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# Documenting Maritime Accidents of Recreational Vessels in the Republic of Croatia

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## ABSTRACT

Nautical tourism in the Republic of Croatia represents an important segment of Croatian tourism. Due to the natural conditions that Croatia possesses, it is recognized as one of the most desirable European and world destinations for boaters. The increase of nautical tourism activities in the Adriatic in recent years also increases the possibility of accidents at sea. In order to reduce the risk of accidents, analyses of available data on accidents from the National Maritime Rescue Coordination Center (MRCC) were carried out. In the aforementioned database, recreational vessels were selected and analyzed. The compiled data refers to sailing vessels, yachts, small fishing vessels, boats, and inflatable boats regardless of their flag state. Based on the research conducted, suggestions were made to optimize the existing way of filling out reports in order to better manage statistical data, and potentially identify the causes of recreational vessel accidents.

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## 1 Introduction

Tourism represents a set of relations resulting from the travel and stay of non-residents which does not lead to a permanent stay. Nautical tourism, as one of the specific categories of tourism, has a significant role and is beneficial for the Republic of Croatia, where its development has been increasing in recent years. Tourism as a whole, including its nautical segment, is of great importance for the development of the national economy.

The Republic of Croatia, as a Mediterranean country with an indented coastline and islands, is recognized as one of the nautical tourist centers. As a result, the number of recreational vessels on the Adriatic Sea is increasing [1]. Recreational vessels represent any vessel being manufactured, operated or primarily used for sport, pleasure, and recreation, as opposed to financial gain [2]. With the increase in traffic of recreational vessels, the probability of accidents is increasing as well.

In order to minimize the probability of accidents and enable a sustainable, safe, and environmentally acceptable

growth of nautical tourism, risk assessment could be used as a tool. The aim of this paper is to analyze the documenting accidents at sea and based on it, to propose an improved method. The improved method of documenting accidents could help in the investigation of marine accidents

- determine the placement of additional AIS station
- determine the location for the establishment of a new ship's routing system
- implement risk assessment and determine acceptable risk, etc.

The first part of this paper shows the importance and increase of nautical tourism in Croatia in the number of recreational vessels and ports. The paper analyzes data on accidents based on the MRCC database. Some essential data from the database such as position, meteorological conditions, and information about the people involved in accidents were analyzed, which can be important in determining the cause of accidents at sea. The paper concludes with suggestions for documenting maritime accidents of

recreational vessels at sea, aiming for a safer navigation and accident risk reduction.

## 2 Nautical tourism in Croatia

Two important regulations in relation to nautical tourism in Croatia are the *Act on Provision of Tourist Services*, and *Regulations on vessel types in nautical tourism*. In the *Act on Provision of Tourist Services*, nautical tourism is defined as navigation and stay of tourists (navigators or passengers) on ships for personal and commercial activities, as well as stay in ports for recreation and cruising. When discussing the type of vessels according to the *Regulation on vessel types in nautical tourism* by the type of service, they are divided into [3]:

- excursion vessels,
- cruise vessels and
- fishing vessels (sport and recreational fishing).

In line with the increase of nautical tourism that is connected with attractiveness, since the Croatian coastline is abundant in natural beauties, islands, ports etc., there is an increase of recreational vessels [1]. Assuredly, the number of ports of nautical tourism and recreational vessels can be considered as one of the most important indicators of the development of nautical tourism. In the period from 2011 to 2019 the number of ports shows a continuous increase. The following data presented in Figure 1 which include ports of nautical tourism consist of marinas (with land marinas) and other nautical ports (anchorage, mooring, uncategorized nautical ports and boat storages).

Luković T. described nautical tourism with two central subjects in his paper *Nautical tourism in Europe*, defini-

tion and classification [4]. The first refers to active subject, which consists of boaters defined as non-professionals, and skippers as professionals. The second consists of passive subject that refer to visitors and passengers. Both categories have recreational vessels as a common means of transportation which record an increase in the last year.

The Table 1 contains data on the transit number of vessels and vessels on permanent berth. The transit number of the vessel refers to vessels that have registered upon arrival at the port of arrival, thereby, a single vessel can be counted several times in case of sailing along the Adriatic coast. The term "permanent berth" refers to vessels moored in a port of nautical tourism during the year. However, if the vessel is registered in another port of nautical tourism during the year, it is registered as a vessel in transit.

Due to the attractiveness of the coast, the largest quantity of vessels and increase in traffic are recorded in the counties of the central part of the Croatian coast. According to the length of the vessels, the largest amount belongs to the category up to 15 m.

The Table 2 shows the total number of vessels for which only sea berths were used. In accordance with the Croatian Maritime Code, vessels with a length of 15 meters or less are considered a boat. A recreational vessel of more than 15 and less than 24 meters in length that may carry up to 12 passengers is considered a yacht. Yachts with a full length of more than 24 meters are considered large passenger yachts [3].

With the increase in nautical traffic, the risk of accidents is increasing as well. In case of an accident, assistance is supervised by the Maritime Rescue Coordination Center, whose primary task is the coordination of search and rescue operations at sea.

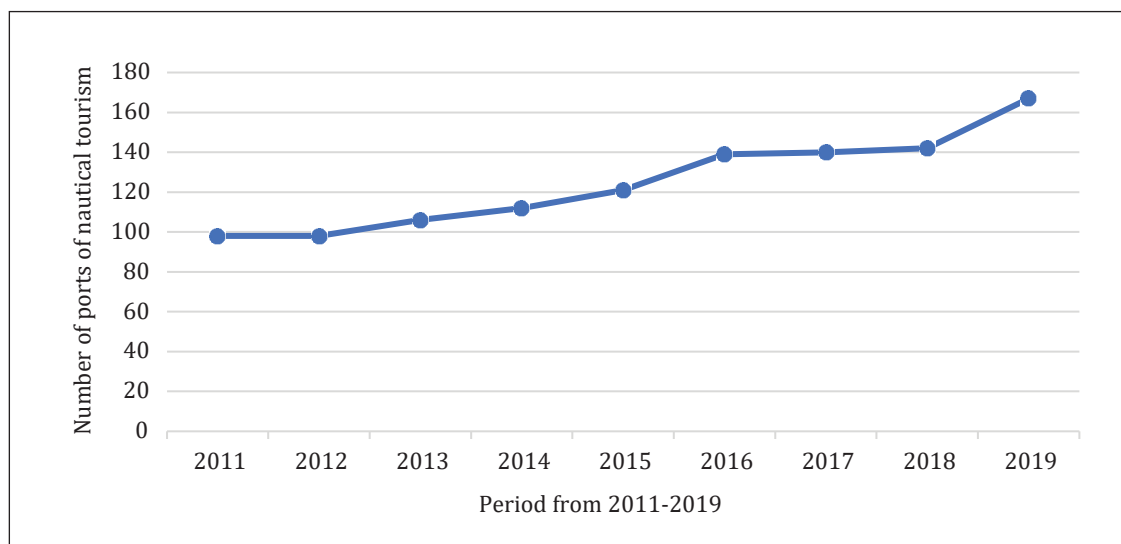


Figure 1 Ports of Nautical tourism

**Table 1** Total number of recreational vessels

County	2011	2012	2013	2014	2015	2016	2017	2018	2019
Istria	28.636	28.181	25.949	25.437	25.416	26.476	22.285	20.829	21.763
Primorje & Gorski kotar	25.839	24.058	23.909	22.435	23.622	24.978	23.786	23.145	25.366
Zadar	50.122	40.444	40.567	38.301	44.360	37.266	40.337	35.299	41.857
Šibenik & Knin	43.436	44.629	44.883	44.086	46.375	50.898	52.883	54.261	54.921
Split & Dalmatia	37.669	43.281	46.090	51.097	52.317	54.945	57.340	57.244	57.697
Dubrovnik & Neretva	17.041	15.431	15.258	13.759	14.759	17.010	18.698	17.003	17.503
<b>TOTAL</b>	202.743	196.024	196.656	195.115	206.849	211.573	215.329	207.781	219.107

Source: Croatian Bureau of Statistics

**Table 2** Number of recreational vessels according to the length

Length (m)	2011	2012	2013	2014	2015	2016	2017	2018	2019	Aver.
< 6	5.394	3.874	3.745	4.323	4.092	3.594	1.900	3.023	4.175	3.791
6 - 9.9	49.348	44.624	43.764	42.500	47.167	46.489	40.844	38.055	44.552	44.149
10 - 14.9	123.175	121.747	121.866	121.496	127.846	135.972	139.999	134.939	143.150	130.021
15 - 20	12.830	14.092	14.829	15.186	16.593	16.040	23.271	21.846	17.463	16.906
> 20	3.898	3.995	4.655	4.557	4.532	5.476	5.250	5.022	5.172	4.729

Source: Croatian Bureau of Statistics

### 3 Background

Detailed information on accidents is extremely important for increasing safety at sea. To analyse accidents and prevent them as much as possible in the future, it is necessary to collect detailed information about the accident. Analysis of the MRCC database revealed that a large percentage of the information important for determining the cause of accidents is incompletely recorded. Some of the data that are not regularly maintained are important for marine accident investigations and for identifying the root causes of accidents.

Some of the data that is often overlooked in reporting accidents is location (latitude and longitude). Previous accident data, primarily latitude and longitude, is an important source for identifying the highest risk areas. These areas are called black spots. They can be described as a number or characteristic concentration of water traffic accidents in a given time period. There are numerous related works on black spots. Authors Xia F., Yang Ya identify in their research paper [5] ten black spots and their corresponding boundaries using DBSCAN algorithm and accident level weighting method. Zhang J., et al. identify in their [6] 12 preliminary black spots and 5 detailed black spots in investigated waters. Chen H. and Du S. analyzed in their research paper [7] the advantages and disadvantages of black-spot identification and types of models suitable for proper identification.

Many researchers today use a Bayesian network model to predict accidents at sea. With large and detailed data sets, it is possible to predict shipping accidents, accident

black spots, or factors affecting accidents such as meteorological conditions. The authors Koromila I., et al. in the research paper [8] suggest optimal safe route planning for ships and risk of possible accident occurrence in the Aegean Sea using Bayesian networks based on previous accidents. Vojković L., et al. in their research paper [9] developed a method for assessing the risk factors of a maritime accident using a Bayesian belief network.

One of the leading causes of accidents of recreational vessels in the world is the inexperience of operators. From the U.S. Coast Guard 2020 Recreational Boating Statistics it is visible how operator inexperience together with operator inattention accounts for the largest number of accidents [10]. Arthur R. Copeland analyzes [11] the inexperience of boaters as a key role in accidents and provides recommendations on how to avoid them. Data that are often omitted in the MRCC when accidents are being recorded is the nationality of boaters. If the number of foreign nationals involved in accidents leads, it is possible to connect the cause of these accidents with inexperience. This refers primarily to unfamiliarity with the localities, weather conditions, etc. The research in the paper is based on detailed data about accidents at sea. Based on them, it is possible to identify the areas, measures and, regulation changes that are of great importance for the prevention of traffic accidents.

### 4 Analysis of recreational vessel accidents

The Maritime Rescue Coordination Centre (MRCC) operates under the direction of the Ministry of Maritime Af-

fairs, Transport and Infrastructure and is organized in accordance with the international guidelines adopted when the International Convention on Maritime Search and Rescue was signed. In Croatia the MRCC is also responsible for maintaining data on all search and rescue operations. Their data of intervention consist of the Table 3.

An analysis of accident data from the MRCC showed that more than 50% of all accidents are caused by recreational vessels [12]. A total of 3,837 search and rescue operations (2011 – 2019) were conducted in the area of responsibility of the MRCC Rijeka and other MRSCs due to various accidents and incidents at sea. In the Figure 2 the ratio of overall interventions with interventions of recreational vessels is presented in the period from 2011 to 2019.

The total number of recreational vessel interventions in the observed period was 2,049. Most of the interventions were carried out in the summer months during the tourist season. In Split-Dalmatia County and Primorje-Gorski Kotar County the number of accidents involving recreational vessels is the highest [12].

According to the type of accidents, the largest number of interventions falls under the group of vessels not under command, followed by groundings. In the research paper Mohović et al. in [13] gave the possible solution to minimize risk for the not under command as a type of accident. They recommend better inspections of the crafts as well as organizing training for boaters to be able to prepare the crafts for navigation. For a certain period, it was assumed

**Table 3** MRCC intervention report data

Topics	Elements
<b>Information about accidents</b>	<ul style="list-style-type: none"> <li>• Location</li> <li>• Position</li> <li>• Start of intervention</li> <li>• End of intervention</li> <li>• MRCC area</li> </ul>
<b>Type of accident</b>	<ul style="list-style-type: none"> <li>• Sinking</li> <li>• Collision</li> <li>• Flooding</li> <li>• Grounding</li> <li>• Impact</li> <li>• Fire/explosion and etc.</li> </ul>
<b>Subjects informed</b>	<ul style="list-style-type: none"> <li>• Ministry of the Interior</li> <li>• Croatian Coastguard</li> <li>• Directorate of Civil Protection</li> <li>• Foreign MRCC</li> <li>• Other</li> </ul>
<b>Type of intervention</b>	<ul style="list-style-type: none"> <li>• Search</li> <li>• Rescue</li> <li>• MAS</li> <li>• Planned action</li> <li>• Other</li> </ul>
<b>Meteorological condition</b>	<ul style="list-style-type: none"> <li>• Visibility</li> <li>• Sea condition</li> <li>• Wind force</li> <li>• Sea current direction</li> <li>• Sea temperature</li> </ul>
<b>Intervention info.</b>	<ul style="list-style-type: none"> <li>• Subject which performed action</li> <li>• Duration</li> <li>• Type of rescue unit</li> </ul>
<b>Casualties info.</b>	<ul style="list-style-type: none"> <li>• Number of persons involved</li> <li>• Type of casualties</li> </ul>
<b>Notification method</b>	<ul style="list-style-type: none"> <li>• GMDSS</li> <li>• Cell phone</li> <li>• Safeseanet/Cleanseanet</li> <li>• LRIT</li> <li>• EPIRB</li> <li>• SSAS</li> <li>• POLREP</li> <li>• Other</li> </ul>
<b>Report came from</b>	<ul style="list-style-type: none"> <li>• Casualty</li> <li>• Witness</li> <li>• Port authority</li> <li>• VTS and etc.</li> </ul>
<b>Type of vessels involved</b>	<ul style="list-style-type: none"> <li>• Passenger</li> <li>• Tanker</li> <li>• Container</li> <li>• Cargo</li> <li>• HSC</li> <li>• Fishing</li> <li>• Recreational</li> <li>• Other</li> </ul>
<b>Property damage</b>	<ul style="list-style-type: none"> <li>• Loss of vessel</li> <li>• Damage to the vessel</li> <li>• Loss of cargo</li> </ul>
<b>Pollution of the sea</b>	<ul style="list-style-type: none"> <li>• Location</li> <li>• Cause</li> <li>• Quantity and etc.</li> </ul>
<b>Casualty info. (vessel/person)</b>	<ul style="list-style-type: none"> <li>• Flag</li> <li>• Port of destination</li> <li>• Year of built</li> <li>• IMO/Ident. number</li> </ul>
<b>Short description</b>	

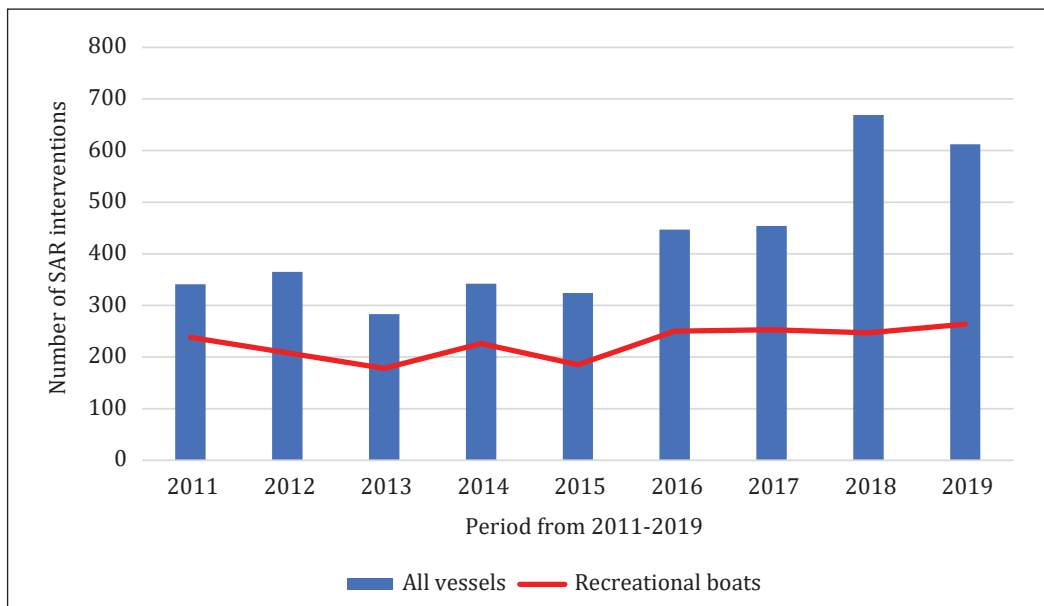


Figure 2 Ratio of overall interventions with interventions of recreational vessels

Source: MRCC database

that groundings of recreational vessels were related to meteorological events such as strong winds and visibility. The authors Toman et al. in their paper [14] analyzed and determined that most of the grounding accidents of leisure crafts occurred in light wind conditions. Visibility is often associated with maritime accidents at sea as one of the key elements that lead to accidents. Based on available data from MRCC, the accidents with the greatest severity were analyzed by time of occurrence.

Considering that most of the accidents occurred during the day, and conclusion from the research paper of Toman I., et al., it can be concluded that meteorological conditions were not the primary cause of the accidents. Identifying the root causes of accidents will require further research with a larger and more detailed data set.

Table 4 Accidents of collision, impact and grounding of recreational vessels according to day/night occurrence

	Grounding		Collision		Impact	
	Day	Night	Day	Night	Day	Night
2011	19	23	4	3	2	0
2012	34	17	6	2	1	0
2013	21	17	3	4	3	0
2014	17	35	6	7	4	1
2015	17	12	2	3	3	0
2016	29	24	8	2	5	0
2017	20	28	14	5	1	2
2018	25	15	11	3	2	1
2019	23	28	14	2	8	4
<b>Total</b>	<b>212</b>	<b>201</b>	<b>73</b>	<b>32</b>	<b>29</b>	<b>8</b>

Source: MRCC database

### 5 Documenting maritime accidents of recreational vessels

Documenting accident reports plays a key role in marine incident investigations. It is necessary to keep detailed and thorough data to be able to determine the causes of accidents. A good example of documenting recreational vessel accidents can be found in some countries such as the United States of America and Australia. Their statistical data are recorded based on a predetermined form that boaters are obliged to fill out in the event of an accident.

In the United States of America, the U.S. Coast Guard issues a form that requires the operator or owner of a recreational vessel to file a vessel accident report. The U.S. Coast Guard report consists of six pages of detailed accident information that must be completed. The U.S. Coast Guard report consists of [15]:

- Accident summary
- Information about vessel
- Accident details – external conditions
- Accident details – activities and operations
- Accident details – contributing factors
- Accident details – type of event
- Accident details – injury, deaths, and disappearance
- Accident details – operator information
- Accident details – other key people

The first part of the report consists of a summary of the accident with a brief description, the location, the number of people and the vessels involved in the accident. The second part consists of information about the vessel such as



type, size, hull material and engine type. This is followed by information on the external conditions, where the weather and water conditions are elaborated in detail. Additionally, there are details about the vessel at the time of the accident as well as contributing factors which lead to accidents that need to be indicated. This is followed by information about the types of accidents that have occurred and information about injuries, deaths, or disappearances. The report ends with information about the experience of the vessel operator, his safety measures and other people involved in accidents.

The Queensland Government has a similar reporting requirement in its Marine Incident Report. The master/owner of a vessel must report an incident at sea to a marine inspector. The report includes a description of [16]:

- Accident description
- Vessels involved
- People involved
- Report details

The first part consists of position, type of accident, severity, and environmental conditions. It is followed by details of all vessels involved in the accident, such as type of vessel, engine, hull material, and damage to the vessel as a result of the accident. The third part contains information about the people involved in the accident. The report ends with a detailed description of the accident.

In the Republic of Croatia, documenting reports is done by the MRCC. Once they receive a call for the intervention, they start with documenting their data. It is documented through the Nautical Information Service (NIS) digital application. The NIS present a multilingual, free application that not only documents accident reports, but is also designed to allow the user of the application to provide safety information to the marine safety service [17]. The disadvantage of the digital application is that it does not contain essential information that would be used primarily to determine the cause of future recreational vessel accidents. Some elements from the above-mentioned detailed

reports were analyzed to compare them with the documentation of the existing MRCC report.

Comparing the MRCC data with the report from U.S. Coast Guard and Queensland Government it is clear that certain elements are missing. The first element from the table is information about the vessel. In other reports information about the vessel involved in the accident is described in detail, such as name, hull identification, length, hull material, engine type, year of built etc. Information about the people involved consists of general information, license type, and most importantly, operator experience. These additional factors are included in U.S. Coast Guard report which indicate the cause of the accident.

After analyzing the MRCC data, the authors consider that it should be complemented with additional information. Vessel information such as year of construction would give the average age of vessels involved in accidents. Knowing the age, additional inspections and checks of these vessels could be implemented, which would force boaters to perform additional maintenance on their vessels, which primarily refers to vessels of older construction. When it comes to boater experience, including additional information should be considered. For example, when entering data, it should also include information on whether the operators are professional fishermen who go out to sea every day and have extensive experience, or whether they are people who fish occasionally for private purposes and therefore do not have experience like professional fishermen. By identifying the inadequate experience of boaters involved in accidents, recommendations and guidelines for boating licenses could be provided. Obtaining a boating license in Croatia is possible without the practical part of navigation at sea. One of the main lacks of the report today is the absence of additional factors. In order to maintain better statistics and implement risk assessment, it should be clearly defined which causes lead to accidents with which consequences. The authors believe that the number of accidents at sea could be reduced if the original additional factors that contributed to the previous accidents were known.

**Table 5** Comparison of data collected from the accidents reports

ELEMENTS OF REPORT	USA	AUSTRALIA	CROATIA
Position/Location	✓	✓	✓
Type of accident	✓	✓	✓
Accident severity rating	✓	✓	✓
Vessel information	✓	✓	X
People involved information	✓	✓	X
External conditions	✓	✓	✓
Contributing factors	✓	X	X
Injury/deaths/disappearances details	✓	✓	X
Accident description	✓	✓	✓

Source: Authors

## 6 Conclusion

The importance of nautical tourism in the Republic of Croatia is significant. Due to the natural beauty of the coastline and islands, the growth and demand for boaters are increasing. With the increase in the number of recreational vessels comes an increase in the risk of accidents. To identify the possible causes of accidents and thereby reduce them, a detailed database of existing accidents is required which should follow appropriate documenting procedure.

Although the digital database of search and rescue interventions is used as the main one, the authors consider that a standardized form for the written report should be created. By standardizing the written report, it would be possible to record the required data without incomplete information. In other words, MRCC operators would then be "forced" to adhere to the above information. In analyzing MRCC accident reports from recreational vessels, the authors consider that there is much room for improvement. This primarily relates to the improvement of the nIS digital application to include important additional information. Although the method of documenting contains a sufficient amount of information, a major drawback is that a large percentage of this information is not filled out. The authors consider that operators should be additionally trained with emphasis on the importance of documenting accidents properly. Detailed databases of accidents can be used as risk assessment tools to develop solutions for potential risks. Therefore, the authors consider that it is possible to determine the area of increased risk and thus determine the placement of additional AIS stations or even determine the location for the establishment of a new ships' routing system.

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