

Sustainable Development of Nautical Anchorages: Case study Zadar County

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ABSTRACT

Nautical tourism plays a key role in local development in Croatia. The continuous growth of nautical tourism in Croatia is the result of its favourable geographical position, indented coastline and rich nautical offer. Nautical anchorages are a key element of Croatia's nautical infrastructure, and, based on the intensity of tourist demand, Zadar County stands out as the largest and nautically the most significant nautical destination in Croatia. This paper analyses the strategic role of Zadar County in the development of nautical tourism in the Republic of Croatia.

The paper aims to give an overall review and analysis of nautical anchorages and buoys in Zadar County, whose indented coastline and numerous islands create exceptional conditions for the development of nautical tourism. The purpose of the paper is to provide a basis for a better understanding of current situation and to contribute to the planning of sustainable use of marine area, emphasising the need for regulated anchoring in order to protect sensitive ecosystems. Special attention is given to the system of nautical anchorages as organised parts of marine waters equipped for the safe anchoring. The research methodology included field research and literature analysis, which provided a detailed insight into the capacity distribution and spatial concentration of anchorages.

The research results indicate uneven market interest in areas within Zadar County, which is a sign of structural challenges such as financial unprofitability, location-related constraints, or complex regulatory requirements. Such a situation hinders the development of nautical infrastructure and leads to the underutilisation of coastal resources.

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1. Introduction.

The development of nautical tourism is closely linked not only to marinas' infrastructure, anchorages and vessel facilities, but to the preservation of vulnerable marine ecosystems and seabed as well. Sustainable planning enables both economic growth and the protection of natural resources at the same time. Nautical tourism, as a tourism phenomenon, is developing rapidly and is achieving physical and financial results that no other sector consistently achieves (Luković, 2007). Furthermore, nautical tourism brings significant economic benefits to coastal areas, especially through new jobs, the stimulation of

investments, and infrastructure development (Carreño & Lloret, 2021).

The Republic of Croatia is a country with an extremely indented coast and a great number of islands, islets and cliffs (Linardić et al., 2022). Croatia offers a mild climate, preserved environment, beautiful beaches, intact islands and picturesque towns (Dević et al., 2025), and the largest charter fleet in the world (The Strategy for the Sustainable Development of Tourism until 2030). Croatia's natural resources, due to their composition, richness and attractiveness, place Croatia among the leading European tourist destinations (Bartoluci & Čavlek, 2007). In addition to its natural beauty, Croatia also has a rich historical and cultural heritage (Luković et al., 2015).

Nautical tourism in Croatia is of special importance because it is a driving force of local development, especially in small towns and on islands (Luković et al., 2024). Nautical tourism

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has been experiencing a continuous growth in the Republic of Croatia as a result of its favourable geographical position, indented coastline, and rich nautical offer. The development of nautical tourism increases the demand for berths in marinas and ports, and for vessel accommodation in dry marinas.

An increased demand for berths has been noticed in Zadar County. Of the total of 206 nautical tourism ports in Croatia, 56 are located in Zadar County and include marinas, anchorages, berths and dry marinas. Zadar County is the Croatia's largest nautical destination and, with a total capacity of 4,298 berths, leads in overall capacities (<https://investcroatia.gov.hr/en/county-stats/zadar-county/>). Apart from the berth itself, boaters expect comprehensive service for their vessel, including supplies, maintenance and technical support (Kovačić & Favro, 2012).

Nautical tourism is seasonal in nature (Luković, 2008), and every decision on the construction of new marinas or the expansion of existing ones requires thorough planning. Space is the most significant resource in tourism (Vukelić, 2005). Construction along the coast changes natural environment in the long term and can endanger vulnerable ecosystems. Physical interventions such as embankment filling, concreting and vegetation removal change coastal natural dynamics. Such interventions disrupt natural habitats of numerous plant and animal species, reduce biological diversity, increase erosion and vulnerability of the coastal areas to climate change. Long-term protection of maritime and coastal environment requires the consistent application of sustainable development principles and alignment of sectoral interests within a clearly defined maritime policy. The planning of new anchorages, the development of marinas, and other nautical capacities must be based on a thorough assessment of the ecological and spatial capacities of the marine area, and the actual needs of nautical tourism. In such a situation anchorages and marinas represent complementary forms of nautical infrastructure with different functions. Such an integrated approach enables balanced development of nautical infrastructure, the reduction of anthropogenic pressures, and the preservation of vulnerable marine ecosystems, thereby ensuring long-term sustainability and competitiveness of Zadar County as the nautical destination.

The paper is structurally divided into four chapters. Following the introduction, an overview of the legal framework regulating the establishment, management, and the use of nautical anchorages in the Republic of Croatia is provided. Special attention has been given to legal regulations, and the concessionaires' authority and obligations. The third part presents an overview of the distribution of nautical anchorages by counties, a detailed analysis of their development in Zadar County, including the role of spatial plans, current challenges, and the impact of anchoring systems on the seabed. The final section contains concluding remarks, emphasising the importance of the sustainable management of nautical anchorages.

2. Legal aspects of sustainable management of nautical anchorages in the Republic of Croatia.

To ensure efficient and sustainable operation of nautical anchorages, it is necessary to establish a legal framework to de-

fine rules, jurisdiction and technical standards for nautical anchorages. The legal framework for the management of nautical anchorages is based on multiple levels of regulation, including primary laws, secondary legislation, and specific ordinances. Laws define fundamental rules and jurisdiction, while regulations and ordinances elaborate technical conditions, standards, and management procedures. This ensures consistent planning of coastal areas and nautical infrastructure, as well as the navigation safety and sustainable use and protection of maritime domain. These regulations define the legal status of the maritime domain, the management mechanisms for nautical ports and anchorages, and the standards for navigation safety, thereby providing a strong foundation for the efficient and sustainable management of the coastal and marine area. The overview of key regulations is presented in Table 1.

Table 1: Key regulations overview.

N°	LAWS
1.	Maritime Code (Official Gazette, N° 181/04, 76/07, 146/08, 61/11, 56/13, 26/15, 17/19)
2.	Law on Maritime Property and Seaports (Official Gazette, N° 83/2023)
3.	Law on Hydrographic Activities (Official Gazette, N° 68/98, 110/98, 163/03, 71/14)
4.	Law on Concessions (Official Gazette, N° 69/17, 107/20)
5.	Physical Planning Act (Official Gazette, N° 153/13, 65/17, 114/18, 39/19, 98/19, 67/23)
6.	Construction Act (Official gazette, N° 153/13, 20/17, 39/19, 125/19)
REGULATIONS	
7.	Decree on the Conditions that Ports Must Meet (Official Gazette, N° 110/04)
ORDINANCES	
8.	Ordinance on Maintaining Order in Ports and Other Parts of Internal Waters and the Territorial Sea of the Republic of Croatia (Official Gazette, N° 72/2021)
9.	Ordinance on the Safety of Maritime Navigation in Inland Waters and the Territorial Sea of the Republic of Croatia and the Manner and Conditions for the Supervision and Management of Maritime Traffic (Official Gazette, N° 52/2025)
10.	Ordinance on the Categorization of Nautical Ports and Classification of Other Facilities for Berthing and Accommodation of Vessels (Official Gazette, N° 120/2019)

Source: Authors.

Although the table presents a wider legal framework, including various laws, regulations and ordinances relevant to maritime domain and port management, the following text focuses primarily on the *Law on Maritime Property and Seaports* and the *Law on Hydrographic Activities*. This is because these laws clearly define the status and the organisation of nautical anchorages, their spatial boundaries, concessionaires' obligations regarding navigation safety, order maintenance, and the economic use of anchorages. Other laws, regulations and ordinances are important for the wider context of maritime and spatial planning. The *Law on Maritime Property and Seaports* enables a direct application of regulations regarding anchorages in Zadar County. According to the *Law on Maritime Property and Seaports*, a nautical anchorage is a part of the marine water area equipped with anchoring facilities whose economic use is realised through a concession. The anchorage area is defined

by the concession decision, taking into account safe navigation and access to the shore, with the possibility of establishing one emergency berth on land. The anchorage must be visible and properly marked, while the anchorage system must hold the appropriate certificates in accordance with navigation safety regulations. The concessionaire must ensure safety and the order in the anchorage area and organise municipal waste collection from vessels. Moreover, they must provide additional services to boaters if stipulated in the concession contract. The concessionaire must also prepare and implement the *Waste Reception and Handling Plan*, in accordance with the waste management regulations in ports, thereby ensuring that the operations comply with environmental and safety standards.

Alongside the regulations defining the establishment, use, and management of nautical anchorages in the Republic of Croatia, spatial plan is a basic instrument for managing coastal and marine areas. The appropriate legislative and institutional framework conditions its practical implementation. Spatial planning refers to key questions regarding spatial development (Faludi, 2000), and enables rational, coordinated and long-term sustainable space management. Since spatial resources are limited, they must be thoughtfully and sustainably managed to prevent their degradation and to ensure their preservation for future generations. It must be emphasised that space once utilised for port activities becomes unavailable for other purposes and activities, which, practically, makes it a non-renewable resource (Panžić, 2010).

Zadar County has determined locations for nautical anchorages through its 2023 *Spatial Plan*. New locations can also be determined by the spatial development plans of cities or municipalities. The spatial development plan of cities or municipality is a fundamental plan that regulates purpose and use of space at the local level. It applies to areas that are not included in detailed plans, such as urban development plan and detailed development plan. The planning of new nautical anchorages requires the approval of the authority or Harbour Master's Office. Anchorages can be planned either within the port area or outside it. If the anchorage is located within the port area, it must not interfere with port operations or endanger navigation routes. When both an anchorage and a future nautical port are planned in the same area, the anchorage may be used temporarily until the port is constructed. A nautical anchorage can include one or more anchoring areas. Minimal distance between the anchorage and the shore is 50m, and it can be smaller if the location is not in the immediate vicinity of settlement boundaries, existing hospitality-tourism zones, or beaches. A location permit for nautical anchorages is issued on the basis of the provisions of the *County Plan*. Locations for emergency berths are planned outside port areas. An emergency berth is used for the temporary berthing of vessels in adverse weather conditions and for emergency vessels. At these locations, coastline development of up to 10 meters in length is permitted to ensure safe berthing.

3. Nautical anchorages in Zadar County.

Nautical anchorages are a key element of the nautical infrastructure in the Republic of Croatia. Their development and

management are closely related to the legal framework which regulates their establishment and use. Along the Croatian part of the Adriatic coast there are seven counties (Istria County, Primorje-Gorski Kotar County, Lika-Senj County, Zadar County, Šibenik-Knin County, Split-Dalmatia County, Dubrovnik - Neretva County), 120 towns and municipalities. Figure 1 presents all counties of the Republic of Croatia that have access to the sea – areas where nautical anchorages are concentrated.

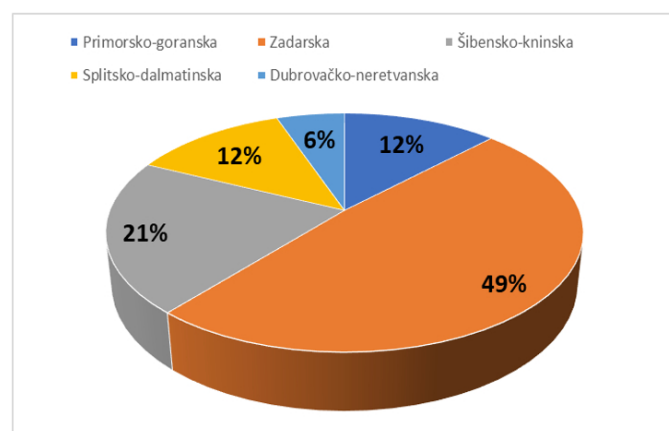
Figure 1: Counties that have access to the sea.



Source: Šušković (2021).

These counties encompass the Adriatic coast and islands, forming a key part of Croatia's coastal area and tourism offer. Their geographical and maritime connection with the Adriatic Sea makes them natural locations for the development of nautical infrastructure. Figure 2 presents the distribution of nautical anchorages by county in 2025.

Figure 2: Distribution of nautical anchorages by county in 2025.



Source: Authors.

In 2025, Zadar County was the leading county with a total of 35 concessions for nautical anchorages, which is significantly more than in other countries. Šibenik-Knin County fol-

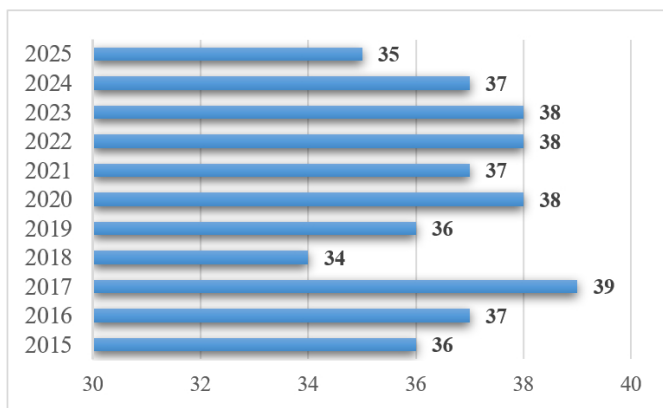
lows with 15 concessions, Split-Dalmatia and Primorje-Gorski Kotar County have 9 concessions each, and Dubrovnik-Neretva County has 4 concessions. Lika-Senj County and Istria County have no recorded concessions, which may be the result of their spatial and environmental specificities.

This overview confirms that legal framework and spatial plans form a coordinated system. It manages nautical anchorages, taking into account spatial capacities and the protection of the environment. The dominance of Zadar County also reflects its strategic role in Croatia's nautical tourism, which further emphasises the importance of coordinated planning and implementation of regulations for sustainable development of the coastal area.

3.1. Development of nautical anchorages in Zadar County from 2015 to 2025.

The indented coast of Zadar County and its numerous islands create extremely favourable conditions for the development of nautical tourism in this area. However, such natural features increase the need for regulated and controlled anchoring, which contributes to the sustainable use of marine areas and the protection of vulnerable ecosystems. Figure 3 presents the number of nautical anchorages in Zadar County from 2015 to 2025.

Figure 3: Number of nautical anchorages in Zadar County from 2015 to 2025.



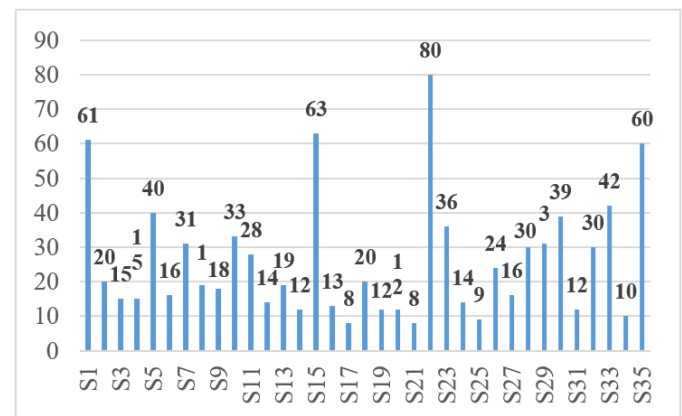
Source: Authors.

In the last decade the number of anchorages varied from 34 to 39. The lowest value was recorded in 2018, while in 2017, the largest number of concessions was recorded. In the period after 2020, the number of nautical anchorages is mostly stable and varies from 37 to 38, with a slight decline to 35 in 2025. The data indicate a relatively stable system with smaller annual oscillations.

The *Waste Reception and Handling Plans* have been adopted for 33 nautical anchorages, which is a legal obligation under Article 145 of the *Law on Maritime Property and Seaports*. This indicates a relatively high level of compliance by concessionaires with their obligations to protect the marine environment, with potential for further improvement. This primarily refers to the possibility of organised reception of black and grey

waters from vessels, for which no suitable solution currently exists. This issue represents one of the greatest challenges in the management of nautical anchorages in Zadar County. Moreover, according to the *Law on Hydrographic Activities*, it is necessary to carry out hydrographic surveys of anchorages. However, such surveys have not been carried out yet, which remains a priority task. All anchorages in Zadar County have been marked with buoys designated by decision of the Harbour Master's Office. A total of 910 buoys has been installed across 35 nautical anchorages. Figure 4 shows the distribution of the number of buoys by location across nautical anchorages in Zadar County in 2025.

Figure 4: Number of buoys across nautical anchorages.



Source: Authors.

The analysis of the number of buoys at nautical anchorages has revealed a disproportionate distribution of buoys, with most anchorages having between 10 and 40 buoys, while only a few have more than 60. In order to obtain an accurate insight into the distribution of capacity and the spatial concentration of anchorages, Tables 2 and 3 present detailed numerical data including marks, number of buoys, surface, names and locations of the anchorages. Table 2 shows 35 anchorages with their marks, names, surface, and number of buoys, while Table 3 presents the data organised by locations.

The data show that anchorages are distributed across multiple islands and coastal areas, and their capacities differ. Table 3 presents the anchorage distribution across the islands and coastal areas with their total number, surfaces, and the total number of buoys.

The analysis has revealed that 35 nautical anchorages are distributed across 14 locations. A significant number of anchorages have less than 20 buoys, indicating their smaller capacity and local importance. However, some anchorages such as Pantera 2 Bay on the island of Dugi Otok (60,200 m², 61 buoys), Brkulje on the island of Molat (67,525 m², 80 buoys), Krijal on the island of Premuda (47,675 m², 63 buoys) and Široka on the island of Ist, have a greater number of buoys. These locations are characterised by greater capacity and higher traffic, which indicates their more significant role in the system of regulated anchoring. Moreover, it was found out that Dugi Otok dominates with 9 anchorages, a total area of 160,175 m², and 181

Table 2: Nautical anchorages in Zadar County (2025).

Mark	Name and location	Surface (m ²)	Buoy number
S1	Pantera 2 Bay, Dugi otok	60,200	61
S2	Pantera Bay, Dugi otok	7,300	20
S3	Sakarun 1 Bay, Dugi Otok	3,600	15
S4	Sakarun Bay, Dugi Otok	3,600	15
S5	St. Filip and Jakov Anchorage	10,890	40
S6	Kranje Anchorage, Vrgada Island	9,600	16
S7	Lučina 2 Anchorage, Brbinj, Dugi Otok	32,500	31
S8	Bok Anchorage, Brbinj, Dugi Otok	13,000	19
S9	Soline 1 Anchorage, Pašman Island	19,000	18
S10	Soline 2 Anchorage, Pašman Island	34,000	33
S11	Vodenjak Anchorage, Iž Island	26,890	28
S12	Lokvina Anchorage, Rava Island	11,870	14
S13	Mljake Anchorage, Ist Island	7,550	19
S14	Zaklopica Anchorage, Pašman Island	8,400	12
S15	Krijal Anchorage, Premuda Island	47,675	63
S16	Artina Anchorage, Vrgada Island	6,450	13
S17	Južni Porat Anchorage, Silba Island	3,200	8
S18	St. Ante Anchorage, Silba Island	21,560	20
S19	St. Nikola Anchorage, Olib Island	5,000	12
S20	Slatinica Anchorage, Olib Island	4,560	12
S21	Knež Anchorage, Iž Island	7,461	8
S22	Brgulje Anchorage, Molat Island	67,525	80
S23	Landin Anchorage, Pašman Island	49,197	36
S24	Lučica Anchorage, Dugi Otok	8,600	14
S25	Lučina Anchorage, Molat Island	1,400	9
S26	Poforča Anchorage, Ugljan Island	15,450	24
S27	Muline Anchorage, Ugljan Island	10,400	16
S28	Stržna Anchorage, Brbinj, Dugi Otok	10,300	30
S29	Zapuntel Anchorage, Molat Island	16,000	31
S30	Soline Anchorage, Biograd na Moru	12,291	39
S31	Grbavac Anchorage, Rava Island	8,400	12
S32	Pantera 1 Bay, Dugi Otok	34,975	30
S33	Mandre Anchorage, Kolan, Pag Island	16,800	42
S34	Silba	9,000	10
S35	Široka, Ist	54,000	60

Source: Authors.

buoys, which indicates its extraordinary importance for nautical tourism in Zadar County.

New concession award procedures are underway; however, some public calls must be repeated due to the insufficient interest from potential concessionaires. Such a situation indicates an uneven market interest and points to potential structural challenges, such as financial profitability, location constraints, or regulatory requirements that may influence investors' decisions. Furthermore, the repetition of concession award procedures may slow down the planned development of nautical infrastructure and lead to underutilisation of available resources in coastal areas.

3.2. Impact of nautical anchorages on seabed.

All nautical anchoring areas within Zadar County are made of concrete mooring blocks. A comparative analysis of conceptual projects for concessioned nautical anchorages has shown that they are mostly designed to accommodate vessels 10 to 15 meters in length and with a displacement of 11 to 16 tons. Considering the depth and hydrodynamic conditions of specific locations, the use of concrete mooring blocks of standardised dimensions of 1.2 x 1.2 x 0.5 m has been suggested to achieve the required holding force of the anchoring system. Furthermore, it has been proposed that the mooring blocks be interconnected

Table 3: Nautical anchorages in Zadar County by locations.

Location	Anchorage (marks)	Number of anchorages	Surface (m ²)	Buoy number
Dugi otok	S1, S2, S3, S4, S7, S8, S24, S28, S32	9	160,175	181
Vrgada	S6, S16	2	16,050	29
Brbinj	S7, S8, S28	3	55,800	80
Pašman	S9, S10, S14, S23, S26	5	111,597	99
Iž	S11, S21	2	34,351	36
Rava	S12, S31	2	20,270	26
Ist	S13, S35	2	61,550	79
Premuda	S15	1	47,675	63
Silba	S17, S18	2	24,760	28
Olib	S19, S20	2	9,560	24
Ugljan	S26, S27	2	25,850	40
Kolan, Pag	S33	1	16,800	42
Biograd na Moru	S30	1	12,291	39
St. Filip and Jakov	S5	1	10,890	40

Source: Authors.

in a network arrangement to ensure stability and reliability of anchoring areas.

Since the study area includes 35 anchorage concessions with a total of 910 buoys, an assessment of the total seabed surface covered by concrete mooring blocks was carried out. The base surface of a single block that is in direct contact with the seabed is 1.44 m² (1.2 m × 1.2 m).

$$P_{\text{total}} = A_{\text{block}} \times N \quad (1)$$

where:

P_{total} – total seabed surface covered by concrete mooring blocks (m²)

A_{block} – surface covered by a single block (m²)

N – number of buoys

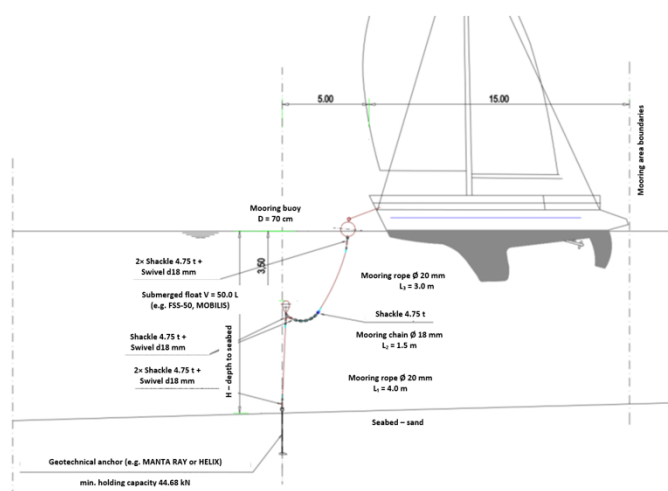
The total surface of the seabed coverage is obtained by multiplying the surface of a single block with a total number of anchoring areas:

$$P = 1.44 \text{ m}^2 \times 910 = 1,310.40 \text{ m}^2 \quad (2)$$

The data reveal that traditional concrete anchoring systems leave a significant physical footprint on the seabed. Considering the ecological consequences of such an anchoring system, especially on vulnerable habitats such as Posidonia meadows and marine flowering plants, it is important to explore the possibility of gradual transition to more environmentally friendly anchoring technologies (Figure 5).

Drilled anchors systems represent more sustainable alternative since they enable a stable anchoring with minimal physical contact with the seabed. Unlike concrete mooring blocks, cover a large seabed surface mechanically, drilled anchors reduce the habitat degradation, preserve biodiversity, and contribute to long-term management of nautical infrastructure. Such technological solutions have an important role in aligning the

Figure 5: Anchoring system for vessels to 15 m in length, geotechnical anchor.



Source: Conceptual Project, Project code: IP-15-6/24 Magrovica Bay Anchorage in the Telašćica Nature park, Municipality of Sali.

demands of nautical tourism development with the objective of preserving the marine environment.

In July 2021, as part of the *Interreg Italy-Croatia SASPAS Project*, 40 environmentally friendly buoys were installed across four anchoring areas in Kornati National Park using the *Earth Anchor System*. This system minimally disturbs the marine sediment and eliminates contact with marine flowering plants. This solution is an example of good practice, as it offers a sustainable alternative to traditional concrete mooring blocks and contributes to the preservation of *Posidonia* meadows. The installation of buoys is a part of a larger project intended to raise boaters' awareness on the importance of protecting marine ecosystems, while its successful implementation represents significant progress toward Kornati National Park's long-term objective of providing anchorages in every cove and fully prohibiting non-regulated anchoring.

4. Conclusions.

Regulated nautical anchorages have an important role in the development of nautical tourism. They enable controlled anchoring and reduce harmful impacts on marine environment. Among seven counties of the Republic of Croatia, Zadar County has a significant potential for the development of nautical tourism. The paper offers an analysis of the distribution of nautical anchorages and buoys in Zadar County. The proposed approach allows an insight into the capacity distribution and spatial concentration of nautical anchorages and buoys. An uneven distribution of the number of buoys was identified, highlighting the need to optimise management and eventual traffic rerouting towards less congested anchorages to better protect the environment.

Currently, all anchoring areas are made of concrete mooring blocks. However, more advanced and environmentally more

acceptable anchoring systems should be considered. The implementation of environmentally acceptable anchoring areas is an important step in protecting marine ecosystems. The drilled anchor system has a minimal impact on marine sediment and does not endanger *Posidonia* meadows and other marine flowering plants. Therefore, such a system is a better alternative than traditional concrete mooring blocks. The *Interreg Italy-Croatia SASPAS Project* has shown that these solutions help protect biological diversity and raise boaters' awareness of responsible anchoring. These results support long-term sustainable management of nautical anchorages in different coastal regions.

The implementation of ecological anchoring systems, compliance with regulations, and the development of waste management plans are crucial for sea protection. The cooperation between concessionaires, local authorities, and other relevant services is essential for the successful management of the marine area. Regulated and sustainable anchorages contribute to navigation safety, protection of the environment, and the quality of tourism offer. Therefore, the long-term sustainability and development of nautical tourism are ensured. Moreover, well-planned anchorages can minimize the demand for new marina construction and serve as a preventive measure against coastal degradation.

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