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1. EXECUTIVE SUMMARY

Some data regarding availability of C02 emission from vessels sailing in the Adriatic Sea are analysed. They are obtained from the Thetis – MRV system and refer to year 2018. Data refer to three Croatian and one Italian ferry that operate on cross-boundary routes between Italy and Croatia. All four ferries, being above 5000 GT in size, are obligated to report their data according to the EU Regulation 757/2015.

2. INTRODUCTION

This report is based on a public database of vessel performance and CO2 emissions available from June 2019 (e.g. using data from voyage reports stemming from several maritime routes) from THETIS-MRV website which is published by European Maritime Safety Agency (EMSA). In addition, some data regarding the number of passengers and vehicles are obtained from Croatian Coastal Shipping Agency for complementing this analysis.

Currently, ferries that sail from Italy to Croatia are departing from Ancona, Bari, Cesenatico, Pesaro, Pescara, Trieste and Venice. Possible options to get to Croatia from Italy and vice versa are by car, bus, track, motorbike or bikes.

- RoPax service between Ancona and Split;
- RoPax service between Ancona and Zadar;
- RoPax service between Bari and Dubrovnik.

RoPax vessels between Ancona and Split sail all year round while Ancona to Zadar and Bari to Dubrovnik RoPax vessels usually sail just from April to October.

Figure 1: Adriatic sea ports

Source: JimB Sail, http://www.jimbsail.info/mediterranean/adriatic/east-italy

Figure 1 represents the main ports of the Adriatic Sea which include following Countries: Italy, Croatia, Slovenia, Montenegro, and Albania. It is important to mention that the shortest line of 70 nm is between the island of Lastovo (Croatia) and Vieste (Italy). However, the only cross border cooperation between Italy and Croatia that is operated by the ships above 5.000 GT is made on the following route:

- Split – Stari Grad – Ancona

- Zadar – Ancona
- Dubrovnik – Bari
- Split – Ancona

Therefore, the ships that operate on these lines will be analyzed in this report.

3. METHODOLOGY

According to MRV Regulation, shipowners are required to monitor, report and verify C02 emissions, and upload it to THETIS-MRV. In order to represent the results, this report will include the following methods:

- Extraction of a few information from the public Thetis – MRV database
- Complement information from the Thetis – MRV database with information from other sources
- Comparison of a few metrics from the various vessels considered

For effective display of results, some graphical comparisons will be used.

In the first part of this chapter, basic characteristics of the ships will be displayed and then emission report details will be shown.

3.1 Basic characteristics of the ships

From Italian side there are two ships which have been analysed::

1. Aurelia, owned by Snav SPA
2. GNV Azzurra, owned by the Mediterranean Shipping Company (MSC)

From the Croatian side, there are three ships owned by company Jadrolinija which have been analysed:

1. M/B Marko Polo;
2. M/B Zadar;
3. MT Dubrovnik.

3.1.1 M/B Marko Polo

Ship M/B Marko Polo is defined as Ro-Ro/Passenger Ship. It was built in the year 1973 and the following characteristics are show in the table below.

Table 1: Characteristics of the ship M/B Marko Polo

IMO NUMBER	7230599
LENGTH	128,1 meters
WIDTH	19,6 meters
DRAFT	5,7 meters
SPEED	19,5 knots
PASSENGER CAPACTIY	1.100
CABIN PASSENGER CAPACITY	547
VEHICLE CAPACITY	270
GROSS TONNAGE	10.154
DEADWEIGHT	1.132 tons

Source: Jadrolinija, https://www.jadrolinija.hr/en/about-us/ships/ferries/ferries-for-coastal-and-international-shipping/marko-polo,MarineTraffic, https://www.marinetraffic.com/en/ais/details/ships/shipid:208981/mmsi:238144000/imo:7230599/vessel:MARKO_POLO

Figure 2: Ship M/B Marko Polo, Jadrolinija

Source: Jadrolinija, https://www.jadrolinija.hr/en/about-us/ships/ferries/ferries-for-coastal-and-international-shipping/marko-polo

According to the Croatian Coastal Line Services Agency, in the period from January 1 until December 31, 2018, ship Marko Polo transported 78.841 passengers and 19.753 vehicles on a route Split - Stari Grad – Ancona. Allowed vehicles are: cars (up and over 5 m length), trailers (up to 3 m length), camper/motorhome (up to 5 m/to 7 m/over 7 m length), motorcycles/mopeds and bikes.

3.1.2 M/B Zadar

Ship M/B Zadar is defined as Ro-Ro/Passenger Ship. It was built in the year 1993 and the following characteristics are show in the table below.

Table 2: Characteristics of the ship M/B Zadar

IMO NUMBER	9021485
LENGTH	116 meters
WIDTH	18,9 meters
DRAFT	5,2 meters
SPEED	17,5 knots
PASSENGER CAPACTIY	1.053
CABIN PASSENGER CAPACITY	56
VEHICLE CAPACITY	280
GROSS TONNAGE	9.487
DEADWEIGHT	2.152 tons

Source: Jadrolinija, https://www.jadrolinija.hr/en/about-us/ships/ferries/ferries-for-coastal-and-international-shipping/zadar, MarineTraffic, https://www.marinetraffic.com/en/ais/details/ships/shipid:209105/mmsi:238201000/vessel:ZADAR

Figure 3: Ship M/B Zadar, Jadrolinija

Source: Jadrolinija, https://www.jadrolinija.hr/en/about-us/ships/ferries/ferries-for-coastal-and-international-shipping/zadar

According to the Croatian Coastal Line Services Agency, in the period from June 4 until September 25, 2018, Zadar transported 39.290 passengers and 8.526 vehicles on a route Zadar – Ancona. Allowed vehicles are: cars (up and over 5 m length), trailers (up to 3 m length), camper/motorhome (up to 5 m/to 7 m/over 7 m length), motorcycles/mopeds and bikes.

3.1.3 MT Dubrovnik

Ship M/B Zadar is defined as Ro-Ro/Passenger Ship. It was built in year 1993 and the following characteristics are are show in the table below.

Table 3: Characteristics of the ship MT Dubrovnik

IMO NUMBER	7615048
LENGTH	122 meters
WIDTH	18,8 meters

DRAFT	4,8 meters
SPEED	20 knots
PASSENGER CAPACTIY	1.300
CABIN PASSENGER CAPACITY	457
VEHICLE CAPACITY	300
GROSS TONNAGE	9.795
DEADWEIGHT	1.310 tons

Source: Jadrolinija, https://www.jadrolinija.hr/en/about-us/ships/ferries/ferries-for-coastal-and-international-shipping/dubrovnik, MarineTraffic, https://www.marinetraffic.com/en/ais/details/ships/shipid:208978/mmsi:238143000/vessel:DUBROVNIK

Figure 4: Ship MT Dubrovnik, Jadrolinija

Source: Jadrolinija, https://www.jadrolinija.hr/en/about-us/ships/ferries/ferries-for-coastal-and-international-shipping/dubrovnik

According to the Croatian Coastal Line Services Agency, in the period from March 23 until November 19, 2018, Zadar transported 67.923 passengers and 13.890 vehicles on a route Dubrovnik - Bari. Allowed vehicles are: cars (up and over 5 m length), trailers (up to 3 m length), camper/motorhome (up to 5 m/to 7 m/over 7 m length), motorcycles/mopeds and bikes.

3.1.4 Aurelia

Ship Aurelia is defined as Ro-Ro/Passenger Ship. It was built in year 1980 and the following characteristics are shown in the table below.

Table 4: Characteristics of the ship Aurelia, Snav SPA

IMO NUMBER	7602120
LENGTH	147,99 meters
WIDTH	25,4 meters
DRAFT	5,8 meters
SPEED	19,5 knots
PASSENGER CAPACTIY	2.280
CABIN PASSENGER CAPACITY	568
VEHICLE CAPACITY	1.434
GROSS TONNAGE	21.518
DEADWEIGHT	3.250 tons

Source: The ferry site, http://www.ferry-site.dk/ferry.php?id=7602120&lang=en, MarineTraffic, https://www.marinetraffic.com/hr/ais/details/ships/shipid:273447/imo:7602120/mmsi:247001200/vessel:AURELIA

Figure 5: Ship Aurelia, Snav SPA

Source:MarineTraffic,
https://www.marinetraffic.com/hr/ais/details/ships/shipid:273447/imo:7602120/mmsi:247001200/vessel:AURELIA

According to the CIMIS dataset GNV Azzura operated between Split and Ancona in May 2019 but Croatian Coastal Line Services Agency didn't receive any records regarding this ship for the year 2018.

3.1.5 GNV Azzura

Ship GNV Azzura is defined as Ro-pax ship. It was built in year 1981 and the following characteristics are shown in the table below.

Table 5: Characteristics of the ship GNV Azzurra

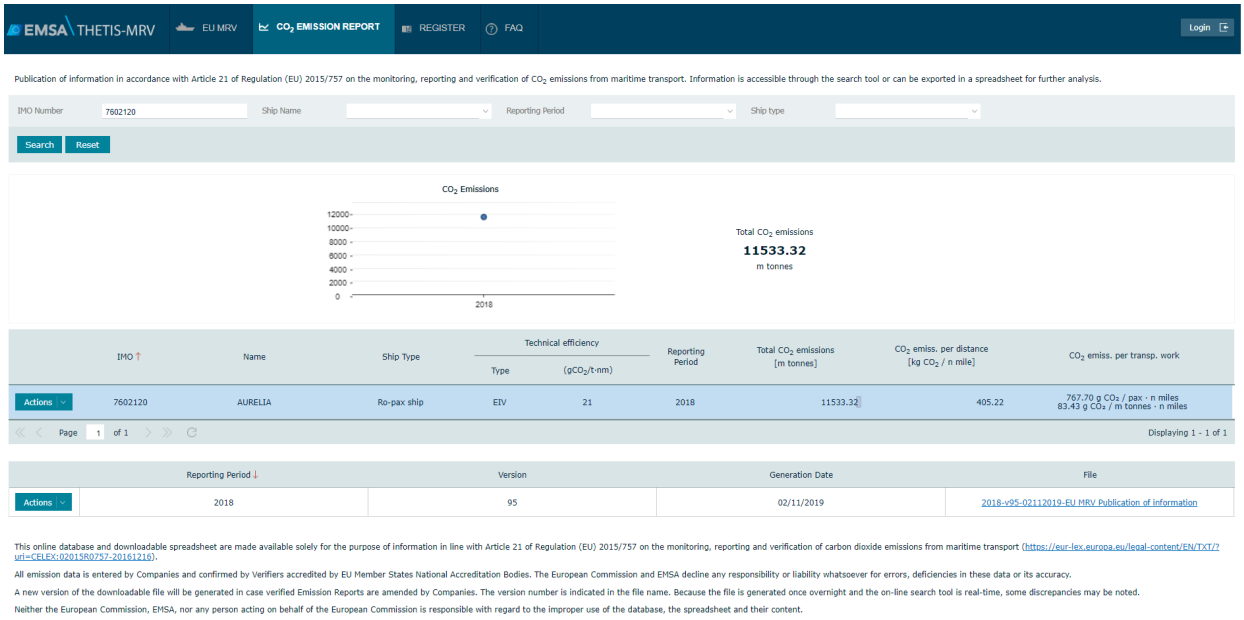
IMO NUMBER	7826790
LENGTH	168,49 meters
WIDTH	26,4 meters
DRAFT	n.a.
SPEED	17 knots
PASSENGER CAPACTIY	2.180
CABIN PASSENGER CAPACITY	522
VEHICLE CAPACITY	562
GROSS TONNAGE	30.316
DEADWEIGHT	3.630 tons

Source:MarineTraffic,https://www.marinetraffic.com/en/ais/details/ships/shipid:279499/mmsi:247237700/vessel:GNV%20AZZURRA,

3.2 Emission Report Details

In order to support the Regulation (EU) 2015/757 on Monitoring, Reporting and Verification of CO2 from marine transport, European Maritime Safety Agency (EMSA) has developed a new module in THETIS, namely THETIS-MRV which serves as Information System where companies are able to report their CO2 emissions regarding the operation of large ships using EU ports. THETIS-MRV is a web-based application where all relevant parties foreseen by the Regulation can fulfil their monitoring and reporting obligations in a centralized and harmonized way. It consists of a mandatory and a voluntary module. Through the mandatory module, companies will generate Emission Reports which will then be assessed by Verifiers who will issue a Document of Compliance in system. While through the voluntary module, companies may draft their monitoring plans and the system will make them available for verifier' assessment.

Figure 6: THETIS-MRV overview



Source: EMSA, https://mrv.emsa.europa.eu/#public/emission-report

For the purpose of this report, the method of extracting data regarding emission details from the public Thetis – MRV database will be used. For each ship mentioned above, the following information will be extracted:

- basic overview of the CO2 emission;
- ship and verifier details;
- monitoring details;
- annual monitoring results;
- voluntary reporting.

3.2.1 Basic overview of the CO2 emission

The table below presents the basics overview of the CO2 emission which includes data for three Croatian ships and one Italian ship.

Estimated Index Value (EIV) provides a newbuilding standard, assuring that ship designs achieve a certain level of efficiency and decrease carbon emissions.

Table 6: THETIS-MRV overview of the ships

	MARKO POLO	**ZADAR**	**DUBROVNIK**	**AURELIA**
Ship type	Ro-pax ship	Ro-pax ship	Ro-pax ship	Ro-pax ship
Technical efficiency - Type	EIV	EIV	EIV	EIV
Technical efficiency – GCo2/t · nm	45	23	30	21
Reporting period	2018	2018	2018	2018
Total C02 emissions (m tones)	11703.31	8815.83	11502.23	11533.32
CO2 emiss.per distance (kg CO2/nmile)	355.43	261.63	344.74	405.22
CO2 emiss. per transp. work	4.90 g CO_2 / pax · n miles	1.18 g CO_2 / pax · n miles	3.59 g CO_2 / pax · n miles	767.70 g CO_2 / pax · n miles
	2.35 g CO_2 / m tones · n miles	0.42 g CO_2 / m tones · n miles	2.50 g CO_2 / m tones · n miles	83.43 g CO_2 / m tones · n miles

Source: THETIS-MRV database, https://mrv.emsa.europa.eu/#public/emission-report

From the Table 6 it can be distinguished that the biggest amount of total CO2 emissions is released by the ship Marko Polo. The reason could be found in the fact that that is the only ship which operates during the whole year while other three only in certain period of the year.

3.2.3 Monitoring details

The company shall define in the monitoring plan which monitoring methodology is used to calculate fuel consumption for each ship type under its responsibility and ensure that once it has been chosen, is consistently applied. In selecting a monitoring methodology, the improvements from greater accuracy shall be balanced against the additional costs. Actual fuel consumption for each voyage shall be used and be calculated using one of the following methods:

- A: Bunker Fuel Delivery Note (BDN) and periodic stocktakes of fuel tanks
- B: Bunker fuel tank monitoring on board
- C: Flow meters for applicable combustion processes
- D: Direct emissions measurements

For the purposes of calculating CO2 emissions companies shall apply the following formula: **Fuel consumption × emission factor** (method A, B and C).

Fuel consumption shall include fuel consumed by main engines, auxiliary engines, gas turbines, boilers and inert gas generators. Fuel consumption within ports at berth shall be calculated separately. In principle, default values for emission factors of fuels shall be used unless the company decides to use data on fuel quality set out in the Bunker Fuel Delivery Notes (BDN) and used for demonstrating compliance with applicable regulations of sulphur emissions. Those default values for emission factors shall be based on the latest available values of the Intergovernmental Panel for Climate Change (IPCC). Those values can be derived from Annex VI to Commission Regulation (EU) No 601/2012 (1). Appropriate emission factors shall be applied in respect of biofuels and alternative non-fossil fuels.

The company shall define in the monitoring plan which monitoring method is to be used to calculate fuel consumption for each ship under its responsibility and ensure that once the method has been chosen, it is consistently applied.

Actual fuel consumption for each voyage shall be used and be calculated using one of the following methods:

- Method A: Bunker Fuel Delivery Note (BDN) and periodic stocktakes of fuel tanks;
- Method B: Bunker fuel tank monitoring on board;
- Method C: Flow meters for applicable combustion processes;
- Method D: Direct CO2 emissions measurements.

Any combination of these methods, once assessed by the verifier, may be used if it enhances the overall accuracy of the measurement.

Method A is based on the quantity and type of fuel as defined on the BDN combined with periodic stocktakes of fuel tanks based on tank readings. The fuel at the beginning of the period, plus deliveries, minus fuel available at the end of the period and de-bunkered fuel between the beginning of the period and the end of the period together constitute the fuel consumed over the period. The period means the time between two port calls or time within a port. For the fuel used during a period, the fuel type and the sulphur content need to be specified. This method shall not be used when BDN are not available on board ships, especially when cargo is used as a fuel, for example, liquefied natural gas (LNG) boil-off.

Under existing MARPOL Annex VI regulations, the BDN is mandatory, is to be retained on board for three years after the delivery of the bunker fuel and is to be readily available. The periodic stocktake of fuel tanks on-board is based on fuel tank readings. It uses tank tables relevant to each fuel tank to determine the volume at the time of the fuel tank reading. The uncertainty associated with the BDN shall be specified in the monitoring plan. Fuel tank readings shall be carried out by appropriate methods such as automated systems, soundings and dip tapes. The method for tank sounding and uncertainty associated shall be specified in the monitoring plan.

Where the amount of fuel uplift or the amount of fuel remaining in the tanks is determined in units of volume, expressed in litres, the company shall convert that amount from volume to mass by using actual density values. The company shall determine the actual density by using one of the following:

- on-board measurement systems
- the density measured by the fuel supplier at fuel uplift and recorded on the fuel invoice or BDN

- the density measured in a test analysis conducted in an accredited fuel test laboratory, where available

The actual density shall be expressed in kg/l and determined for the applicable temperature for a specific measurement. In cases for which actual density values are not available, a standard density factor for the relevant fuel type shall be applied once assessed by the verifier.

Method B is based on fuel tank readings for all fuel tanks on-board. The tank readings shall occur daily when the ship is at sea and each time the ship is bunkering or de-bunkering. The cumulative variations of the fuel tank level between two readings constitute the fuel consumed over the period. The period means the time between two port calls or time within a port. For the fuel used during a period, the fuel type and the Sulphur content need to be specified. Fuel tank readings shall be carried out by appropriate methods such as automated systems, soundings and dip tapes. The method for tank sounding and uncertainty associated shall be specified in the monitoring plan.

Where the amount of fuel uplift or the amount of fuel remaining in the tanks is determined in units of volume, expressed in liters, the company shall convert that amount from volume to mass by using actual density values. The company shall determine the actual density by using one of the following:

- on-board measurement systems
- the density measured by the fuel supplier at fuel uplift and recorded on the fuel invoice or BDN
- the density measured in a test analysis conducted in an accredited fuel test laboratory, where available

The actual density shall be expressed in kg/l and determined for the applicable temperature for a specific measurement. In cases for which actual density values are not available, a standard density factor for the relevant fuel type shall be applied once assessed by the verifier.

Method C is based on measured fuel flows on-board. The data from all flow meters linked to relevant CO2 emission sources shall be combined to determine all fuel consumption for a specific period. The period means the time between two port calls or time within a port. For the fuel used during a period, the fuel type and the Sulphur content need to be monitored. The calibration methods applied and the uncertainty associated with flow meters used shall be specified in the monitoring plan.

Where the amount of fuel consumed is determined in units of volume, expressed in liters, the company shall convert that amount from volume to mass by using actual density values. The company shall determine the actual density by using one of the following:

- on-board measurement systems
- the density measured by the fuel supplier at fuel uplift and recorded on the fuel invoice or BDN

The actual density shall be expressed in kg/l and determined for the applicable temperature for a specific measurement. In cases for which actual density values are not available, a standard density factor for the relevant fuel type shall be applied once assessed by the verifier.

For the **method D**, The direct CO2 emissions measurements may be used for voyages and for CO2 emissions occurring in ports located in a Member State's jurisdiction. CO2 emitted shall include CO2 emitted by main engines, auxiliary engines, gas turbines, boilers and inert gas generators. For ships for which reporting is based on this method, the fuel consumption shall be calculated using the measured CO2 emissions and the applicable emission factor of the relevant fuels. This method is based on the determination of CO2 emission flows in exhaust gas stacks (funnels) by multiplying the CO2 concentration of the exhaust gas with the exhaust gas flow. The calibration methods applied and the uncertainty associated with the devices used shall be specified in the monitoring plan.

Table 7: Monitoring details

	MARKO POLO	**ZADAR**	**DUBROVNIK**	**AURELIA**
Monitoring method	Method B: Bunker fuel tank monitoring on-board	Method B: Bunker fuel tank monitoring on-board	Method B: Bunker fuel tank monitoring on-board	Method A: BDN and period stock takes of fuel tanks

Source: THETIS-MRV database, https://mrv.emsa.europa.eu/#public/emission-report

From the Table 7 it could be read that all three Croatian ships use method B while Aurelia uses method A.

3.2.4 Annual monitoring results

Companies reporting on an annual basis are to monitor:

- Quantity of fuel used, each type of fuel used and emission factor for each type of fuel;
- Total aggregated CO2 emitted within the scope of this Regulation;
- Aggregated CO2 emissions from all voyages between ports under a Member State's jurisdiction;
- aggregated CO2 emissions from all voyages to or from ports under a Member State's jurisdiction;
- CO2 emissions which occurred within ports under a Member State's jurisdiction at berth;
- Total distance travelled;
- Total time spent at sea;
- Total transport work;
- Average energy efficiency
- Information relating to the ship's ice class and to navigation through ice, where applicable.

Table 8: Annual monitoring results

	MARKO POLO	**ZADAR**	**DUBROVNIK**	**AURELIA**
Total fuel consumption	3650.44 m tones	2749.79 m tones	3587.72 m tones	3663.55 m tones
Total CO_2 emissions	11703.31 m tones	8815.83 m tones	11502.23 m tones	11533.32 m tones
CO_2 emissions from all voyages between ports under a MS jurisdiction	9803.81m tones	6084.01m tones	7488.75m tones	10560.11m tones

CO_2 emissions from all voyages which departed from ports under a MS jurisdiction	0.00m tones	0.00m tones	1359.17m tones	0.00m tones
CO_2 emissions from all voyages to ports under a MS jurisdiction	0.00m tones	0.00m tones	1356.82m tones	0.00m tones
CO_2 emissions which occurred within ports under a MS jurisdiction at berth	1899.49m tones	2731.81m tones	1167.34m tones	973.21m tones
CO_2 emissions assigned to Passenger transport	11703.31m tones	8815.83m tones	11502.23m tones	10725.98m tones
CO_2 emissions assigned to Freight transport	11703.31m tones	8815.83m tones	11502.23m tones	807.34m tones
Annual Total time spent at sea	2618.75hours	2778.00hours	2843.25hours	2196.41hours

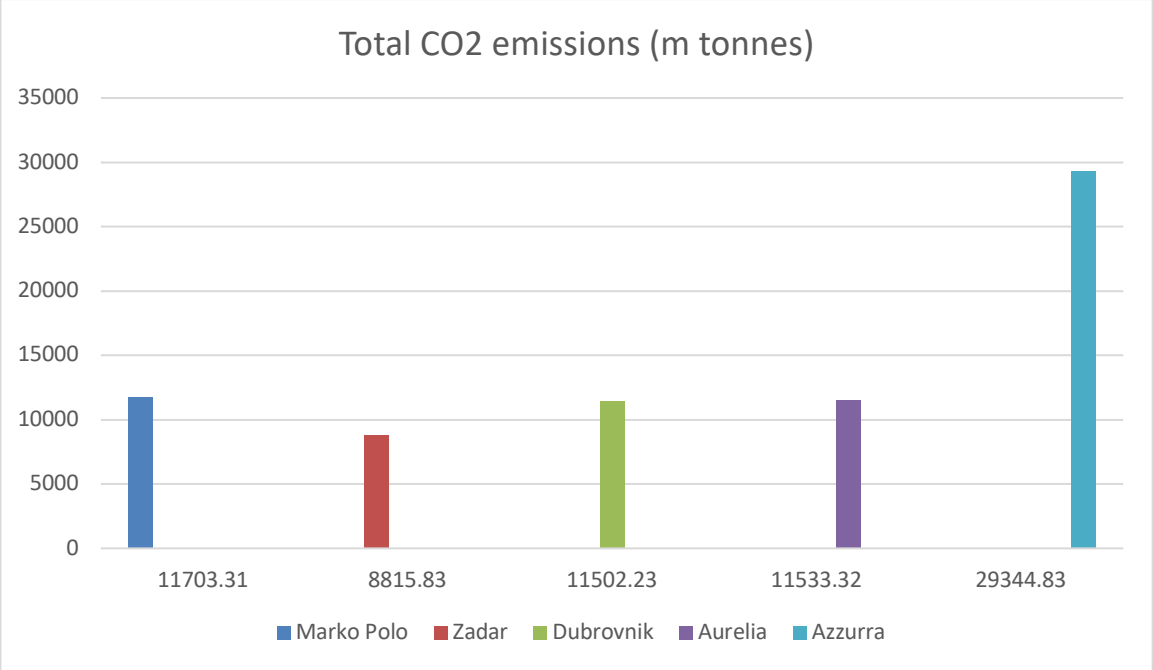
Source: THETIS-MRV database, https://mrv.emsa.europa.eu/#public/emission-report

From the Table 8 it is interesting to read that the Dubrovnik ship spent the most hours at the sea while the Marko Polo ship has the biggest amount of CO2 emissions. Also, the lowest amount of the fuel consumption is by the Zadar ship and on the opposite is the Aurelia ship with the largest amount of the fuel consumption.

4. RESULTS

All four ferries operate differently and it is important to compare the crucial parameters.

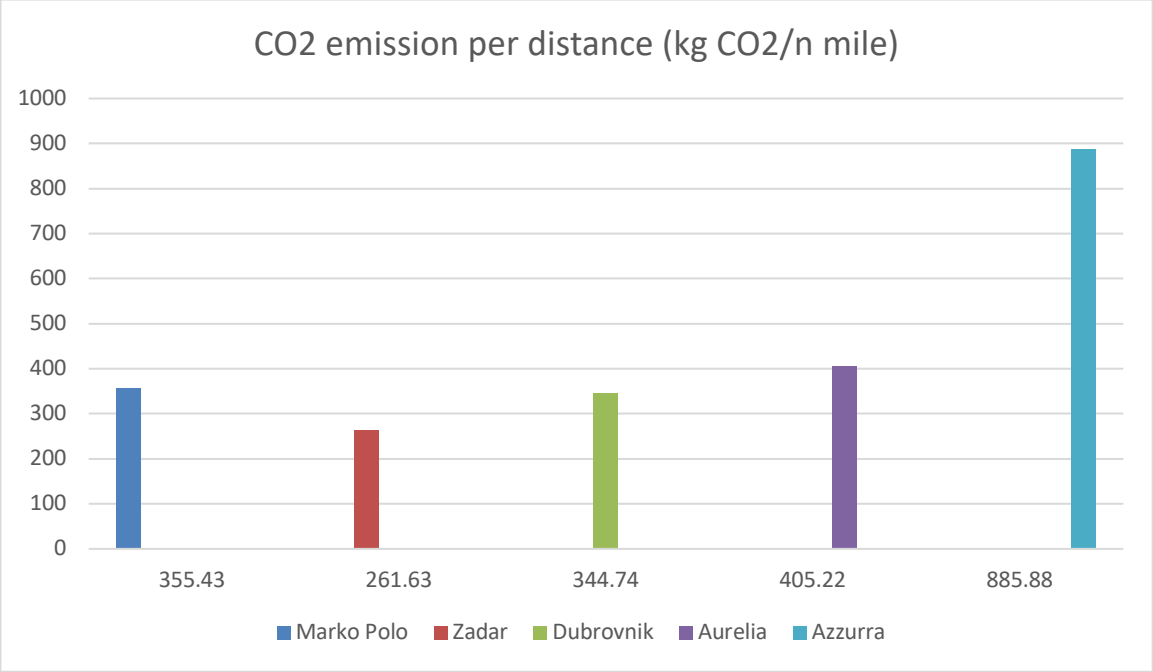
Figure 7: Overview of total C02 emissions



Source: THETIS-MRV database, https://mrv.emsa.europa.eu/#public/emission-report

The Figure 7 shows comparison of the total CO2 emissions from 2018. The GNV Azzurra ship released the biggest amount of 11.703,31 of total C02 emissions (m tones) while the least amount is released by the Zadar ship. The next biggest releaser is the ship Marko Polo which operated from January 1 until December 31, 2018 and Zadar from June 4 until September 25, 2018.

Figure 8: Overview of C02 emission per distance



Source: THETIS-MRV database, https://mrv.emsa.europa.eu/#public/emission-report

From the Figure 8 it could be seen that the biggest amount of CO2 emission per distance is released by the GNV Azzurra while the next biggest releaser is Aurelia ship . Furthermore, Aurelia spent the lowest amount of hours at the sea which is 2196.41 hours. On the other side, the Zadar ship has the lowest amount of CO2 emission per distance with 2778.00 hours spent at the sea.

5. CONCLUSIONS

From the five vessels considered in this report, the total amount of fuel consumption in 2018 is 22.959,07 metric tonnes and the total amount of CO2 emission is 72.899,52 metric tonnes.

The source of data for this report were the THETIS-MRV database and the Croatian Coastal Line Services Agency.

Finally, CSA Mare Nostrum recommends to track THETIS-MRV database in the coming years in order to compare the parameters with the year 2018.