SAFEGUARDING MEDITERRANEAN SEAGRASS BLUE FORESTS FROM ANCHORING DAMAGE

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MEDITERRANEAN POSIDONIA NETWORK

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EXECUTIVE SUMMARY

Seagrass meadows, particularly Posidonia oceanica, are foundational to the ecological health and coastal resilience of the Mediterranean Sea. In this study, we conducted a comprehensive assessment of anchoring-related impacts on Posidonia oceanica meadows throughout the Mediterranean region. Our findings highlight the widespread nature of the threats to seagrass meadows and their significant implications for coastal biodiversity, habitat stability, and carbon sequestration. Based on this assessment, we propose a set of priority recommendations aimed at mitigating anchoring pressure and enhancing the protection and resilience of these vital marine ecosystems.

Seagrasses, these ancient marine flowering plants, form highly productive ecosystems supporting rich biodiversity, stabilizing shorelines, and serving as significant carbon sinks. Despite their crucial role, Mediterranean seagrass meadows are increasingly threatened by a range of human activities, including vessel anchoring—particularly in popular boating destinations—which poses a significant and immediate threat.

This report examines anchoring densities across the Mediterranean and their potential impact on *Posidonia oceanica* ecosystems. Over the past 50 years, more than 30% of *Posidonia oceanica* meadows have been lost to activities such as anchoring, coastal development, pollution and bottom trawling. Anchoring is particularly harmful, causing direct and persistent physical damage, habitat fragmentation, and a decline in the ecosystem's capacity to sequester carbon and sustain marine biodiversity. The vulnerability of *Posidonia oceanica* is heightened by its exceptionally slow growth and recovery rates, making it especially susceptible to long-term degradation.

Using Automatic Identification System (AIS) data from 2024 and a novel geospatial methodology, the study identifies anchoring hotspots across the Mediterranean. Over 179,000

vessels potentially anchored on seagrass meadows during the year, with nearly half of this activity involving large vessels over 24 metres in length. Italy, Türkiye, Greece, France, Spain and Croatia are the most impacted countries. High-risk areas—such as La Maddalena (Italy) and Datça (Türkiye)—see peaks in intensity, especially in summer, exacerbating environmental damage and socioeconomic consequences for fisheries and tourism. Despite regulatory progress in some countries, enforcement remains inconsistent and insufficient in many regions.

To address these growing threats, this report recommends urgent action, particularly from governments and leisure boaters:

Recommendations for government authorities

Mediterranean governments should implement and enforce anchoring regulations to protect seagrass ecosystems, especially *Posidonia oceanica*. Key actions include:

- Banning anchoring of large vessels (>15 m) over seagrass meadows.
- Legally protecting *Posidonia oceanica* nationally.
- Creating no-anchoring zones in sensitive or impacted areas.
- Integrating sustainable anchoring policies into marine and coastal planning.
- Expanding affordable eco-mooring infrastructure.
- Offering incentives for low-impact mooring technologies.
- Harmonizing protection standards through cross-border agreements.
- Incorporating *Posidonia oceanica* distribution maps and no anchoring zones in national hydrographic charts.
- Strengthening enforcement using technology and patrols.
- Promoting public education and training for marine users.
- Supporting scientific research, habitat mapping and blue carbon assessments.
- Recognizing the high economic value of *Posidonia oceanica*.

Recommendations for leisure boaters

Boaters can help protect seagrass by:

- Using navigation tools to find seagrass-safe anchoring spots.
- Anchoring only on sand and avoiding seagrass areas.
- Using adequate anchor chain length (3-5× depth).
- Choosing eco-mooring options when available.
- Staying informed about local marine regulations.
- Participating in educational programmes.
- Reporting illegal anchoring to authorities.

Without coordinated regional action and preventive measures, continued anchoring-related degradation will further jeopardize the health of seagrass meadows and the communities that depend on them. Protecting these ecosystems is essential for climate resilience, biodiversity conservation, and for the sustainable future of the Mediterranean region and its coastal communities.

SEAGRASS MEADOWS IN THE MEDITERRANEAN SEA


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SEAGRASS ECOSYSTEMS: STATUS, IMPORTANCE AND THREATS

The status of seagrass meadows in the Mediterranean Sea

Seagrasses are coastal marine ecosystems dominated by vascular marine plants known as angiosperms. Although still perceived as overgrown algae by many, seagrasses are ancient flowering marine plants with irreplaceable qualities as a species and as a habitat; extending across continents over millennia. They typically inhabit shallow waters—up to 40-45 m—near the shoreline, growing on sandy or muddy substrates. These marine ecosystems aggregate into extensive areas referred to as "meadows" and are found across most of the world's continents[1]. Seven species of seagrass have been documented in the Mediterranean region; five of these are native species (*Cymodocea nodosa, Zostera marina, Z. noltei, Ruppia maritima*) or endemic species (*Posidonia oceanica*), while two are introduced species (*Halophila stipulacea* and *H. decipiens*)[3]. The distribution of these species varies across the Mediterranean, but the range of *Posidonia oceanica* is considered the most ecologically significant and widespread, occurring along most of the region's coastlines[4]. Covering more than 20,000 km² around the Mediterranean coast—an area almost as large as Slovenia—*Posidonia oceanica* meadows are considered the most important and well-studied seagrass species in the region. Due to their ecological significance and the multiple threats to these ecosystems, seagrass meadows benefit from a comprehensive regulatory protection framework at the Mediterranean scale. This framework is governed by various European Directives and regional instruments, including their designation as a priority habitat under the EU Habitats Directive (92/43/EEC), a dedicated Action Plan at the regional level under the Barcelona Convention, and their consideration within the Marine Strategy Framework Directive (2008/56/EC).

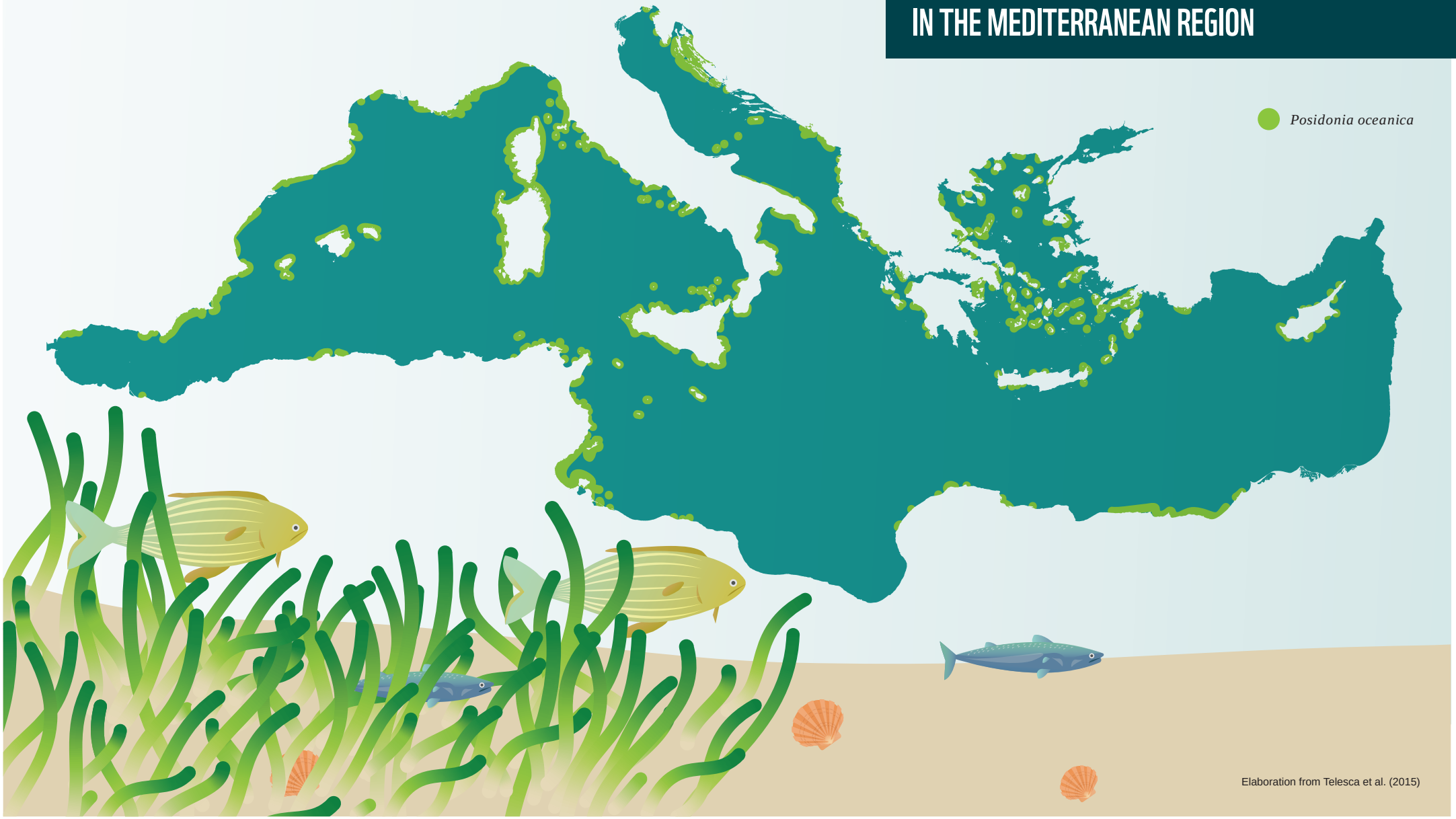
The importance of seagrass meadows for marine biodiversity and coastal protection

Seagrass meadows are highly productive ecosystems considered among the most valuable ecosystems globally[5]. They provide a broad spectrum of ecosystem services that enhance marine ecosystem health, human well-being, and the resilience of coastal communities. They function as biodiversity hotspots, serving as permanent habitats, nursery grounds, feeding areas and refuges for numerous marine species[6]. Due to their role as essential nursery habitats, seagrass meadows also support the productivity of highly valuable fisheries[7], thereby contributing to the livelihoods of coastal populations. They also provide valuable nature-based solutions to mitigate the impacts of climate change on coastal areas, particularly regarding shoreline erosion and carbon storage[6]. Frequently recognized as "ecosystem engineers"[8], seagrasses reduce flow velocities within their canopies, thereby enhancing sedimentation processes and contributing to sediment stabilization. Furthermore, widely considered as blue carbon ecosystems[9], seagrass meadows function as major carbon sinks, storing nearly 20% of the world's oceanic carbon[10]. At the Mediterranean scale, *Posidonia oceanica* meadows store about 540 million tonnes of carbon which is the equivalent to the annual CO_2 emissions of approximately 430 million cars. Their exceptional capacity for carbon sequestration and storage position seagrass ecosystems as key assets in achieving current climate targets. In addition to this, seagrass meadows are recognized for their role in maintaining coastal water quality[12]. The range of ecosystem services provided by seagrass meadows highlights their critical ecological and social importance. Their preservation and restoration, therefore, emerge as strategic priorities to address current environmental challenges.

Their exceptional capacity for carbon sequestration and storage position seagrass ecosystems as key assets in achieving current climate targets.

POSIDONIA OCEANICA DISTRIBUTION

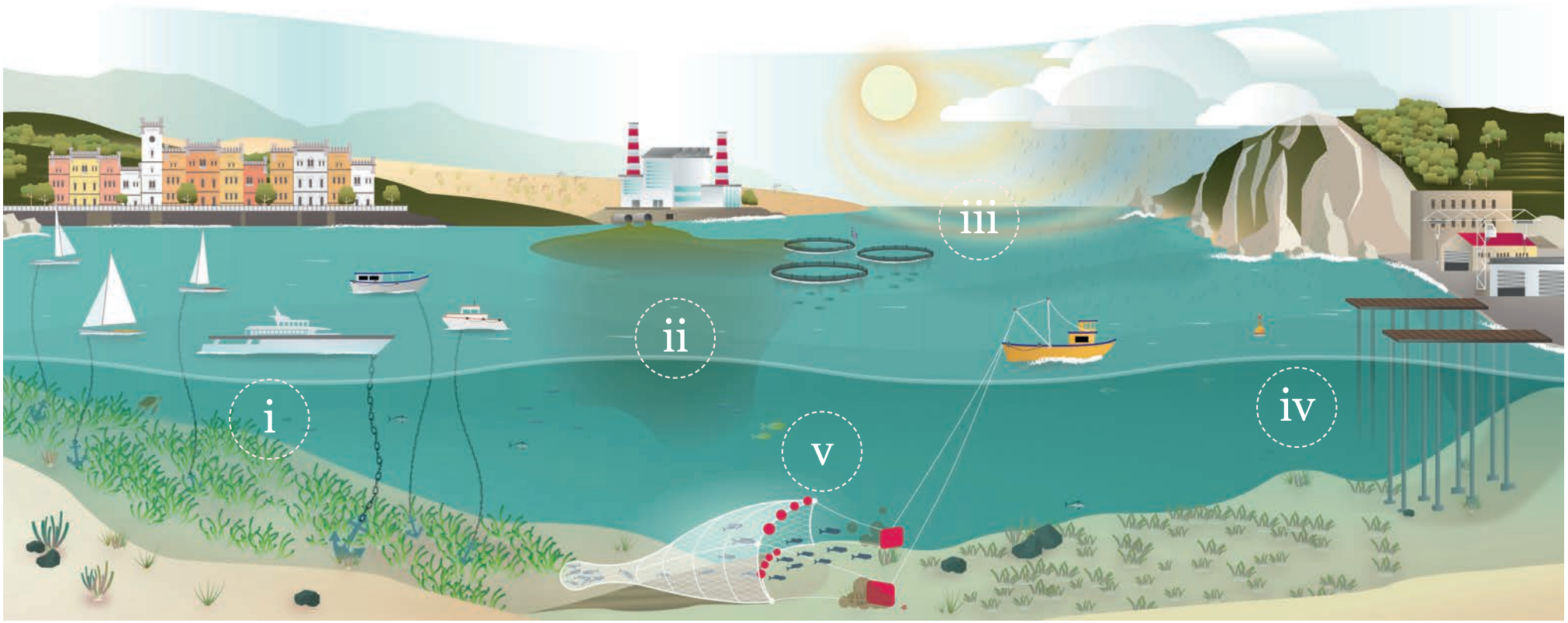
IN THE MEDITERRANEAN REGION



Elaboration from Telesca et al. (2015)

Main current threats to seagrass meadow ecosystems

Despite their crucial role in maintaining marine ecosystem balance and providing essential services, seagrass meadows face numerous threats. These habitats are particularly fragile due to their slow growth rate—especially for the species *Posidonia oceanica*—and their high sensitivity to fluctuations in salinity, turbidity, and sediment dynamics[13]. It is estimated that almost 34% of seagrass meadows have been lost in the Mediterranean in the past 50 years[14]. This regression is largely attributed to the anthropogenic pressures affecting these vulnerable ecosystems, principally:
(i) **Anchoring and mooring of vessels**, causing often irreversible damage. This threat is particularly significant in the Mediterranean due to the high density of leisure boats and vessels navigating these waters. (ii) **Marine pollution**, from industrial and agricultural activities, which leads to water quality degradation and eutrophication[16]. In addition, nutrient-rich waste from fish farming leads to eutrophication, oxygen depletion, and sediment enrichment, causing up to 20× higher mortality of *Posidonia oceanica* shoots within 100 m of farms[48]. Long-term impacts have been observed up to 900 m from former farm sites, with seagrass recovery taking over a decade[41].
(iii) Seagrass meadows, while relatively resistant to fluctuations in temperature[13], can be affected by **climate-related stressors** such as extreme weather events, ocean acidification, and the proliferation of invasive species—particularly *Halophila stipulacea* and Caulerpa sp. in the Mediterranean via the Suez Canal[16]—which hinder their development[15].
(iv) **Construction of coastal infrastructure** such as harbours and marinas, including the associated dredging, excavation, and sedimentation processes, can cause direct damage to seagrass meadow habitats and disrupt their growth, particularly through reduced photosynthesis.
(v) **Bottom trawling** damages seagrass meadows due to the dragging of nets along the seafloor, causing the uprooting of seagrass and the destruction of habitats. This issue is especially critical in Türkiye[22, 23] and in parts of North Africa, where the practice of "kiss trawling" in very shallow waters has led to the destruction of vast areas of *Posidonia oceanica* meadows[17].



IMPACTS OF ANCHORING

Intense and frequent anchoring activities significantly impact seagrass meadows, especially *Posidonia oceanica*, in the Mediterranean Sea due to the region's popularity as a boating and leisure tourism destination. This puts severe pressure on sensitive coastal habitats.

Understanding the scale and nature of anchoring impacts is crucial to implementing effective management and conservation strategies. The main consequences include direct physical damage, prolonged habitat degradation, indirect ecological effects, and socioeconomic repercussions affecting fisheries and tourism.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Direct physical damage from anchoring

Anchors cause immediate physical damage to seagrass meadows by penetrating the seabed and uprooting plants, resulting in scars and fragmented habitats. In the Ligurian Sea (northwest Mediterranean), anchoring activities have caused meadow cover losses exceeding 34% in highly frequented areas[18]. Traditional anchors have caused fragmentation rates ranging between 20% and 50%, depending on the anchor type[19]. Frequent anchoring exacerbates habitat fragmentation and significantly impedes natural regeneration[20].

Long-term degradation and recovery challenges

Posidonia oceanica meadows have particularly slow growth rates (approximately 1-6 cm/year), making recovery from anchoring damage extremely slow, sometimes taking decades or proving irreversible[3]. Studies have observed anchoring scars persisting for 10-15 years after the initial damage, significantly impacting overall meadow health[5]. Restoration initiatives are increasingly effective but remain costly, with restoration projects averaging around €250 per m^2 as demonstrated by a case study in the Balearic Islands[4], underscoring the need to prioritize preventive measures over restoration[3, 4].

Dramatic ecological consequences

Anchoring-induced degradation reduces the capacity of seagrass ecosystems to deliver crucial ecological services. In some cases, damaged *Posidonia oceanica* meadows exhibited approximately 30% reduced capacity for carbon sequestration compared to intact areas, severely impacting their potential in mitigating regional climate-related stress[11]. Additionally, fragmented meadows showed reductions in biodiversity and species abundance of up to 40%, impacting ecological stability and resilience[21]. Such ecological degradation enhances sediment erosion rates, altering coastal dynamics and affecting adjacent habitats negatively.

Socioeconomic impacts on fisheries and tourism

Healthy seagrass ecosystems support vital socioeconomic activities like fisheries and tourism. Fisheries reliant on healthy *Posidonia oceanica* habitats experienced catch reductions of approximately 25-40% due to habitat degradation, directly impacting local economies [7]. Moreover, tourism in regions such as Port-Cros National Park in France has seen declines in recreational diving and snorkeling activities due to habitat loss, translating into economic losses for local communities[20].

Comparative overview of Mediterranean countries

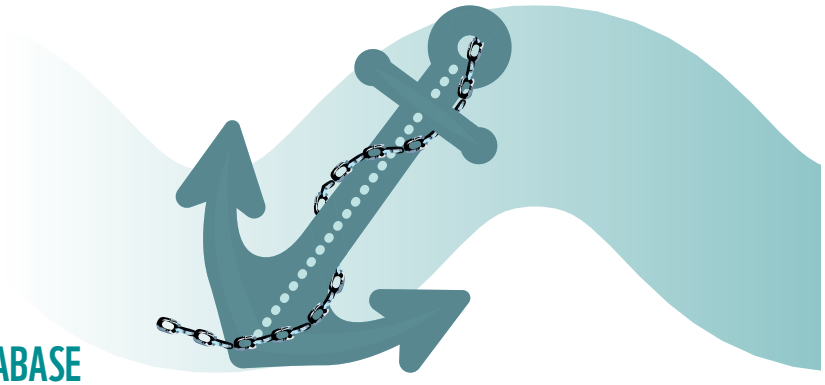
The severity of anchoring damage varies across Mediterranean countries depending on the intensity of local maritime traffic and the effectiveness of management measures. Severe anchoring impacts have been documented in Italy (Ligurian Sea and Sicily), Spain (Balearic Islands), and France (Port-Cros). Conversely, regions with effective anchoring regulations, such as protected marine areas in Spain and France, demonstrated lower damage levels (10-15% habitat damage compared to 40-50% in less regulated regions)[18, 19, 20].

COMPARATIVE ANCHORING DAMAGE ACROSS SITES IN MEDITERRANEAN COUNTRIES

SITE	% MEADOW AREA LOST	DETAILS
Sant'Amanza Bay (Corsica, France)	11%	Cumulative loss of 72.9 ha of *Posidonia oceanica* (~11% of the bay's meadow) attributed to yacht anchoring; 7.5 ha lost in one year (2019–2020) alone[25].
Ligurian Sea (Prelo Cove, NW Italy)	~34%	Anchor chain system caused a loss of ~34% of seagrass cover in the cove's meadow (comparison of anchored vs. undisturbed areas)[24].
Lastovo & Mljet Islands (Dalmatian Coast, Croatia)	40%	Live *Posidonia oceanica* cover was ~50-60% compared to ~85-90% in undisturbed reference sites[28].
Ses Salines NP (Formentera, Balearic Islands)	44%	*Posidonia oceanica* meadow area declined ~20% in four years due to illegal anchoring; losses ranged from 16% to 44%[26].
Fethiye–Göcek Bay (Aegean, SW Türkiye)	50%	Yacht anchoring caused meadow cover to be halved compared to adjacent undisturbed zones[29].
Aegean & Ionian Seas (30 Natura 2000 sites)	66%	In addition, **signs of anchoring damage** were observed in over 66% of *Posidonia oceanica* meadows in 30 Natura 2000 sites in the Aegean and Ionian Seas[27].

In unregulated or high-traffic areas, damage levels of 30-50% meadow loss are commonly reported[24, 25, 29]. In Italy, Greece, and Türkiye, studies show one-third to one-half of meadow area has been lost in heavily used anchor zones[24, 27, 29]. Even in Spain and France—where awareness and protection have improved—certain hotspots (e.g. Formentera and Corsica) have suffered double-digit percentage losses within just a few years[25, 26]. In contrast, regions with enforced anchoring regulations (e.g., eco-mooring facilities in protected zones) have seen markedly lower impact levels (<15%)[25]. This illustrates the importance of effective regulation and alternative mooring solutions to preserve *Posidonia oceanica* habitats.

METHODOLOGICAL APPROACH



THE DATABASE

The data used for this report, and to compile the following maps and infographics, was provided by the Global Fishing Watch (GFW) platform. The initial database consists of point data provided by GFW, aggregated into areas of 0.001°x0.001° (~1 hectare), derived from Automatic Identification System (AIS) position data in the Mediterranean Sea for the entire year of 2024. AIS data is transmitted primarily by vessels over 15 m in length, as required by international maritime regulations. Therefore, references to "all vessels" throughout the report pertain exclusively to those over 15 m, and do not include smaller craft that are not mandated to carry AIS. With GFW's assistance, only vessels categorized as "other" were selected from their database as "potential anchoring events"—meaning all non-fishing vessels, non-commercial vessels, and non-passenger transport vessels with speeds below 2 knots. This extraction was performed for all vessels, vessels under 24 m in length, and vessels over 24 m in length. The aggregated point data used includes latitude and longitude coordinates for each point, a field with the number of vessels recorded in that area, and the total cumulative hours of vessel presence in that area.

STATISTICAL ANALYSIS

For statistical analysis, a 0.001°x0.001° vector grid was reconstructed from the filtered point dataset to represent the data aggregation areas. These grid polygons were clipped based on *Posidonia oceanica* meadow boundaries and then intersected with each country's exclusive economic zone (EEZ) to separate them into national jurisdictions. Finally, the area of each grid polygon (in hectares) was calculated to estimate the potential impact of anchoring on *Posidonia oceanica* meadows. The data was divided into anchoring duration classes for further analysis.

RECONSTRUCTION OF OFFSHORE ANCHORING

Spatial filter for ports

To exclude data from vessels anchored inside ports, port area data from OpenStreetMap covering the Mediterranean was downloaded. A 100 m buffer was applied to these areas, followed by manual refinement to maximize data accuracy. Using GIS software, points falling within these port areas were removed to avoid the inclusion of docked vessels.

Temporal filter for offshore anchoring

To reconstruct potential anchoring events, theoretical assumptions were applied to filter the data:

- The average dwell time was calculated by dividing the total dwell time by the number of vessels.
- Only points with an average dwell time greater than 0.5 hours were retained to exclude vessels merely passing through.
- To minimize the effect of possible buoy-anchored vessels not excluded by the spatial port filter, a maximum dwell time filter was applied, keeping only data with an average dwell time below 360 hours (15 days).

Spatial filter for impact on *Posidonia oceanica* meadows

The dataset was further filtered by selecting only point data falling within the *Posidonia oceanica* meadow polygons used in the report. This allowed for the analysis of potential anchoring pressure on this seagrass.

Raster reconstruction

Using GIS software, rasters at varying resolutions were created for data analysis and cartographic visualization. For the three datasets (all vessels, vessels under 24 m, and vessels over 24 m), rasters were generated for:

- Total anchoring hours
- Number of vessels.

A spatial summation was performed at the following resolutions:

- 0.001°x0.001° (original resolution)
- 0.03°x0.03° (regional focus maps)
- 0.05°x0.05° (regional focus maps)
- 0.1°x 0.1° (Mediterranean-wide map).

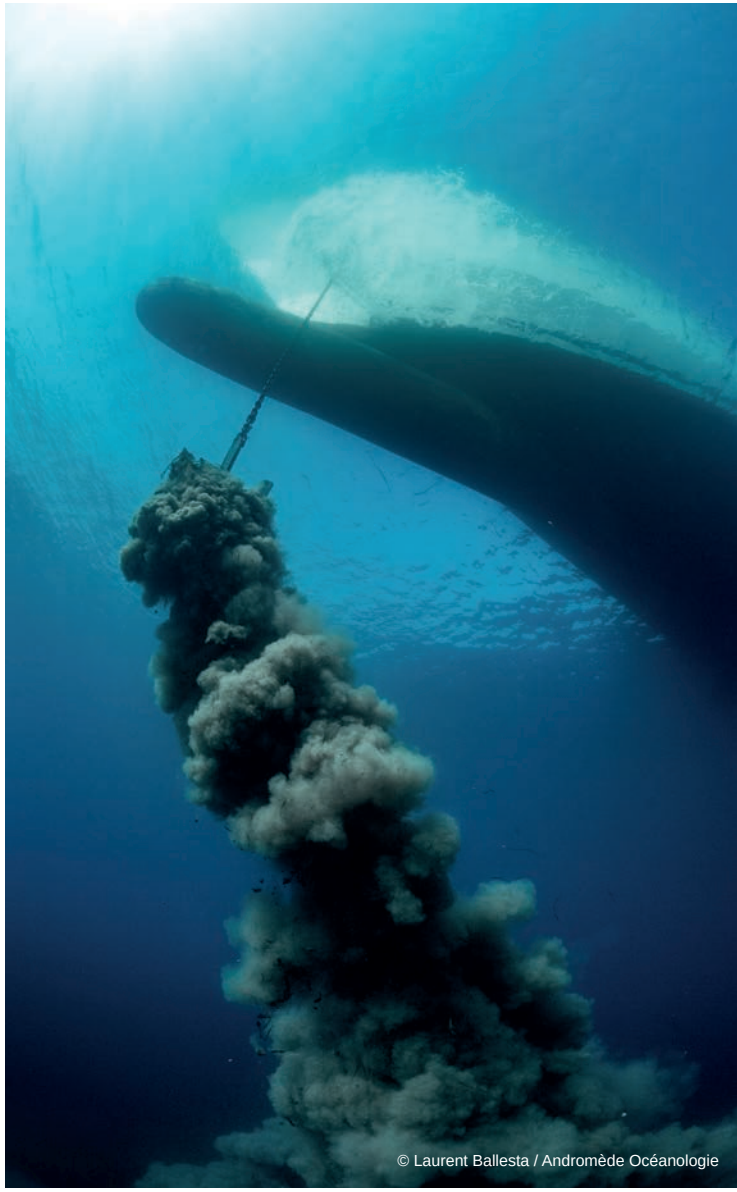
MEDITERRANEAN ANCHORING HOTSPOTS

The AIS data analysis provided a detailed quantitative overview of anchoring pressure on *Posidonia oceanica* meadows in the Mediterranean Sea in 2024. The results highlight significant variability between countries, with some bearing considerably more pressure than others. The distinction between the impact of smaller and larger boats provides useful insights into understanding the sources of pressure. The analysis of anchoring duration classes offers a more precise picture of the nature of this pressure. Finally, the percentage of anchoring pressure area relative to the total *Posidonia oceanica* area at the national level highlights the areas where anchoring could pose a proportionally greater threat to this crucial habitat. Further analysis and interpretation of this data could lead to the detailed identification of specific anchoring "hotspots" and inform the development of more targeted management and conservation measures.

The analysis highlights notable differences in anchoring pressure between the various countries considered. Countries like Croatia, France, Greece, Italy, and Türkiye show the highest values in terms of anchoring density and area of *Posidonia oceanica* meadows potentially affected. Conversely, countries like Tunisia present overall lower values.

Areas such as Datça in Türkiye and La Maddalena in Italy demonstrate the highest anchoring intensity, particularly during the summer season (May-September). High-resolution mapping confirms that seagrass degradation is most severe in unregulated bays and coves, where anchoring is unmonitored and restoration efforts remain limited[42, 43].

These high-risk areas are also where local livelihoods most directly depend on healthy seagrass systems. Artisanal fishers across Greece, Türkiye, and Tunisia rely on *Posidonia oceanica* beds as spawning and nursery grounds for economically vital species; damage to these habitats has been associated with declining catches and growing income insecurity[44, 45]. Similarly, in tourist economies like those of the Balearics, Malta, and southern France, the degradation of seagrass meadows impacts the clarity of coastal waters and the abundance of marine life, reducing the appeal of diving, snorkelling, and eco-tourism activities[46]. Seasonal meadow degradation often coincides with peak tourist demand, creating a conflict between economic opportunity and ecosystem resilience. Despite their importance, many of these zones lack integrated spatial anchoring plans, and enforcement outside MPAs remains weak, leaving livelihoods and biodiversity vulnerable to further decline[47].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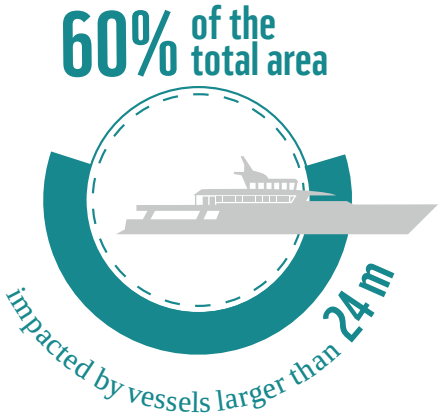
WWF

LEISURE BOATING ANCHORING HOTSPOTS

LIKELY TO IMPACT POSIDONIA OCEANICA

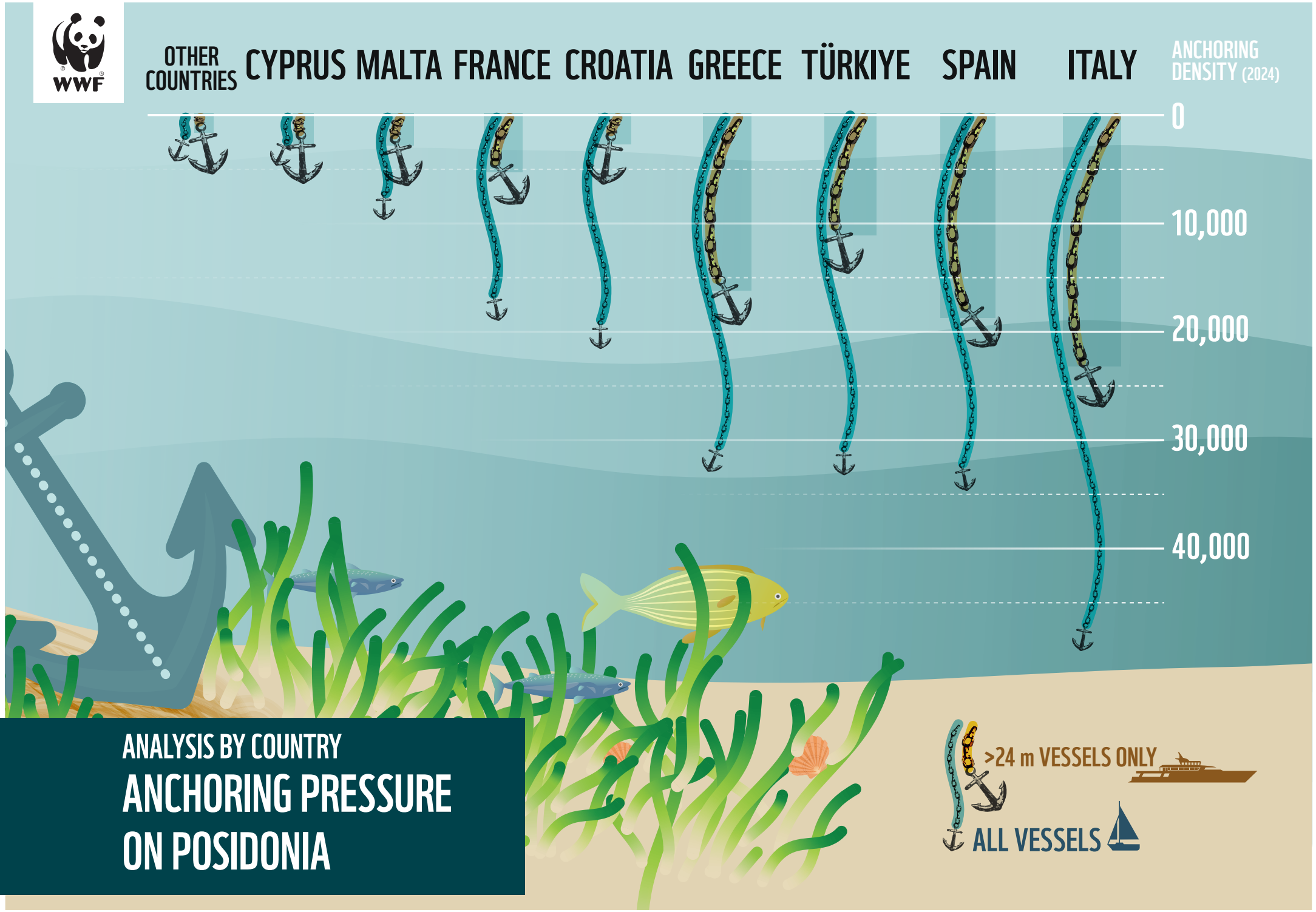
ANALYSIS BY COUNTRY

According to our assessment of data from 2024, across the Mediterranean over 179,000 vessels potentially anchored on seagrass, with nearly half of those anchoring events (88,810 vessels) involving vessels larger than 24 m. Italy alone accounts for 46,365 anchoring events—22,952 of which are from large vessels—making it one of the most heavily impacted countries. The infographic on the next page shows that countries like Italy, France, Croatia, Spain, Türkiye, and Greece experience the highest number of vessels anchoring on seagrass; they also face the most significant ecological consequences. Collectively, over 50,000 hectares of *Posidonia oceanica* are potentially affected, with large vessels responsible for the impact on more than 30,000 of those hectares. The visual contrast between total anchoring pressure and large vessel impact across countries highlights how certain hotspots—particularly in Italy, Türkiye, and Greece—bear the brunt of damage, underscoring the need for targeted anchoring regulations in these areas.



KEY DATA

- Over 1 year (2024) 179,000 vessels potentially anchored on seagrass in the Mediterranean, half of them (88,810) larger than 24 m.
- Collectively over 50,000 ha of seagrass were potentially affected by anchoring in the Mediterranean. Around 60% (30,000 ha) of this area was impacted by vessels larger than 24 m.
- Anchoring over seagrass potentially occurs in all assessed countries. In some hotspots the situation is particularly severe. Hotspots are found in Italy, Spain, Türkiye, Greece, Croatia, France, Malta and Cyprus. These hotspots alone include around 140,000 vessels potentially anchoring on seagrass (75% of the total) with peaks of over 13,000 anchoring events in Italy (La Maddalena - Golfo Aranci) and in Türkiye (Datça - Bodrum).
- North African countries are generally less affected by anchoring activities compared to the rest of the region.
- The data does not account for all vessels, only those with AIS. The numbers in this report, and the damage to *Posidonia oceanica* in the Mediterranean, therefore, are underestimated.

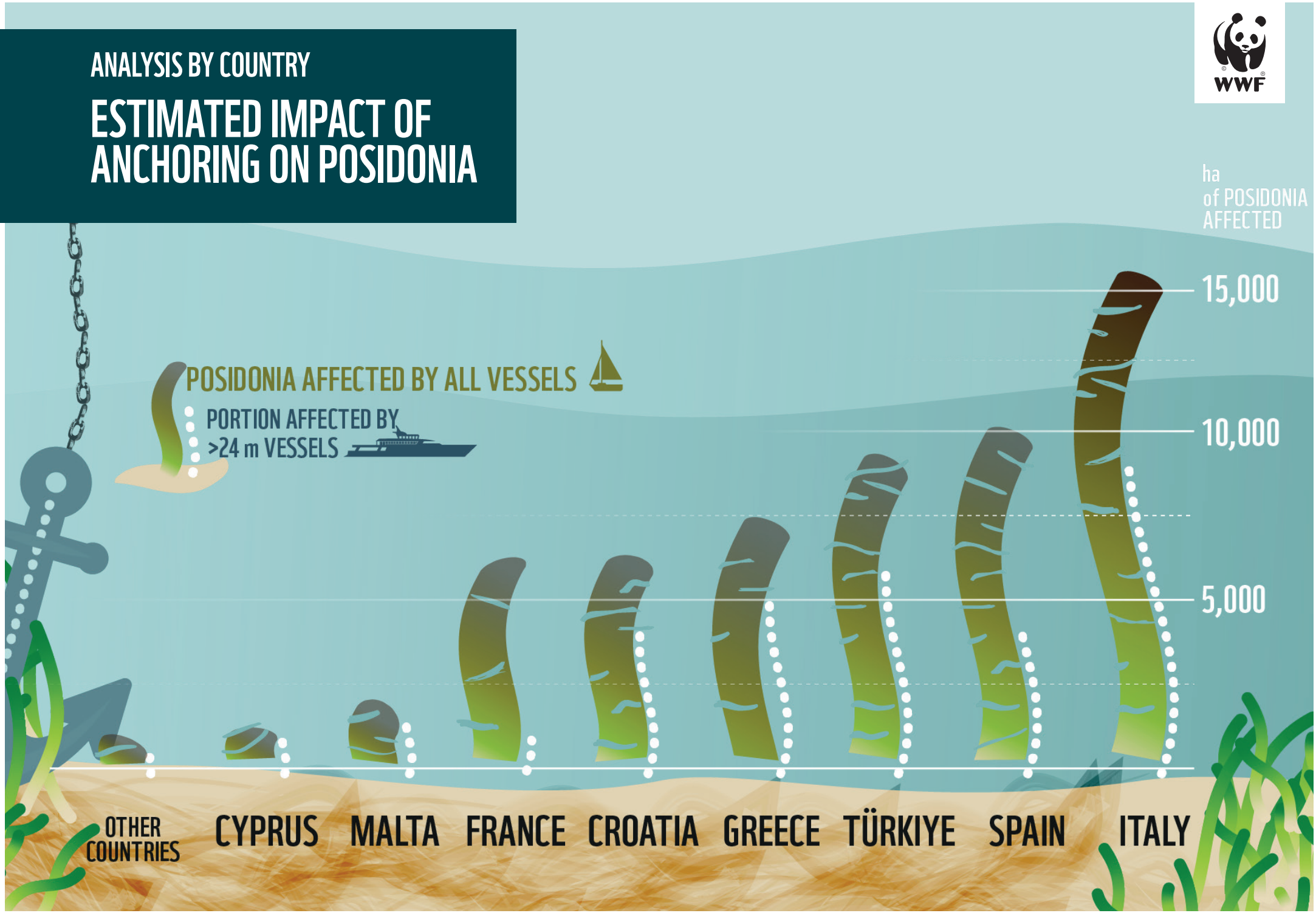


ANALYSIS BY COUNTRY

ANCHORING PRESSURE ON POSIDONIA

ANALYSIS BY COUNTRY

ESTIMATED IMPACT OF ANCHORING ON POSIDONIA



RECOMMENDATIONS

Our assessment reveals that anchoring on seagrass potentially occurs over a large coastal area in the Mediterranean, and that high-traffic coastal zones are disproportionately affected by anchor-related damage, eventually resulting in long-term ecological degradation. Given the importance of *Posidonia oceanica* to biodiversity, shoreline protection, carbon sequestration and local economies, it's essential that authorities take the following actions to mitigate the impacts of anchoring and to promote sustainable practices.

RECOMMENDATIONS FOR GOVERNMENT AUTHORITIES:

To mitigate anchor-related damage and promote sustainable marine use, Mediterranean governments should:

- **Establish and enforce national anchoring regulations**, including comprehensive bans on anchoring large vessels (at least above 15 m) over seagrass meadows.
- Ensure that *Posidonia oceanica* is legally **protected at the national level.**
- Designate seasonal and permanent **no-anchoring zones** in ecologically sensitive (e.g., marine protected areas) or highly impacted areas.
- Develop national **anchoring impacts mitigation plans** and integrate sustainable mooring policies into marine spatial planning, coastal zone management, and tourism development frameworks.
- Expand **eco-mooring infrastructure** (e.g., seagrass-friendly buoys) in popular boating destinations and ensure affordable access for users.
- Provide **financial incentives and regulatory support** for the adoption of low-impact mooring technologies.
- Develop **cross-border agreements** to harmonize seagrass protection standards across the Mediterranean basin.
- Strengthen **enforcement and monitoring capacity**, including the deployment of satellite imagery, drones, and patrols to ensure compliance.
- Incorporate *Posidonia oceanica* **distribution maps and no anchoring zones** in national hydrographic charts.
- **Support public education campaigns and professional training**, targeting recreational boaters, charter operators, and marina personnel.
- **Fund and facilitate long-term scientific research**, including detailed mapping of seagrass habitats, monitoring of restoration efforts, blue carbon assessments and modeling future pressures under climate change scenarios.
- **Recognize the fundamental asset value** of *Posidonia oceanica* which in 2024 was estimated by a French judge to be around €86,000 ha/year.

RECOMMENDATIONS FOR LEISURE BOATERS:

Leisure boaters play a key role in protecting seagrass ecosystems and should commit to the following best practices:

- **Use navigation screens and apps** to identify approved, seagrass-safe anchoring or mooring locations.
- **Anchor exclusively on sand**, avoiding all visible seagrass meadows.
- **Anchor with sufficient chain** (at least 3 to 5 times the depth).
- **Use eco-mooring systems** whenever available instead of dropping anchors.
- Stay informed about **local regulations and protected zones** before setting out.
- Participate in **boater education programmes**, both online and in marinas, to understand the ecological impact of anchoring and how to minimize it.
- **Report illegal anchoring to local authorities** to support enforcement and ecosystem recovery.

CONCLUSIONS

The future resilience of Mediterranean coastal ecosystems hinges on coordinated, science-based management and responsible user behaviour. Preserving and restoring *Posidonia oceanica* meadows is not only a conservation imperative, it is a strategic investment in biodiversity, climate stability, and the sustainable livelihoods of coastal communities.

Future research should focus on fine-scale mapping of seagrass distribution, developing predictive models for human-induced pressures under climate change and evaluating long-term restoration success. A coordinated, science-based approach is essential to ensure the resilience and recovery of these vital Mediterranean ecosystems.

We must ensure the protection of the habitats we rely on for survival. Preserving and restoring seagrass meadows isn't just an ecological mission–it's a strategic necessity for our future.

REFERENCES AND ADDITIONAL RESOURCES

1. Short, F. T., Carruthers, T. J. B., Dennison, W. C., & Waycott, M. (2001). Global seagrass distribution and diversity: A bioregional model. In F. T. Short & R. G. Coles (Eds.), *Global Seagrass Research Methods* (pp. 5-23). Elsevier. https://www-sciencedirect-com.wwf.idm.oclc.org/sdfe/pdf/download/eid/3-s2.0-B9780444508911500025/first-page-pdf.

3. Boudouresque, C.-F., Blanfuné, A., Pergent, G., & Thibaut, T. (2021). Restoration of seagrass meadows in the Mediterranean Sea: A critical review of effectiveness and ethical issues. *Water, 13*(8), 1034. https://doi.org/10.3390/w13081034.

4. United Nations Environment Programme (UNEP) - Mediterranean Action Plan (MAP) - Regional Activity Centre for Specially Protected Areas (RAC/SPA). (2010). *Action Plan for the conservation of marine vegetation in the Mediterranean Sea*. https://www.rac-spa.org/sites/default/files/doc_cop/biodiversity.pdf.

5. Telesca, L., Belluscio, A., Criscoli, A., Ardizzone, G., Apostolaki, E. T., Fraschetti, S., Gristina, M., Knittweis, L., Martin, C. S., Pergent, G., Alagna, A., & Badalamenti, F. (2015). Seagrass meadows (Posidonia oceanica) distribution and trajectories of change. *Scientific Reports, 5*, 12505. https://www.nature.com/articles/srep12505.

6. United Nations Environment Programme (2020). *Out of the blue: The value of seagrasses to the environment and to people*. UNEP, Nairobi.

7. Jackson, E. L., Rowden, A. A., Attrill, M. J., Bossey, S. J., & Jones, M. B. (2001). The importance of seagrass beds as a habitat for fishery species. *Oceanography and Marine Biology: An Annual Review, 39*, 269-303.

8. Bos, A. R., Bouma, T. J., de Kort, G. L. J., & van Katwijk, M. M. (2007). Ecosystem engineering by annual intertidal seagrass beds: Sediment accretion and modification. *Estuarine, Coastal and Shelf Science, 74*(3), 344–348. https://doi.org/10.1016/j.ecss.2007.05.005.

9. Majtényi-Hill, C., Reithmaier, G., Yau, Y. Y. Y., Serrano, O., Piñeiro-Juncal, N., & Santos, I. R. (2023). Inorganic carbon outwelling from a Mediterranean seagrass meadow using radium isotopes. *Estuarine, Coastal and Shelf Science, 283*, 108248. https://doi.org/10.1016/j.ecss.2023.108248.

10. Duarte, C. M., Kennedy, H., Marbà, N., & Hendriks, I. (2013). Assessing the capacity of seagrass meadows for carbon burial: Current limitations and future strategies. *Ocean & Coastal Management, 83*, 32-38. https://doi.org/10.1016/j.ocecoaman.2011.09.001.

11. Pergent-Martini, C., Pergent, G., Monnier, B., Boudouresque, C.-F., Mori, C., & Valette-Sansevin, A. (2021). Contribution of *Posidonia oceanica* meadows in the context of climate change mitigation in the Mediterranean Sea. *Marine Environmental Research, 165*, 105236. https://doi.org/10.1016/j.marenvres.2020.105236.

12. McGlathery, K. J., Sundbäck, K., & Anderson, I. (2007). Eutrophication in shallow coastal bays and lagoons: The role of plants in the coastal filter. *Marine Ecology Progress Series, 348*, 1–18. https://doi.org/10.3354/meps07132.

13. Pergent-Martini, C., André, S., Castejon, I., Deter, J., Frau, F., Gerakaris, V., Mancini, G., Molenaar, H., Montefalcone, M., Oprandi, A., Pergent, G., Poursanidis, D., Royo, L., Terrados, J., Tomasello, A., Ventura, D., & Villers, F. (2024). *Guidelines for Posidonia oceanica restoration* (Report No. OFB-22-1310). Cooperation agreement Mediterranean Posidonia Network (MPN), French Biodiversity Agency (OFB) & University of Corsica Pasquale Paoli (UCPP).

14. United Nations Environment Programme (UNEP). Communication on World Seagrass Day (n.d). Retrieved from https://www.un.org/en/observances/seagrass-day.

15. Caparrós-Martínez, J. L., Martínez-Vázquez, R. M., & de Pablo-Valenciano, J. (2025). Future challenges in the conservation and valuation of environmental services provided by the seagrass meadows of *Posidonia oceanica*. *Marine Policy, 175*, 106630. https://doi.org/10.1016/j.marpol.2025.106630.

16. Beca-Carretero, P., Winters, G., Teichberg, M., Procaccini, G., Schneekloth, F., Zambrano, R., Chiquillo, K., & Reuter, H. (2024). Climate change and the presence of invasive species will threaten the persistence of the Mediterranean seagrass community. *Science of The Total Environment, 168675*. https://doi.org/10.1016/j.scitotenv.2023.168675.

17. FISH ACT. (2023). *Illegal shallow water bottom trawling, i.e. "Kiss" trawling in the Gulf of Gabes, Tunisia* (Investigation Report). https://fishact.org/tunisia-campaign-report-2022/.

18. Montefalcone, M., Lasagna, R., Bianchi, C. N., & Morri, C. (2008). Anchoring damage on Posidonia oceanica meadow cover. *Chemistry and Ecology*, 24(S1), 105-110.

19. Milazzo, M., Chemello, R., Badalamenti, F., Riggio, S., & D'Anna, G. (2004). Boat anchoring on Posidonia oceanica beds. *Journal of Experimental Marine Biology and Ecology*, 299(1), 51-62.

20. Francour, P., Ganteaume, A., & Poulain, M. (1999). Boat anchoring in Posidonia oceanica seagrass beds in Port-Cros National Park. *Aquatic Conservation*, 9(4), 391-400.

21. Waycott, M., Duarte, C. M., Carruthers, T. J., et al. (2009). Accelerating loss of seagrasses threatens coastal ecosystems. *PNAS*, 106(30), 12377-12381.

22. Duman, M., Eronat, A. H., İlhan, T., Talas, E., et al. (2019). Mapping Posidonia oceanica (Linnaeus) Meadows in the Eastern Aegean Sea Coastal Areas of Turkey: Evaluation of Habitat Maps Produced Using the Acoustic Ground Discrimination Systems. *International Journal of Environment and Geoinformatics*, 6(1), 67-75. https://doi.org/10.30897/ijegeo.544695.

23. Michael L. Brennan, Robert D. Ballard, Chris Roman, Katherine L.C. Bell, Bridget Buxton, Dwight F. Coleman, Gabrielle Inglis, Orkan Köyağasıoğlu, Tufan Turanlı, Evaluation of the modern submarine landscape off southwestern Turkey through the documentation of ancient shipwreck sites. *Continental Shelf Research,* Volume 43, 2012, Pages 55-70, ISSN 0278-4343, https://doi.org/10.1016/j.csr.2012.04.017.

24. Montefalcone, M., Lasagna, R., Bianchi, C. N., & Morri, C. (2008). Anchoring damage on Posidonia oceanica meadow cover: A case study in Prelo Cove (Ligurian Sea, NW Mediterranean). *Chemistry and Ecology*, 24(S1), 105–110.

25. Pergent-Martini, C., Monnier, B., Lehmann, L., Barralon, E., & Pergent, G. (2023). Major regression of Posidonia oceanica meadows in relation with recreational boat anchoring: A case study from Sant'Amanza Bay. Journal of Sea Research, 192, 102258.

26. Oceana. (2013). Anchors have destroyed over 20% of Posidonia in Spanish Natural Park in only four years. Press Release, 18 April 2013.

27. Mediterranean Posidonia Network. (2024). Report on the "Anchors Away" Networking Event. WWF Greece/MPN.

28. Association Sunce. (2012). *Monitoring of Posidonia oceanica meadows in Croatian Protected Areas – Technical Report*. WWF MedPO/Sunce Project.

29. Okudan, E.Ş., Demir, V., Kalkan, E., & Karhan, S.Ü. (2011). Anchoring damage on seagrass meadows (Posidonia oceanica) in Fethiye-Göcek Specially Protected Area (Eastern Mediterranean Sea, Turkey). *Journal of Coastal Research*, SI 61, 417–420.

30. Pergent-Martini, C., et al. (2023). Major regression of Posidonia oceanica meadows in relation with recreational boat anchoring: A case study from Sant'Amanza Bay. *Journal of Sea Research*, 192, 102258.

31. UNEP/MAP-SPA/RAC. (2023). *Guidelines for anchoring management in the Mediterranean*. Regional Activity Centre for Specially Protected Areas.

32. Waycott, M., et al. (2009). Accelerating loss of seagrasses threatens coastal ecosystems. *Proceedings of the National Academy of Sciences*, 106(30), 12377-12381.

33. Jackson, E.L., et al. (2001). Importance of seagrass beds as habitat for fishery species. *Oceanography and Marine Biology: An Annual Review*, 39, 269-303.

34. Donia App. Presented in: MedPAN/WWF *Posidonia Anchoring Report* (2021). Mediterranean Anchoring Impact and Management Measures.

35. Okudan, E.Ş., et al. (2011). Anchoring damage on seagrass meadows in Fethiye-Göcek Protected Area (Turkey). *Journal of Coastal Research*, SI 61, 417–420.

36. MPN & WWF Greece. (2024). Anchors Away Event Report. Mediterranean Posidonia Network.

37. Pergent, G., et al. (2021). Contribution of Posidonia oceanica in the context of climate change mitigation. *Marine Environmental Research*, 165, 105236.

38. Govern Balear. (2018). *Atlas de Posidonia y herramientas digitales para la protección de praderas*.

39. Mediterranean Posidonia Network. (2022). *Assessment of MPA effectiveness in Posidonia conservation*.

40. WWF Mediterranean Marine Initiative. (2023). *Posidonia protection gaps in southern and eastern Mediterranean countries*.

41. The Fish Site (2023). Oxford study finds lasting impacts of aquaculture on Greek seagrass. https://thefishsite.com/articles/oxford-study-finds-lasting-impacts-of-aquaculture-on-greek-seagrass.

42. Mediterranean Posidonia Network. (2022). *Assessment of MPA effectiveness in Posidonia conservation*.

43. WWF Mediterranean Marine Initiative. (2023). *Spatial mapping of anchoring risk zones and Posidonia decline*.

44. Jackson, E.L., Rowden, A.A., Attrill, M.J., Bossey, S.J., & Jones, M.B. (2001). The importance of seagrass beds as a habitat for fishery species. *Oceanography and Marine Biology: An Annual Review*, 39, 269-303.

45. Boudouresque, C.F., Bernard, G., Pergent, G., Shili, A., & Pergent-Martini, C. (2009). Regression of Mediterranean seagrasses caused by natural processes and anthropogenic disturbances and stress: A critical review. Botanica Marina, 52(5), 395–418.

46. Waycott, M., Duarte, C.M., Carruthers, T.J.B., et al. (2009). Accelerating loss of seagrasses across the globe threatens coastal ecosystems. *Proceedings of the National Academy of Sciences*, 106(30), 12377–12381.

47. WWF & MPN. (2021). *Anchors Away: Posidonia protection and policy gaps in the Mediterranean*.

48. FAO (2005). Impact of aquaculture on environment in the Mediterranean. FAO Fisheries Report No. 779. https://www.fao.org/4/a0466e/A0466E07.htm.

ANNEXES

1. DETAILED MAPS

- CROATIA
- FRANCE
- GREECE
- ITALY
- SPAIN
- TUNISIA
- TÜRKIYE
- MEDITERRANEAN
- OTHER MED COUNTRIES

2. MEASURES FOR THE PROTECTION OF POSIDONIA OCEANICA FROM ANCHORING

MEASURE	IMPACT ON ANCHORING DAMAGE	BIODIVERSITY AND LIVELIHOODS BENEFIT	MOST EFFECTIVE WHEN
National bans (e.g. France, Spain)	HIGH (≥70% damage reduction) [30, 31]	HIGH (nurseries, tourism, carbon) [32, 33]	Enforced with mapping and patrols [30, 34]
Eco-moorings	MODERATE-HIGH (30-60%) [35, 36]	HIGH (protects root systems, stable access) [32, 37]	Properly installed and maintained [35, 36]
Awareness and navigation apps	MODERATE [34, 38]	MODERATE-HIGH [38]	Coupled with legal backing and education [3]
Local MPAs without enforcement	LOW-MODERATE [39]	LIMITED [39]	Only effective when well-managed and funded [39]
No specific policy	INEFFECTIVE [40]	BIODIVERSITY LOSS, UNREGULATED DECLINE [40]	

SAFEGUARDING MEDITERRANEAN SEAGRASS BLUE FORESTS FROM ANCHORING DAMAGE

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