Analysis of the maritime traffic in the central part of the Adriatic

Zvonimir Lušić
Faculty of Maritime Studies Split, Split, Croatia

Danijel Pušić
Croatian Hydrographic Institute-Split, Split, Croatia

Dario Medić
Faculty of Maritime Studies Split, Split, Croatia

ABSTRACT: This paper analyzes maritime traffic in the central part of the Adriatic Sea as well as risk of collisions and groundings on the main sailing routes passing through this area. For the purpose of this study the main sailing routes will be those that pass in the vicinity of the island Palagruža, i.e. through the area bounded from north by line that connect islands Sušac and Jabuka and from the South by line connecting island Pianosa and cape Gargano. Although this part of Adriatic is almost completely open sea, large concentration of ship traffic cause increased probability of maritime accidents, especially collisions. Two main traffic flows, northwest and southeast, are concentrated in two narrow paths, mainly safely separated due to traffic separation schemes in vicinity. But these main traffic flows overlap with routes of other vessels; fishing vessels, yachts, transversal traffic, etc. accordingly causing increased probability of accident. Calculation of probability of collisions and groundings, in this paper, will be based on AIS traffic data and IWRAP software. Accordingly, some recommendations how to reduce risk of accidents will be given.
Keywords: Central part of Adriatic, Island Palagruža, main longitudinal sailing routes, AIS traffic, collisions and groundings.

1 INTRODUCTION

The biggest ports in the Adriatic are situated on its northwestern coasts. Accordingly, the greatest traffic can be found on sailing routes which connect these ports and the Strait of Otranto, i.e. the exit to the Adriatic. Regarding these sailing routes, the biggest concentration can be found in the main sailing route, which mainly goes through the open sea. This sailing route is defined by three key points: separation zones of the Northern Adriatic, separation zone near the island Palagruža and the Strait of Otranto. As a result, a massive concentration of traffic is grouped into two separate navigational directions; one northwestern, the other southeastern with the width of several naut. m. (Figure 1). The aforementioned separation zones separate opposite waterways hence reducing the possibility of collisions in opposite courses. If the traffic in the central part of the Adriatic is observed, i.e. in the larger area of Palagruža, at first glance it could be concluded that the marine traffic is regulated well, with a relatively small probability of collisions and groundings. This is mostly contributed by the established separation zones, VTS system and a relatively large distance to the coast. However, the constant growth of the traffic concentration shows that the danger of accidents, especially collisions, is in fact not negligible. The main reasons are crossing of longitudinal sailing route with the transversal ones, branching of the main waterway in the area of the Northern Adriatic in two parts, overlapping of the main sailing routes with fishing zones, passenger ships traffic and nautical tourism ships, economical activity etc.

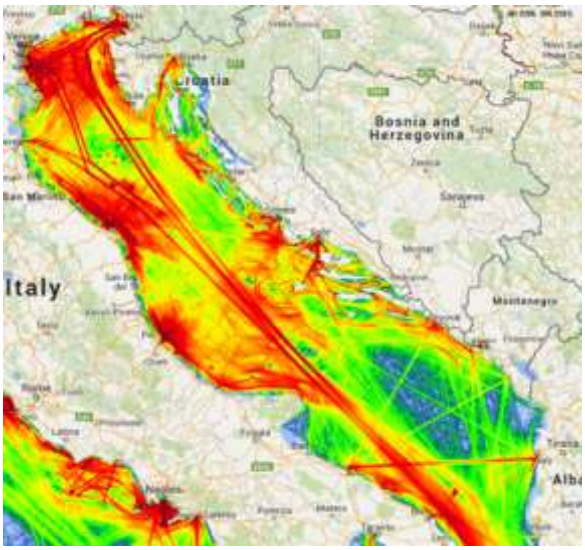


Figure 1. Ais Traffic-2014
Source: HHI-map 101Source: Marinetraffic

This paper will analyze the effect of the remaining ship traffic on the ships that move in central longitudinal sailing routes in the open sea of the Adriatic, i.e. that move in the larger area of the island Palagruža. For the collision and grounding assessment IWRAP software will be used, i.e. the model based on the quantitative determination of potential collisions and groundings (IWRAP). Input data for the analysis will be obtained by gathering AIS ship tracking in the summer months of the 2015. IWRAP is a modeling tool that can estimate the frequency of

collisions and groundings in a given waterway based on information about traffic volume/composition and route geometry [www.IALA]. The assessment of the number of collisions and groundings based on the IWRAP methodology can be justified in the cases when the amount of traffic is big enough and when the traffic and ships characteristics are known.

2 GEOGRAPHIC AND NAVIGATION ANALYSIS OF THE AREA

Based on its geographic and sailing characteristics the Adriatic Sea is a unique sailing area [Lakoš, 1980]. Sailing in the Adriatic Sea as the specific and unique area as it is, in the sense of safe navigation requires good knowledge of hydro-navigational and hydro-meteorological conditions. In the summer period navigation in the Adriatic, particularly around the island area, requires indispensable knowledge and respect of the navigation conditions which derive from hydro-navigational and hydro-meteorological conditions in certain areas. Quick change of weather, especially the sudden appearance of gale in the entire and especially northern part of the Adriatic, a large number of navigational obstacles, numerous islands, islets, shallows, rocks, reefs, narrow passages and canals and a large number of non-merchant ships (fishing vessels, small vessels, yachts…) make navigation in the Adriatic Sea demanding, particularly in the coastal area.

The island Palagruža is the largest of a small group of islets lying southeast of Biševo island, nearly in the middle of the Adriatic, some 35 miles far from the Croatian coast. Two lights are exhibited from the summit: the main light is exhibited from the lighthouse - stone tower on dwelling, and a secondary light about 20 m east - white column on hut. The island is 91m high, rocky and almost barren. The steep and rocky south coast is almost inaccessible. Off the west extremity of the island lie the above-water rocks Volići and Pupak. Small craft can find some shelter in the cove Stara Vlaka on northern side, and in the cove Žalo on southern side of the island. The rocky islet of Mala Palagruža (51 m) lies southeast of the island, and is bordered by above and below-water rocks and shoals. The islet Kamik Od Tramuntane stands to NE and the islet Kamik Od Oštra to SE. The islet of Galijula is situated about 3 miles southeast of Palagruža island. In the broader area of Palagruža there are no greater dangers, the distance from island line to nearest island on east coast is circa 23 naut. m., and to island Pianos 24 naut. m., to Gargano 28 naut. m.. The greatest danger is represented by hydro-meteorological conditions. Prevailing wind is maestral and the greatest danger is represented by jugo which can develop waves up to 7 m high.

3 EXISTING SAFETY MEASURES

The area around the island Palagruža belongs to the outside island area with a very notable traffic density, right after the Strait of Otranto by the number of ships navigating the area. Due to convergence of the navigational direction, i.e. merging of two navigational directions in the narrow area around the island Palagruža, and the great traffic density, system-oriented navigation was established and all for the purpose of improving the safety of navigation. The traffic separation scheme in the area around the island Palagruža (Figure 2) was established in 1989 by the Command of sailing routes of foreign warships, foreign tankers, foreign nuclear ships and other foreign ships that transport nuclear or other dangerous and harmful substances during harmless passage through the territorial sea of the Socialistic Federative Republic of Jugoslavia . The scheme itself consists of the traffic separation zone of two (2) naut. m. of total width. The area of traffic separation is determined by the central line which connects points with coordinates: a) 42° 04,7'N - 016° 24,6'E i b) 42° 23,0'N - 015° 56,2'E. Sailing paths continue laterally to the separation zone in three (3) naut. m. to the both sides, in which case in the sailing path closer to the Italian coast the navigational direction is 136°, and in the path close to the island Palagruža, it is 316°. Separation zones one naut. m. wide are situated next to both external edges of the traffic separation system´s sailing paths, in purpose of separating the traffic in the system from the traffic in the area of the coastal navigation. The position of the traffic separation system is the most suitable because the passage through the island Palagruža and the coast, i.e. Pianos island on the approximately same distance (somewhat closer to Palagruža island, i.e. somewhat deeper in the territorial waters of the Republic of Croatia), ensures optimal usage of radar devices with the scope of determining the ship position.

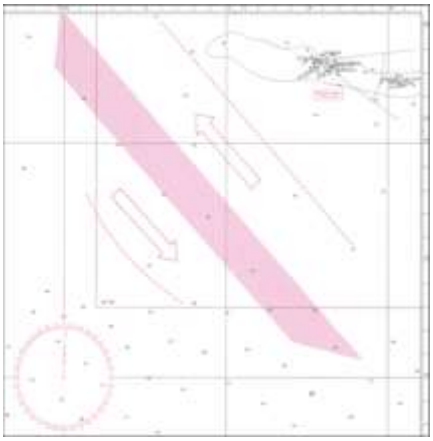


Figure 2. Sailing close to the island Palagruža
Source: HHI, 1995 map 100-23

The traffic separation scheme is not accepted by the IMO (International Maritime Organization), and its establishment occurred based on the IMO Resolution

principle of the existing (regular) maritime traffic flow. Principle of the existing (regular) maritime traffic flow makes a general assumption according to which navigational direction measures should respect the usual maritime-traffic flows as much as possible. The basis of this principle is the need to introduce separation measures in a certain area to navigational practice as simply and in as short adjustment period of time as possible. Analyzing the so far accepted navigational direction measures, this principle proves fundamental. In practice, there are no examples of not being respected consistently. Considering that the traffic separation system near the island Palagruža is in the territorial waters of the Republic of Croatia the Croatian VTS (Vessel Traffic Service) is applied in the area. Vessel traffic service´s main scope is the navigation safety and this system reduces the risk of collisions at sea, makes better control of the ships and ecological protection of the sea and the islands. Such systems are placed in the zones of dense traffic, where the freedom of ship movement is limited by the size of the maritime area, existence of obstacles in navigation, limited depths or unfavorable meteorological conditions. Traffic separation scheme close to the island Palagruža is situated in the Croatian VTS sector B. Sector B – comprises the parts of internal waters and the part of the territorial waters of the Republic of Croatia from the border (external border of the territorial waters) to the VTS sector limits: Rijeka, Zadar, Šibenik, Split, Ploče, Dubrovnik and Pula – maneuver sector. VTS service gives information service (IS) significant to safe navigation of sea crafts in the VTS area on VHF channels Ch10 and Ch60. All sea crafts are obligated to communicate with the VTS service, Port Authority and port management and to vigil over VHF radio channel of the VTS sector in which they are located. Participation in the VTS services is obligatory for:

a. Ships of 150 gross tonnage,
b. Ships over 50 m and more in length,
c. Ships on international voyages,
d. Sea crafts with limited maneuver abilities,
e. Sea crafts that transport dangerous substances or pollutants,
f. All sea crafts regardless of the length, tonnage or purpose that represent or are in a situation of potential navigation risk or navigation safety, safety of people or environment protection,
g. Ships that tow or push other sea crafts, regardless of their length.

The vigil on Ch10 is obligatory for those sea crafts that are in accordance with the directives of the Resolution of the IMO´s Maritime Safety Committee, MSC: 139(76) from December 5, 2002. which are obligated to participate in the Adriatic Reporting System (ADRIREP). The operational area of the mandatory ship reporting system covers the whole Adriatic Sea, north from the latitude 40° 25'.00 N. The area is divided into 5 (five) sectors, each of them assigned to a competent authority, operating on a designated VHF channel.

4 MAIN SAILING ROUTES AND STRUCTURE OF THE TRAFFIC

On the main longitudinal sailing route more longitudinal sailing routes can be formed. Generally, they can be divided into the main longitudinal sailing route in the central part of the Adriatic and those closer to eastern and western coasts (Figure 3). Considering the fact that the east coast is more indented than the west coast, the choice of longitudinal sailing routes along it is greater. Most frequently, they are divided into those out of and inside the outer line of islands of the east coast. The main longitudinal sailing route extends in the central Adriatic in the NW-SE direction following the direction of the main longitudinal axis of the Adriatic Sea and is 400 naut. m. long in total. In its central part, it goes between islands Palagruža and Pianos, i.e. the circle which is made of islands Sušac, Pianos and cape Gargano. The greater part of the longitudinal sailing route extends in the area of sufficient depth and width where there are no significant dangers to navigation, with the exception of danger of collision with the opposite or transverse traffic, danger of grounding on the final parts of the path or in the broader area of Palagruža island, possible unfavorable hydrometeorological conditions and similar.

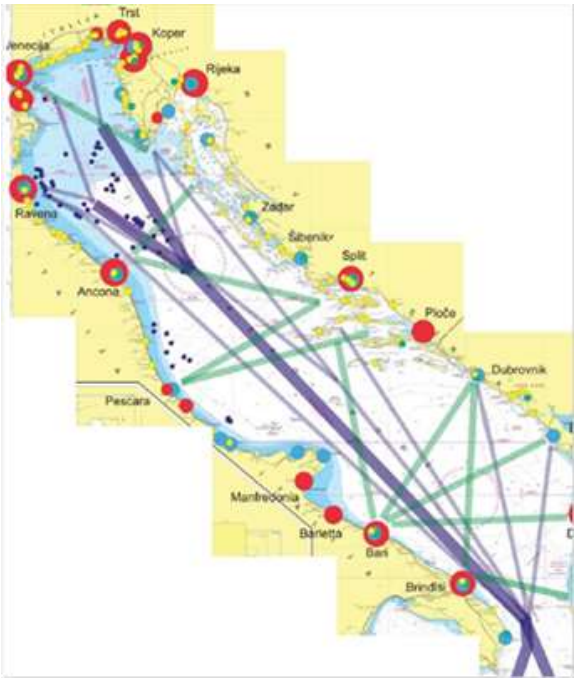


Figure 3. The main sailing routes in the Adriatic
Source: Komadina et all, 2013.

The main longitudinal sailing routes in the Adriatic are formed between bigger ports on the eastern coast

(Rijeka, Zadar, Šibenik, Split, Ploče, Dubrovnik, Bar, Durres) and the ports on the western coast of the Adriatic (Ravenna, Ancona, Pescara, Bari, Brindisi). These routes are formed according to the criterion of the shortest distance, if the hydro-meteorological conditions allow it (wind and waves above all) and are not moved more than 50 naut. m. from the coast. The ship traffic between the ports of the eastern and the western coast are multiple times smaller in comparison to the longitudinal traffic. The biggest parts of the mentioned traffic are passenger lines between bigger ports of the eastern and western coast [Lušić, Kos, 2006].

Overall traffic in the longitudinal sailing routes can be relatively well estimated based on the number of ships that sail into the ports of the Northern Adriatic. According to the available data approximately 19.000 ships annually sails into the most important ports of the north Adriatic in the international navigation (Table 1). The biggest part of the mentioned traffic is on the longitudinal sailing route, i.e. it can be estimated that its daily load is up to 50 ships in one direction daily.

Based on the AIS data it can also be concluded that daily, in every moment, 100-200 ships sail in the Adriatic [marinetraffic]. Circa 20% of all vessels are tankers and circa 10% of all vessels report dangerous cargo on board [Matika, 2013][Adria VTS, 2009].

Table 1. Ship traffic in the international navigation according to the main northern Adriatic ports

Rijeka	1.230*
Koper	2.032
Trieste	3.949*
Venezia	3.402
Monfalcone	768
Ravenna	3.122*
Ancona	4.482

Source: Port statistics 2014*/2015

The traffic in the narrow area of Palagruža on the main sailing route is approximately circa 10-15 ships daily in one direction [marinetraffic]. According to the collected AIS data for June 2015 in the area of TSS Palagruža in every direction daily, yearly, there are circa 11 ships [AIS-PFST]. The greatest traffic density is in the Northern Adriatic area and in the directed navigation area SW of Palagruža. This increased density is a consequence of relatively small width of opposite sailing routes due to which the traffic is concentrated in the relatively small area, especially around Palagruža where TSS is positioned so that it does not cross the borders of the Croatian territorial waters. In Figure 4 there is a current view of navigation in the central part of the Adriatic.

02.02.2016. UT=0000 08.06.2016. UT=0000 28.08.2016. UT=1847

Figure 4. State of ship traffic in a given moment (cargo-green, tanker-red; fish.-purple; passenger-blue, other-black; vectors-30 min)
Source: Marinetraffic-August, AIS Station PFST-February, June

Figure 5 shows annual traffic density according to the type of ship based on the AIS data for 2014. It is clear that only fishing boats and recreational crafts do not follow the standard longitudinal sailing route. Almost immediately when observing the state of navigation it can be concluded that, in the Adriatic, mainly cargo ships move on the longitudinal sailing routes, with a great number of tankers. Equally, it can be concluded that fishing boats are formed in the vicinity of this area very often.

For the purposes of this paper AIS data about the movement of ships in the area of directed navigation around Palagruža are analyzed, from June 22-29, 2015 and the results are shown in Figure 5 and 6 and the table 2. The results of the analysis, reduced to an annual level, result in the ship traffic from 4200 for NW direction and 4241 for SE direction, i.e. that is a daily average of circa 11,5 ships. The collected data confirm the expected structure and traffic distribution and the data that tankers make 20% of the traffic on the main longitudinal sailing route.

Because of the interruption and mistakes in the AIS signal reception, it was expected that the traffic calculated in such manner should be greater than obtained, also for the same reason there is a relatively great number of ships of unknown type. Also, the data was collected in the part of year when the traffic in the Adriatic is significantly greater than average, but as the structure of the traffic is mainly made of cargo ships, seasonal changes in this sailing route are not so expressed as in the others (Figure 4).

Passanger Cargo Tanker

Tug and special Pleasure Fishing

Figure 5. Traffic density according to the type of ship, year 2014.

Source: Marinetraffic

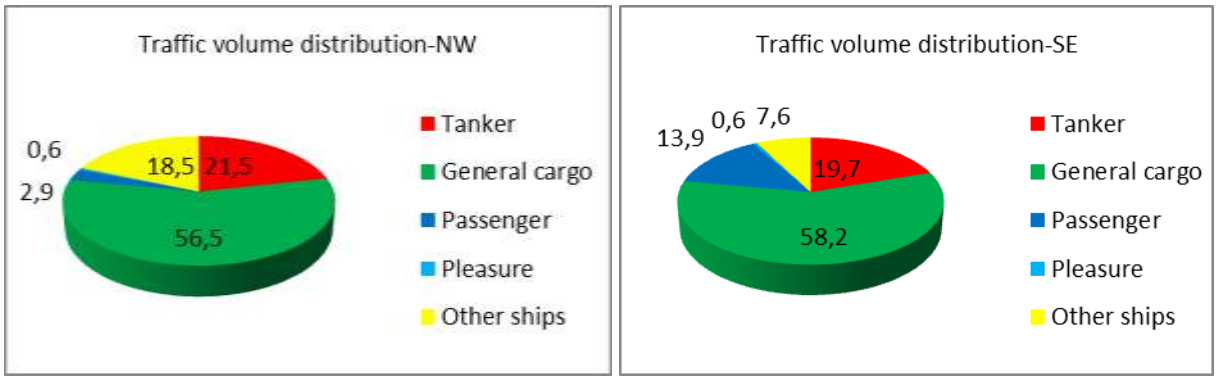


Figure 6. Traffic volume distribution 06/2016

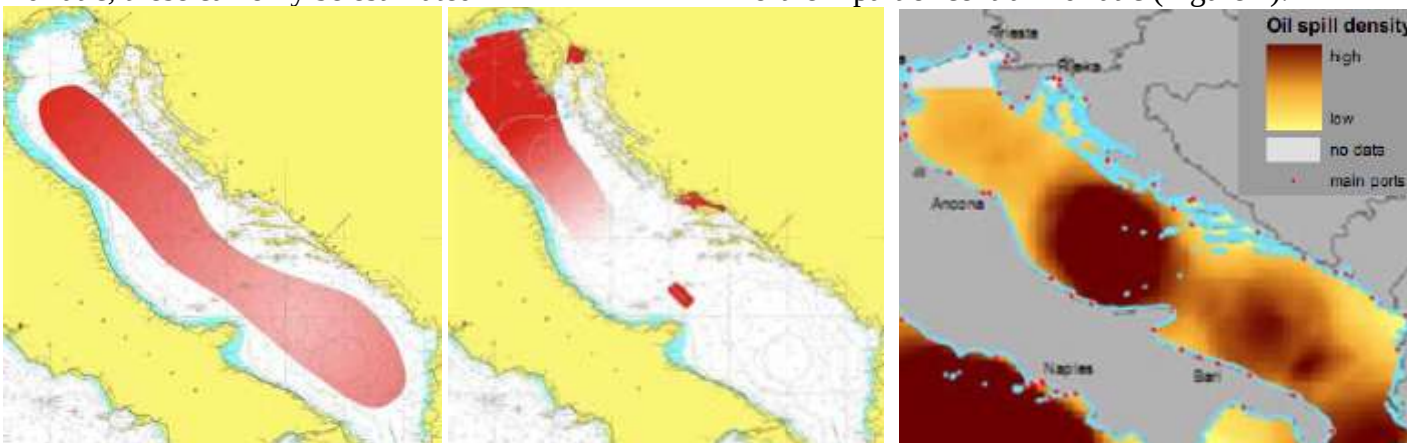
Table 2. Average speed and draft

	SE		NW	
	Average speed	Average draft	Average speed	Average draft
Oil produkt	12,6	6,7	12,5	6,7
General	14,3	5,4	13,6	5,4
Passenger	21,6	3,5	20,1	3,5
Pleasure	10,3	3,4	17,7	3,4
Other	13,8	3,4	12,4	3,4

5 ACCIDENT ANALYSIS

The number of accidents of big merchant ships in the Adriatic is relatively small. Generally speaking, total number of collisions and groundings is great; however this number is mainly relevant to smaller vessels that sail very close to the coast. For instance, in the area of Croatian responsibility, based on the interventions by Port Authority, in the year 2015 there were 11 collisions, 43 groundings, 48 flooding, 9 fires, and so on [www.mmpi.hr]. Examples of greater accidents: sinking of the dry cargo transportation ship ″Cavtat″ in Otranto in 1974 5 nautical miles from the Italian coast; sinking of the tanker "Brigitta Montanari" in 1984; in Murter sea with 1300 t VCM; fire on ro-ro ship "UND Adriyatik" 13 naut. m. SW of Rovinj in 2008; collision of cargo ships

off Ravenna in 2014 etc. In the area of open sea in the Central Adriatic it is important to mention eventual sinking of fishing boats in 2014, after the collision with a merchant ship circa 30 naut. m. before TSS north Adriatic. Since there is no greater number of collisions and groundings in open parts of the Adriatic, these can only be estimated according to some other similar areas in the world. Potential places of groundings derive from positions of the most protruding parts of the coast towards the open sea, and as far as the collisions go, these are mainly places where crossings and narrowing of sailing routes occur. For collisions it will be the area of northern part of central Adriatic (Figure 7).



a) Sinking b) Collision c) Oil pollution

Figure 7. Areas of increased risks
Source: Zec et all., 2009; Case study report-The Adriatic Sea, 2011.

The main longitudinal sailing routes are especially dangerous because it is the main route for tankers. For bigger ports of the Northern Adriatic (Trieste, Venice, Omišalj and Koper) it is annually transported circa 58 million T [Morović, Ivanov, 2011]. So far there were no greater tanker accidents. Smaller slicks, as a consequence to daily operations, were mostly widespread precisely along this route (Figure 8).

Figure 8. Oil slicks detected in the Adriatic
Source: Morović et all, 2015

Additional potential danger for environment is found in gas fields of the Northern Adriatic, as well as the plan to spread the plan to exploit gas and oil along the entire Adriatic. Figure 9 shows the positions of the existing exploitation fields (red) and the plan of researching areas of gas and oil in the area of the Croatian part of the Adriatic [Strategic study, 2015].

Figure 9. Exploitation and researching areas
Source: Strategic study, 2015

6 RESULTS OF THE IWRAP ANALYSIS

As it was already mentioned, AIS ship traffic was analyzed in details in the central Adriatic area, from 12 to 29 June 2015. If the traffic is observed on the main longitudinal sailing route which goes through TSS Palagruža it can be concluded that the probability of collisions and groundings in this area is minimal or, in other words, the expected return period of collision is over 2.000 years, and for groundings 50 years. A small probability like this is expected considering that due to the existence of the traffic separation schemes the opposite waterways are almost completely separated and the transversal traffic is negligible. However, the situation changes considerably if taking into consideration that the main longi-

tudinal sailing route crosses with many small ships´ routes. For example, if in the larger area of the island of Palagruža (marked area in Figure 10) there are 50 ships in average, in 24 hours´ time (30 m of average size) and that each one of them within the 24 hours spends 20 hours sailing and 4 hours drifting, the probability of collision increases significantly, around to 3,39x10-2 (return period 29,5 years). There are no important changes for groundings. Furthermore, if the area of observation expands to TSS Northern Adriatic (Figure 10) the probability of collisions and groundings increases minimally, under condition that a number of smaller vessels within the referential area stays the same. The results confirm that the critical points for collisions are somewhat more to the west than TSS Palagruža, points in which sailing routes branch towards TSS Northern Adriatic.

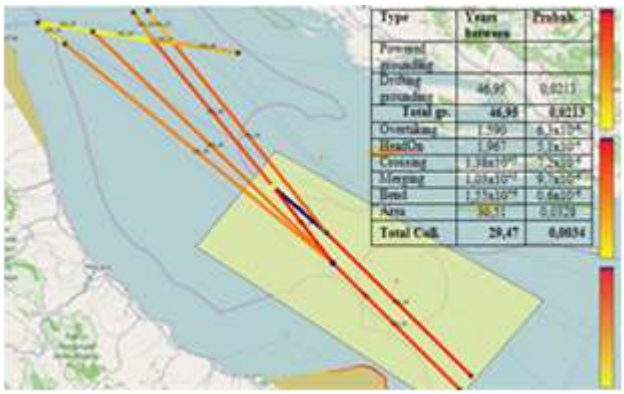


Figure10.Results of the analysis of collisions and groundings - IWRAP

The results of the analysis also show that the probability of tanker participation in potential accidents is very high, especially when observing collisions of bigger ships in the longitudinal sailing route. The results of the analysis also show that the probability of tanker participation in potential accidents is very high, especially when observing collisions of bigger ships in the longitudinal sailing route.

7 RECOMMENDATIONS

Generally, it has to be emphasized that the Adriatic Sea is recorded with regard to accidents and casualties as a high risks area. According to the IMO frequency of accidents in the Adriatic Sea is recorded at a five times higher level than the world average, a fact mostly due to speed boats and yachts accidents [Kačić, 2011].

System-oriented navigation on the main longitudinal sailing route of the Adriatic exists and efficiently separates opposite waterways. Improvements can be made in the establishment of the traffic separation system in Otranto and in the improvement of the traffic separation system near Palagruža, first of all in mutual agreement of the interested countries and acceptance by the IMO. Additional traffic separation systems closer to eastern coasts are not to be expected for now, however suggestions and plans exist. The establishment of hydrocarbon exploitation areas in the Central and Southern Adriatic could consequently demand changes in navigation regulation in the Adriatic, i.e. changes of the existing and establishment of additional regulatory measures as well as navigation supervision. Wider area of Palagruža is an important fishing area as well and in that sense significant fishing vessels traffic can be expected in the future as well as the dangers of collisions. Corresponding movement supervision of these ships and officer training are objective measures which can have a preventive influence on navigation safety.

Navigation supervision service exists in the Adriatic, but the activity needs to be directed towards better coordination of coastal countries and the improvement of the system itself with focus on active tracking of ship traffic. Considering the consequences which can cause accidents of bigger ships, especially tankers, expansion and restructuring of power to act in situations of crisis seem justified, as well as the improvement of the coordination of coastal countries.

8 CONCLUSION

The open sea area of the Central Adriatic at first glance seems like an area in which maritime accidents of bigger ships rarely happen and that navigation in this part of the Adriatic is safe in comparison to other parts. The reason for this are established separation zones, established navigation supervision service, small intensity transversal traffic, moderate traffic on the main longitudinal route and lack of bigger accidents. Precisely the lack of bigger accidents is one of the main reasons of fake safety. In other words, the main longitudinal route is tankers´ main path from Otranto to bigger ports in the NW Adriatic and any bigger accident of these ships would have catastrophic consequences to coastal countries, their economies, environment etc.

If AIS ship traffic is observed, it can be concluded that this traffic on the main longitudinal sailing route is of moderate intensity, mostly consistent throughout the entire year. The greatest danger is the narrowing and crossing of sailing routes in the part between TSS Northern Adriatic and TSS Palagruža. In the summer months this part of the Adriatic is additionally loaded by ships and yachts traffic, and somewhat increased transversal traffic. Also, a great danger is found in fishing vessels that frequently concentrate in this area crossing their routes with the

main longitudinal sailing route. The results of the analysis show that the probability of bigger ships collisions with these vessels in the part of the mentioned TSS is the biggest.

Bearing in mind further increase in maritime traffic in the Adriatic, the same or bigger fishing or other vessels traffic, hydrocarbon exploitation expansion to the entire Adriatic and negative or better yet catastrophic effect of any bigger accident on the main longitudinal sailing route, the need to additionally improve the navigation safety system is unquestionable. There is room for that, especially in the establishment of more effective and modern ship supervision system, improvement of regulatory measures of navigation regulation (ships routing), improvement of system of action in situations of crisis and better coordination between countries, preventively as well as after the accidents.

REFERENCES

Adria VTS-služba nadzora i upravljanja pomorskom plovidbom na Jadranu, report v2.1, 2009

http://www.autoritaportuale.ancona.it/images/RAPPORTO_STATISTICO_2015.pdf (Port of Ancona-statistics 2015, August 2016)

http://www.iala-aism.org/products/technical/risk-management-tools.html (IWRAP MkII, August 2016)

http://www.mppi.hr/UserDocsImages/SAR%20stat%202015%201.I.-31.XII.%2020-1_16.pdf (SAR akcije-RH, september 2016.)

http://www.port.ravenna.it/traffico-porto-di-ravenna-il-2014-si-chiude-con-lottimo-risultato-di-un-88/ (Traffico porto di Ravenna 2014-August 2015)

http://www.porto.monfalcone.gorizia.it/public/allegati/23-4-2016-11-59-56_354084.pdf (Porto Monfalcone-2015, August 2016)

http://www.porto.trieste.it/wp-content/uploads/2015/04/ESPO-Statistics-2014-EN-2.pdf (Port of Trieste-statistics, August 2016)

https://luka-kp.si/eng/311 (Port of Koper-statistics 2015, August 2016)

https://www.port.venice.it/files/page/apvstatistiche2015_0.pdf (PORT OF VENICE, August 2016)

IMO-a, MSC.139(76)

IWRAP software

Kačić, H.: Traffic separation schemes in the Adriatic Sea, Round table "EU Maritime Policy and the (Northern) Adriatic" organized by the Maritime Law Association of Slovenia (MLAS), Portorose, 2011.

Komadina, P.; Brčić, D.; Frančić, V.: VTMIS služba u funkciji unaprjeđenja sigurnosti pomorskog prometa i zaštite okoliša na Jadranu, Pomorski zbornik 47-48 (2013), 27-40

Lakoš, S.: Prilog istraživanju regulacije plovidbe Jadranom- Doktorat, Pomorski fakultet u Rijeci, 1980.

Lušić, Z.: Kos, S.: Glavni plovidbeni putovi na Jadranu, Naše more 53 (5-6), Dubrovnik, 2006, 198-205.

Morović. M.; Ivanov, A.: Oil Spill Monitoring in the Croatian Adriatic Waters:needs and possibilities, ACTA ADR IAT., 52(1): 2011, 45 – 56.

Morović. M.; Ivanov, A.; Oluić, M.: Oil spills distribution in the Middle and Southern Adriatic Sea as a result of intensive ship traffic, ACTA ADR IAT., 56(2): 2015, 145 – 156.

Nadzor i upravljanje pomorskim prometom u unutarnjim morskim vodama i teritorijalnom moru Republike Hrvatske, Hrvatski hidrografski institut, Split, 2015.

Peljar I, Jadransko more-istočna obala, Hrvatski hidrografski Institut, Split, 2012.

Plovput d.o.o Split

Pre-accesion maritime transport strategy of the republic of Croatia, The Ministry of the Sea, Tourism, Transport and Development, Zagreb, 2005.

Prometno-plovidbena studija, plovna područja: Primorsko-goranske, Ličko-senjske, Zadarske i Šibensko-kninske županije, Pomorski fakultet u Rijeci, Rijeka, 2015.

Prometno-plovidbena studija, plovno području Split, Ploče i Dubrovnik, Pomorski fakultet u Rijeci, Rijeka, 2014.

Službeni list SFRJ, Broj 21 – str 555, od 17. Ožujka 1989

Strateška studija o vjerojatno značajnom utjecaju na okoliš Okvirnog plana i programa istraživanja i eksploatacije ugljikovodika na Jadranu, Ires ekologija d.o.o. za zaštitu prirode i okoliša, Zagreb, 2015.

The potential of Maritime Spatial Planning in the Mediterranean Sea" Case study report: The Adriatic Sea, Policy Research Corporation , Brussels, 2011.

Zec, D.; Maglic, L.; Simic Hlaca, M.: "Maritime Transport and Possible Accidents in the Adriatic Sea", Presentation in Dubrovnik, 2009 (https://bib.irb.hr/datoteka/450379.Maritime_Transport_and_Possible_Accidents_in_the_Adriatic.pdf)