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Method for Analyzing AIS Data and Determination of Simultaneously Ships Passage via Strait of Split

M. Bukljaš Skočibušić
University of Zagreb, Zagreb, Croatia

S. Vukša & I. Pavić
University of Split, Split, Croatia

ABSTRACT: The traffic density is a basic characteristic of marine traffic for some navigational area. In the case of narrow channels such as Strait of Split (Splitska vrata), apart from the traffic density, the number of simultaneous ship passages is also important as well as ships characteristics. Based on such data, additional navigational safety guidelines and regulations may be planned for the observed area. The purpose of this research is to determine the number of simultaneous ship passages via Strait of Split for a certain period of time. Collected AIS data in SPNMEA format was decoded by AIS Decoder online program to csv file.
For five randomly selected days in the summer period, based on AIS data, the number of simultaneous ship passages was determined and ships information presented.

1 INTRODUCTION

Focus of this research is analysis of AIS data for the passage Strait of Split, Split waterway area - Croatia. Through AIS antenna at the Maritime Faculty in Split, AIS data is collected for the Split waterway area. The data is stored on a computer for traffic flow/density analysis. The aim is to collect AIS data continuously and analyze them to improve and enhance navigation safety.

Strait of Split is the shortest way to and from Split to island of Hvar, Vis, Korcula and further to Strait of Otrant. The Strait is located between the islands of Solta and Brac. In addition to being the shortest, this Strait is also the most frequent and narrowest channel comparing to the other approach channel to port of Split. In its narrowest part, the distance between islands of Solta and Brac is 0.42 NM (Figure 1). Navigational area with the depth greater than 20 meters is 0.15 NM wide. The Strait is marked with the navigational lights on the Cape Razanj (island of Brac), Cape Livka (island of Solta) and on the islet of Mrduja [3, 4]. Regarding the regulations that apply to Strait of Split, anchoring is prohibited for all vessels.

Split becomes an increasingly popular tourist destination and marine traffic is intensifying. Except mentioned navigational marks, regulation of prohibited anchoring and Vessel Traffic Service (VTS) there are no additional safety navigational precautions for the Strait of Split. During the summer time a large number of different types of ships navigate in this area and that is why risk of maritime accidents exist. Although the Strait in its narrow part is only 2 NM long due increased traffic density, especially during the summer months, it is necessary to plan additionally precautions and/or regulations that will improve safety of navigation for that area. Regulation would improve safety of navigation for that area. Occurrence of the maritime accident could have disastrous consequences for the population, marine environment and for the economy of the City of Split (tourism).

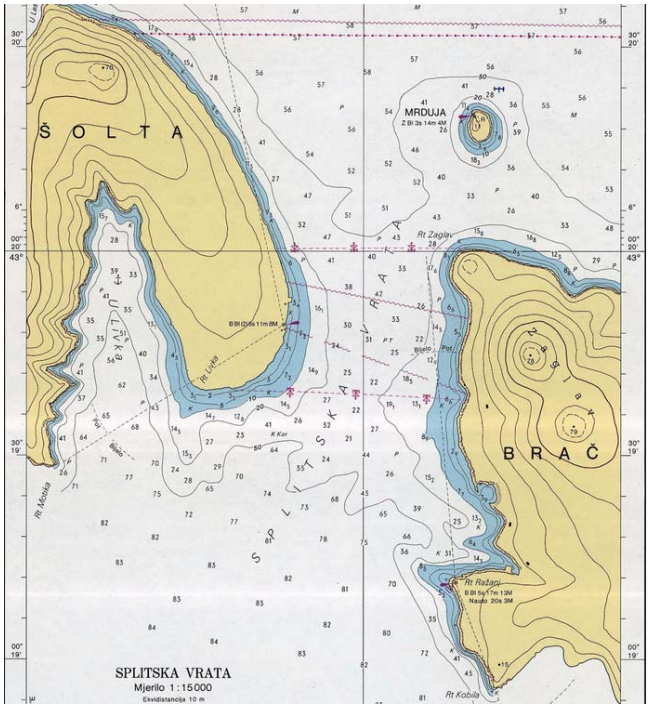

Figure 1. Strait of Split
(Source: http://www.hhi.hr/catalogmaps/viewmap/129) [4]

The Automatic Identification System (AIS) is an automated tracking system used on ships for locating and identifying vessels and avoiding collisions. The automatic identification system broadcasts information on ship identity, speed, direction and position every 2 to 10 seconds while underway, and every 3 minutes while at anchor [6].

AIS is a carriage requirement for SOLAS vessels (SOLAS Chapter V Regulation 19).

Two types of AIS devices are in use, Class A and Class B. Type A is mandatory for vessels of 300 GT or more operating on international voyages, cargo vessels of 500 GT or more not operating on international voyages and for passenger vessels (carrying more than 12 passengers) regardless of their size. AIS Class B is intended for use on non-SOLAS vessels. These can include domestic commercial vessels and pleasure craft.

AIS Class B units have less functionality than Class A units but they operate and communicate with AIS Class A units and other types of AIS units[1].

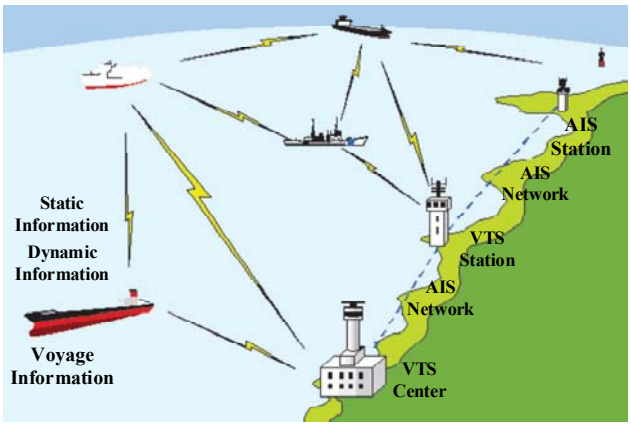

Figure 2.Automatic identification system data
(Source: https://doi.org/10.7225/toms.v01.n02.002)[1]

AIS data analysis and presentation of the obtained results are subject of many scientific studies. The research work (K. Naus et al, September 2007) describe one of the ways for decoding AIS data and their analysis with regard to the type and speed of ships for the Gulf of port Gdansk [8]. By analyzing the AIS data, the navigation routes of certain types of ships with the speeds greater than 2 kt is shown. Based on such data, it is possible to recommend and adopt new surveillance measures to increase the safety of navigation for an area.

Such methods of processing AIS data can be used to determine traffic density and track navigation routes of larger areas.

With a such analyzes it is a possible to monitor maritime traffic flows/density, illegal activities such as smuggling, marine environment pollution, fishing in protected areas, sea border control [2,9,7].

Analysis of maritime traffic for the Split waterway area and AIS data (in one part) was subject for research of the Faculty of Maritime Studies in Rijeka (2014), called "Maritime traffic study for the water way area of Split, Ploce and Dubrovnik" (PROMETNO - PLOVIDBENA STUDIJA PLOVNO PODRUČJE SPLIT, PLOČE I DUBROVNIK) [12]. The International Waterway Risk Assessment Program (IWRAP) have been used for numerical maritime traffic simulation.

The IWRAP model starts with the assumption that the risk of collision or grounding is proportional to the density of traffic. Collision and grounding risk assessment according to the IWRAP is justified in the following cases [5]:

- marine traffic is enough dense that the obtained results have a satisfactory reliability,
- the characteristics of traffic and ships are known with sufficient reliability,
- navigational routes are recognizable.

Based on the AIS data and the IWRAP program, the risk assessment for collision and grounding for the Strait of Split have been obtained. The types of ships and the number of passages through the Strait of Split are also presented. (Table 1).

Table 1. Types of ships and the number of passages through the Strait of Split (over one year period) [12]

TYPE OF SHIP	NUMBER OF PASSAGES	AVERAGE SHIP LENGTH
Ro-Ro ships	9490	70 m
High speed crafts	3650	35 m
Cruiser ships	7752	25 m
	22	< 100 m
	136	100 – 200 m
	96	200 – 300
	16	> 300 m
Bulk carriers	326	60 m
Tankers	250	90 m
Yachts	5840	40 m
Fishing boats	2190	30 m

Data analyzed by IWRAP are very valuable. Based on those data, guidelines for additionally traffic regulations are recommended for Split waterway.

However, data on the simultaneous passage of ships via Strait of Split are not available. Annual

number of ship passages via Strait of Split and the average lengths of the ship shows the density of traffic. The density of traffic in narrow channels does not give a clear picture of the possibility of a maritime accident/collisions. If traffic density is arranged in a way that ships do not pass through the Strait of Split at the same time, the risk of collision is lower. It is therefore important to determine the number of simultaneous passages through the Strait.

2 HYPOTHESIS

Traffic density is a factor that affects the navigational safety of the Strait of Split and Split waterway. Traffic density increases, and the characteristics of ships (type, dimensions, speed, drought, etc.) which navigate in this area are such that the risk of maritime accidents exists. For navigation in narrow channels it is important to determine how many ships passing in the same time through this area. The traffic density for narrow channels does not give a clear picture of the danger of a marine accident if we do not have data about the ships passing simultaneously. Based on the analysis of traffic density and simultaneous ships passages, additional navigational safety precautions and regulations may be planned.

Analyzing AIS data valuable conclusions can be drawn and this can improve the traffic safety and navigation for some waterways [11]. If the frequency of simultaneous ship passages is large it is necessary to plan additional precautions and regulations. If a situation such as this occurs rarely or only periodically (summer / seasonally), it is not necessary to introduce additional safety precautions and regulations for the whole year.

The paper presents a simple method of determining the number of simultaneous ship passages for Strait of Split and information's of those ships for 5 randomly selected days.

3 METHODOLOGY

A flow chart shows the AIS data processing methodology. The data collected were processed using AIS Decoder and were exported to cvs.file. Such data should be further processed in the Excel table. The processing gives a table of all ships broadcasting the AIS signal for the observed date. According to the operating instructions of the AIS Decoder, the decoding program is set in such a way that the following ship information's are recorded in the table:

- MMSI,
- name of the ship,
- speed over ground (SOG)
- latitude,
- longitude,
- course over ground (COG),
- UTC,
- type of ship
- length over all (LOA),
- breadth.

After that, coordinates of area in Strait of Split for which traffic analysis will be performed are determined. Area in Strait is defined by the geographical coordinates P1, P2, P3 and P4 (Figure 3). Filter F1 tests if position of the ships are inside given area.

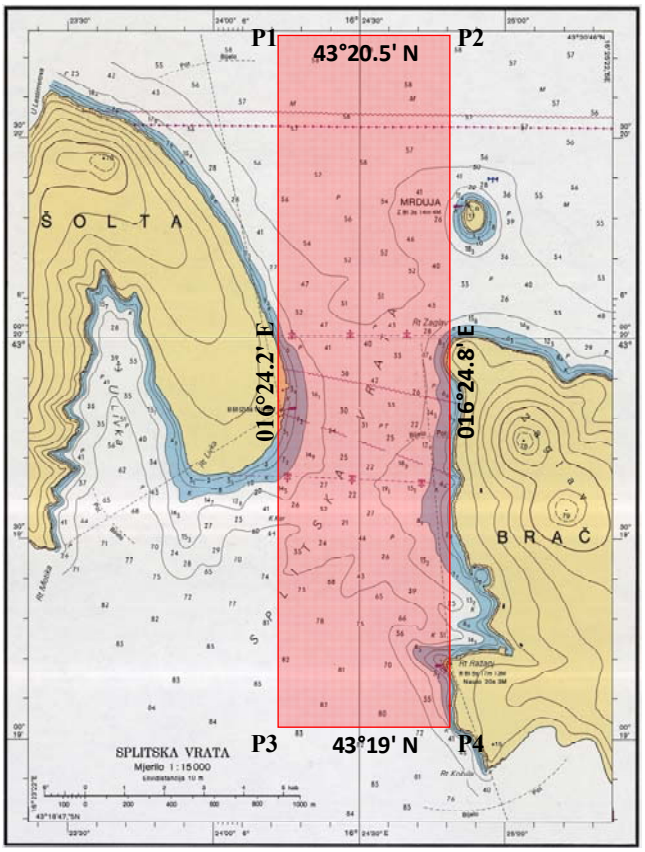

Figure 3. Coordinates of determined area at Strait of Split (Source: http://www.hhi.hr/catalogmaps/viewmap/129, Authors)

Additionally, F2 tests the number of ships in a 6-minute gap at simultaneous passage, and what are the characteristics of a ships (dimensions, speed, type, navigational status and course).

Logic for filter F1 and F2 algorithm is presented below.

FILTER F1
Input: .csv file I
Output: no. of ships in area P1,P2,P3,P4
Define column with Longitude and Latitude L1 & L2

```
for each row do
   if ((L1<P1&P2)&(L1>P3&P4)) then
      if ((L2<P1&P3)&(L2>P2&P4)) then
         Save ship AIS data
      else
         Delete ship AIS data
      end if
   else
      Delete ship AIS data
   end if
end for
return I1
```

FILTER F2
Input: .csv file I1
Output: no. of ships in each simultaneously passage and maximum A&T
Define column with UTC, D1

for each row **do**
  if ((D1>(D1+3))&(D1<(D1-3))) **then**
    count number of cases T
  else
    reject
  end if
end for
for each T **do**
  count and save number of ships A
end for
for each A **do**
  max of A
end for
return ((max of A) & T)

According to the frequency of simultaneous passages for a certain period of time, it is possible to plan additionally guidelines / regulations to improve the safety of navigation.

Results for five randomly selected days will be presented for the summer period when traffic density is increased, due to amount of data and time necessary for decoding and analysis.

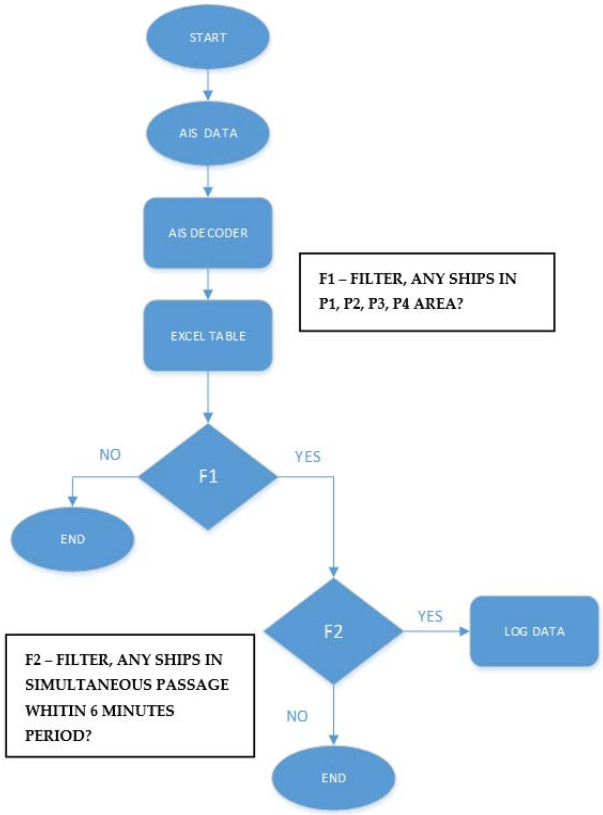

Figure 4. AIS data processing methodology (Source: Authors)

Analog to described methodology in Figure 5 actual decoding process is presented.

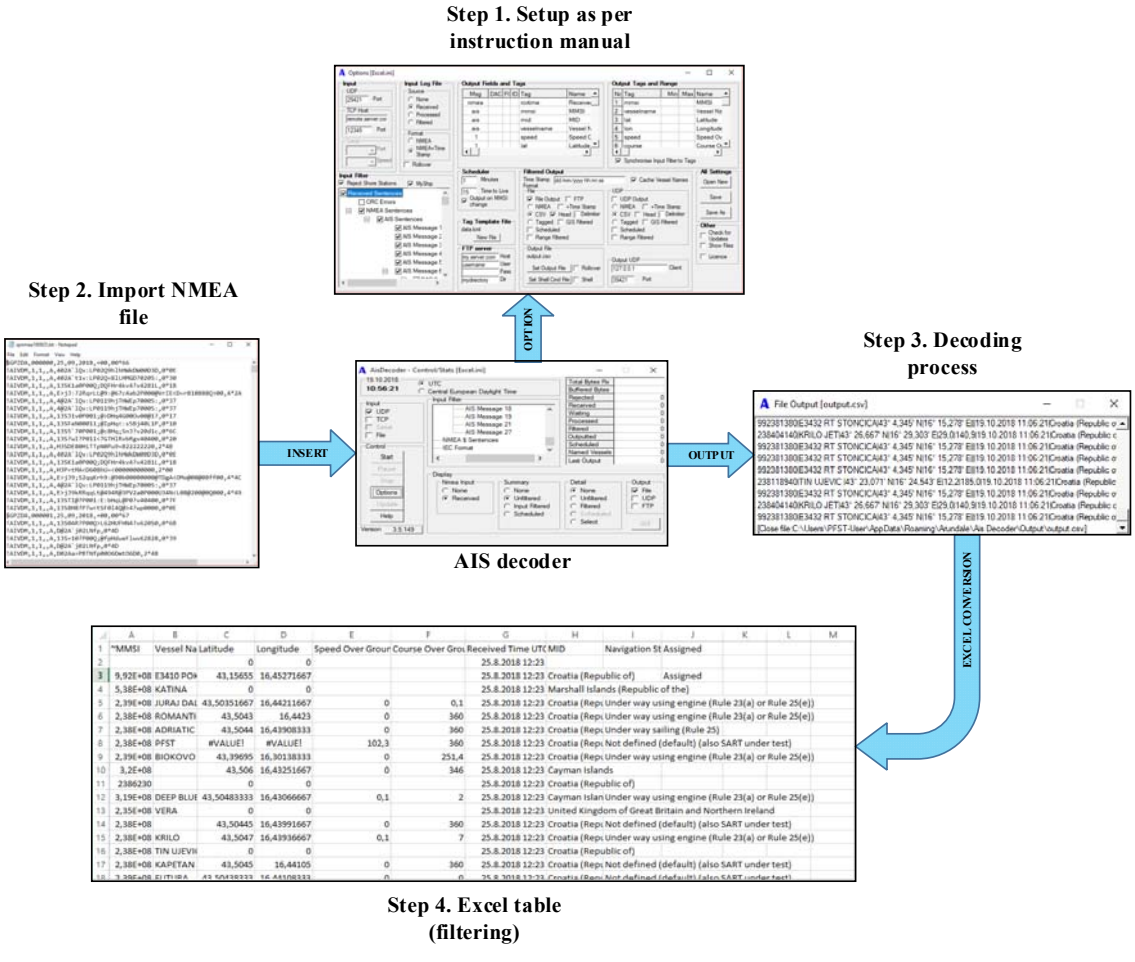

Figure 5. AIS data decoding proces (Source: Authors)

Table 2. The number of simultaneous passes for the observed dates and the characteristics of the ships for the maximum occurrence (Source: Autors)

Date	Number Of Simultaneously ships passage	Maximum number of ships in simultaneously passage	Ship informations								
			MMSI	Vessel Name	Speed Over Ground	Latitude (north)	Longitude (east)	Course Over Ground	UTC Time	Type	LOA	B
16.7.2018	13	4	238100940	VIDA	23,3	43,34158333	16,40355	180,5	11:31:40	High Speed Craft	38,5	10,4
			238398840	KRILO CARBO	26,3	43,32338333	16,40333333	009	11:32:43	High Speed Craft	40,8	11
			378296000	DYNASTY	13,1	43,32883333	16,40338333	010	11:33:16	Pleasure Craft	44,82	8,8
			238190840	NOVALJA	21,8	43,31733333	16,40598333	351,5	11:33:52	High Speed Craft	41,57	11,02
20.7.2018	23	4	238405640	PRINCESS SOFIA	8,4	43,32025	16,40623333	356,6	11:20:33	Sailing Vessel	14	8
			238190940	KAROLINA	25,1	43,31996667	16,40336667	012,5	11:20:49	High Speed Craft	41,51	11
			238092540	MANCI	4,7	43,31701667	16,40511667	006,6	11:23:42	Sailing Vessel	14	4
			238160000	PETAR HEKTOROVIC	14,2	43,32411667	16,40336667	014,9	11:24:46	Passenger	91,8	8,49
15.8.2018	23	3	238823640	KORCULA	14,2	43,3321	16,40335	011,2	06:34:35	Passenger	101,42	17,48
			238434340	ADRIATIC PEARL	8,3	43,34153333	16,40438333	190,6	06:34:41	Passenger	40	9
			238288740	DAVORIN	9,1	43,33496667	16,41273333	286,7	06:38:33	Fishing	25,4	6,51
24.8.2018	39	5	238160000	PETAR HEKTOROVIC	14,1	43,32785	16,40338333	012,5	11:28:45	Passenger	91,8	18,49
			247132800	TM BLUE ONE	10,4	43,33188333	16,40395	024,1	11:31:00	Pleasure Craft	50	9
			238398840	KRILO CARBO	27,2	43,32896667	16,40333333	005,4	11:31:08	High Speed Craft	40,8	11
			229000313	PRIVATEGG	11,8	43,336	16,40505	087,6	11:31:43	Pleasure Craft	27	8
			238190840	NOVALJA	21,6	43,34128333	16,4045	185,9	11:33:31	High Speed Craft	41,57	11,02
4.9.2018	31	5	238003140	ATLANTIC	7,2	43,31726667	16,40545	347,9	11:04:42	Passenger	37	8
			238507240	XENA	3,7	43,33601667	16,40823333	222,2	11:04:45	Sailing Vessel	14	4
			211747230	NICOLE	6,8	43,32658333	16,4034	177,8	11:05:16	Passenger	49	9
			238458140	ADRIS	9,2	43,31708333	16,40485	350,8	11:07:02	Passenger	49	9
			367593160	DAYTRIPPER 2	28,8	43,33568333	16,40363333	102,3	11:09:08	Pleasure Craft	N/A	N/A

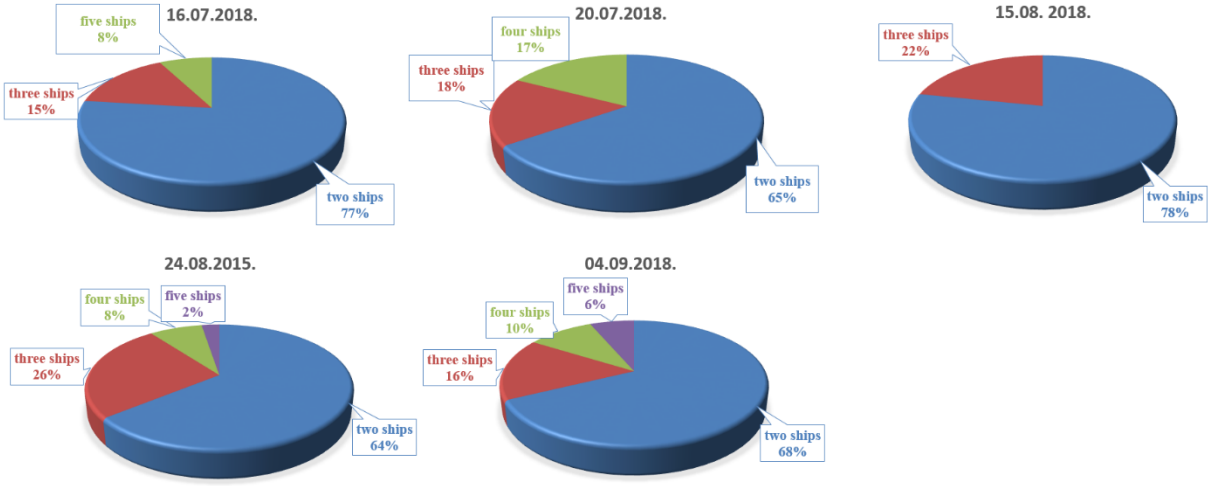

Figure 6. Number of ships in percentage for each simultaneously passage (Source: Authors)

4 RESULTS

Table 2 shows the total number of simultaneous passages for a given day. From total number of these passages, the maximum occurrence and characteristics of these ships are shown. During all these occurrences length of only one ship is longer than 100 meters. Length of other ships, except Petar Hektorović, is less than 50 meters. It can be said that the length of ships for observed occurrences does not significantly affect the safety of navigation.

More than half of the ships passing Strait have a speed exceeding 10 kt and in some cases speed is higher than 20 kt. The velocity factor greatly affects the safety of navigation, especially in narrow passages such as Split door. It is necessary to avoid situations where more ships with speed greater than 20 kt are passing simultaneously through Strait of Split.Figure 6 shows the number of ships in percentage for each simultaneously passage for the observed day considering total number of simultaneously passages. In more than 60% of cases only two ships are passing simultaneously.

The maximum number of ships in simultaneously passage is five. From observed data this happened during two days. On the 24.08.2018. it happened once and on the 04.09.2018. twice. In these cases length of the ships is less than 100 meters.

5 CONCLUSION

In this paper method of maritime traffic analysis for passage through the Strait of Split using AIS data is presented. Although the density of maritime traffic through Strait is high, from the number of simultaneous passages and the characteristics of the ships it can be concluded that existing regulations and arrangements (navigational markings) meet the requirements. Also it should be considered that the number of smaller ships without AIS is very high, especially during the summer period. Because of this, navigation through Split door requires compliance with regulations and extreme caution [10].

Based on such simple AIS data analysis it is possible to predict traffic density for a certain period of time and it is possible to determine structure of that traffic. To get more accurate results while analyzing data it is necessary to keep in mind technical and human errors the AIS system is subject to [5].

The observed analyzed period in this research is short, and based on it, the final decision on planning

and introducing additional security measures cannot be made. This study represents a simple method to track and analyze marine traffic for a longer period of time. A year-long sample would give a more accurate information about the traffic density, the number of simultaneous passages and the characteristics of those ships. It is also a proposal for future research with continuous collection of AIS data for the Strait of Split area. Considering the results obtained, it may be planned to introduce additional safety measures for navigation through Strait of Split.

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