recovery capacity of damaged meadows observed in some protected areas. More information on species distribution and threats impact in the Eastern and Southern Mediterranean basin is needed (IUCN, 2015). In Annex I of the Bern Convention (1979), *P. oceanica* is indicated as protected species. Many studies proved that *P. oceanica* is very sensitive to changes in the marine environment caused by anthropogenic disturbances (Borum et al., 2004; Boudouresque et al., 2006; Marbà & Duarte, 2010). Meadow regression has been documented in different areas of the Mediterranean as a reduction in the meadow cover and shoot density (Di Carlo et al., 2011). Available evaluations designated that between 13% and 50% of seagrass areal extent of *P. oceanica* in the Mediterranean basin seems to be lost, and that the remaining meadows of the Mediterranean may have thinned shoot density by 50% and have become more fragmented. The possible loss in *P. oceanica* areal range, cover, and density, is quantified by about 6.9% annually over the last 50 years (Marbà et al., 2014a).

The loss of *P. oceanica* meadows in the Mediterranean basin may have led to a considerable drop between 11% and 52% of the capability of this key coastal ecosystem to sequester carbon in the last 50 years, thus reducing the carbon basin capacity of the whole Mediterranean Sea. Past reports have indicated that the widespread local disturbances were the major causes of *P. oceanica* loss, but recently, global disturbances, such as climate change and the spread of invasive exotic species, were also seriously threatening *Posidonia* meadows in the Mediterranean (Marbà et al., 2014b). While herbivores may sometimes defoliate massive areas of *P. oceanica* (Kirkman & Young, 1981), the intensity of herbivory on this seagrass is believed to be generally modest (Cebrian & Duarte, 1998). Past studies have reported that most leaf production (≥90%) is channeled to higher trophic levels as detritus (Pergent et al., 1997).

The multiple stresses experienced by *P. oceanica* meadows have been resulted in their decline across the entire Mediterranean basin (e.g. Boudouresque et al., 2009). These observations have increased awareness of the vulnerability of this key ecosystem and have led to efforts to assess their conservation status in several Mediterranean areas. Nevertheless, an assessment of the rates of alteration of the extension and richness of *P. oceanica* meadows in the whole Mediterranean basin for the last 50 years is missing, thus the degree and rate of decline along the Mediterranean area still a matter of assumption (Marbà et al., 2014a).

Studies in many Mediterranean countries showed that *P. oceanica* is officially threatened (Platini, 2000). An action plan in 1999, was adopted by the United Nations Environment Program (UNEP) for the conservation of marine vegetation in the Mediterranean Sea, in which *P. oceanica* meadows featured as priority habitat (Anonymous, 2000). Despite these protection measures, significant regression of these meadows has been shown in several sectors of the Mediterranean coastal zone, particularly around conurbations and large industrial port centers (Ardizzone & Pelusi, 1984; Boudouresque, 2003). Assessment of the status of *P. oceanica* meadows is mostly based on the monitoring of a set of morphological, structural, and dynamic variables.

Because of the ecological importance of *P. oceanica*, and in response to the need to restore damaged meadows, numerous transplanting experiments have been undertaken. Those experiments have focused mainly on the development of vegetative transplantation techniques (Meinesz et al., 1992, 1993; Molenaar & Meinesz, 1995). Re-establishment of seeds or seedlings as an alternate renovation method has received little attention (Meinesz et al., 1993). Generally, transplanting techniques have achieved limited success, due to poor knowledge of the environmental factors controlling the distribution and development of this species, as well as of the exact role played by seeds in the maintenance of existing meadows and also in the reestablishment and recruitment of new or disturbed areas. Other problems such as disturbance by biota (Charbonnel et al., 1995), and sediment instability (Molenaar & Meinesz, 1995), may cause establishment difficulties.

To examine the feasibility of a large-scale restoration, a project was conducted in a damaged coastal area of the Ligurian Sea (Italy) in 1988. Two sites were selected in the area and two-month-old aquarium-grown *P. oceanica* seedlings were transplanted on different substrata at each site (Balestri et al., 1998). The results show that seedlings of *P. oceanica* may be successfully used in the study area for restoration purposes. The data also support the hypothesis that sexual recruitment may occur in *P. oceanica* but could be limited by post-settlement factors relating to substratum type.

The great variation between years, flowering, and fruiting has been detected in studies conducted in many parts of the Mediterranean basin (Semroud, 1993). Although field and laboratory studies have demonstrated high germination rates (Caye & Meinesz, 1989; Balestri et al., 1998), the establishment of seedlings in nature seems a rare phenomenon (Buia & Piraino, 1989; Gambi et al., 1996) and little is known about the influence of environmental factors on the development and germination patterns in nature. Meanwhile, some recent studies show that seedlings of *Posidonia* have high plasticity to the type of substrate and environment in which they grow (Guerrero-Meseguer et al., 2018; Kendrick et al., 2019). Therefore, it is still unknown whether the apparent lack of sexual recruitment in *P. oceanica* results from ecological or genetic factors. The question is also if seedlings could make an important contribution to the maintenance of genetic diversity in populations of *P. oceanica*.

Marbà et al. (2014b) collected published information in peer-review articles and hoary literature reports, which joined with their own data, to measure the changes in areal extent, shoot and cover density of *P. oceanica* meadows between years 1842 and 2009 in the Mediterranean basin. The results show an overall tendency towards a decline of the areal extent, shoot and cover density of *P. oceanica* meadows throughout the last 50 years, the period with the prevalent accessibility of records.

Reduced light intensity may cause change of seascape micro-structure, as stated by Dalla Via et al. (1998) who verified a decrease of 72% in shoot density among a water depth of 310-m range. Anthropogenic activities, such as coastal development, fish farms, anchoring, and trawling, are well known to directly modif the structure of *P. oceanica* meadow at all depths (Boudouresque et al., 2009; Giakoumi et al., 2015). As in the case of naturally occurring patches of the seagrass, patches resulting from Human impacts can be clearly identified at a large spatial scale according to their shape and size (Abadiea et al., 2018).

A multiscale biomonitoring approach, which encompasses multiple levels of observations (from ultra- to meso- and macroscale, photo mosaicking, and SRS), was applied by Cozza et al. (2019), to evaluate the conservation status of a meadow of *P. oceanica*. The applied multi-level biomonitoring approach, based on the integration of rapidly-responding and sensitive biomarkers (biochemical and molecular markers) with a slower-responding bioindicator (large-spatial bed structure, plant phenology, and heterogeneity) resulted in to increase the ability to efficiently monitor the meadow status allowing correlation the effects of environmental stressors at different organizational level, from molecular to eco-systemic, and therefore at different temporal scale. It was proposed that further implementation of this approach, through a study performed on many meadows and at different seasons, may lead to developing a new integrated index encompassing phenological, physio-molecular, and population data, to be applied for efficient monitoring and risk assessment of *P. oceanica* meadows.

Remote sensing studies on Posidonia oceanica

Satellite images is considered one of the most popular methods to detect, map, and monitor seagrass ecosystems over large areas. Spectral imagery obtained from sensors onboard satellites is preferable in data collection due to its time- and cost-effectiveness over any other surveying methods. Stable revisits to the same locations by the satellites can be used to monitor and characterize the *P. oceanica* change detection analysis. Moreover, recent advances of image-processing and classification algorithms with improved computational power have opened the new era of new quantitative and machine-learning techniques to achieve state-of-art results in terms of cost, effectiveness, independence, scale, and accuracy (Moniruzzaman et al., 2019).

Several studies have used satellite imagery to monitor and study the distribution of *P. oceanica* in the Mediterranean seagrass ecosystems (Borfecchia et al., 2013, 2019; Dattola et al., 2018; Matta et al., 2014; Traganos et al., 2017, 2018; Traganos & Reinartz, 2018a, 2018b, 2018c). The most common satellite imagery for the seagrass mapping are Landsat, IKONOS, Quickbird, WorldView-2, and Sentinel-2, as well as MIVIS, KOMPSAT-2, and PlanetScope CubeSat. The meadows of *P. oceanica* habitats to occupy depths of up to 20 m were investigated with the SPOT5 imagery in the Laganas Bay of Zakynthos Island, Greece with accuracy from 73% to 96% (Pasqualini et al., 2005).

Fornes et al. (2006) used an IKONOS image to map *P. oceanica* habitats up to 15 m of depth in the Balearic Islands, SW Mallorca, Spain with an accuracy of 92%. The usage of multispectral and high-resolution Quickbird imagery was processed to map *P. oceanica* habitats in the middle Tyrrhenian Sea, Italy (Borfecchia et al., 2013). The artificial neural network (ANN) algorithm was implemented to achieve an overall accuracy of 84%. The *P. oceanica* beds that range with a depth between 0 to10m, were studied by Matta et al. (2014) using MIVIS, KOMPSAT-2 and RapidEye imagery to map its distribution in the Gulf of Oristano, Italy with an overall accuracy of 84%.

Recently, a team from German Aerospace Center (DLR) have published numerous studies that utilized multiple sources of satellite imagery (CubeSat, Sentinel-2, RapidEye) to map the *P. oceanica* habitats in the Greece part of the Aegean Sea and Ionian Sea (Traganos et al., 2018). A variety of machine learning algorithms such as Support Vector Machine (SVM), Random Forest, Maximum Likelihood, Classification, And Regression Trees (CART) were selected and evaluated to monitor the seagrass changes and the accuracy was ranged between 68.1% to 99.5%. The differences between medium-resolution satellite images (Sentinel-2 and Landsat-8 OLI) and high-resolution images (MIVIS and WorldView-2) in terms of spatial accuracy to map *P. oceanica* habitats were also evaluated in the Marine Protected Areas of Capo Rizzuto, Southern Ionian Sea, Italy (Dattola et al., 2018). The results showed high-resolution satellite and airborne images are more accurate and thus more effective than medium-resolution images in obtaining mapping products, mapping elements to local spatial scales, and estimating parameters such as extension, habitat coverage, and produced biomass. While the Sentinel-2 and Landsat-8 OLI imagery are still valid for mapping on a regional scale. In addition, Borfecchia et al. (2019) also demonstrated the improvement of Landsat-8 OLI through the introduction of a new coastal band to produce more reliable distribution maps of *P. oceanica* leaf area index (LAI) and seabed substrates in the middle Tyrrhenian coast, Italy. Besides, multiple satellite-derived products, including significant wave height (SWH), sea surface temperature (SST), sea level anomalies (SLA), and other meteorological data are used to investigate recent large scale environmental changes in the Mediterranean Sea and their potential impacts on *P. oceanica* (Stramska & Aniskiewicz, 2019). The aforementioned studies were local Mediterranean region and more advances in satellite remote sensing technology for *P. oceanica* monitoring are expected since their publication. Table 1 lists all the discussed studies in the article which relied on satellite imagery data to implement *P. oceanica* detection.

Posidonia oceanica in Egypt

Unfortunately, most studies in Egypt have focused on the economic value, medical importance, and environmental problems that this grass can cause when it accumulates on beaches, while no actual large-scale study has been done on the distribution and density of this grass on the Egyptian Mediterranean coasts. El-Gamal & Abd El-Kader (2019) studied *Posidonia* wrack at Garawla Islands Village (270.05 to 270.76) and considered *Posidonia* wrack is one of the serious ecological, social and economic environmental problems. The slow breakdown of the wrack into organic matter can lead to unpleasant odors and by wind, dead *Posidonia* leaves were scattered in the backshore area. The study recommends to use net to prevent the transported dead *Posidonia* to park in the beach. These nets would be useful also to prevent the jelly fish to visit the beach.

TABLE 1. List of *Posidonia oceanica* detection approaches based on satellite imagery data

Author	Location	Satellite Data	Method	Accuracy
Pasqualini et al. (2005)	Zakynthos Island, Greece	SPOT 5	PCA, Supervised Classifier	73% - 96%
Fornes et al. (2006)	Balearic Islands, SW Mallorca, Spain	IKONOS Imager	Supervised Classifier	92%
Borfecchia et al. (2013)	Middle Tyrrhenian Sea, Italy	Quickbird	ANN	84%
Matta et al. (2014)	Gulf of Oristano, Italy	MIVIS, KOMPSAT-2, RapidEye	Vegetation Maps	84%
Traganos et al. (2017)	Thermaikos Gulf, Greece	PlanetScope CubeSat	SVM	68.1%
Traganos & Reinartz (2018a)	Thermaikos Gulf, Greece	RapidEye	Random Forest	73.5% - 82%
Traganos & Reinartz (2018b)	Thermaikos Gulf, Greece	Sentinel-2	Maximum Likelihood, SVM, Random Forest	86%
Traganos & Reinartz (2018c)	Thermaikos Gulf, Greece	Sentinel-2	Semi-analytical inversion method, SVM	95.3% - 99.5%
Traganos et al. (2018)	Ionian Sea and Greek part of the Aegean Sea	Sentinel-2	CART, SVM, Random Forest	72%
Dattolae et al. (2018)	Marine Protected Areas of Capo Rizzuto, Southern Ionian Sea, Italy	Sentinel 2, Landsat 8 OLI, MIVIS, WorldView-2	N/A	N/A
Borfecchia et al. (2019)	Middle Tyrrhenian Sea, Italy	Landsat 8 OLI	Leaf area index (LAI) Modelling	N/A

Shams El Din & El Sherif (2013) studied the nutritional value of the two seagrasses *Cymodocea nodosa* and *Posidonia oceanica* at 5 stations along the western Egyptian Mediterranean coast. The study recommended the potential use of these seagrasses as organic fertilizer. They reported that Leaves of *P. oceanica* were rich source of biochemical components and the major element concentrations in *P. oceanica* (P, 930.00; Na, 2765.00; Ca, 3890.00mg/100gm) exceed that of the compost. Total proteins, total carbohydrates and total lipids in *P. oceanica* were 28.98, 607.50 and 40.50mg/gm, respectively. The calorific content was 3.93k cal/gm.

In Egypt, the leaves were used to cure skin and throat conditions. Debris of *P. oceanica* has been widely used to make compost, even commercialized in countries like Greece since 1999. Before it can be used, a number of preliminary steps must be undergo (washing with fresh water, storage and drying in natural aeration conditions, etc.) in order to remove sand, salt and humidity (Guillén et al., 2014). Farid et al. (2018) Collected Leaves and neptune balls (fibers) of *P. oceanica* from Marsa Matrouh city, Al-Obayed Beach on May 2016. They reported that leaves extract exhibited a significance anticancer activity against HepG2 cell line with IC50 17μg/mL while the ball extract showed a moderate inhibition (45%) against H5N1 virus. The Plant used and sell as medicinal plants by the herbalists in the region (through the Egyptian Center for Herbs and Cross, Alexandria and Tahreer Street in Matrouh City, Egypt). The price ranged from 60 to 200LE. (Seif El-Nasr & Bidak, 2005). Medicinal uses of the plant date back to ancient Egypt, It was used for skin disease, recently it has been used as a remedy for acne, leg pain, diabetes, respiratory infections, hypertension and colitis (EEWMP, 2020).

Although hundreds of publications on the ecology of the land coastal vegetation of the Egyptian Mediterranean, the ecological information on the marine flora are poor and limited with few publications mainly on Alexandria district. Bidak et al. (2015) stated that *P. oceanica* is one of 11 plant species confined to the north western coastal region, many of these plants have become rare, threatened or endangered under the influence of environmental conditions or human activities. Seif El-Naser et al. (2016) recommended in-vitro Propagation of *Posidonia* to conserve its population from threat. Although, it is a common feature on the sandy beaches in Egypt, Boulos (2005) reported that it seem to be rare. Yet, no conservation program to preserve *Posidonia* and coastal habitat in Egypt is implemented. Absolutely, the current status of marine macrophytes, especially *P. oceanica*, meadows is ignored in Egypt and therefore, this study is important to enhance their conservation. The need for conservation action to protect this species and establishment of protection sites for this population is a must, and we had to investigate the seagrass beds during a long program aimed to study the diversity of marine macrophytes along the less explored Egyptian Mediterranean coast. Observations, data, and measurements will permit to understand the value of *Posidonia* beds and will focus on ecological conditions, biometry, biomass, associated flora, epiphytes, and associated fauna.

Conclusion

The growing awareness of the seagrass meadows' ecological importance of has prompted increasing efforts for protection of existing beds and restoration of degraded habitats (Alagna et al., 2015). It is an urgent need for implementation of management measures aiming at mitigating coastal deterioration by combining local and global actions. Most important actions needed to prevent seagrass loss are (Duman et al., 2019):

- Sewage control and treatment to reduce the loading with organic matter, nutrients, chemicals.
- Land use regulation in catchment areas to reduce nutrients.
- Regulation of coastal constructions, land reclamation, and downscaling of water exchange.
- Regulation of fisheries, aquaculture.
- Create awareness of the ecological importance of seagrasses.

According to budget availability, projects could be devoted to verifying the effectiveness of videography and remote sensing techniques for the monitoring of the conservation status of *Posidonia oceanica* meadows and its consistency with the direct, traditional SCUBA-based protocol (especially, its capability to distinguish substrate types and dead matte in different conditions, whenever seabed is covered with sediment, leaf litter or dense leaf canopy).

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حشيشة البحر المتوسط *Posidonia oceanica* (L.) Delile، أحد انواع الحشائش البحرية المهددة بالانقراض

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من أكثر الحشائش البحرية وفرة وأهمية في البحر المتوسط هي *Posidonia oceanica* L. (Delile) نظرًا لقدرتها على إنشاء موطن ثلاثي الأبعاد مع تنوع بيولوجي عالٍ وبناء "حصيرة" (مصطبة من الرواسب الجذرية المتشابكة). تؤثر هذه الحصيرة بشكل كبير على ميزات الساحل من حيث توهين الأمواج وتثبيت الخط الساحلي. بالإضافة إلى ذلك ، فإن مروج *P. oceanica*، التي يمكن أن تمتد على طول الساحل من الخط الساحلي حتى عمق ٤٠ مترًا، تتعرض مباشرة للضغط البشري القادم من المناطق الساحلية وهي حساسة بشكل خاص للظروف البيئية. في العقود الماضية، أثرت الأنشطة البشرية التي نُفِّذت في المناطق الساحلية على العمليات الرسوبية التي أثرت بشدة على مروج *P. oceanica* مما أدى إلى فقدان هذه الحشائش البحرية. تهدف هذه المراجعة إلى إلقاء الضوء على أهمية هذا النبات، ومدى خطورة وضعه ، وحث المجتمع الدولي والحكومات على محاولة حمايته بكل الطرق الممكنة، وخاصة في مصر.