Deliverable D.T1.2.1 - Risk measures report

Version n. 1.00

Subtitle **12/2023**

SUMMARY

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LIST OF ACRONYMS

ADRIREP - Mandatory ships reporting system in the Adriatic Sea

AIS – Automatic Identification System

AMSPM - Administration for Maritime Safety and Port Management of Montenegro

ASL - Above Sea Level

ASTERIX - All-Purpose Structured Eurocontrol Surveillance Information Exchange

ATA - Actual Time of Arrival

AtoN - Aids to Navigation

BC - Beneficiary Country

BoQ - Bill of Quantity

BS - Base Station

CA - Contracting Authority

CAMP - Coastal Area Management Programme

CS - Coastal Station

CCTV - Closed Circuit TV

DB - Database

DF - Direction Finding

DGNSS – Differential Global Navigation Satellite System

DGPS - Differential Global Positioning System

EC – European Commission

ECDIS - Electronic Charts Display and Information System

EEZ - Exclusive Economic Zone

EMSA – European Maritime Safety Agency

ETA - Estimated Time of Arrival

ETD - Estimated Time of Departure

ENI - European Neighbourhood Instrument

EU – European Union

FAL - Convention on Facilitation of International Maritime Traffic

GMDSS - Global Maritime Distress and Safety System

GIS - Geographic Information System

GPS - Global Positioning System

HAZMAT - Dangerous and Polluting Goods

HM - Harbour Master

IALA - International Association of Marine Aids to Navigation and Lighthouse Authorities

ICG - Italian Coast Guard

IMDG - International Maritime Dangerous Goods

IMO - International Maritime Organization

IMS - Integrated Maritime Services

IPA II - Instrument for Pre-Accession II

ISPS - International Code for the Security of Ships and of Port Facilities

ITOPF - The International Tanker Owners Pollution Federation Limited

IVEF - Inter VTS Exchange Format

LRIT - Long Range Information and Tracking system

MAREΣ – Mediterranean Regional AIS server

MARPOL - International Convention for the Prevention of Pollution from Ships

MMSI – Maritime Mobile Service Identities

MRCC - Maritime Rescue Coordination Centre

MTTR - Mean time to repair

N.A. - Not Applicable

NAS - Navigational Assistance Service

NAIS - National Agency for Information Society

NCA – National Competent Authority

NM - Nautical Miles

OPRC - International Convention on Oil Pollution Preparedness, Response and Cooperation

OSD - Oil Spill Detection

PCS - Port Community System

PFSO - Port Facility Security Officer

PMC - Port Monitoring Centre

PSSA - Particularly Sensitive Sea Area

PS - Port State

PSC - Port State Control

RF - Radio Frequency

SafeSeaNet - Vessel traffic monitoring in EU waters

SAR - Search and Rescue

SOLAS - Safety of Life at Sea SP State Police

SAR - Synthetic Aperture Radar or Search and Rescue

SLA – Service Level Agreement

SSL - Secure Sockets Layer

TBC - To Be Confirmed

UPS - Uninterruptible Power Supply

VHF - Very High Frequency

VoIP - Voice over Internet Protocol

VPN - Virtual Private Network

VTMIS - Vessel Traffic Monitoring and Information Services

VTS - Vessel Traffic Services

WAN - Wide Area Network

WMS - Web Mapping Services

XML - eXtensible Markup Language

1. INTRODUCTION

The Adriatic Sea is an 870-km-long, semi-closed gulf that stretches in a southeast-northwest direction. It is connected to the Mediterranean basin by the Otranto channel which is about 70 km wide and has a maximum depth of 789 m. According to the bathymetry and different oceanographic properties, there are three basins of the Adriatic Sea: northern, middle and southern. The biological characteristics of these basins are determined by different factors morphology of the seabed, meteorological characteristics, hydrodynamics and influence of land.

The Adriatic Sea has dense vessel traffic, and accordingly, with significant risks of operational pollution along with the constant threat of maritime accidents. There have developed the means to detect much of the pollution in the Adriatic Sea using satellite images and the process of backtracking, resulting in the estimation of its extent, involved means, and identification of polluters. It is concluded that the increasing volume of traffic in the Adriatic is related to pollution from commercial vessels. There are other sources pollution including various industries and waste the seabed, and the wrecks.

In other hand maritime transportation among Italy, Albania, and Montenegro has enormous potential for the rise. It has a positive effect on the economic side. I will also increase the chance of disasters related to hazardous materials, which may have a negative impact on the economy.

The Interreg Albania-Italy-Montenegro project CRISIS (Cross-border RISk management of hazardous material transportation) aims to study these peculiar risks by considering data and records in the Italian, Albanian and Montenegrin territories. The project intends to develop Decision Support modules, to assist cross-border management of hazardous materials, from risk prevention to cooperation in case of disaster. These modules will implement an ICT platform for monitoring the transportation of these materials, which will assist the stakeholders in several ways to minimise risks[1].

1.1 General Background

Every year, ships sail through the Adriatic Sea, carrying an average of 75 million tons of oil and dangerous goods[2]. This amount increases from year to year and has a tendency to continue growing because the ports of the northern Adriatic, especially Trieste, Koper and Rijeka, and other ports in Albania , Italy and Montenegro are constantly increasing the total cargo traffic. The risk of pollution of the Adriatic has also increased due to hydrocarbon exploration on the sea. Tourism also continues to grow on an annual basis and increases its share in GDP from year to year. In Croatia, tourism is 17% of GDP, in Slovenia about 12%, in Montenegro as much as 24%, while in Italy it is only about 2% of GDP. Cargo transportation is from the strategic importance of the Adriatic countries. All the mentioned events show the importance of the Adriatic Sea as an economic generator. Potentially accidental pollution of the sea would threaten all economic

[1] https://crisis.italy-albania-montenegro.eu/

[2] https://n1info.hr/english/news/a304302-threat-of-major-spills-in-adriatic-sea-relatively-small/

activities in the Adriatic Sea, cause multiple damages, the restoration would take an extremely long time and would require considerable costs.

The non-strict enough legislation regarding the cases of platforms and chemical tankers is one of the additional problems together with the very nature of the sea and submarine terrain, which is shallow and is fed by a high number of streams and rivers and prone to earthquake risks. The Adriatic is classified as a Special Area (according to MARPOL Annex I), which limits the amount of legal discharging of oily wastes, for instance, but it is discussed the possibility of extending to the Adriatic the status of the Particularly Sensitive Sea Area (PSSA). It is obvious that the likelihood of further traffic and the subsequent causes of marine pollution is increasing, which suggests that the need for continued scientific intervention and further legislation improvement will preserve Adriatic sea environment.

There is concern about the effects of a large marine oil spill that could affect the above mentioned countries coastal zone. Despite the framework of preventive measures currently in place, the national communities in these three countries have shown concerns and provided a trigger for the ongoing development of regulations, technology and systems to reduce the risks of marine incidents. According to some documents capacities of responsible authorities are very limited in response to incidental oil spills on the sea [1], [2].

2. OBJECTIVES, BENEFICIARIES, DESCRIPTION OF ASSIGNMENT AND OUTPUTS

This chapter will describe objectives, beneficiaries, and descriptions of assignments and outputs.

2.1 General Objective

The main objective of this project is to improve the transportation activities in the programme area, emphasising the transportation of hazardous materials. In particular, this project will contribute to the specific objective "4.1 Transport" by studying the peculiar risks in the programme area and developing novel decision support modules aiming to assist cross-border management of hazardous materials.

2.1.1 Specific Objectives

The CRISIS project will contribute to allocating ships carrying hazardous materials to berths based on real-time numerical simulations of weather (wave and wind) conditions. The main outputs of the project will be: the identification of specific risk measures capturing the main aspects of hazardous material transportation in the programme area, the design and development of a multimodal safest routing algorithm for dangerous material transportation in the programme area, and the design and development of a berth allocation algorithm for hazardous material transportation in the programme area.

2.2 Beneficiaries

The main beneficiaries are listed below:

- Città di Molfetta (IT)[3], Lead partner
- FLAG Molise Costiero[4] (IT), project partner and
- Municipality of Ulcinj[5] (ME), project partner and
- National Environment Agency (AL), associated partner.

[3] https://www.comune.molfetta.ba.it/

[4] www.Flagmolise.it

[5] www.ul-gov.me

However, the benefit from the project will have the whole society in the programming area, where the action is taking place.

2.3 Description of the assignment and tasks

In order to ensure the smooth implementation of the project and tasks, in line with the approved application form, the Municipality of Ulcinj has engaged an external expert to support the spread of project activities, results, and outputs to the Programme area and beyond.

According to ToR following objectives must be achieved: data collection and analysis of the problems of routing hazardous materials inside the ports, and the surrounding areas, monitoring and supporting passing ships and allocating ships carrying dangerous materials to berths according to the approved Application Form of the project CRISIS „Cross-border RISk management of hazardous material transportation“.

The requested services are divided into four activities and presented below. This deliverable covers the tasks under activity A.T.!.2.

2.3.1 Activity A.T1.1 - Data collection and analysis

This activity aims to analyse the problems of routing hazardous materials inside the ports and surrounding areas, monitoring and supporting passing ships and allocating ships carrying dangerous materials to berths [3]. The goal is to identify the peculiar problems, and to collect the data related to the different ports and areas where the proposed methodologies could be implemented.

In this activity, maritime traffic analysis in the programming area and data related to maritime dangerous cargo transportation in Albania, Italy and Montenegro is performed.

2.3.2 Activity A.T1.2 - Definition of specific risk measures

This activity will define specific risk measures that will be considered when designing the models and algorithms.

In the frame of this activity, data on previous incidents while handling dangerous cargo in the programming area and Montenegro will be performed. Based on historical data, the specific risk measures will be proposed.

2.3.3 Activity A.T1.3 - Multimodal safest path algorithm design

This activity aims to develop models and algorithms to route shipments in the transportation network in such a way that not only is travel cost reduced, but also transportation risk is minimised.

2.3.4 Activity A.T1.4 - Berth allocation algorithm design

The berth allocation problem aims to optimally assign and schedule ships to berthing areas along a quay. The objective is the depreciation of the total (weighted) service time for all ships, defined as the time elapsed between the arrival in the port and the completion of handling the minimisation activity. It includes the estimate of the downtime due to wave and wind action at a particular berth.

2.4 Required output and deliverables

In the frame of T1 following four deliverables will be prepared and listed and shortly explained in the following subchapters. This document is actually the deliverable D.T1.1.2 described in subchapter 2.4.2.

2.4.1 Deliverable D.T1.1.1 - Data analysis report

A report with a preliminary analysis aimed at making sense of the data collected in order to highlight the peculiarities and critical aspects of hazardous transportation in the programme area.

The desk research is conducted and data collection is performed on the maritime transport and transport of dangerous cargo in program area.

2.4.2 Deliverable D.T1.1.2 - Risk measures report

A report on specific risk measures capturing the main aspects of hazardous material transportation in the programme area.

The desk research and data collection will be performed on previous incidents and potential risks during the maritime transport of dangerous cargo in program area. The results will be presented in this deliverable.

2.4.3 Deliverable D.T1.1.3 - Multimodal safest path algorithm design report

A report on designing the multimodal safest routing algorithm for hazardous material transportation in the programme area.

2.4.4 Deliverable D.T1.1.4 - Berth allocation algorithm design report

A report on the design of the berth allocation algorithm for hazardous material transportation in the programme area.

3. LEGAL FRAMEWORK FOR RISK MITIGATION DURING MARITIME TRANSPORT OF DANGEROUS CARGO

There are three levels of the legal framework for reporting dangerous cargo on vessels:

- International level set by IMO
- European level set by EU
- The national level is set by national laws and bylaw acts

3.1 International Maritime Organisation – IMO

IMO has developed an international legal framework for risk mitigation during maritime transport of dangerous cargo on ships. The framework is designed to ensure the safe transportation of hazardous materials and protect the marine environment from potential pollution incidents.

Following are International instruments and regulations related to the mitigation of risks during dangerous cargo transportation on sea:

- United Nations Convention on the Law of the Sea (UNCLOS), in particular Article 221. 4
- International Convention on Open-Views Intervention in the Case of Oil Pollution Victims (Convention on Interventions), 1969, with Amendments;
- Protocol relating to open-sea intervention in cases of pollution from non-oil substances, 1973;
- International Convention on the Safety of Life at Sea, 1974 (SOLAS 1974), amended, in particular Chapter V ;
- International Rescue Convention, 1989 (Rescue Convention);
- International Convention on the Prevention of Oil Pollution, Response and Cooperation, 1990 (OPRC Convention);
- International Convention on the Prevention of Pollution from Ships, 1973, modified by Protocol 1978 (MARPOL 73/78);
- Convention on the Prevention of Marine Pollution through the Release of Waste and Other Substances, 1972;
- Convention on civil liability in the field of maritime transport of nuclear material, 1971;
- Convention on Limitation of Liability for Maritime Claims (LLMC), 1976;
- International Convention on Civil Liability for Oil Pollution Damage (CLC), 1969;

- International Convention on Civil Liability for Oil Pollution Damage (CLC), 1992;
- International Convention on the Establishment of the International Fund for Compensation for Oil Pollution Damage (FOND), 1992;
- International Convention on the Safety of Life at Sea (SOLAS), 1974, as amended by Regulation V / 31 (messages for danger); Regulation VII / 6 and V11 / 7-4 (reporting of incidents involving dangerous substances); Regulation VIII / 12 (accidents on nuclear ships);
- International Convention for the Prevention of Pollution from Ships (MARPOL), 1973, as amended by the 1978 Protocol relating, with amendments, Article 8 (reports of incidents involving the discharge or eventual release of harmful substances); Protocol I (provisions relating to reports of incidents involving the release or eventual release of harmful substances (in application of Article 8));
- International Convention on Open-Sea Intervention in cases of Oil Pollution Victims, 1969 (Convention of Intervention), Article III (a) and (f) (consultations, notifications);
- International conventions on oil pollution preparedness, response and cooperation, 1990 (OPRC conventions), Articles 4 and 5;
- International Code for the Safe Transport of Processed Nuclear Fuels, Plutonium and Radioactive Wastes on Ships (INF Code), paragraphs 29 and 30;

3.2 European legal acts on reporting

The European Union (EU) has established a legal framework for mitigation of risks during transporting of dangerous goods by sea, which aims to ensure the safety of people, property, and the environment. The EU's legal framework for transport of dangerous cargo on vessels is based on the International Maritime Dangerous Goods (IMDG) Code and the International Convention for the Safety of Life at Sea (SOLAS) but also includes additional requirements and regulations.

Additional requirements and regulations are imposed after Erika disaster [6]. On 12 December 1999, the Erika, a 25 year-old single-hull oil tanker, broke in two off France, polluting almost 400 km of French coastline and causing unprecedented damage to marine environment, claiming the title of one of the most major environmental disasters of recent years. As a result of the sinking, a large proportion of the vessel's cargo and bunkers spilled into the sea. Namely, according to ITOPF data, during the cleanup operation, between 190,000 and 200,000 tonnes of oily waste was collected from shorelines and temporarily stockpiled.

Two years after the Erika ran aground, the European Union has made considerable progress towards increasing maritime safety. Adoption of the Erika I package of measures and progress made on the Erika II and Erika III packages are a major step towards putting effective rules into place to increase maritime safety

[6] https://safety4sea.com/cm-learn-from-the-past-erika-oil-spill-europes-environmental-disaster/

and to counter the risks of oil spills. Thanks to these measures substandard ships and floating rust buckets disappear from Europe's waters within two years [7].

Some of the most important EU legal acts related to maritime transport of dangerous cargo by sea include:

- Directive 2009/17 / EC amending directive2002 / 59 / EC on the establishment of a navigation control system and a community information system.
- Directive 2010/65/EU on reporting formalities for ships: This directive aims to simplify and harmonize administrative procedures for ships calling at EU ports, including those carrying dangerous cargo. It requires electronic reporting of cargo information and related data to ensure the efficient and safe movement of vessels.
- Directive 2002/59/EC establishing a Community vessel traffic monitoring and information system: This directive focuses on the establishment of a vessel traffic monitoring and information system (VTMIS) in the EU, which helps enhance maritime safety, including for ships carrying dangerous cargo.
- Directive 2008/68/EC on the inland transport of dangerous goods: Although this directive primarily concerns the inland transport of dangerous goods, it may also apply to certain aspects of the maritime transport of dangerous cargo when goods are transported between inland locations and ports.
- Regulation (EC) No 1013/2006 on shipments of waste: This regulation controls the shipment of waste, including dangerous waste, to ensure environmentally sound management during transportation by sea.
- Regulation (EU) No 1257/2013 on ship recycling: While mainly focused on ship recycling, this regulation also addresses the environmentally sound management of hazardous materials on ships, including those intended for recycling.

It is essential to note that the EU's legal framework is continually evolving including EU legal acts related to maritime transport of dangerous cargo by sea.

3.2.1 Reporting incidents in SafeSeaNet

[7] https://ec.europa.eu/commission/presscorner/detail/en/MEMO_01_387

SafeSeaNet (SSN) is a European Union vessel traffic monitoring and information system that aims to enhance maritime safety and protect the marine environment. It enables EU member states to exchange information about maritime traffic in their waters, including the reporting of maritime incidents.

Here's an overview of how maritime incidents are reported in the SafeSeaNet system:

1. Incident Reporting: When a maritime incident occurs within the territorial waters or Exclusive Economic Zone (EEZ) of an EU member state, the relevant authorities are responsible for reporting the incident to SafeSeaNet.
2. Data Input: The reporting authority enters relevant information about the incident into the SafeSeaNet system. This information typically includes details about the vessel involved, the nature of the incident, the location, and any potential hazards, such as the type of dangerous cargo carried on board.
3. Automatic Identification System (AIS) Data: SafeSeaNet integrates data from the Automatic Identification System (AIS), which is a tracking system used on most commercial vessels. AIS transponders on ships continuously broadcast their position, speed, and other relevant data. This helps provide real-time information about the vessel's movements and status during the incident.
4. Data Validation: The information provided is subject to validation by the relevant authorities or designated administrators. This step ensures that the data entered into the system is accurate and reliable.
5. Data Sharing: SafeSeaNet facilitates the automatic exchange of information between EU member states. This means that once an incident is reported in one country's SafeSeaNet, other nearby countries and relevant authorities will receive the information promptly.
6. Decision Support: The data shared through SafeSeaNet helps authorities make informed decisions during an incident. They can assess the situation, take appropriate actions to mitigate risks, and coordinate responses effectively.
7. Enhancing Safety and Monitoring: By having access to real-time and historical data on maritime incidents, SafeSeaNet enables EU member states to identify trends, enhance safety measures, and implement appropriate regulations to prevent similar incidents in the future.

It's important to note that SafeSeaNet serves as a central information-sharing platform, and the actual response to maritime incidents may involve multiple agencies, including coast guard, maritime authorities, port authorities, and emergency services, depending on the severity and nature of the incident.

As the maritime industry and safety regulations continue to evolve, SafeSeaNet is continuously updated and improved to meet the changing needs of maritime incident reporting and response.

At the moment SafeSeaNet is mandatory in all EU member states. In Montenegro, SafeSeaNet is partly implemented by only sending *PortPlus messages*, while in Albania, it is not implemented. Several EU initiatives and projects, like the EUREKA InterregADRION project, aim to include IPA countries in the SafeSeaNet system.

3.2.2 CleanSeaNet service

CleanSeaNet[8] is an innovative EU maritime surveillance service for marine pollution detection and response. It is an advanced maritime surveillance service developed and managed by the European Maritime Safety Agency (EMSA). It was established to address the pressing issue of marine pollution, specifically oil spills, and to enhance the protection of Europe's coastal and marine environments. The service utilizes cutting-edge satellite technology, data analysis, and expert support to rapidly detect and respond to pollution incidents in real-time.

Key features and components of CleanSeaNet service are:

1. Satellite-Based Observation: CleanSeaNet relies on Synthetic Aperture Radar (SAR) imagery obtained from various satellites orbiting the Earth. SAR technology allows for all-weather and day-and-night observation because of using SAR imagery, ensuring constant monitoring capabilities for detecting oil spills, bilge dumping, and other sources of pollution.
2. 24/7 Monitoring: The service operates around the clock, continuously analysing satellite data to identify potential pollution events. This real-time monitoring significantly improves response times and allows authorities to take prompt action in mitigating environmental damages.
3. Detection and Analysis: CleanSeaNet's advanced algorithms process SAR imagery to detect and distinguish oil spills from other marine phenomena, such as algae blooms or natural seepages. The system's automated analysis provides precise information about the location, size, and drift of the pollution, aiding in devising efficient response strategies.
4. Integrated Data Sharing: CleanSeaNet collaborates with national authorities, coast guards, and other relevant stakeholders, ensuring seamless information exchange. This fosters a coordinated response to pollution incidents and enhances the effectiveness of environmental protection efforts.

The CleanSeaNet functions in following way:

[8] https://www.emsa.europa.eu/csn-menu.html

1. Satellite Data Acquisition: SAR imagery is collected by CleanSeaNet from multiple satellites equipped with SAR sensors. These satellites cover vast areas of the oceans and seas around Europe, facilitating comprehensive surveillance.
2. Image Processing and Analysis: The collected SAR images are processed through sophisticated algorithms developed by EMSA. These algorithms utilize pattern recognition and machine learning techniques to identify and classify potential oil spills with high accuracy.
3. Pollution Event Identification: The detected potential oil spills are then reviewed by expert analysts to validate the findings and eliminate false positives. The refined data is then transmitted to the relevant national authorities and the European Maritime Safety Agency for further action.
4. Rapid Response and Action: Upon verification, coastal states and competent authorities are promptly informed of the pollution event. This enables them to launch targeted response operations, such as deploying clean-up teams, containing the spread of the pollution, and minimizing environmental impacts.

There are many benefits and positive impact of CleanSeaNet such as:

- Environmental Protection: CleanSeaNet plays a crucial role in safeguarding marine ecosystems and coastal environments. By swiftly detecting and addressing pollution incidents, it minimizes the adverse effects on marine life, coastal habitats, and sensitive ecosystems.
- Efficient Resource Allocation: The service optimizes resource utilization by providing accurate and timely information. This allows authorities to focus their efforts precisely where pollution events occur, reducing costs and enhancing the overall effectiveness of response measures.
- Compliance and Deterrence: CleanSeaNet's monitoring capabilities act as a deterrent against illegal discharges and pollution activities, encouraging compliance with environmental regulations and fostering responsible maritime practices.

CleanSeaNet is a remarkable example of how advanced technology and international collaboration can contribute to environmental preservation and maritime safety. Through its satellite-based observation, real-time monitoring, and rapid response mechanism, CleanSeaNet continues to play a crucial role in protecting Europe's coastal and marine ecosystems from the devastating impacts of marine pollution. The service's comprehensive approach to maritime surveillance serves as a valuable model for other regions seeking to combat environmental challenges in the maritime domain.

Albania did not implement the CleanSeaNet system. Italy has implemented a CleanSeaNet system since beginning of operation, while Montenegro was one of the first non-EU countries which implement the system since 2013[9].

3.3 Albanian legal framework

Albania is a candidate country for EU membership and has an obligation to implement international and EU legal instruments related to maritime transport of dangerous cargo. The most important Albanian legal acts related to maritime transport of dangerous cargo by sea include:

1. Law No. 16/2017 "On the Maritime Code of the Republic of Albania": This comprehensive law governs various aspects of maritime activities, including the transport of dangerous cargo by sea. It outlines the legal framework for shipping, ship registration, navigation, marine pollution prevention, and safety standards, including those related to dangerous goods.
2. Law No. 48/2012 "On Transport of Dangerous Goods by Road, Rail, Inland Waterways, and Sea": This law specifically addresses the transport of dangerous goods, including dangerous cargo by sea. It sets out the requirements, regulations, and safety measures for handling and transporting hazardous materials through different modes of transportation.
3. Decision of the Council of Ministers No. 421, dated 24 May 2017, "On Approval of the National Plan for the Preparedness and Response to Marine Pollution from Ships": This decision establishes a national plan for responding to marine pollution incidents, including spills of hazardous substances from ships carrying dangerous cargo.
4. Decision of the Council of Ministers No. 525, dated 15 June 2011, "On Approval of the Regulation on Safe Transport of Dangerous Goods by Sea": This decision approves the regulations for the safe transport of dangerous goods by sea within Albanian waters. It outlines the specific requirements and safety standards that ships must adhere to when carrying hazardous materials.
5. Decision of the Council of Ministers No. 580, dated 6 July 2011, "On Approval of the Regulation on the Control of Compliance with the Rules of Maritime Safety and Navigation": This decision

[9] https://www.vijesti.me/vijesti/drustvo/210624/i-crna-gora-ce-moci-da-prati-brodove-na-velikim-daljinama

establishes the regulations for ensuring compliance with maritime safety rules, including those related to the transport of dangerous cargo by sea.

6. Albanian Port Authority (APA) Regulations: The APA is responsible for overseeing the operation of ports in Albania, and its regulations may include specific provisions related to the handling and transport of dangerous goods within port facilities.

3.4 Italian legal framework

Italy is an EU member state and it has already implemented EU regulations in its legislation. The most important Italian legal acts related to maritime transport of dangerous cargo by sea include:

1. Legislative Decree No. 171/2005 "Implementation of Directive 2002/59/EC establishing a Community vessel traffic monitoring and information system": This legislative decree transposes the EU Directive 2002/59/EC into Italian law and establishes provisions for the monitoring and information system for vessel traffic in Italian waters. It contributes to enhancing maritime safety, including for ships carrying dangerous cargo.
2. Legislative Decree No. 152/2006 "Environmental Code": This extensive legislation addresses various environmental matters, including the transport of dangerous goods by sea. It includes provisions related to the handling, storage, and transport of hazardous materials to prevent marine pollution and protect the marine environment.
3. Ministerial Decree of 19 December 2002 "Regulations on the Carriage of Dangerous Goods by Sea": This ministerial decree provides specific regulations for the carriage of dangerous goods by sea, setting out requirements, procedures, and safety standards for vessels transporting hazardous cargo in Italian waters.
4. Ministerial Decree of 30 January 2018 "Technical Provisions on Maritime Safety": This decree sets out technical provisions to ensure maritime safety, and it may include specific measures related to the transport of dangerous cargo by sea.
5. Code of Navigation (Codice della Navigazione): This comprehensive legal framework governs various aspects of navigation, including maritime transport. It may include provisions relevant to the carriage of dangerous goods by sea, ship safety, and navigation requirements.

6. Port Regulations: Different Italian ports may have their own regulations concerning the handling and transport of dangerous cargo within their facilities. These regulations are issued by the port authorities and provide guidelines for safe operations within their jurisdiction.

3.5 Montenegrin legal framework

Montenegro is a candidate country for EU membership and has an obligation to implement international and EU legal instruments related to maritime transport of dangerous cargo. The basic legal framework of Montenegro on this topic is:

1. Law on the Safety of Maritime Navigation ("Official Gazette of Montenegro" No. 62/13, 06/14, 53/16);
2. Law on the Protection of the Sea from Vessels Pollution ("Official Gazette of Montenegro" No. 20/11 and 26/11, 27/14);
3. Law on the Sea ("Official Gazette of the Republic of Montenegro" No. 17/07, 06/08, 40/11);
4. Law on ports ("Official Gazette of Montenegro" No. 51/08, 27/13);
5. Rulebook on internal organization and systematization of the Ministry of Transport and Maritime Affairs, since March 2017
6. Law on Amending the Law on Yachts ("Official Gazette of Montenegro", number 42/15, 16/06)
7. Marine Law ("Official Gazette of Montenegro" No. 14/92, 27/94 and "Official Gazette of Montenegro" No. 51/08 and 21/09);
8. Law on Marine Fisheries and Mariculture ("Official Gazette of Montenegro" No. 56/09, 40/11 and 47/15);
9. Water Law ("Official Gazette of Montenegro" No. 27/07, "Official Gazette of Montenegro" No. 32/11, 47/11 and 52/16);
10. Law on Marine Fisheries and Mariculture ("Official Gazette of Montenegro" No. 56/09, 40/11 and 47/15);
11. Water Law ("Official Gazette of Montenegro" No. 27/07, "Official Gazette of Montenegro" No. 32/11, 47/11 and 52/16);
12. Decree on the Prolonged Procedure and Method of Conducting Research on Marine Accidents and Accidents ("Official Gazette of Montenegro", No. 52/15);
13. Rulebook on the amount for use of the coast, boat berth and anchoring ("Official Gazette of Montenegro", number 5/2015);

14. Rulebook on special conditions to be fulfilled by maritime navigation inspectors and the procedure of performing inspection supervision ("Official Gazette of Montenegro", number 22/15, 15/16);
15. Rulebook on markings on waterways in the internal sea waters and territorial sea of Montenegro ("Official Gazette of Montenegro", number 16/2015);
16. Rulebook on categories of navigation of ships ("Official Gazette of Montenegro", number 22/15);
17. Rulebook on the manner of conducting surveillance, information and management of maritime traffic ("Official Gazette of Montenegro", No. 34/2015);
18. Rulebook on types of vocation and authority, conditions for obtaining a title and issuing authorizations for crew members ("Official Gazette of Montenegro", number 51/15, 44/16);
19. Rulebook on amending the rulebook forms and manner of keeping the registry of yachts of Montenegro and the book of records for renting yachts ("Official Gazette of Montenegro", number 59/2015);
20. Rulebook on Technical Conditions for the Capability of Yacht for Navigation ("Official Gazette of Montenegro", No. 74/16); Rulebook on conditions for placing on the market of equipment for ships ("Official Gazette of Montenegro", No. 43/16 of 20 July 2016);
21. Rulebook on the manner of determining the name of the ship, the name and mark of the technical navigable object and the port of entry ("Official Gazette of Montenegro", number 41/16);
22. Rulebook on detailed conditions for the legal entity that drafts the assessment and the security of port security ("Official Gazette of Montenegro", No. 78/16);
23. Rulebook on detailed conditions for the legal entity that drafts the assessment and the security of port protection ("Official Gazette of Montenegro", No. 78/16);
24. Rulebook on the ability of the ship for the carriage of passengers ("Official Gazette of Montenegro", No. 82/16);
25. Rulebook on conditions in terms of occupational safety and accommodation of crew members and other persons on board ("Official Gazette of Montenegro", No. 82/1
26. Rulebook on the manner of announcing the arrival of the ship in the port and departure of the vessel from the port ("Official Gazette of Montenegro", number 42;
27. National plan for search and rescue at sea, (Official Gazette of the Republic of Montenegro, No. 4/06).

There are also other important legal acts that are relevant to maritime transport of dangerous cargo and mitigation of potential risks such as:

1. Law on Environment of Montenegro ("Official Gazette of Montenegro" No. 52/16);

2. Law on Nature Protection ("Official Gazette of Montenegro" No. 54/16);
3. Law on Environmental Impact Assessment of Montenegro ("Official Gazette of the Republic of Montenegro" No. 80/05 and "Official Gazette of Montenegro" No. 40/10, 73/10, 40/11, 27/13 and 52/16);
4. Law on Integrated Prevention and Control of Environmental Pollution (Official Gazette of the Republic of Serbia No. 80/05 and Official Gazette of the Republic of Montenegro 50/09, No. 40/11 and No. 54/16)
5. Law on Responsibility for Environmental Damage ("Official Gazette of Montenegro" No. 27/14);
6. Law on Tourism ("Official Gazette of Montenegro" No. 61/10, 40/11, 53/11);
7. Law on Waste Management in Montenegro ("Official Gazette of Montenegro" No. 64/11 and 39/16);
8. Law on Confirmation of the Paris Memorandum of Understanding on the Control of the State Port ("Official Gazette of Montenegro - International Contracts", No. 10/15);
9. Law on the Confirmation of the Convention on Biological Diversity (Official Gazette of FRY-International Agreements, No. 11 / 01-28);
10. Law on the Confirmation of the Convention on the Protection of European Wildlife and Natural Habitats (Berns Convention) (Official Gazette of Montenegro, no. 7);
11. Law on the Confirmation of the Convention on Wetlands (Ramsar Conventions) (Official Gazette SFRY, No. 9 / 77-675);

4. DATA COLLECTED ON MARITIME RISKS AND INCIDENTS

Marine pollution in the Adriatic Sea is a topic of high significance for national and EU ecological and sustainable management of marine resources and it should be persistently monitored and controlled in order to avoid environmental accidents. As already known, the Adriatic Sea is a semi-enclosed basin with poor seawater flows and a long retaining of water masses, making it vulnerable and highly sensitive to persistent pollution, especially when it comes to plastic waste. Tourism, as a strategic sector of the eastern Adriatic coast (Albania, Bosnia and Herzegovina, Croatia, Greece, Italy, Montenegro and Slovenia) is based on the purity of the Adriatic Sea. The increased concentration of population and the intensive economic activities, combined with the riverine inputs from large drainage basins (such as the Po, Buna/Bojana etc), have led to a deterioration of the marine environment of the Adriatic Sea. The global growth of cruise tourism has brought increasing concern for the pollution of the marine environment. Marine pollution from sanitary wastewater is a problem especially pronounced on large cruise ships where the number of people on board may exceed 8,000 [4]. The United Nations Environment Programme (UNEP) has identified tourist ships as one of the principal pollution sources of marine ecosystems [5].

In addition to solid waste, air pollution from marine diesel engines is another threat to the marine environment, biodiversity and human health. Marine diesel engines use heavy oil fuels containing large concentrations of sulphur and ash-forming metals [6]. The Adriatic Sea is crossed by important oil transport routes from the Otranto Strait to the north Adriatic ports (Trieste, Venice, Omišalj and Koper), transporting around 58.000.000 tonnes of oil annually, according to data from 200, and nowadays, this figure is even higher and is around 75.000.000 tonnes[10]. Maritime transport activity is increasing because of important industrial centres, especially in Italy, Croatia and Slovenia. Some of these are also transit ports for Central Europe (Trieste, Venice, Koper, and Rijeka), and some new transit ports are gaining significance, such as Ploče, Bar, Durres and Vlorë. The joint study performed by the Joint Research Centre in 2006 reported for the Adriatic Sea a total of 257 ship-made oil spills in 1999, 263 in 2000, 184 in 2001, and 244 in 2002, with the number of detected oil spills in Croatian waters ranging from 24 to 68 [7] .

The released ballast waters in the Adriatic is estimated to be 8 106 t in 2003 [8], 80% of which was discharged in the Italian Adriatic ports, while the rest is shared between Koper (Slovenia) and the Croatian ports [7].

Therefore, each type of sea pollution in the Adriatic has specific consequences and lifetime, which, depending on its characteristics and sources, in some cases can cause irreversible consequences. In the DEFISHGEAR – EU funded project, the conducted assessment showed that the average beach litter density is 0.67 items/m2 (average: 658 items/ 100m; range: 219-2914 items/100m); average density of floating macro-litter (items > 2.5 cm) in coastal Adriatic waters obtained by small-scale vessels was found to be 332 ± 749 items/km2; average seafloor litter density found at regional level by bottom trawl surveys was 510 ± 517 items/km2 (range: 79-1099 items/km2) and 65 ± 322 kg/km2 (range: 3-339 kg/km2) [9], [10]. Monitoring activities of floating litter in Adriatic and Ionian seas showed that the abundance of microplastics in the enclosed gulfs (Kotor, Split, Trieste, Venice) of the Adriatic Sea shows some increasing trend in parallel to the population density. Possible explanations are considered the sea-based sources of macroplastics as well as the different buoyancy features of various macroplastic items most probably related to their polymer types and shape.

[10] https://n1info.hr/english/news/a304302-threat-of-major-spills-in-adriatic-sea-relatively-small/

With the exception of fisheries, no other apparent sea-based source of floating plastics could be discerned. In addition, macroplastic compositional differences between inshore and offshore waters infer that items properties (polymer type and shape) are also crucial in determining their distribution [11]. Therefore, the spatial distribution of the floating debris inputs into the Adriatic Basin together with specific elements of analysis is shown in Figure 1, as follows.

It is important to note that there is no specific national legislation or directives relating to marine litter in the region of the Adriatic Sea. Of course, there are general legal regulations and by-laws relating mainly to waste management as well as port waste. Marine waste goes beyond national borders, so it is obvious that a coordinated response is needed to address the marine waste issue of each country in the Adriatic and its coastal zone. Collaboration with partner countries will affect the exchange of ideas, experiences, techniques, and knowledge, creating a favourable environment for future cooperation and joint activities in the Adriatic.

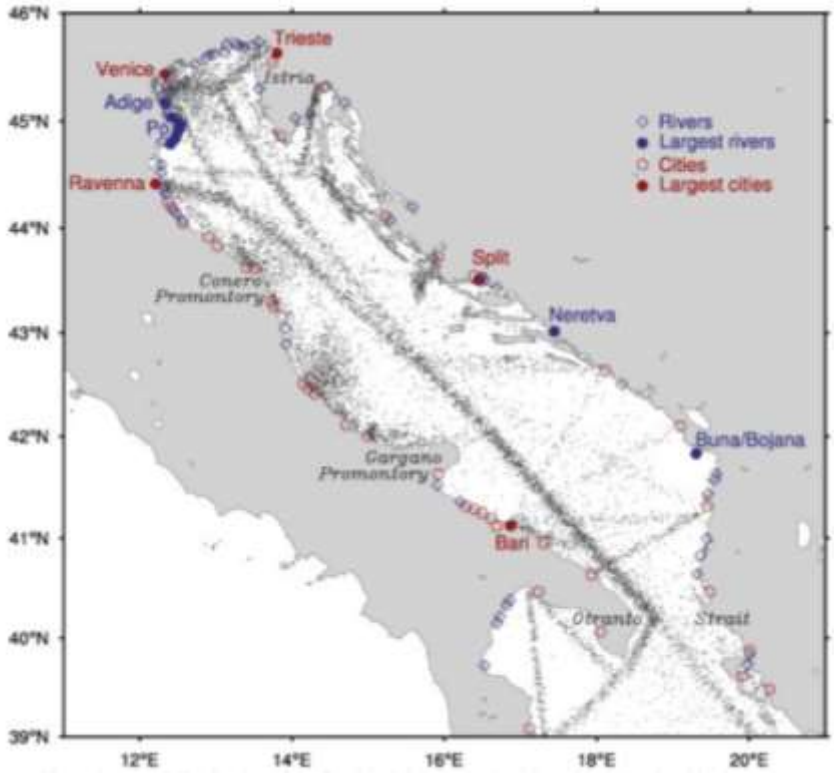

Figure 1 - Spatial distribution of the floating debris inputs into the Adriatic Basin: shipping lanes (grey scatter plot); rivers (open blue diamonds), the largest rivers (closed blue circles); cities (open red circles); and the largest cities (closed red circles). Source [12]

4.1 Albania

The consultants contacted officials of the Albanian maritime administration and representatives of ports in Albania, asking about previous incidents related to the maritime transport of dangerous cargo in Albanian waters and ports. They did not report any incident.

According to ITOPF (The International Tanker Owners Pollution Federation Limited), which has responded to over 840 incidents involving oil or chemical spills worldwide regarding previous spill experience, it is noted that there have been no significant incidents in Albanian waters[11].

Desk research has been performed and here are some notable maritime incidents or accidents that have occurred in Albania in the past:

1. July 14, 1997 - During the Albanian civil unrest and economic crisis, the Italian cargo ship "Iliria" caught fire and sank in the Port of Durres. Rioters triggered the fire, and the ship eventually capsized and became submerged.
2. February 11, 2008 - The cargo ship "Albanian Trader" sank near the Port of Durres after encountering rough seas and bad weather. All six crew members on board were rescued.
3. January 26, 2012 - The Moldovan-flagged cargo ship "Felicia" sank off the coast of Durres. The vessel was carrying scrap metal at the time of the accident. All six crew members were rescued.
4. January 10, 2017 - A cargo ship sank off the coast of Durres.

Time to time there are some news on the media related to risks during maritime transport of dangerous cargo.

In November 2015, oil slick was spotted in in Durres which caused outrage of local population and civil sector. Oil pollution that struck the beach of the Albanian port and resort of Durres has revealed the negligence of institutions in preventing such situations. According to article, as a result of the lack of rules, some of ships skip depositing their waste in the ports and do so in the open sea. The officials said that the new regulation would seek to control the waste processing of all ships entering ports, forcing them to deposit their waste in a more organized way. It was unclear if the oil came from a ship passing through Albanian territorial waters or if the vessel was anchored in the port of Durres, which is the biggest in the country[12].

[11] https://www.itopf.org/knowledge-resources/countries-territories-regions/albania/

[12] https://balkaninsight.com/2015/11/12/oil-slick-in-durres-causes-outrage-in-albania1-11-12-2015/

In May 2016, oil spill pollutes Albanian Zvernec Coastline[13]. The oil spill came from a Turkish-flagged vessel which was moored at the La Petrolifera Italo Albanese[14] storage terminal for LPG and oil products, located in the Bay of Vlora, according to the Albanian officials. Local media reported that the operations at the terminal had been suspended and that the company has received a fine of some USD 8,000 for causing an environmental disaster. It is estimated that over 5 tons of crude oil spilled off the coast, covering nearly five kilometres of the coastline as it reached shore [15].

In December 2015, according to Albania Daily News, a ship with 3,000 Gallons of oil sank near Albania and polluted the Adriatic Sea near the north-western Albanian town of Shengjin. There were no reports about the level of pollution and the volume of oil spilled in the sea[16].

In December 2018, an Italian-flagged car ferry chartered by Greek operator ANEK Lines, raised the alarm in the early hours after fire broke out in its lower decks. An international rescue operation involving ships and aircraft from Greece, Italy and Albania had battled heavy seas and strong winds to try to evacuate the 478 passengers and crew[17]. The weather conditions were extremely bad, which made it impossible to tow the ship. Albanians, Italians and Greek experts thought that the wind and waves direction may require that the Greek ship be anchored in one of the Albanian ports. Therefore, the Ministries of Defence, Health, Interior, Transport and the Ministry of Foreign Affairs had taken all necessary measures to cope with the situation. At the time of the fire, an estimated 475 people were on board the ship, including 417 passengers, 55 crew and at least three illegal immigrants. 452 people were rescued and the bodies of 11 were recovered. It is known that 16 passengers died and it was estimated that there were 28 deaths overall, the uncertainty arising from estimates of the number of illegal immigrants on board. Additionally, two crewmembers of the Albanian tug Iliria were killed during the salvage operations on 30 December 2018 [18].

Albania has become lately attractive yachting destination. As there will be more traffic, also accidents could be more frequent where yachts or other non-SOLAS ships can be part of it. In June 2022 authorities of Port of Durres received a signal for sinking of Italian yacht. Authorities provided immediate assistance to the yacht, so there were no casualties and no oil spill[19].

[13] https://www.manufacturing.net/chemical-processing/news/13125452/oil-spilled-from-ship-pollutes-albanian-beach

[14] https://www.gruppopir.com/en/la-petroliera-italo-albanese

[15] https://www.offshore-energy.biz/oil-spill-pollutes-albanian-zvernec-coastline/

[16] https://sputnikglobe.com/20151230/albania-ship-oil-1032492990.html

[17] https://www.reuters.com/article/us-greece-ship-albania-idUKKBN0K60HE20141228

[18] https://en.wikipedia.org/wiki/MS_Norman_Atlantic

[19] https://albaniandailynews.com/news/italian-yacht-incident-avoided-in-durr-s-port-

4.2 Italy

4.2.1 Data from Italian ports and maritime administration

Maritime traffic plays a crucial role in the European economy; in fact, considering both imports and exports, the continent has had the second biggest traffic in tons of material in 2017, after Asia (Figure 2). EU's waters are among the busiest in the world [13].

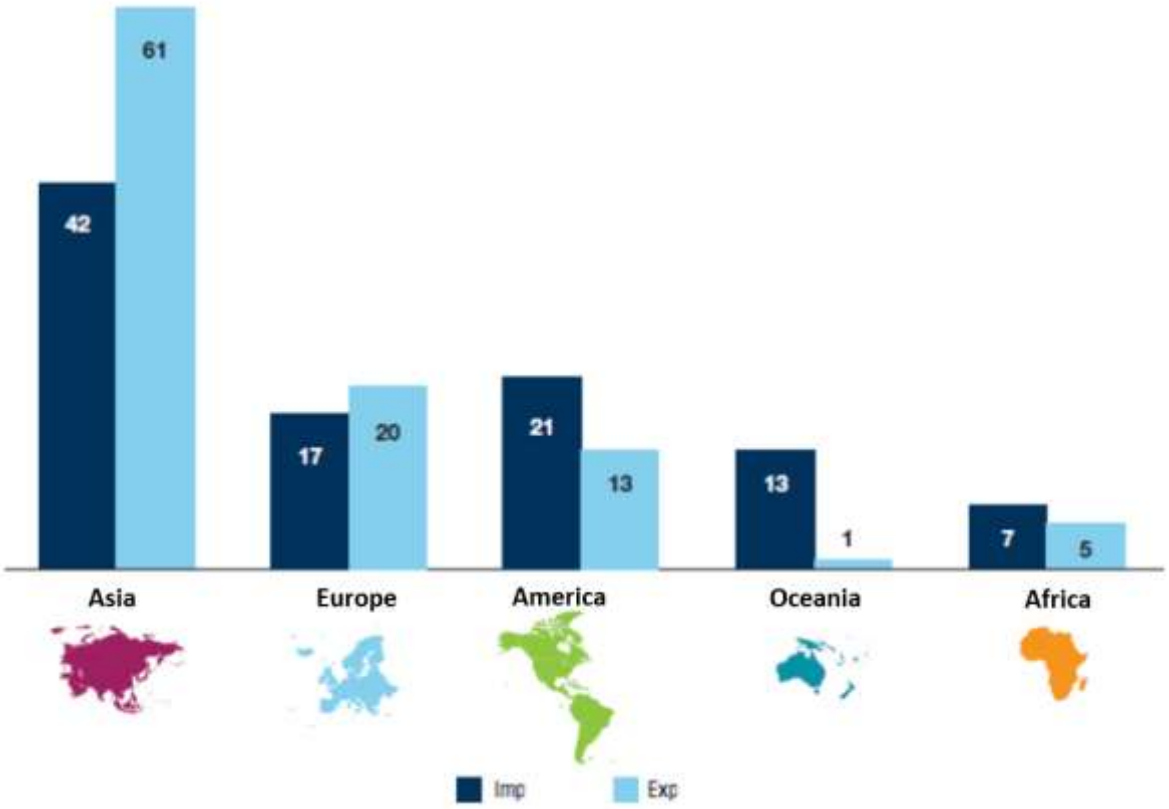

Figure 2 – Global maritime commerce divided by region (percentage of the global total in tons) in 2017 [14]

In Italy, more than 28% of the import-export exchange with other countries is through maritime routes (Figure 3). This mode of transportation is particularly important considering other Mediterranean countries – in 2017, it reached 68% of total transportation of imported-exported goods.

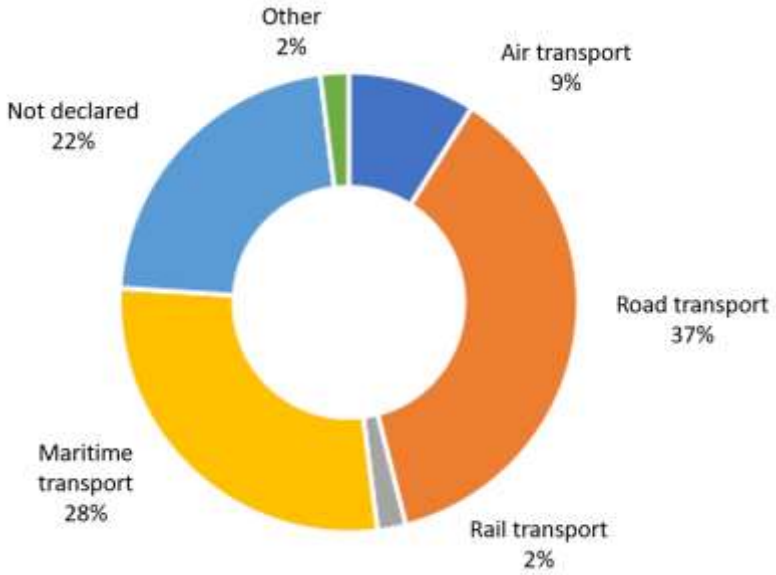

Figure 3 – Transportation modalities in import-export goods between Italy and the world, 2017 [14]

Tourism also plays an important role in maritime transportation; in particular, in the Mediterranean in 2017 it represented 15,8% of total maritime transport. It is the second most important region for cruise tourism in the world, after the Caribbean. The Southern Adriatic Sea is the 7th in cruise traffic at the national level, with the transportation of over 507 thousand passengers in 2017, or 5% of the Italian total for that year. Bari is the main port for cruises in the region.

The maritime economy represents an important development opportunity not only at the national level, but in particular in the area of the CRISIS Project. In fact, in the Apulia Region 53% of import-export commerce goes through maritime routes (equivalent to 8,2 MEUR), in comparison to the Italian average of 36%. The main Apulian ports in the Adriatic Sea (Bari, Brindisi, Manfredonia, Barletta and Monopoli - Figure 4) and Molise's Termoli Port are managed by the AdSP MAM (*Autorità di Sistema Portuale del Mare Adriatico Meridionale* - Port Authority System of the Southern Adriatic Sea). Its ports managed to grow in traffic even during the pandemic, surpassing pre-pandemic levels in 2021 [15].

Figure 4 – Main ports of the Apulia Region in the Adriatic Sea [16]

In 2019 these ports registered 4.716 stops, amounting to 15,5 M tons of goods (Figure 5, left). The number of passengers in the same period amounted to almost 2,5 M (Figure 5, right).

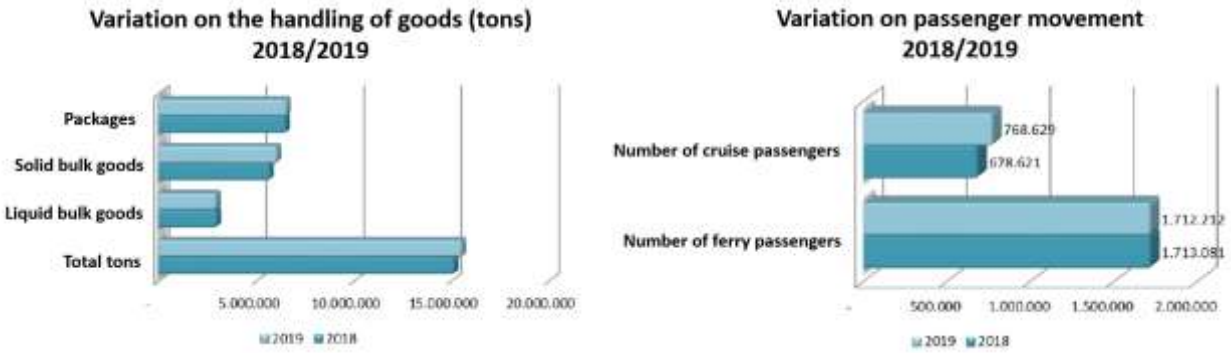

Figure 5 – Goods (left) and passengers (right) that went through the Italian Southern Adriatic ports in 2018 and 2019 (in tons) (based on [17]*)*

All this traffic creates wealth, but it also comes with a cost. The next chapter explores marine accidents and their environmental and societal consequences, with particular emphasis to the area of interest of the Project CRISIS.

4.2.2 Data and analysis of highly environmental impact accidents in Italian Marine Area

In 2021, a total of 2637 marine casualties and incidents were reported in EU waters; of which more than half happened inside ports, followed by territorial sea waters [18]. Fishing vessels were identified as particularly vulnerable to accidents, in that 50% of all accidents involving these vessels were either serious or very serious (the average for all ships categories is 27%). Moreover, the number of fishing vessels lost is 59% of total

number of lost vessels, even though they represent 17% of the total number of ships involved in reported accidents [13]:

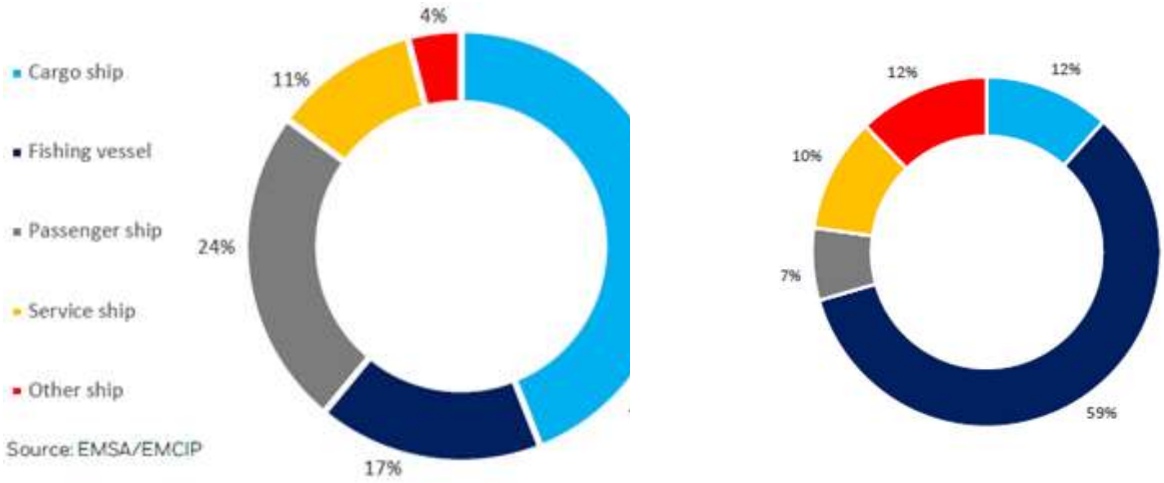

Figure 6 – (Left) Distribution of ships involved in accidents per ship type; (Right) Ships lost per category.

Annual overview of marine casualties and incidents (2021) [13]

The conclusion that can be drawn is that fishing vessels are more vulnerable to accidents, not in terms of frequency, but of seriousness of the accidents.

In Italy, the overall picture of accidents from 2010 to 2019, regardless of their flags, presented a slight decreasing trend, with the exception of 2018. This year, in fact, registered 271 naval units in maritime accidents in October, most of which can be linked to unfavourable climatic events in the Ligurian coast and involved recreational boats.

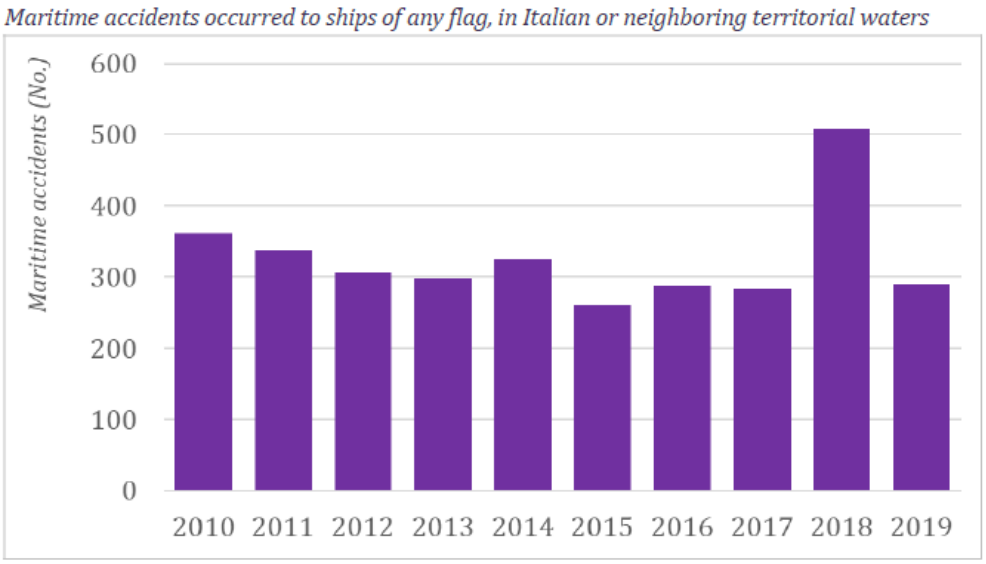

Figure 7 – Maritime accidents in Italian or neighbouring territorial waters (2010-2019) [19]

Table 1 –Numbers on maritime accidents in Italian waters (2019-2019) (based on [19])

Maritime accidents occurred to ships of any flag, in Italian or neighboring territorial waters

Indicators	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
Accidents	362	338	306	298	325	261	288	283	508	289	3.258
No. vessels	440	434	385	405	411	329	347	362	602	367	4.082
Lost vessels	26	36	43	31	32	22	30	30	59	22	331
Deaths	12	227	41	360	35	9	11	19	7	8	729
Injuries	79	91	226	228	85	46	45	91	44	36	971

Unfortunately, Apulia Region, alongside Liguria, had the highest frequency of accidents in 2019 (both with 14,53% of the total in Italy – of which 6,57% were in Brindisi):

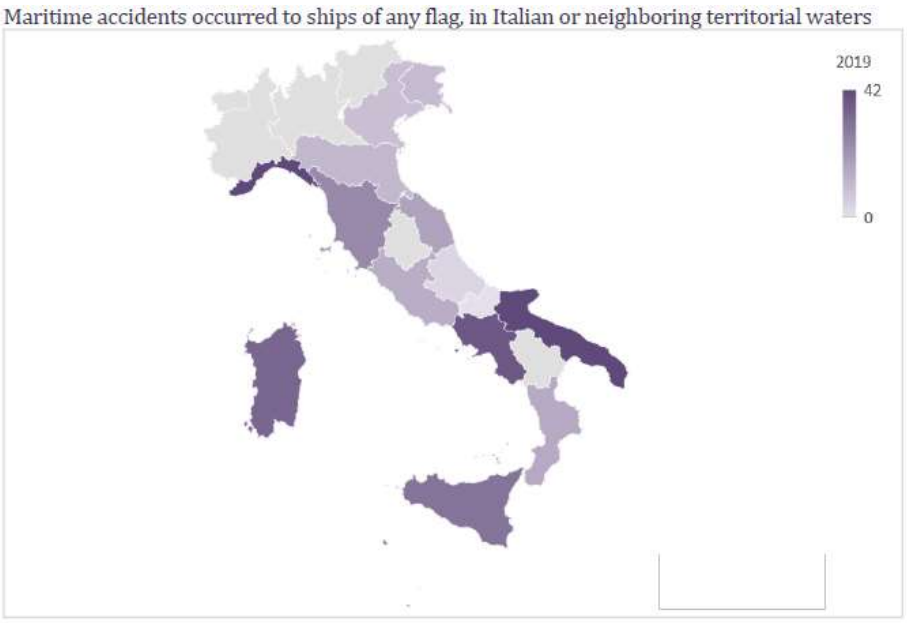

Figure 8 – Maritime accidents in Italy or neighbouring territorial water by region (2019) [19]

Most of the accidents were due to sinking (23,73%), collision between naval units (19,09%) and contact[20] (17,13%). The main causes for sinking are lack or errors in maintenance practices or the excessive and/or unbalanced load distribution, while the main cause behind the collisions is the lack of a look-out [19]. The overall reasons behind the maritime accidents can be seen in greater detail in Figure 9.

[20] collision with some object other than a naval unit

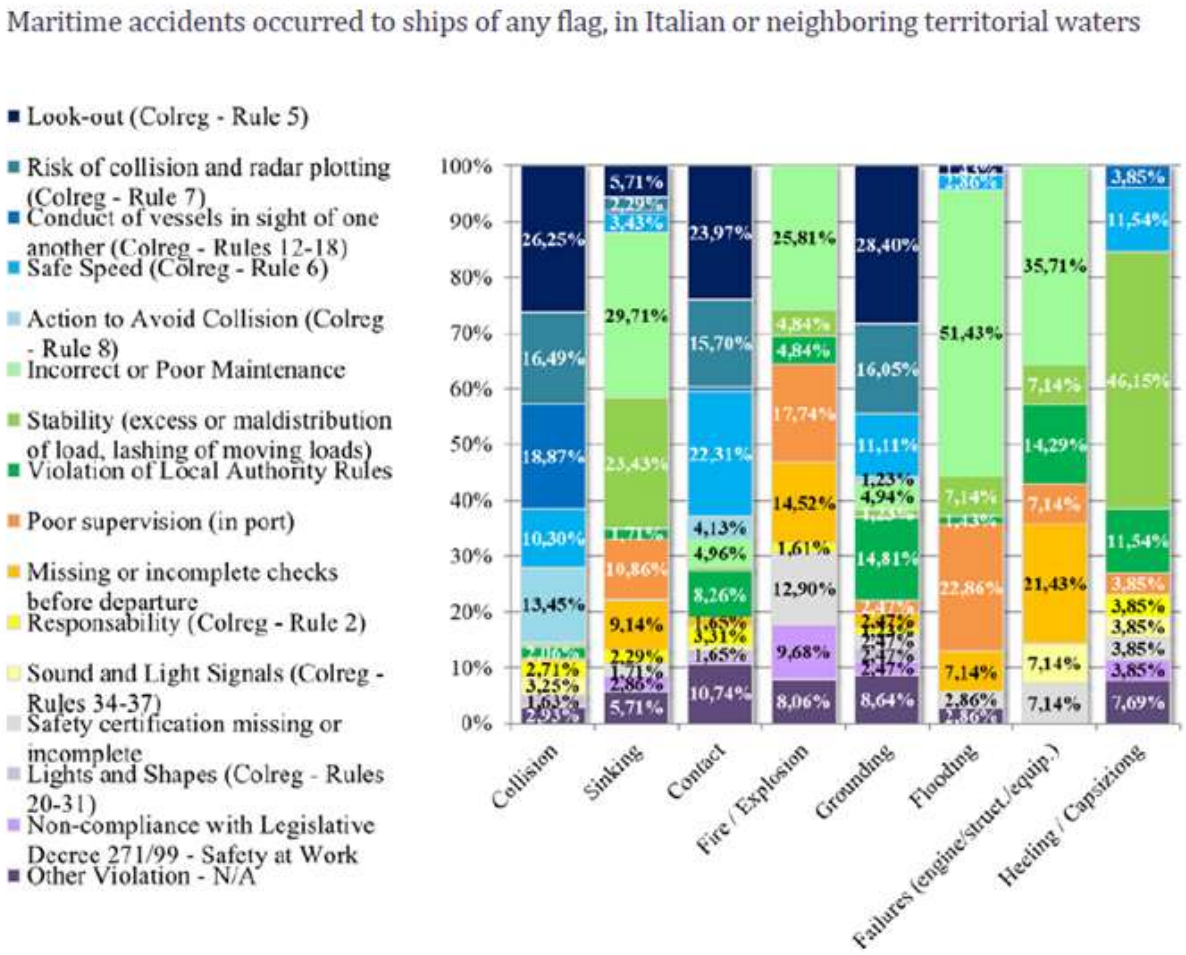

Figure 9 – Maritime accidents in Italian or neighbouring territorial waters (2019) [19]

At the European level, the main contributing factors that lead to marine accidents are “human behaviour” and “environment”:

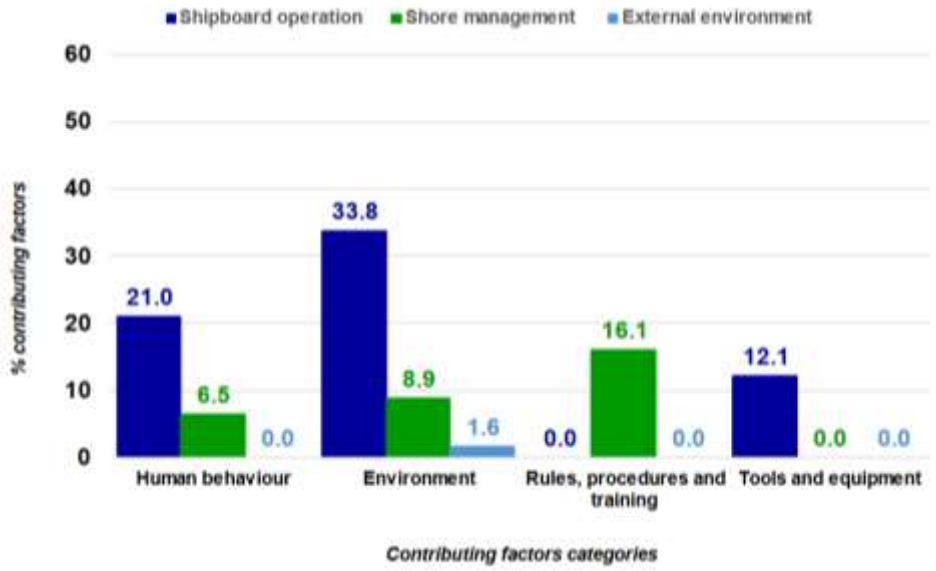

Figure 10 – Percentage of contributing factors involved in hazardous material accident events (2014-2021) [18]

In particular, regarding hazardous material accident events, "environment" is the main contributing factor category (44,3%) [18].

Of particular interest for the CRISIS project, extreme weather conditions can cause serious maritime accidents – which can be accentuated by failure in taking appropriate actions to protect the ship and the crew, poorly maintained or unseaworthy vessels that cannot endure bad conditions, poor planning and/or lack of crew training [20].

Other than the human and monetary costs, these accidents have repercussions on the environment. In 2022, out of the 2.345 maritime casualties registered in the EU by EMSA (European Maritime Safety Agency), 37 resulted in pollution events, in a decreasing trend. [21]

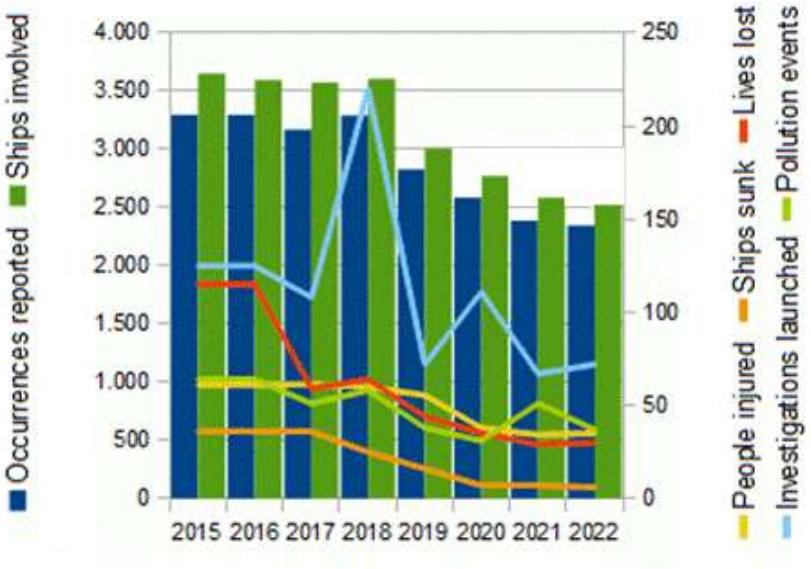

Figure 11 – Maritime accidents in the EU (2015-2022) [22]

Pollution events can have dramatic effects on affected areas, both on marine life and humans alike. Of particular concern for marine environments are oil spills, which are difficult to clean up and can last for long periods in the environment. Oil spills usually are divided in three categories: small (<7 tons), medium (7-700 tons) and large (>700 tons).

In the last 30 years the total amount of accidents and spills from tankers has declined, even though the net quantity of oil transported by sea has grown, as well as CleanSeaNet's[21] monitoring capacities. In European Union waters the last major oil spill accident was in 2002, off the coast of Spain.

[21] EMSA's European satellite-based monitoring systems for marine oil spill detection, which address detections worldwide – although the EU has the higher density of satellite image acquisition

Table 4.1 Top oil spill accidents in the EU since 1990

Ship name	Year	Location	Oil lost (tonnes)
MT *Haven*	1991	Genoa, Italy	144 000
MV *Braer*	1993	Shetland Islands, UK	85 000
Aegean Sea	1992	La Coruña, Spain	74 000
MT *Nassia*	1994	Black Sea, Turkey	33 000
MV *Sea Empress*	1996	Milford Haven, UK	72 000
MV *Erika*	1999	Off Brittany, France	20 000
MV *Prestige*	2002	Off Cape Finisterre, Spain	63 000

Figure 12 – Top oil spill accidents in the EU since 1990 [23]

Other spills that can have devastating consequences for the environment are chemical spills. Hazardous and Noxious Substances (HNS) are defined as "*any substance other than oil which, if introduced into the marine environment, is likely to create hazards to human health, to harm living resources and marine life, to damage amenities of to interfere with other legitimate uses of the Sea*" [23]. This is a broad description, and specific impacts depend on the characteristics of the substances spilled (e.g. their toxicity, dispersion, the quantity spilled etc.).

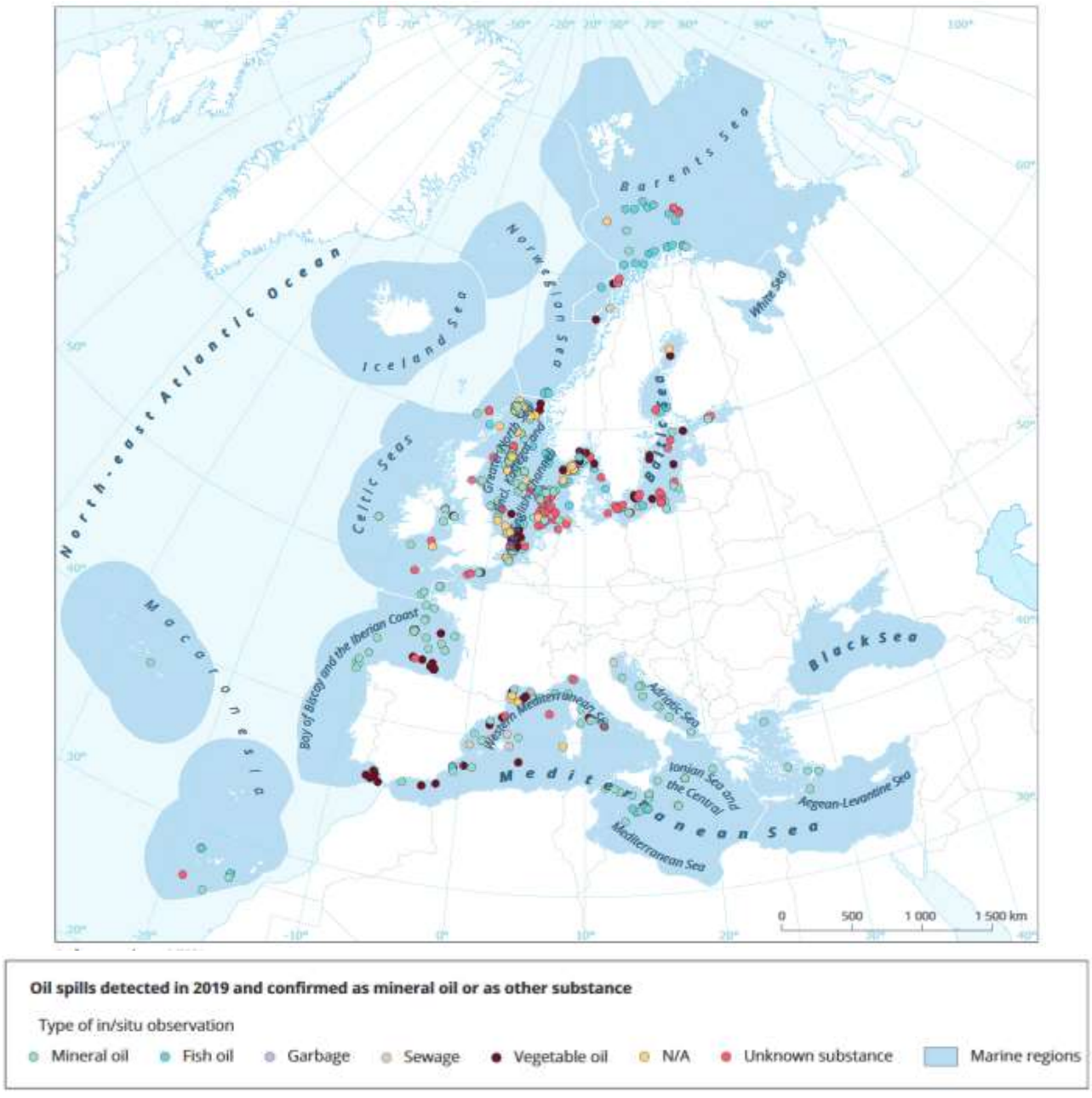

Figure 13 – Confirmed spills detected by CleanSeaNet, 2019 [23]

Another source of pollution is the loss of containers at sea – a ship's movement, especially in bad weather conditions and in higher tiers, can cause containers to fall if not properly secured. They can also represent a navigation hazard to other vessels. The annual loss of containers at EU's water follows a similar rate to global numbers (that is, around 0,0006% of containers get lost at sea). [13]

From 2014 to 2021, 495 cases of pollution were reported in the EU (Figure 14), most of which from cargo ships (53,4%) and fishing vessels (16,8%). In total, there have been 115 oil pollution responses during this period in EU waters.

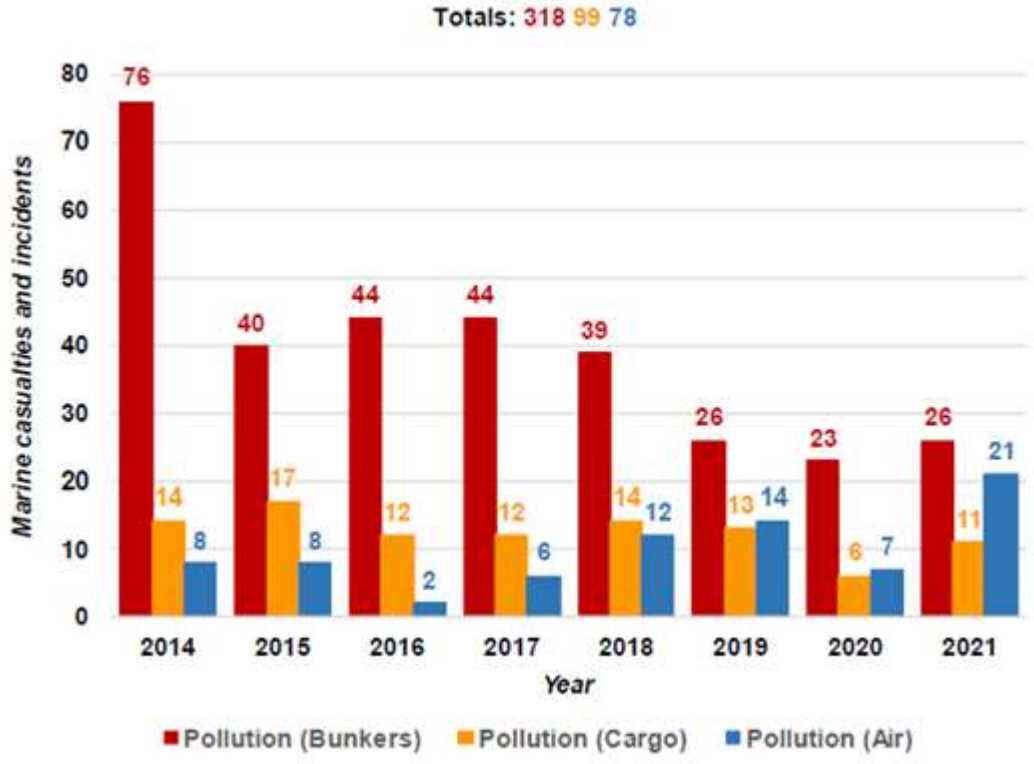

Figure 14 – Evolution of pollution, by type of pollution [18]

4.2.3 Marine accidents in the Adriatic Sea

The Adriatic Sea has a general positive record regarding marine accidents, due to favourable environmental conditions (shallow waters, no typhoons or the like). However, increasing oil tanker traffic is bound to increase the risks of a major oil spill. Moreover, the cross-border cooperation concerning maritime safety has not yet reached its full potential [24]. In the years 1978 to 2003 the main marine accidents that resulted in pollution in the Adriatic Sea were:

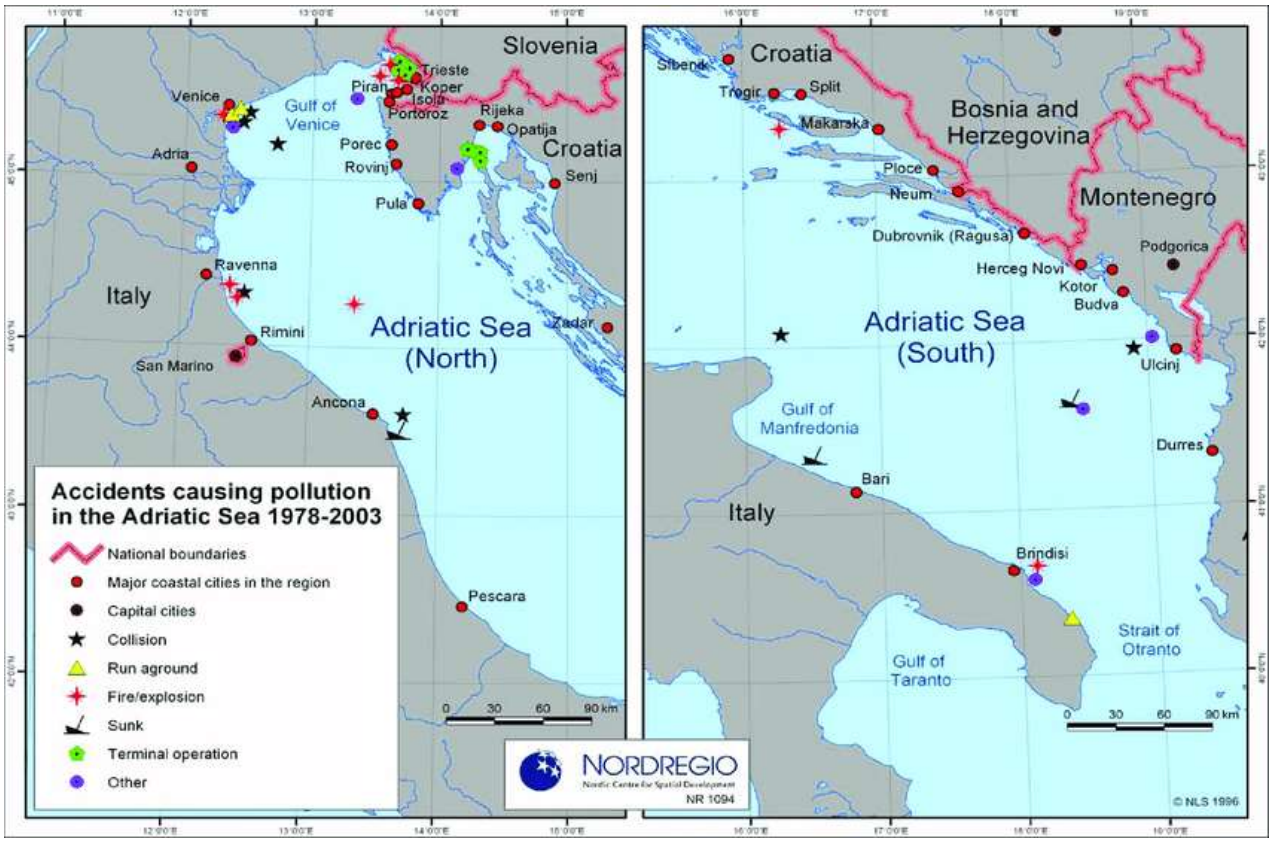

Figure 15 – Accidents in the Adriatic Sea that have resulted in major pollution, between 1978-2003 [24]

Table 2 – Most significant polluting events in the Adriatic Sea 1978-2003 [24]

Year	Place	Accident	Transported material	Environmental impact
1978	Trieste	Spill	Oil	Oil pollution
1979	Venice	Collision	Oil	Oil pollution
1983	Porto Marghera	Collision	Oil	Oil pollution
1985	Porto Marghera	Fire	Oil	Oil pollution
1985	Triestre Terminal	Spill	Oil	Oil pollution
1986	Urinj	Spill due to storm	Oil	Oil pollution
1986	Malamocco	Run aground	Oil	Oil pollution
1987	Bar	Spill	Oil	Oil pollution
1989	Bakar	Spill	Oil	Heavy oil pollution
1989	Baker	Oil pollution due to strong wind while discharging	Oil	Oil pollution
1990	Koper	Oil pollution due to faulty valve	Oil	Oil pollution
1990	Brindisi	Propylene left to burn out	Propylene	Hazardous substances pollution
1991	Off Chioggia	Collision	Oil	Oil pollution

Year	Place	Accident	Transported material	Environmental impact
1991	Off Ravenna	Explosion and fire	Oil	Oil pollution
1992	Brindisi	Oil pollution due to wrong manoeuvre	Oil	Oil pollution
1993	Brindisi	Leakage from oil pipe terminal	Oil	Oil pollution
1994	Off Ravenna	Collision	Hazardous substances	Hazardous substances pollution
1994	Off Ancona	Collision	Hazardous substances	Hazardous substances pollution
1994	Off Ravenna	Explosion	Hazardous substances	Hazardous substances pollution
1995	Off Vieste	Collision; 2 crew members missing	Oil	Oil pollution
1995	Venice	Pipeline leakage	Oil	Oil pollution
1995	Venice	Run aground	Hazardous substances	Hazardous substances pollution
1996	Bakar	Large leak from tank at the INA refinery	Oil	Oil pollution
1996	Trieste	Loss of part of cargo + spill	Oil and cargo	Oil and cargo pollution
1997	Split	Fire; 1 casualty	Oil	Oil pollution
1998	Trieste	Spill	Oil	Amna crude oil pollution
1999	Trieste	Fire; 1 casualty	Oil	Oil pollution
1999	Ravenna	Fire; 9 injured	Oil	Oil pollution
2000	Trieste	Fire at Siot pipeline terminal	Oil	Oil pollution
2001	Izola	Fire	Oil	Oil pollution
2001	South of Brestova	Oil leakage from a wreck	Oil	Oil pollution
2002	Bar	Contact	Oil	Oil pollution
2003	Odd Conero Cape	Slick pushed back to sea by winds	Oil	Oil pollution
2003	South Adriatic	Sinking	Hazardous substances	Hazardous substances pollution

More recently, some of the worse marine accidents in the Adriatic Sea were:

- Isola di Capraia, a 71 meter long ro-ro passenger ferry that ran aground at the harbour of San Nicola, Tremiti Islands (IT) in 2020, when it lost control due to a mechanical breakdown. Fortunately, there were only minor damages, and no reported injury or pollution release.
- Kanga, a 40 meter yacht that caught fire off Dubrovnik (Croatia), due to electrical problems in 2018. Three firefighters were injured and the boat suffered extensive damage.
- Cement Carries. In 2015, three cement carriers broke their moorings and were blown ashore due to heavy seas and strong wind gusts. Two carriers washed ashore on Marian beach, while a third ended up in Slatina No one was injured because the three vessels were unmanned.

- Franco P, a tug that sank en route from Ancona to Bari in 2022, due to unknown causes. Five people died.
- Norman Atlantic, a 186 meter ferry travelling from Igoumenitsa to Ancona, caught fire in the Strait of Otranto in 2014. In total 30 people died.
- Und Adriyatik, a Turkish-flagged ship that caught fire off Rovinj (Croatia) in 2008. It carried 11 tons of crude oil and 200 trucks aboard, raising concerns regarding the environmental impact. Fortunately, the flames were contained, and all crew members and passengers were rescued.
- Gökbel, a Turkish general cargo ship which sank in the waters off Ravenna in 2014 after a collision with another vessel. Environmental conditions (fog and strong winds) contributed to the accident. Six people died.

Unfortunately no more updated analytical detailed information about accidents in Italian waters are publicly available because of institutional lacks. More in depth, since 2015, Italy started a dematerialization process about railway and maritime accidents report in order to collect the whole data and analyse them in a more efficient way. A specific office (DIGIFEMA) was created with the goal to interconnect Italian Harbour Offices [25] in order to collect every single accident with details like: a brief description about the kind of the event, the date and location in which it occurred. All of these data are subsequently notified from DIGIFEMA to the EMSA (European Maritime Safety Agency) through the EMCIP (European Maritime Casualty Information Platform) [26] database where only institutional bodies can request to obtain the access. At a national level, another platform with many functionalities [27] should be available, the so called SIGE (SIstema Gestione Eventi incidentali) however, to date, this is not available for public consultation too.

4.3 Montenegro

In 2021 the national competent authorities started exploring potential oil and gas locations in Montenegro's coast and territorial waters, but some issues emerged very soon. The environmentalists say that competent authorities are not doing enough to mitigate the potential impact of oil spills or other environmental disasters. However, a state audit body and environmentalists say that Montenegro is unprepared to deal with the impact of a potential environmental disaster on its 313 kilometres of Adriatic coastline[22] . Exploratory drilling for oil and gas off the Montenegrin coast has focussed attention on the steps taken by the state to minimize the threat to the marine ecosystem from any eventual environmental incident, such as a significant oil spill. In its annual report, the State Audit Institution of Montenegro said the legal framework was outdated and the country lacked the technical and human resources to cope with potential threats and environmental risks [28].

Montenegro hoped an exploration project in its territorial waters will confirm the presence of billions of euros worth of oil and gas. However, environmentalists and anti-corruption campaigners are concerned. In April 2021, Italian oil company ENI and Russian gas giant Novatek began searching for oil and gas 28 kilometres off the shore of Montenegro. The entire project has been criticized from the outset, beset with accusations of a lack of transparency and concerns over the possible damage it could cause both to the

[22] https://balkaninsight.com/2021/06/16/montenegro-failing-to-protect-sea-from-potential-accidents/

environment and to the Montenegrin tourism industry, which contributes more than 20% of the country's GDP. It's a familiar scenario for such projects in the Western Balkans. On one side are government officials pointing out the potential economic benefits. For Montenegro, a country so reliant on tourism, oil and/or natural gas exploitation could help diversify the economy, a priority whose importance was made starkly clear by the Covid-19 pandemic and associated travel and hospitality industry restrictions.

In the statements of Montenegro officials from the Ministry of capital investments, the "drilling is in the initial phase and it's still early to draw conclusions. Still, results up to now show that geological prognoses based on interpreting seismic data were correct. If the expectations about the size of the well are confirmed, the revenue that Montenegro would receive means not just a financial injection for a faltering economy but security and stability for several next future generations." as reported by Deutsche Welle in April 2021.

ENI and Novatek were drilling at a depth of 6,500 meters. Possible effects on the tourism industry are also causing concern. The NGO environmentalist campaign said that if oil or gas are found, the construction of accompanying infrastructure such as pipes and even possible LGN terminals, as well as the presence of tankers might give tourists pause when choosing Montenegro's coast as their vacation spot. They explain that "tourists that come will express doubts about the seafood, the fish they are eating, the provenance of olive oil and other products Montenegro is recognized for. And the oil rigs, even though they are some twenty kilometres out, are still visible from the shore"[23]. In the end, Italy's Eni and Russia's Novatek had discovered no petroleum or gas deposits at the exploration well offshore Montenegro between Bar and Ulcinj[24].

From a scientific point of view, a major threat to the marine and coastal environment comes from oil spill accidents. Such events have a great impact on both the ecosystem and the economy, and the risk increases over time due to increasing ship traffic in many sensitive areas. In recent years, numerical simulation of oil spills has become an affordable tool for the analysis of the risk and for the preparation of contingency plans. However, in coastal areas, the complexity of the bathymetry and of the orography requires an adequate resolution of sea and wind flows. Therefore, recently is made a study on the subject of adopting Large Eddy Simulations for both the low-atmosphere and sea dynamics in order to provide highly-resolved marine surface current and wind stress to the oil slick model, within a one-way coupling procedure. Based on a wide examination of literature and related publications, such an approach is applied to the relevant case of Kotor Bay (UNESCO heritage since 1979), in Montenegro, which is a semi-closed basin surrounded by mountains that is subject to intense ship traffic for touristic purposes. Oil spill spots are tracked along ship paths, in two wind scenarios in this study [29].

It should be noted that Montenegro has been proclaimed an Ecological State since the 1991 Constitution. Apart from being the first and only country in the world with such a constitutional commitment, national development was based on nautical, marine, mountain, rural, and river tourism, from which 23 percent of the gross domestic product is collected. The latest report by the World Tourism Organization said that by 2025, Montenegro could employ about 75,000 people in the tourism sector. However, the idea of returning to the high-risk oil research project in the coastal area after 70 years of unsuccessful oil and gas exploration, was actualized again. Thus, the executive and the Montenegrin legislature made a noteworthy move by signing different contracts in the same year, such as the agreements with oil magnates ENI - Novatek and

[23] https://emerging-europe.com/news/montenegro-starts-offshore-oil-exploration-worrying-environmentalists-and-anti-corruption-activists/

[24] https://seenews.com/news/eni-novatek-find-no-oil-gas-offshore-montenegro-report-771272

Energean Oil and Gas for the opening of the first exploitation in the Montenegrin Sea, and the climate agreement that together with 200 other signatories, is obliged to phase out the use of fossil sources. The first contracts signed for 30 years and over are likely to completely exhaust this fossil resource, regardless of the European path of reducing gas emissions to a minimum by 2050, as the Agreement bounds.

Especially, the fossil fuels exploration and exploitation could severely affect the damage to life, fishing, and tourism. The situation was that research in the six oil and gas exploration blocks in Bar and Ulcinj submarine had been underway for 40 days, with 7,000 echo strikes of the sea bottom every day. The impact on the biodiversity of the sea and the ecosystem is significant but insufficiently explored. Damage to the living world, fishing, and tourism are evident because only one strike, for research purposes, produces the noise of one jet airplane. Underwater detonations cause the utterance of the auditory organs of marine mammals (whales, dolphins, sea bears), damage to fish balancing organs, and spraying of fish nests and organs in turtles and juvenile aquatic species, affecting a diameter of up to 60 km. Therefore, the first direct impacts are expected in the fishing industry, which depends on about 1000 people employed in fisheries, aquaculture, processing, and catering, and a large number of local communities on the Montenegrin coast.

Unfortunately, the affected fisheries and tourist communities through formal processes of public hearings have not received the information they are expected to experience regarding the risks of pollution of the sea, the impact on tourism and fisheries as the primary activity they are generating but also on the future nutrition, health, and quality of life. However, as stated in research and daily journal articles, the greatest dangers come from the exploitation process, where accidents with about a hundred thousands of barrels of oil flood could completely cover the small range of sea in Montenegro. It would take half an hour to get to the shore, only 3 to 10km away. Even during regular operations, oil leaks are on average 1-4 times a year, while a particular risk is the overload and transport of oil and gas tankers, pipelines at the bottom of the sea, gas explosions on platforms, etc. Researches increase the risk of induced earthquakes in the already seismologically sensitive area of Montenegro, and the first research will be done in the most vulnerable seismic zone of the Ulcinj[25].

4.3.1 Data received from the maritime administration of Montenegro

The list of main cases and related data on maritime pollution in Montenegro is received from AMSPM of Montenegro. Data is represented in Table 3.

[25] https://www.total-montenegro-news.com/business/3656-fossil-fuels

Table 3 Main incidents related to dangerous goods in Montenegro (source: AMSPM)

Nr	Ship name	Date	Location	Type	Quantity
1	Mexica	10.08.2007.	Shipyard Bijela	Oil and oily mixtures	640.000 l
2	Syrena	26.05.2013	Herceg Novi bay, Njivice	Oil and oily mixtures	450 l
3	Tunj	15.12.2013.	Perast	Oil and oily mixtures	720 l
4	MP	20.06.2014.	Kotor bay, Muo	Oily mixtures and oil residues	80 l
5	Independia	21.07.2016.	Tivat bay, Bonići	Oily mixtures and oil residues	70 l
6	Yulia	24.04.2017.	Tivat bay, Solila	Oily mixtures and oil residues	6.000 l
7	Marija D	15.08.2018.	Risan bay, Port of Risan	Oily mixtures and oil residues	4.000 l
8	Dubravica	13.07.2021	Kumbor	Oily mixtures and oil residues	5.000 l

4.3.2 Data from the ports and marinas

The consultant has contacted ports and marinas in Montenegro, asking if there were any incidents related to dangerous cargo transport in their area of responsibility.

Luštica Bay Marina answered that they had no incident related to dangerous cargo since the marina opened in 2018.

Luka Bar stated that according to their statistical data, there were no incidents related to dangerous cargo transport in their port area from 2018 to 2022.

Porto Montenegro and Porto Novi stated that they had no previous incidents related to dangerous goods in their area of responsibility.

4.3.3 Analysis of marine pollution cases in Montenegro

In this section, we elaborate the background, specifics and circumstances under several maritime accidents and incident related to ships, small vessels, yachts and other means of transportation at sea happened in previous 20 years[26].

Accidents and sea pollution can occur in all ports and marinas, and are especially related to the Port of Bar, where various types of liquid fuel, chemicals, and explosive substances are handled. It is also possible to transport dangerous goods of class 7 (radioactive materials), and in this connection, there is a potential risk of a radiation accident during transport by sea. In addition to the above, a potential accident with radioactive materials at sea can occur during the exploration of hydrocarbons, oil, and gas, which is described in more detail in the Strategy for Protection against ionizing radiation, radiation safety and management of radioactive waste for the period 2017-2021. with the Action Plan for the period 2017-2021. years.

Dangerous materials (explosives, initiators, pyrotechnics, weapons and military equipment, oil and oil derivatives, sodium hydroxide, base oil, cement, alumina, etc.) are stored in the Port of Bar, and in the AD Marina Bar is settled a gas station with 3 oil derivatives tanks with a capacity of 81m^3 for the needs of vessels.

Within the Luka Bar complex, there are significant infrastructure facilities, namely: two caustic soda storage tanks owned by Kombinat Alumnijum - Podgorica with a capacity of 3,200 m^3 each, a base oil tank owned by Luka Bar with a capacity of 1,400 m^3, tanks for oil and oil derivatives with a capacity of 128,000 m^3 owned by Jugopetrol AD Podgorica, grain silos, asphalt road - internal road, railway tracks, as well as the tunnel connecting the Port of Bar with the storage of explosive materials. The warehouse of explosive materials is located on the other side of Volujica Hill, along the sea coast. It is the central and largest warehouse of explosive materials in Montenegro, which ware used daily for the construction of the Bar Boljari highway section, for the needs of the Coal Mine - Pljevlja, the Suplja Stijena Lead, and Zinc Mine - Pljevlja, the Bauxite Mine - Nikšić and for the construction of other facilities in Montenegro. It burns where these substances are used.

Accidents can occur due to human error due to the performance of unauthorized actions, such as unauthorized handling, improper storage of derivatives, pumping, topping up, pouring, and other manipulations with these substances, work of third parties near the plant without professional supervision, as well as intentional damage. Also, accidents can occur due to the effects of some natural catastrophes, for example, earthquakes, land subsidence, landslides, atmospheric precipitation, floods, and fires. Given the increasing presence of vessels, especially yachts and boats, there are also risks of accidents on vessels, such as: sinking, stranding, collision, fire, explosion, capsizing, poisoning, infectious diseases, theft, kidnapping, and pollution of the sea and coast. In the following Table 1, is given data about the most recent oil spill accidents in Montenegro.

[26] Strategija za smanjenje rizika od katastrofa sa dinamičkim planom aktivnosti za sprovođenje strategije za period 2018 - 2023. Godina, Ministarstvo unutrašnjih poslova, Decembar 2017. https://wapi.gov.me/download/a9cf7fb1-1c45-4baf-a5bc-5de9a3329be7?version=1.0

Table 4 Historical data on marine pollution on Montenegro's coast [27]

Sea-going Vessel Name	Date	Place	Type of pollution
Ship „Mexica“	10.08.2007.	Shipyard Bijela	Oil spill and oily mixtures. Quantity: 640 000 l
Yacht „Syrena“	26.05.2013.	Herceg Novi Bay, Njivice location	Oil spill and oily mixtures. Quantity: cca 450 l
Tugboat „Tunj“	15.12.2013.	Perast	Oil spill and oily mixtures. Quantity: cca 720 l
Ship „MP“	20.06.2014.	Bay of Kotor, Muo	Oily mixtures and oil remnants. Quantity: cca 80 l
Yacht „Indipendia“	21.07.2016.	Bay of Tivat, Bonići location	Oily mixtures and oil remnants. Quantity: cca 70 l
Catamaran „Yulia“	23.04.2017.	Bay of Tivat, Solila	Oily water and thick oil waste. Quantity: cca 6 000 l

About twenty days after it partially sunk into the sea near the dock of the shipyard in Bijela, the Greek ship Mexica was pulled out of the water on 31st August 2008., thereby eliminating the danger of it capsizing and polluting the sea. The aft part of the ship that was being overhauled sank due to a storm accompanied by strong winds that hit the Bay of Boka Kotor[28]. The responsible authorities worked on the rehabilitation of the mentioned incident[29]. Mexica, which used to sail under the flag of Panama, owned by the Greek and Liberian firm "Reefer and General Ship Management co. inc." and "Seaview Shipping S.A." has been anchored in Bijela since August 2007, where it sailed for overhaul. It partially sank at one of the jetties and since then, until last year, the Montenegrin side and the Greek and Liberian owners were in a legal dispute. The composure of the shipyard workers saved the ship from sinking completely. Last year, a final settlement was concluded, whereby the owner of the ship was obliged to pay the Shipyard 100,000 dollars and to hand over the ship to him without any obligations of the opposite party [30].

It is important to mention that in the last 20 years, there have been no accidents with loss of human life in maritime traffic in cases of major accidents, but there was an oil spill from ships in the Port of Bar in 2001 from the ship "BANIA STAR" due to the impact and sudden changes in weather conditions during the summer tourist season. In addition to the above, in 2001, a strong westerly wind (“punenat”) damaged the main breakwater of Port Bar and the lighthouse at its end[31].

[27] https://wapi.gov.me/download/a9cf7fb1-1c45-4baf-a5bc-5de9a3329be7?version=1.0

[28] https://www.pcnen.com/portal/2007/08/31/brod-meksika-konacno-u-sigurnom-polozaju/

[29] https://hemosan.info/portfolio/incident-broda-mexica/

[30] https://www.portalanalitika.me/clanak/brod-meksika-prodat-za-775-hiljada-eura-grkom-biznismenu

[31] Procjena rizika od katastrofa Crne Gore, Ministarstvo unutrašnjih poslova, Direktorat za zaštitu i spašavanje, Decembar 2021.

Further, due to sea pollution, the ship "Simano" was stopped while the fine was 15,000 euros. The navigation safety inspection of the Port Authority of Kotor stopped the ship "Simano" in the Bijela shipyard due to sea pollution. From Navigation safety inspectorate is stated that all documents were confiscated from the ship and that the investigation is ongoing. "Two barrels of new oil fell from the pallet and on that occasion hit the space between the ship and the mule. The barrels were damaged and oil leaked from them," said inspectorate officials, adding that there was no danger and that the pollution was under control. It was suggested that the ship's company be fined 15,000 euros, and the captain as the responsible person 1,500 euros. On 27th August 2014., the Montenegro Port Authority's inspection fined the yacht "Crowned eagle" in Porto Montenegro marina for spilling four litters of diesel fuel, as well. "The maximum penalty for such incidents is 22,000 euros, and the minimum is 2,000 euros. We did not impose the harshest penalty because the spreading of the greasy stain was prevented and an environmental disaster was prevented," explained the inspectorate officials saying that this pollution is also under control[32].

Another case of pollution of the sea in Boka Kotorska happened on 15th May 2022. The responsible authorities were immediately informed, which found fat stains, oil stains, and white and yellow foam noticeable on the surface of the sea. In the Bay of Kotorska, but also outside the bay in the water area from the Blue Cave to Cape Arza, that day, large-scale sea pollution was recorded. Up to now, it is unknown what or who caused the pollution. On the surface of the sea, there are noticeable greasy stains, oil stains and white and yellow foam, which leads to the conclusion that the contents of the bilge and the so-called black tanks were pumped out from a larger vessel that passed through the water area of the bay last night or early this morning, basically the sea area southeast of the entrance to Boka. Dirt on the surface of the sea in Boka was recorded late at night, so the operational team from the Administration for Maritime Safety and Port Management (AMSPM) of Montenegro and the Montenegro Navy with the special vessel EKO-1, were in preparedness with a floating dam and absorbents that were also on standby for intervention. However, after the patrol of the Navigation Safety Inspection from Kotor passed through the water area, it was decided that there was no need for it because, allegedly, it is not about spilled oil, but various dirt that was washed into the sea the previous day afternoon, from the land, by a large downpour and rain that then grabbed Boka. "Part of the pollution, at first glance, really looks like oil and oil stains, but these are not those substances, but various dirt that came into the sea from the coast with the rain. In any case, the navigation safety inspector took water samples at sea on which that stain and other dirt were present, and they were sent for analysis to the laboratory of the Institute of Marine Biology in Kotor," a source from AMSPM declared[33].

Furthermore, not related to navigation but important for the marine environment was the accident on the underwater part of the sewer system Kotor – Trašte happened at the beginning of August 2013. On the underwater part of the sewer system Kotor - Trašte, which is used by the municipalities of Kotor and Tivat, there was an accident, which is why the fecal content is now pouring directly into the sea. In addition to the fact that sewage spilling into the sea can cause an ecological disaster, a huge pipe, 93 centimetres in diameter, only about 500 meters from the beaches Plavi horizonti (where the Blue Flag flies) and Oblatno, and about three kilometres from the tourist resort of Bigova, is currently sticking out above the surface of

[32] https://www.vijesti.me/vijesti/drustvo/220935/zbog-zagadenja-mora-zaustavljen-brod-simano-kazna-15-000-eura

[33] https://www.vijesti.me/vijesti/drustvo/604231/zagadjenje-mora-u-boki-kotorskoj-obavijesteni-nadlezni

the water and represents an immediate danger to vessels. The accident was first noticed by a tourist from Novi Sad passing by a boat near the burst pipe and immediately informed the Municipal Health Service of Bigovo, which alerted the competent services. Officials from JP Vodovod i Kanalizacija Kotor pointed out that the damage to the submarine outlet is a "serious problem", specifying that the sewage flows into the sea about 1.5 kilometres from the coast of Trašte Bay. The Institute for Marine Biology warns that the spilling of sewage into the sea certainly has a negative impact on the living world under water, and "often on human health as well." Scientists at that institution, explain that the negative impacts will be significantly more intense if there are breakdowns of larger communal wastewater outlets, such as the Trašte outlet, and breakdowns that are of a longer nature[34].

In the incident that took place on 12th July 2015, in the water area near the Dobreč bay on Luštica, a motorboat-speedboat, which is still officially unknown, was completely destroyed, but luckily no one was seriously injured. The competent state services of the Ministry of Maritime Affairs and Transport did not have information about the identity of the destroyed vessel or about the people who were rescued from it, because nobody reported this accident to them through the official channels?! According to the law, the owner of a ship that has suffered a maritime accident must report it to the competent Port Authority within three days, which until now in the case of a burning vessel, no one has done so. According to our unofficial information, the Zelenika marina's speedboat and a couple of smaller vessels came to the aid of the burning vessel and rescued the passengers and crew who had already jumped into the sea. The call for help from the endangered vessel was sent only to the Zelenika marina, which immediately intervened, while the rest of the system of state services, which is provided for interventions in accordance with the state plan for managing emergency situations at sea, was not notified at all, or was notified with a long delay. Also there were some complaints about a stain of dirty-brown colour floating in the sea along the coast in Donja Lastva near Tivat. Under the influence of wind and waves, the pollution soon broke up and disappeared[35].

Another risky case that could affect the environment was on 17th January 2021. the yacht sank in Boka but the Navigation Safety Inspection claims that there was no sea pollution. Actually, the motor yacht "Katarina", type "Sun Quest 44", which flew the Austrian flag, sank next to the dock near the church of St. Matthias in Dobrota. The 13.6-meter-long ship, on which there was no crew at the time of the incident, sank to the bottom right next to the pier, after which only the upper part of the superstructure protruded above the sea surface. The yacht was taken out from the bottom of the sea with the help of divers, a crane and pumps and her buoyancy was restored by pumping out the water because surprisingly, according to the navigation safety inspectors statements, and her hull did not suffer any damage that would have caused her to have another water intrusion. Representatives of the Administration for Maritime Safety and Port Management of Montenegro (AMSPM) were on the spot and were ready to intervene with floating dams and other technical and chemical means in the event that any spillage of fuel or other oily water was recorded from the sunken yacht. Officials were surprised by the fact that the ship's owner left "Katarina", which otherwise seems rather neglected, on an unsafe mooring in Dobrota, without a crew and adequate measures taken to secure the ship against storms that were timely announced by the weather service [36].

[34] https://kotor.tv/havarija-na-podmorskom-dijelu-kanalizacionog-sistema-kotor-traste/

[35] https://bokanews.me/izgorio-gliser-kod-dobreca-nadlezni-nista-ne-znaju-2/

[36] https://bokanews.me/u-boki-potronula-motorma-jahta-inspekcija-sigurnosti-ploviodbe-tvrdi-da-nema-zagadenja-mora/

On 10th March 2017., workers with a large rented crane finally pulled the sunken ship "Independia" hull from the bay in Bonići to the shore. After three months of largely unsuccessful attempts, in which two cranes were also damaged, the bow of the ship's wooden bed was finally pulled dry. "Indipendia", which has been docked in Bonići for ten years, sank in July of this year when the Egyptians used a crane to pull out two large Mercedes diesel engines from its interior in order to sell scrap metal. Around the sunken wooden bed of the fifty-meter-long ship, the Montenegro Navy, the Port Authority and the Administration for Maritime Safety installed a floating dam and the so-called "dispersants" to prevent sea pollution from oil and oily liquids. Months after that, parts of the deck and the ship's cabin were torn from the ship and carried away. The owners were obliged to pull the ship out of the sea within three months, but it took more than half a year for inexplicable reasons.

The catamaran "Yulia" was destroyed by a fire at the mooring on 24th April 2017. in the Movida marina near Solila – Tivat. Officials said that the surface part of the catamaran in the water area is circulated with protective dam, which was installed by the Navy of Montenegro, was cleaned by the company "Hemosan" from Bar, which was hired by the owner of the sunken ship [37].

Another important case is the tugboat „Dubravica“ from whom about 4.5 tons of oily liquids have been pumped out on 3rd August 2021. In addition to this tugboat, the small tugboat "Polaris" belonging to the company "Boka Pilot&Tug Service" from Bijela, which provided pilotage and towing services for large ships that came to the Bijela shipyard for overhaul, was also tied up in the Špiljica tunnel. For reasons not yet officially determined, the old tugboat "Dubravica" sank in the abandoned military mine for warships Špiljica on the west coast of the Luštica peninsula in Boka Kotorska. The Navigation Safety Inspection of the Ministry of Capital Investments and the Administration for Maritime Safety and Port Management (AMSPM) of Montenegro were informed about the incident. AMSPM immediately sent a duty team of the Montenegro Navy from nearby Pristan to the scene, which surrounded the half-sunken ship with floating dams and absorbents that absorbed the spilled layer of oil and oil from the sea surface. The ship's owner hired his team, so they immediately started pumping out the contents of all the oil and oil tanks on the "Dubravica", that is, pumping out the sea from the ship's hull, to restore the tugboat's buoyancy. AMSPM representative, who was on the spot in the Špiljica excavation this morning, noticed that by Tuesday morning, about 4.5 tons of various oily liquids had been pumped from "Dubravica" into a special tank and that the pumping of water continues from the hull of an old tugboat. According to AMSPM estimates, during the sinking of the "Dubravica" at least 80 litters of oil and oil spilled from the engine room of the tug. The visual effect of mixing so much oil and oil with the sea is much greater because the oily liquids in such a layer cover the very surface of the sea in an area of several thousand square meters. By the way, AMSPM and Montenegro Navy teams repaired and removed oil stains near Krašić, just before 2 p.m. In the meantime, near Krašić in the municipality of Tivat, a few miles east of the Špiljica tunnel, two large oil slicks appeared on the surface of the sea. At the request of locals and tourists, the AMSPM and the crew of the Montenegro Navy responded to this pollution with a floating dam, absorbents and dispersants. The authorities assume that the cause of these two oil stains is precisely the spilling of oily liquids from the semi-sunk tugboat "Dubravica", which was

[37] https://radiotivat.com/2017/04/24/cekaju-se-dizalice-za-vadenje-katamarana-iz-marine-movida/

carried away from the Špiljica tunnel towards Krašići by the usual movement of the sea current in this part of Boka [38].

[38] https://www.vijesti.me/vijesti/drustvo/560846/iz-dubravice-do-sada-ispumpano-45-tona-zauljenih-tecnosti

5. MARITIME RISK ANALYSIS AND MEASURES

5.1 Statistical Analysis of Maritime Risk Factors

Maritime activities play a crucial role in global trade, transportation, and commerce. However, they are also associated with various risks that can have significant economic, environmental, and human consequences. Understanding and mitigating these risks require a comprehensive analysis of the factors contributing to maritime incidents. Statistical analysis serves as a valuable tool in identifying patterns, trends, and correlations among these risk factors.

Statistical analysis of maritime risk factors involves examining various elements that contribute to accidents, incidents, and emergencies at sea. These factors can be broadly categorized into operational, environmental, human, and technical aspects.

Operational factors encompass activities related to vessel operations, navigation, and management. Statistical analysis of operational data may include variables such as vessel type, age, size, route, speed, and compliance with regulations. By analysing historical data, researchers can identify patterns such as common routes prone to accidents, high-risk vessel types, or the impact of adverse weather conditions on operational safety.

Environmental factors play a significant role in maritime risk assessment. These factors include weather conditions, sea state, visibility, ice conditions, and geographical features. Statistical analysis helps in quantifying the relationship between environmental variables and maritime incidents. For example, analysing weather data may reveal correlations between storm frequency and ship collisions or groundings in specific regions. Environmental factors are the most important for the CRISIS project.

Human error is a leading cause of maritime accidents. Statistical human factors analysis involves examining crew competency, training, fatigue, workload, decision-making processes, and adherence to safety procedures. By analysing incident reports and crew performance data, researchers can identify trends related to human error and develop strategies to mitigate risks through training programs, crew resource management, and improved work practices.

Technical factors refer to the condition and maintenance of vessels, onboard equipment, and safety systems. Statistical analysis of technical data may include variables such as maintenance records, equipment failures, structural integrity, and compliance with international standards. By analysing maintenance logs and inspection reports, researchers can identify common technical failures leading to accidents and develop preventive maintenance strategies to enhance vessel reliability and safety.

The Adriatic Sea poses various risks to maritime operations, including adverse weather conditions and collision incidents. Bad weather is a primary concern for maritime operations in the Adriatic Sea, with factors such as storms, high winds, fog, and rough seas posing significant risks to vessels. Statistical analysis of weather-related incidents involves examining historical meteorological data and maritime incident reports to identify patterns and correlations. Key statistical parameters include frequency, duration, and severity of

adverse weather events, as well as their spatial and temporal distribution. Statistical analysis reveals the frequency and severity of bad weather occurrences in the Adriatic Sea, highlighting periods of heightened risk for maritime activities. By quantifying the number of days with adverse weather conditions and their intensity, researchers can assess the overall impact on maritime safety and navigation. Analysing spatial data allows researchers to identify geographic areas within the Adriatic Sea that are particularly prone to bad weather events. Certain regions may experience higher wind speeds, rougher seas, or more frequent storms, leading to increased risks for vessels transiting through these areas. Statistical analysis helps identify temporal trends in bad weather occurrences, such as seasonal variations or long-term climate patterns. Understanding these trends enables stakeholders to implement adaptive measures, such as adjusting sailing schedules or deploying additional resources during periods of heightened risk.

Collisions represent another significant risk factor for maritime operations in the Adriatic Sea, often resulting from factors such as dense traffic, narrow shipping lanes, and human error. Statistical analysis of collision incidents involves examining historical data on vessel collisions, including their causes, locations, and consequences. Statistical analysis quantifies the frequency of collision incidents in the Adriatic Sea, providing insights into the likelihood of such events occurring within specific maritime routes or congested areas. By identifying hotspots for collisions, stakeholders can implement targeted measures to reduce risks, such as improving navigational aids or implementing traffic management schemes. Analysis of collision data helps identify the primary factors contributing to these incidents, including human error, technical failures, and adverse weather conditions. Understanding the root causes of collisions enables stakeholders to develop preventive strategies, such as enhanced training programs for maritime personnel or stricter enforcement of safety regulations. Statistical analysis assesses the impact of collision incidents in terms of property damage, environmental consequences, and potential loss of life. By quantifying the costs associated with collisions, policymakers and industry stakeholders can prioritize investments in safety measures and emergency response capabilities.

The literature is pretty scarce when it comes to concrete figures on percentages of particular risk caused due to bad weather conditions, collision etc.

5.2 Project-Relevant Risk Factors

From the studies conducted in literature and historical analysis of accidents in open Adriatic sea and coasts, the following ones were considered of uttermost importance for the project:

- **Weather conditions:** Weather conditions are a critical factor in ensuring the safety of maritime transportation. Adverse weather, such as limited visibility, heavy precipitation, strong winds, and rough seas, significantly impact navigational capabilities and vessel stability. Reduced visibility can impede the detection of obstacles and other vessels, increasing the risk of collisions. High winds and heavy precipitation can destabilize ships, potentially leading to capsizing or loss of control. Moreover, rough seas can cause structural damage to vessels, jeopardizing their seaworthiness. Therefore, the consideration of weather conditions is imperative for safe maritime operations. By monitoring and

assessing weather forecasts, ship operators can make informed decisions and implement necessary precautions to mitigate risks and safeguard the well-being of crew members and cargo.

- **Incorrect Behaviour:** Human negligence poses a significant risk to maritime safety. The COLREG rules serve as a framework for safe navigation and must be strictly adhered to. However, instances of human error, stemming from inattention or improper behaviour, contribute significantly to the frequency of maritime accidents. Adherence to these rules is essential to minimize the occurrence of such incidents and ensure the safety of maritime operations.
- **Traffic Conditions:** Traffic conditions play a crucial role in maritime navigation, governed by a series of signals and regulations depicted on navigational charts. Areas with high traffic, such as ports and coastal zones, often host diverse vessel types, including pleasure crafts, minor vessels, and cargo ships. Manoeuvring in these congested areas poses challenges due to the lower surface friction and the complexities of turning and braking operations at sea. Consequently, highly trafficked areas are more susceptible to accidents. Effective traffic monitoring measures can help mitigate these risks by enhancing situational awareness and facilitating proactive navigation decisions.
- **Marine protected Area Proximity:** The proximity of marine protected areas exacerbates the environmental impact of pollution events resulting from accidents, as previously discussed. Incidents within or near these protected zones pose a heightened threat to biodiversity, affecting both flora and fauna. Damage to these ecosystems can have far-reaching consequences, disrupting fragile habitats and jeopardizing the survival of numerous species. Consequently, accidents occurring in the vicinity of marine protected areas exacerbate environmental harm, underscoring the critical importance of implementing stringent safety measures to safeguard these invaluable natural resources.

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This project is co-financed by the European Union under the instrument for Pre-Accession Assistance (IPA II)

This document has been produced with the financial assistance of the Interreg IPA CBC Italy-Albania-Montenegro Programme. The contents of this document are the sole responsibility of Municipality of Molfetta, Molise Costiero and Municipality of Ulcinj and can under no circumstances be regarded as reflecting the position of the European Union and of the Interreg IPA CBC Italy-Albania-Montenegro Programme Authorities.