DEVELOPMENT OF SMALL PORTS IN ZADAR AREA

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Abstract

In ancient times, the Mediterranean was a shipbuilding centre of the world; port activities in larger bays and harbours along the Adriatic coast had been developing since prehistory. Remains of ancient ports found along the Adriatic coast testify to the rich history of this area.
The paper analyses development of ports of local importance in the area of the town of Zadar. Currently, there are six ports classified as ports of local importance in Zadar area. The aim of the paper is to emphasize the development potentials of these ports. The paper begins with a review of relevant legal frameworks, followed by a detailed analysis of the current situation in each of these six ports. The analysis was focused on locational, navigational and meteorological conditions, berthing equipment, as well as facilities available in ports. The paper gives a comprehensive overview of the current state and development potentials of the mentioned ports, offering concrete guidelines for achieving sustainable and prosperous development.
For the purpose of data collection, a field research was conducted in port areas. The research included gathering data on weather conditions, tides, wind directions, as well as interviews with local population in order to include their needs in the research. Additionally, depth measurements along the coasts of the ports were taken since precise data did not exist. A drone was used to gather visual documentation.
Based on the conducted analysis, development direction and potential limitations have been identified for each port. The suggested development strategies include infrastructure improvement, equipment modernization, technological advancement, and implementation of sustainable solutions for waste management and environmental protection.
It has been concluded that future development challenges these ports are facing with refer to navigation safety, the condition of infrastructure and environmental standards. Common limitations and challenges in the development of analysed ports indicate the need for significant infrastructure modernisation and adherence to environmental standards. Planning, a strategic approach to development and collaboration with the local community are crucial for overcoming these challenges.

1 INTRODUCTION

The term seaport refers to sea and land area directly connected to the sea with well-defined port boundaries. It consists of developed and underdeveloped shores, breakwaters, equipment, facilities and other objects intended for berthing, anchoring and protection of vessels, boarding and disembarking of passengers, (un)loading of the cargo, cargo storage, and other cargo handling. Furthermore, a port is also intended for production, refinement, and processing of goods, as well as the performance of other economic activities, the above-mentioned activities are connected with in economic, transportation, or technological terms [1]. The ports are not only public institutions, but also economic subjects that operate on fundamental technological, and economic principles to provide the appropriate services and expand economic activities [2]. It is to be expected that some ports will not have significant revenues, especially not a significant positive difference between income and expenses. However, considering the multiplicative effects the seaports create, it is certain that the economic effects (employment, additional activities, etc.) they create on district centres ("mother" town/city) and regions will not be missing [3]. The founder of port authority in ports of special (international) economic interest for the Republic of Croatia is the Republic of Croatia itself, and in ports of county and local importance, it is the county [4]. The port authority is a non-profit legal entity. Regulations referring to institutions apply to it and their goal is to fulfil tasks through the appropriate means [5].

The paper is structurally divided into five main parts. In the second part of the paper, that is following the introduction, a legal framework regarding the ports located in Zadar County was given. In the third part, six ports of local importance in the area of the town of Zadar were analysed. General information on ports, navigation and meteorological conditions, berthing characteristics, and available port facilities indicate the need for further development of these ports. The fourth part of the paper presents development recommendations, as well as possible obstacles to the future development. The final, fifth part, consists of concluding remarks.

2 ZADAR COUNTY PORTS, LEGAL FRAMEWORK

Ports are given different categories on the basis of many factors such as port activities, port infrastructure, coast length, the number of berths, and the importance of the port for the traffic and the economy.

According to their importance, ports open to public traffic are classified into:

- ports of special (international) economic interest for the Republic of Croatia
- ports of county importance
- ports of local importance [1].

The *Regulation of the Sorting of Ports Open to Public Traffic and Ports of Special Purpose* [6] prescribes the conditions needed to classify ports open to public traffic. The criteria needed to classify ports open to public traffic into ports of special (international) economic interest for the Republic of Croatia are:

- Average turnaround of more than 1,500,000 tons of cargo per year, with 10% prevalence of transit traffic in the structure of total traffic in the period from 1998 to 2003. Or, the average passenger traffic of more than 500,000 passengers per year with 10% of passengers in the international traffic in the period from 1998 to 2003 in a passenger-only port.
- Adequate road and railway connections with the hinterland and connections with airports.
- Port capacities for traffic of 5,000,000 tons of cargo per year, in accordance with the cargo structure based on main groups of goods, as well as organized wharves, piers and docks adequate for vessels exceeding 130 meters in length and a draught exceeding 6 meters.
- At least one regular international cargo shipping line per month or at least two international passenger lines per year, in a passenger-only port.

The criteria needed to classify ports open to public traffic into ports of county importance are:

- Average turnaround of over 50,000 tons of cargo per year in the period from 1998 to 2003, or average passenger traffic of over 100,000 passengers per year in the same period in a passenger-only port.
- Adequate road connections with the hinterland.
- Port capacities for cargo traffic of 50,000 tons, i.e. piers and wharves for ships up to 80 m and up to 4 m draught.
- At least three lines per month in domestic traffic in passenger-only ports.

The criterion for the classification of ports open to public traffic into ports of local importance is the average traffic of up to 50,000 tons of cargo per year in the period from 1998 to 2003, i.e., the average passenger traffic of up to 100,000 passengers per year in the same period in passenger-only ports. Ports of local importance are also all ports open to the public that only have wharves for the safe berthing of vessels.

Ports of special (international) economic interest for the Republic of Croatia in the area of Zadar County are the port of Gaženica (cargo and passenger port), the port of Vela Lamjana (fishing port) and the port of Zadar (passenger port). Furthermore, in the area of Zadar County, there are 8 ports of county importance and 105 ports of local importance [7] under the authority of Zadar County Port Authority.

In the area of the town of Zadar, there are six ports of local importance. The purpose and the way of usage of only a part of the port open to public traffic of county and local importance are regulated by the *Ordinance on Order in the Port.*

3 THE ANALYSIS OF CURRENT CONDITIONS OF THE PORTS OF LOCAL IMPORTANCE IN THE AREA OF THE TOWN OF ZADAR

The ports of local importance in the area of the town of Zadar are analysed in the following text. These ports are the port of Bregdetti, the port of Foša, the port of Jazine, the port of Maestral, the port of Draženica, and the port of Diklo. The analysis includes general information on the ports, navigation and meteorological conditions, berthing characteristics, and facilities and services available in the port.

3.1 Port of Bregdetti

The port of Bregdetti is located in Zadar Channel, on the south-eastern coast of Zadar. It is connected to the passenger and fishing port of Gaženica. Considering the weather conditions, the port is well protected from all winds except the south-western wind, which can cause swell ("bibavica" in dialect). Due to shallow depths, one should be aware of the tides. During the extremely cold winter days, surface ice forms in the shallow waters of the port. Boats are moored bow on, on the installed mooring rings with their ropes, and stern on with anchoring systems. The berths are marked with numbers, which are barely visible. In the northern part of the port, there is a constructed pier with available shore power cabinets for water and electricity. The port is equipped with oil residue tank and municipal waste bins. In the vicinity, there is a parking lot for vehicles. There is a public lighting in the port, and rest benches along the shore.

Table 1. Port of Bregdetti

PORT OF BREGDETTI			
UN/LOCODE	HR674		
Port importance	Local		
Authority	Port authority County of Zadar		
Function of a port	Port open to public traffic		
VTS area	VTS manoeuvring sector Zadar		
Organisation	Harbour Master's Office Zadar		
Location	φ = 44°05'55,2" N	λ = 015°15'01,2" E	WGS 84
Port area	Land: 4.867 m^2	Sea: 74.909 m^2	Total: 74.909 m^2
Berths	Communal: 466	Nautical port berth: 0	Total: 466
Port depth	Min. 0.5 m		Max. 3.0 m
Seabed	M (mud)		

Average length of small boats in the port	6.17 m		
Navigation safety facilities	No		
Distance	Centre: 2 km	Bus station: 1 km	Airport: 11 km

3.2 Port of Foša

The port of Foša is located in Zadar Channel, on the south-western part of Zadar peninsula. The port can be accessed by sailing from many directions. The access to the port along the north-western shore is shallow. The port is sheltered against all winds except the south-western wind which causes seiches ("štiga" in dialect). Boats are usually moored bow on with their ropes and stern on with anchoring systems. The port is equipped with mooring rings. Since the port is located in the city centre, its visitors can use the town's free internet access. There is a public lighting in the port. Next to the port, there is a parking lot for vehicles. Public transport is also available.

Table 2 Port of Foša

PORT OF FOŠA			
UN/LOCODE	HR676		
Port importance	Local		
Authority	Port authority County of Zadar		
Function of a port	Port open to public traffic		
VTS area	VTS manoeuvring sector Zadar		
Organisation	Harbour Master's Office Zadar		
Location	φ = 44°06'42,2" N	λ = 015°13'41,1" E	WGS 84
Port area	Land: no data	Sea: no data	Total: no data
Berths	Communal: 68	Nautical port berth: 0	Total: 68
Port depth	Min. 1.6 m		Max. -
Seabed	S (sand)		
Average length of small boats in the port	7.04 m		
Navigation safety facilities	No		
Distance	Centre: 500 m	Bus station: 1.3 km	Airport: 12.8 km

3.3 Port of Jazine

The port of Jazine is located in the city centre. The breakwater protects the entrance to the port. Coastal lights and lights on the head of the breakwater mark the access to the port. Through the same entrance to the port, one can sail into the marina, the passenger port of the town of Zadar, and the gas station. The traffic increases significantly during the tourist season in this area. Passenger and high-speed passenger ships on regular lines, smaller tourist ships, yachts and smaller cruise ships are usually berthed in the port. The southern part of the port is entered to by sailing under the bridge whose 2m approximate height varies depending on the tides. The port is exposed to the north and north-western winds that create swell in the port. The boats are berthed along the shore and along three floating Heavy Duty docks. Cross stainless steel bollards are used for mooring along the docks. In the rest of the port, steel bollards and mooring rings are used for mooring. Due to the limited height clearance under the bridge, only vessels with lower cabins can be berthed in the southern part of the port. In the part of the port on the northern side of the pedestrian bridge, there is an operational port area ("operational shore") about 35 meters long with installed mooring bollards. There is a public lighting in the port. The port has a boatyard equipped with a port crane with a lifting capacity of up to 5 tons. Within the boatyard area, waste containers as well as a container for used oil are placed. Stainless steel ladders are installed along the shore for the access to the sea. In the vicinity, there is a parking lot.

Table 3 Port of Jazine

PORT OF JAZINE			
UN/LOCODE	HR677		
Port importance	Local		
Authority	Port authority County of Zadar		
Function of a port	Port open to public traffic		
VTS area	VTS manoeuvring sector Zadar		
Organisation	Harbour Master's Office Zadar		
Location	φ = 44°06'53,4" N	λ = 015°13'53,8" E	WGS 84
Port area	Land: 4.211 m^2	Sea: 76.742 m^2	Total: 80.953 m^2
Berths	Communal: 652	Nautical port berth: 0	Total: 652
Port depth	Min. 2.0 m		Max. 11 m
Seabed	M (mud)		
Average length of small boats in the port	6.20 m		
Navigation safety facilities	No		
Distance	Centre: 550 m	Bus station: 1.1 km	Airport: 12.6 km

3.4 Port of Maestral

The port of Maestral is located in Zadar Channel, on the north-western coast of Zadar. It is connected to the town of Zadar with a one-way road running along the shore. The port is not protected from southern and western winds and waves, therefore, berthing in the port is dangerous. Big waves, and inadequate berths create contacts between the boats. Boats are moored along the shore, bow on with their ropes, and stern on with anchoring systems. Shallow waters are the reason wooden piers have been installed along the shore.

Table 4 Port of Maestral

PORT OF MAESTRAL			
UN/LOCODE	HR678		
Port importance	Local		
Authority	Port authority County of Zadar		
Function of a port	Port open to public traffic		
VTS area	VTS manoeuvring sector Zadar		
Organisation	Harbour Master's Office Zadar		
Location	φ = 44°07'30,1" N	λ = 015°13'28,9" E	WGS 84
Port area	-	-	-
Berths	Communal: 36	Nautical port berth: 0	Total: 36
Port depth	Min. 0.2 m		Max. 3.9 m
Seabed	M (mud) / S (sand) / rocky close to the shore		
Average length of small boats in the port	6.12 m		
Navigation safety facilities	No		
Distance	Centre: 3.1 km	Bus station: 3.5 km	Airport: 14.6 km

3.5 Port of Draženica

The port of Draženica is located in Zadar Channel on the north-western coast of Zadar. It can be accessed from many directions. The port of Draženica is one of the smallest ports of local importance. There aren't any breakwaters in the port. Therefore, it is exposed to southern and western winds and waves making the berthing of boats dangerous there. Boats are moored bow on with their ropes and stern on with anchoring systems. Shallow waters are the reason wooden piers have been installed along the shore. In the port, there is a sturdy

pier, and at the pier head, there is 20 meters long operational port area ("operational shore"). The depth along the operational shore is 4 meters, allowing smaller passenger ships for one-day trips and fishing boats to berth there. The operational shore is equipped with mooring bollards, benches, waste bins, and ladders for entering/exiting the sea. Instead of fenders, truck tires placed along the operational part of the port. In the remaining part of the operational shore, there are communal berths with mooring rings. The boats are moored bow on.

Table 5 Port of Draženica

PORT OF DRAŽENICA			
UN/LOCODE	HR675		
Port importance	Local		
Authority	Port authority County of Zadar		
Function of a port	Port open to public traffic		
VTS area	VTS manoeuvring sector Zadar		
Organisation	Harbour Master's Office Zadar		
Location	φ = 44°07'40,8" N	λ = 015°13'12,2" E	WGS 84
Port area	Land: 3.861 m^2	Sea: 27.530 m^2	Total: 31.391 m^2
Berths	Communal: 103	Nautical port berth: 0	Total: 103
Port depth	Min. 0.2 m		Max. 2.7 m
Seabed	M (mud) / rocky close to the shore		
Average length of small boats in the port	8.43 m		
Navigation safety facilities	No		
Distance	Centre: 3.8 km	Bus station: 4.2 km	Airport: 15.3 km

3.6 Port of Diklo

The port of Diklo is located on the northern coast of Zadar Channel and consists of three basins: the port of Diklo 1- basin 1 (hereinafter Diklo 1), the port of Diklo 2 – basin 2 (hereinafter Diklo 2) and the port of Diklo 3 – basin 3 (hereinafter Diklo 3).

Diklo 1 is enclosed by breakwaters and is, therefore, providing protection from all winds and waves. The basin is entered through two breakwaters that make 6 metres wide passage. Rubber fenders are placed along the sides of the passage. The boats are moored bow on with their ropes and stern on with anchoring systems. Stainless steel mooring bollards are installed along the shores of breakwaters, and mooring rings in other parts of the basin. There is a public lighting in the port basin. The berths are not marked. Rest benches as well as waste bins are installed along the breakwaters.

Diklo 2 is exposed to southern and western winds. The boats are moored mostly bow on with their ropes and stern on with anchoring system. There is a limited space for manoeuvring around the basin's breakwater. Therefore, boats are moored alongside the breakwater. Stainless steel bollards are installed for mooring along the breakwater and mooring rings in other parts of the basin. The berths are not marked. There is a public lighting in the port basin.

Diklo 3 is exposed to southern and western winds. Directly in front of the port basin, there is a cardinal buoy (western one). The boats are moored bow on with their ropes and stern on with anchoring system. In the northern part of the basin, there are no berths due to shallow waters. There is a slight slope in that part of the basin, which residents use for pulling out smaller boats. Along the shore, mooring rings for boats are installed. The berths are not marked. The port basin is not illuminated; so, the light comes from the nearby public lighting.

Table 6 Port of Diklo

PORT OF DIKLO			
UN/LOCODE	HR290		
Port importance	Local		
Authority	Port authority County of Zadar		
Function of a port	Port open to public traffic		
VTS area	VTS manoeuvring sector Zadar		
Organisation	Harbour Master's Office Zadar		
Location Diklo 1 Diklo 2 Diklo 3	 φ = 44°09'06,1" N φ = 44°08'47,9" N φ = 44°08'24,1" N	 λ = 015°12'12,6" E λ = 015°12'21,1" E λ = 015°12'44,9" E	 WGS 84
Port area Diklo 1 Diklo 2 Diklo 3	Land: 4.500 m2 4.639 m^2 3.366 m^2	Sea: 15.703 m^2 20.884 m^2 23.076 m^2	Total: 20.203 m^2 25.523 m^2 26.422 m^2
Berths	Communal: 103	Nautical port berth: 0	Total: 103
Port depth (personal study)	Diklo 1: Min. 0.5 m Diklo 2: Min. 0.5 m Diklo 3: Min. 0.5 m		Diklo 1: Max. 2.0 m Diklo 2: Max. 2.0 m Diklo 3: Max. 1.5 m
Seabed (personal study)	Port basin 1: M (mud) / rocky close to the shore	Port basin 2: S (sand)	Port basin 3: S (sand)
Average length of small boats in the port	5.45 m		
Navigation safety facilities	No		
Distance	Centre: 8 km	Bus station: 8 km	Airport: 17 km

4 RECOMMENDATIONS FOR IMPROVEMENT AND OBSTACLES TO DEVELOPMENT OF PORTS

In the following text, recommendations for improving the condition of ports, analysed in the previous chapter, were given. Guidelines for development were proposed, and potential limitations that may hinder development of ports were outlined. With regard to the effects they cause, the recommendations were classified into several categories, i.e., technical-technological, ecological and other recommendations.

As far as technical-technological recommendations for improvement are concerned, the majority of them refer to enhancing port capacities and port infrastructure. In all ports, it is necessary to install new mooring equipment, new anchoring equipment, shore power cabinets, water supply infrastructure, ladders for exiting/entering the sea, lifebuoys, and portable fire extinguishers. The above-mentioned recommendations would contribute significantly to increasing the safety in ports and ensuring a quick response in emergencies. Furthermore, in order to improve safety, it is recommended to install a navigation safety facility (port light) in the ports of Foša, Maestral, Draženica and Diklo. Coastal lighting should be installed in the ports of Draženica, Maestral and Diklo.

For the ports of Diklo, Draženica, Maestral and Bregdetti, a part of the recommendations refers to the mere location of the ports, i.e. to the restrictions arising from their location. Therefore, it is recommended to measure the depths of the port waters and deepen the port area to improve navigation conditions.

Considering the electrification in navigation, in the ports of Bregdetti, Jazine, Maestral, Draženica, and Diklo, it could be possible to build berths equipped with electric chargers for boats powered by electric propulsion.

In addition to common recommendations, additional recommendations for the improvement were proposed as well. These recommendations are listed in the following text.

The port of Bregdetti – It is recommended to increase berthing capacities by installing floating pontoons. Since the traditional shipyard is available for usage in the port, the recommendation refers to its modernisation by installing cranes and by implementing environmentally acceptable technologies.

The port of Foša – In order to improve navigation conditions, it is recommended to extend the breakwater to protect the port from southern winds and waves.

The port of Jazine – It is recommended to increase berthing capacities, including nautical port berths by installing additional floating piers.

The port of Maestral – It is recommended to expand coastal area to separate the port from the roadway that is currently running along the dock wall, in order to improve safety and differentiate port and roadway infrastructure. Furthermore, it is necessary to build a breakwater to protect the port from southern and western winds.

The port of Draženica – It is recommended to expand coastal area to separate it from the roadway that is currently running along the dock wall. It is necessary to build a breakwater to protect the port from southern and western winds.

The Port of Diklo –It is recommended to realize the existing idea of expanding the port basins towards the sea through the construction of new breakwaters. The development of this port should be in line with the increasing demands for berths, and since the port is located in a tourism-oriented place, it is necessary to build nautical port berths in addition to the existing communal berths in these basins.

In order to increase environmental standards in ports of local importance in Zadar area, the following recommendations were proposed for all ports:

- install more municipal waste containers/bins
- adapt a part of the ports' area for unloading drain tanks from boats
- equip the ports with specialised equipment and safety supplies to protect them from environmental pollution
- base electricity sources on alternative energy sources, and
- implement a strategy that will ensure the preservation of the environment.

Furthermore, in the ports of Maestral, Draženica and Diklo, it is recommended to install charging stations, as well as coastal lighting that utilises alternative energy sources, contributing thus, to energy sustainability.

As for other recommendations regarding all ports, it is proposed to install a signboard with the name of the port and the authority that manages it, as well as devices indicating the direction and strength of the wind to provide information on sea conditions. In the port of Jazine, it is recommended to install a sign indicating the height under the bridge and to develop an application that would provide boat owners with information on the height under the bridge that depends on the tides (high tide and low tide). Furthermore, it is recommended to separate the ports of Draženica and Maestral from the roadways by creating green areas, constructing pedestrian and bicycle paths along the coast, and by providing a fewer number of parking spaces.

The following text gives an overview of the most important development limitations for every port.

The increase of the number of berths in the port of Bregdetti is limited since it depends on the entrance to the port of Gaženica, i.e. to enter the port of Bregdetti, one has to sail through the entrance to the port of Gaženica. Considering that passenger ships (cruisers), liner ships (ferries), fishing ships and boats on their way to the gas station all sail through the same entrance, there is an increased traffic flow leading to potential risks of maritime accidents. It is important to emphasize that watercrafts whose length does not exceed 24 meters must give way

to larger vessels within a radius of one nautical mile when entering and exiting the port. The solution to reduce the traffic through the same entrance could be in the utilisation of the passage between the breakwaters and the land of Cape Punta Bajlo. The sea depth in this passage is around 0.7 m (chart depth). In the area of the port of Bregdetti, sea circulation is a huge problem. There is an underwater sewage channel called *"Centre"* (Centar in Croatian) installed along the coast, running through the fishing and passenger port of Gaženica, below the breakwaters towards Zadar Channel. The channel could become one of the potential challenges when deepening the access to the port.

Since the access area to the port of Foša and the port itself are not under the same authority, there could be a problem with the improvement of this port. The location of the port is an obstacle to its expansion and construction of additional berths. Since there is a lack of communal berths in Zadar area, a repurpose of this port is not an option.

The increase in the numbers of berths in the port of Jazine is limited due to the height of pedestrian bridge (it does not allow ships with larger cabins to sail under the bridge). A study needs to be conducted to determine how many berths can be added to the port without compromising maritime safety and without causing sea pollution. Furthermore, road traffic should be taken into consideration when planning the increase of the port capacity, especially during the summer months.

Expanding the port area on land in the ports of Draženica and Maestral is not possible due to residential units located along the roadway. It is necessary to obtain multiple permits from various government institutions in order to start the process of the improvement of ports. The development of ports requires substantial financial resources since it has to be coordinated for both ports. The goal is to renovate the entire coastal zone starting from Vitrenjak sports port to the breakwater of Zadar passenger port on the peninsula.

The port of Diklo consists of three basins that have to be developed in a joint project. However, the expansion into the coastal zone is not possible since the port is located directly along the roadway with residential units built along it. The project requires substantial financial resources; therefore, there could be financial obstacles to the development. Furthermore, time needed to obtain multiple permits from various government institutions could be another obstacle. The area where the port is located is only now gaining proper infrastructure, which is essential for the further development of this port.

5 CONCLUSION

This paper analyses the development of ports of local importance in the area of the town of Zadar, i.e. the Port of Bregdetti, the port of Foša, the port of Jazine, the port of Maestral, the port of Draženica and the port of Diklo. The challenges, that are representing true obstacles to development of these ports, refer particularly to navigation safety, infrastructure, tourist potential, and environmental standards. They require thorough planning and a strategic approach to development. It is necessary to emphasize the importance of measuring the depth of the accesses to the ports and of port basins for all ports, i.e. it is important to make bathymetric measurements an initial step towards improving navigation safety in all the above-mentioned ports. The modernization of both, infrastructure and superstructure, as emphasized in the development direction for each port, is an imperative for improving functionality and competitiveness at the local and regional level.

Each of the analysed ports faces its own limitations and challenges. Considering that the town of Zadar is tourism-oriented, it is of utmost importance to plan building more nautical port berths. It is particularly noteworthy that the ports of Bregdetti and Jazine, due to their location and surface area, have predisposition for expanding their berth capacities by installing pontoons. On the other hand, the port of Foša faces a limitation referring to the access area, since different authorities manage them. The ports of Maestral and Draženica currently do not meet the prescribed conditions for ports, and their locations require significant investments to become competitive and sustainable. The port of Diklo with its three basins is located in the tourist part of the settlement and has only the possibility to expand towards the sea. Building the breakwaters is a possible solution to meet the growing demands for berths.

It is also important to emphasize the importance of following the highest environmental standards throughout all stages of development. Sustainability is crucial for the long-term success of these ports, and the

implementation of ecological practices ensures harmonious development with the environment. All the recommendations included in this study lay the foundation for the future sustainable and prosperous development of ports of local importance in the town of Zadar.

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