Study regarding the state of the Black Sea for the project *Innovative techniques and methods for reducing the marine litter in the Black sea coastal areas* – RED MAR LITTER

Model of water flows and Model of waste distribution

This report is prepared in implementation of contract no 21/12.02.2021, concluded between the Atlas Research SRL and Nikola Vaptsarov Naval Academy.

Contents

Introduction

The present study was conducted in the interest of the detection of surface water flows in the marine environment and their impact on movement, respectively on the distribution of floating solid waste in the target area.

Figure 1.1 illustrates surface floating waste under the influence of sea surface flow.

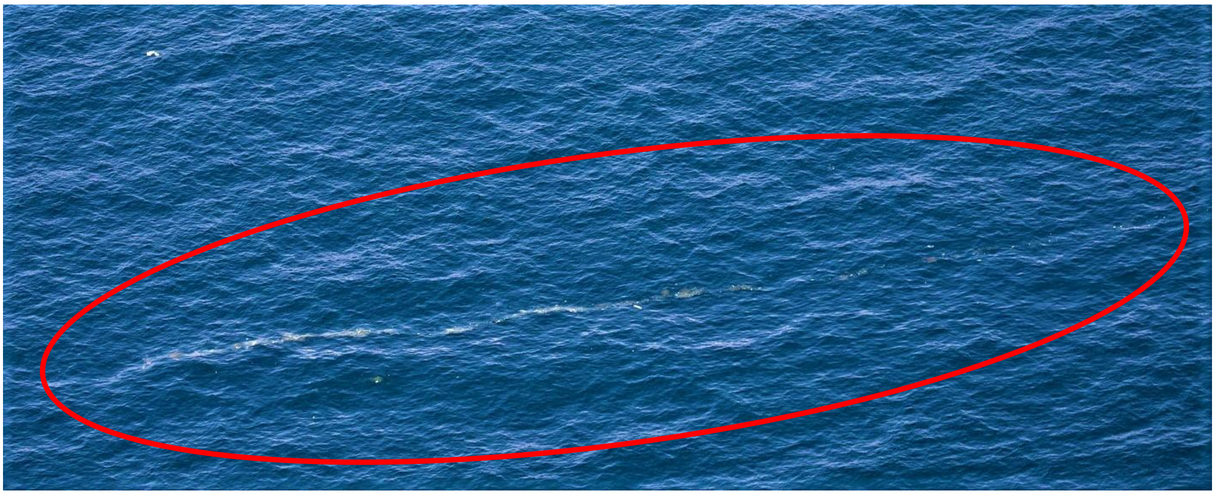


FIG. 1.1 Solid waste floating in the water column under the influence of surface water flows

It can be assumed that most of the floating solid waste is located in the water column at shallow depths or just at the boundary below the water surface. In this case, their movement is mostly caused by the sea surface flows, formed under the influence of sea surface currents.

It is also taken into account that depending on the material, size, shape, mass, volume and especially the degree of immersion of floating waste in the marine environment, to its movement on the sea surface, in addition to water flows, the so-called ground wind may have some influence. Examples of such floating debris are shown in Figure 1.2.

FIG. 1.2 Slightly submerged floating debris on the sea surface

For the purposes of modeling the processes in the surface layer of the marine environment, data sources with the required spatial coverage, resolution and time range, suitable for solving the studied problem have been analyzed.

At a global level marine litter is seen as a developing polluting material, particularly in the maritime environment. Within the European Marine Strategy Framework Directive (MSFD), marine litter is consequently encompassed as a distinct descriptor (descriptor 10). At a state level, governments have to evaluate the amounts and categories of the waste in their marine waters as part of the MSFD implementation.

The Black Sea is a semi-enclosed basin, of relatively small size, with an area of 466,000 km^2. It is located in the eastern part of Europe, between 40° 55' and 46° 32' north latitude, respectively 27° 27' and 41° 42' east longitude.

The northwestern region is considered an estuary, due to the hydrological processes related to the freshwater inflow, but the main characteristic defining the Black Sea is the stable hydrodynamic structure of the water stratification. The Romanian coast is divided into two geographical units: the northern unit and the southern unit, with Cape Midia as an inflection point.

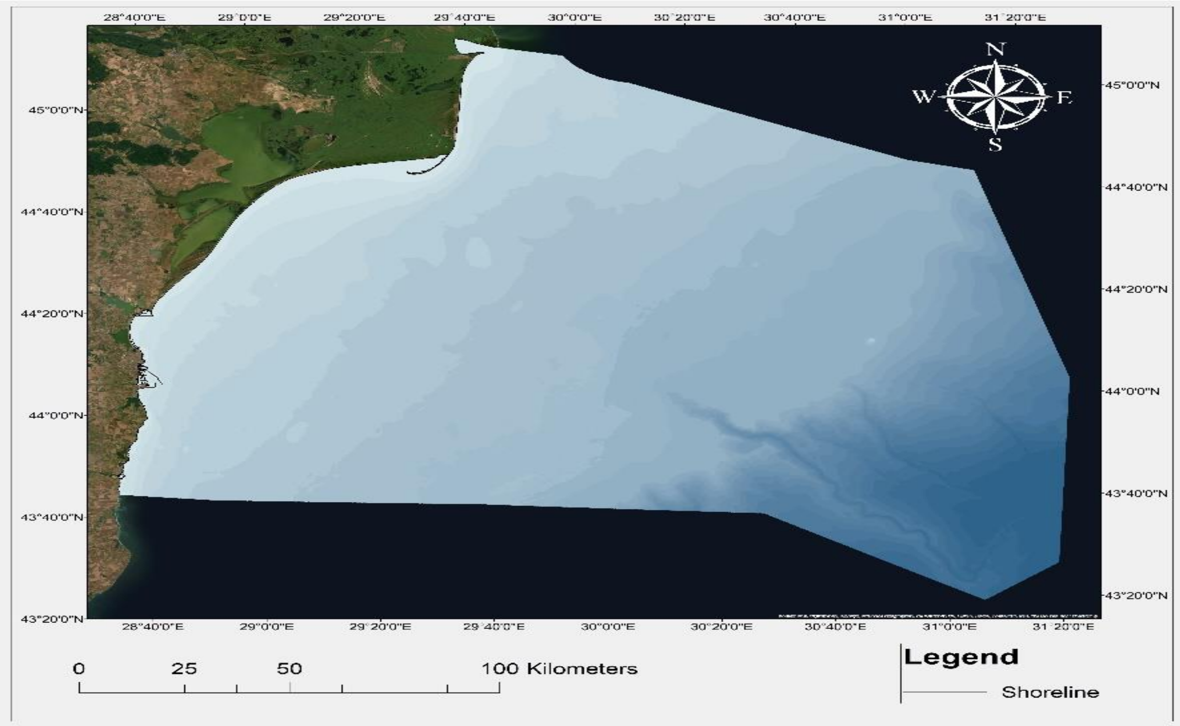


Fig. 1. 3 – Romanian Exclusive Economic Zone, topography [31]

The northern sector is about 170 km long and includes the Danube Delta, which is an important part of it. This sector extends from the border with Ukraine to Midia port. Since the Danube Delta forms a large part of this Nordic sector, a representative feature is the presence of lagoons and low-altitude sand dunes (belts) which generally do not exceed a height of 2 m. [1] [2]

The southern sector is about 74 km long and stretches from Midia Port to the border with Bulgaria. This sector is characterized by high cliffs, which have a maximum height of 80 m in the Constanta port region. Compared to the northern sector, the southern sector has small beaches with a multitude of coastal protections, and in some sub-sectors the beach eroded completely, allowing the waves to break directly into the base of the cliffs.

Wind speed at sea has been measured for centuries. A series of observations have been made by passionate scientists, who understand the important role of meteorological information for marine research. For this reason, meteorological observations have been made in several coastal stations, including Sulina since 1857 [3]

1. **General information on the implementation of the activities and tasks:**

1.1. **The requirements of the following guidelines and documents are compiled in order to fulfill the contract activities:**

- **DIRECTIVE 2008/56 / EC** of the European Parliament and of the Council of 17 June 2008 establishing a framework for Community action in the field of marine environmental policy (Marine Strategy Framework Directive)

  https://eur-lex.europa.eu/legalcontent/EN/TXT/?uri=CELEX%3A32008L0056

- **Regulation (EU) №1255 / 2011** of the European Parliament and of the Council of 30.11.2011 establishing a program to support the further development of the Integrated Maritime Policy

  https://www.bsbd.org/UserFiles//File /Reglament%201255%20ot%202011_EC.pdf

- **Commission Decision (EU) 2017/848 of 17 May 2017** laying down criteria and methodological standards for the good environmental status of marine waters, as well as specifications and standardized methods for monitoring and evaluation, and repealing Decision 2010/477 / EU, available at the following internet address

  https://eur-lex.europa.eu/legal-content/BG/TXT/PDF/?uri=CELEX:32017D0848&from=EN

- **CONVENTION FOR THE PROTECTION OF THE BLACK SEA AGAINST POLLUTION**

  https://www.bsbd.org/UserFiles/File/Convention_for_Protection_of_the_BS_Against_Pollution.pdf

- **MARITIME STRATEGY OF THE REPUBLIC OF BULGARIA 2016-2021**

  https://www.bsbd.org/bg/m_env_and_action.html?URI=

- **Data** from the European Earth Observation Program **Copernicus**, where applicable - https://www.copernicus.eu/en

1.2. The following data has been used:

- European Copernicus Observation Program,

https://www.copernicus.eu/

- data collected so far under the project "Innovative techniques and methods for reducing marine litter in the coastal areas of the Black Sea" - RedMarLitter, which are published in the database of the project (https://map.redmarlitter.eu/bg/database);

- data from other observations and analysis, including own observations and analyzes;

1.3. Target area: Black Sea coast of Romania, the waters of the Republic of Romania in the Black Sea.

2. Analysis of the available data sources for the direction and speed of the sea currents in the surface layer (depth up to 5 meters).

In order to clarify the scale and dimensions of the problems of waste pollution of the Black Sea, it is necessary to apply a holistic approach, in which the Black Sea Basin is considered as part of the World Ocean. Figure 2.1 shows a diagram of the five largest offshore areas in the world ocean in which floating waste accumulates (mostly plastics).

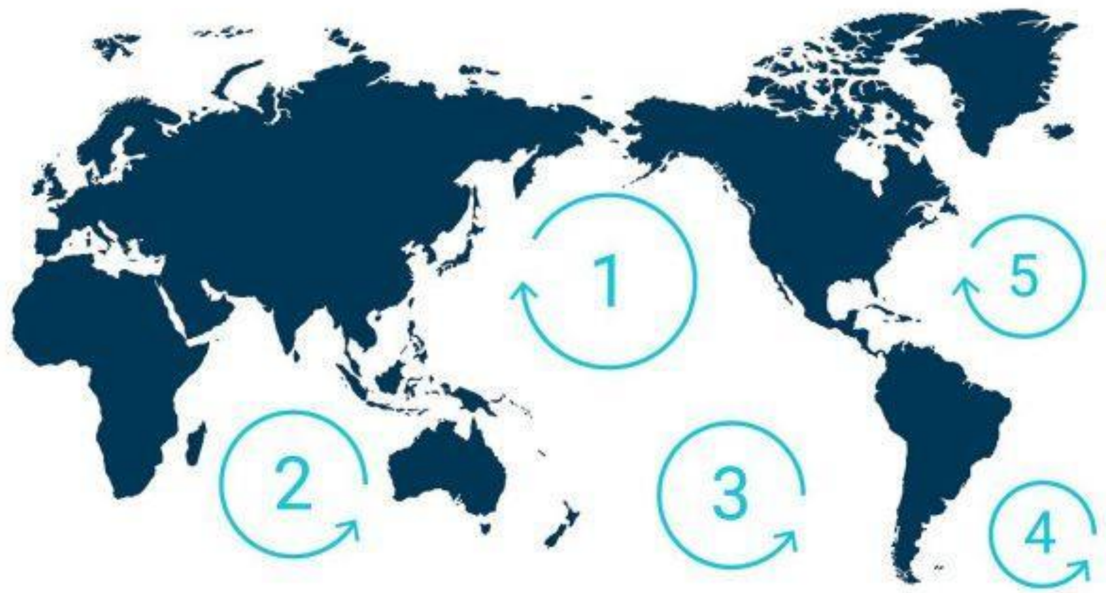
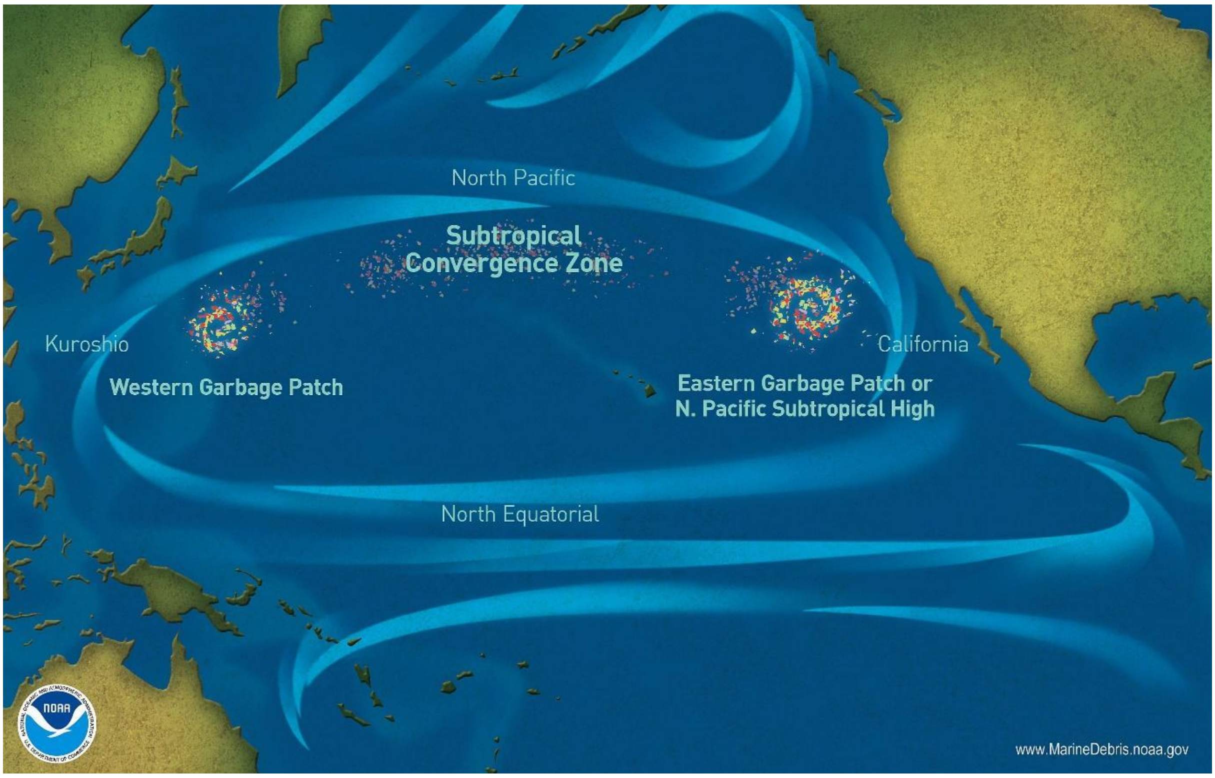


FIG. 2.1 Visualization of the circulation of the five largest offshore areas in the world's oceans with registered floating debris
(source: https://theoceancleanup.com)

The busiest, with approximately 1.15 to 2.41 million tons of plastic waste per year, is considered to be the North Pacific zone (zone 1), with the highest concentrations of waste accumulation being registered in the western and eastern parts of the zone (Fig. 2.2)



2.2 Geographical distribution of floating waste accumulation zones in Zone 1

(source: https://marinedebris.noaa.gov/)

In this regard, for a global leader in data collection and processing, mathematical modeling and forecasting incentive models of the movement of water masses and the objects carried with them are the United States of America (USA).

2.1. Black Sea – marine current regime

The main causes of current generation in the Black Sea Basin are the effect of wind on the sea, the inhomogeneous density of water masses, the accumulation of river waters in the spill areas and the inclination of the sea surface due to atmospheric pressure. The marine current circuit has a peculiarity that makes it unique. In the upper layer there is a permanent, peripheral, current (RIM current) that forms, on a large scale, a cyclonic swirl. This current encompasses two secondary circuits in the east and west of the basin.

There are also several main circulation zones in the Black Sea. According to various literature sources, they are Western and Eastern (see Fig. 2.3) or Western, Central, and Eastern (see Fig. 2.4).

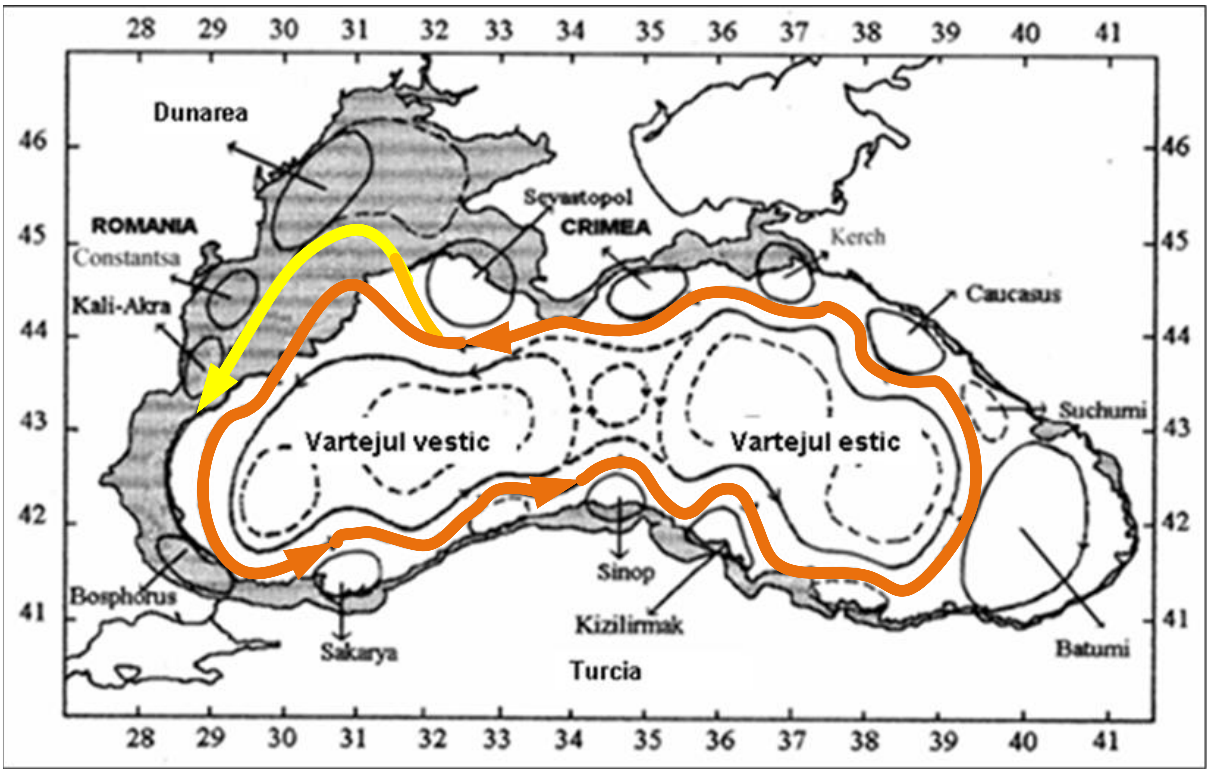
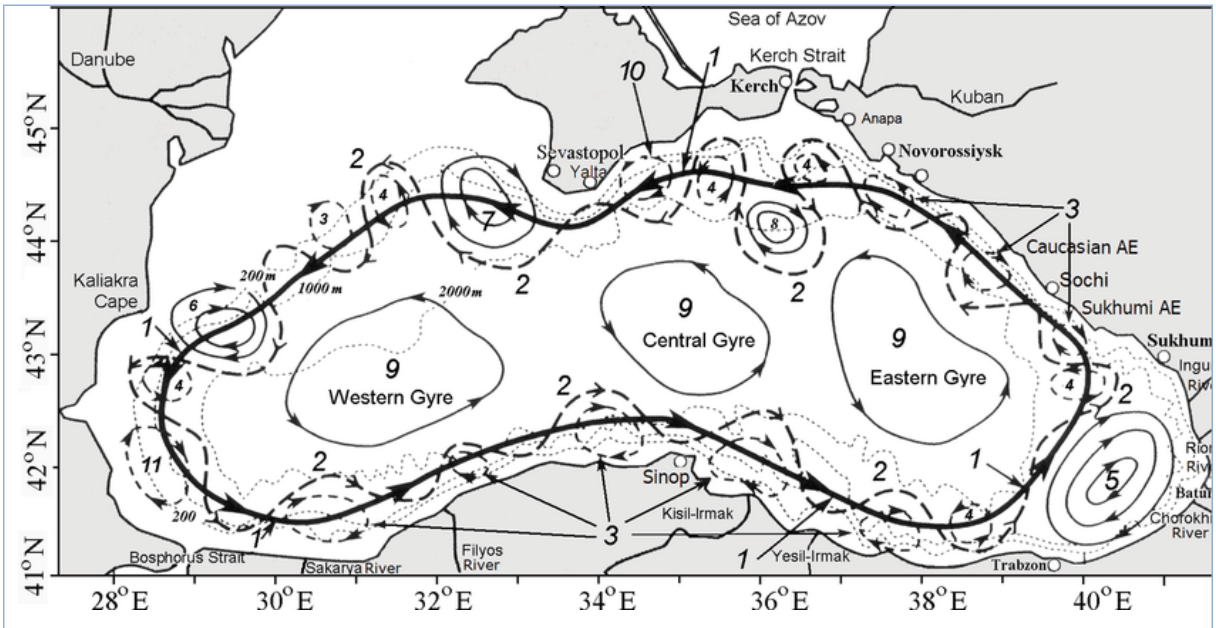


FIG. 2.3 Eastern and Western main circulation zones in the Black Sea

(source: http://dx.doi.org/10.4236/ijg.2013.47094)



1-mean position of the Rim Current jet;

2-meanders;

3-near-shore anticyclonic eddies (NAEs);

4-cyclonic eddies (CEs);

5-Batumi anticyclonic eddy;

6-Kaliakra anticyclonic eddy;

7-Sevastopol anticyclonic eddy;

8-Kerch anticyclonic eddy;

9-quasi-stationary cyclonic gyres;

10-Crimea anticyclonic eddy;

11-Bosphorus anticyclonic eddy

FIG. 2.4 Eastern, Central, and Western main circulation areas in the Black Sea

(source: DOI: 10.7717 / peerj.5448, https://peerj.com/articles/5448/)

The map in Figure 2.5 illustrates the main quasi-stationary circulation areas (9), as well as: the main surface flow (1); coastal anticyclonic (3) and cyclonic (4) vortices, as well as specific anticyclonic vortices in the waters of: Cape Kaliakra (6), Bosphorus Strait (11) and others.

The average RIM / CPMN current is 0,3-0,5 m/s, and at the center of the jet it reaches 0,4-0,6 m/s, under favorable conditions it can exceed 1,5 m/s. Cyclonic circuits have speeds of 0,2-0,4 m/s at the periphery and 0,1-0,2 m/s at the center. Between them, there is an unstable area with currents that have low speeds, and the RIM / CPMN ramifications extend to the western continental shelf (Fig. 2.3). For direct high spatial resolution measurements (both horizontally and in depth), data from an Acoustic Doppler Current Profilers (ADCP) was used. In the image below the current velocity (intensity) can be observed, using an artifact of exaggerating the values to be observed three-dimensionally. The current speed is between 0.01m/s and 0.5 m/s. [7]

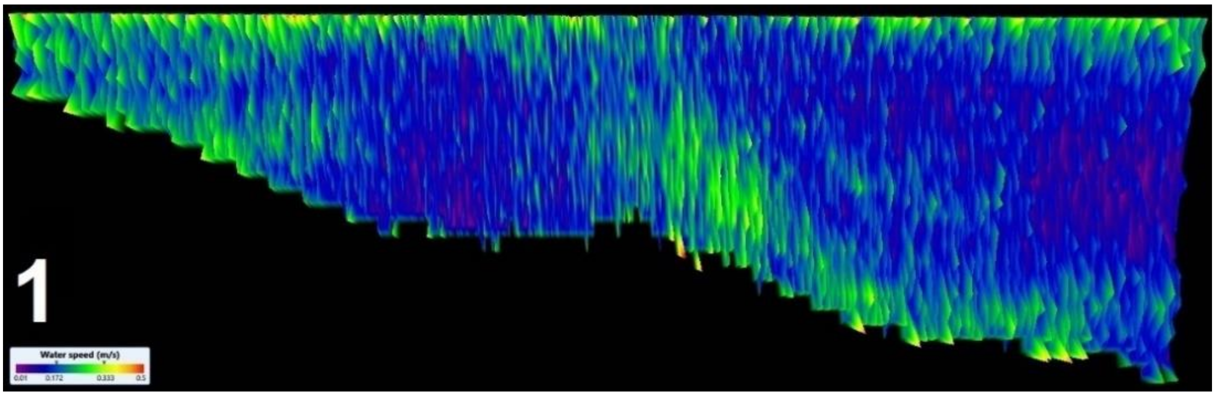


FIG. 2.5 – Water current profile

Since the measurement frequency is high, the amount of data collected is very high and it has been necessary to mediate it at a 5-second interval. The images above are the result of mediation (Fig. 2.5). The average water flow speed was calculated for the three current profiles. Due to the fact that the sea state was good with no waves, the current speed was small, in consequence so was the current flow through the section (First section - 0.15 m^3/s, second one – 0.11 m^3/s and the third one – 0.09 m^3/s). This is mainly linked to the change in bathymetry.

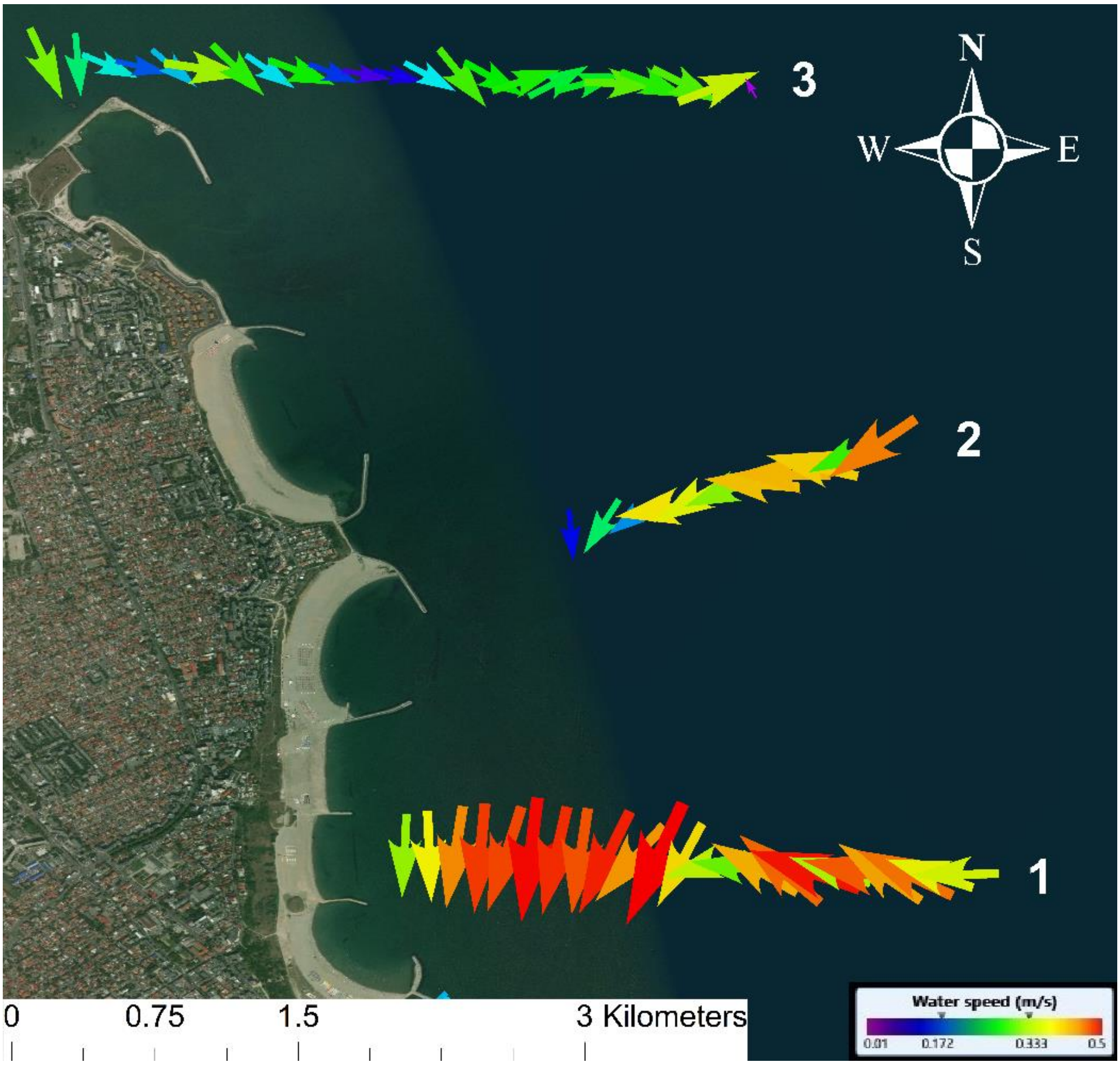


FIG. 2.6 – Current speed and direction

Based on the map made (Fig 2.6), the general direction of the current is from north to south, except for the first profile from the south, which shows that the direction of the marine current from the end to the middle of the profile is heading to WNW and from the middle to the start of the profile it changes its direction to the south. One possible explanation is that a swirl was formed in that area, but without other thickening profiles, it is impossible to make an appreciation.

From a physical perspective, the sector between the two shore units, having as the northern boundary Mamaia Bay and the southern border a commercial port, thus representing an enclosed shore unit and an isolated sedimentary cell by marine obstacles. The regional climate is a temperate continental moderate, due to the Black Sea that has a strong influence, as it induces a strong thermal inertia. [7]

In order to develop an interactive computer model - a map of the movement of pollutant flows in the target area (Romanian waters of the Black Sea) under the influence of water and air currents, analogous to the above data is needed, but for the Black Sea. The data should be accompanied by metadata, to form a dense time series and be representative (including through a data quality control procedure without contradicting the INSPIRE directive) for the study area, and may be derived from actual observations or through use of remote sensing methods, or as a result of modeling using data from actual and remote observations.

2.2. Global system of free-floating buoys

Such a reliable and representative source of data on the direction and speed of sea currents is the **global system of free-floating buoys Argo** (http://www.argo.ucsd.edu/). It is at the heart of the information provision of the Marine Copernicus Monitoring Service of the European Commission, as well as the US National Environmental Information Centers.

Deployment of the Argo system began in 2000 and by November 2007, the millionth profile had been collected.

Up to date, more than 4,000 units of these technical devices have sailed in the world's oceans to measure the temperature and salinity of the upper 2,000 m (just over a nautical mile) of the ocean, and by tracking their movement the profile of the water currents is obtained with sufficient accuracy.

This allows, for the first time, continuous monitoring of the temperature, salinity and speed of the "upper ocean", with all data transmitted and made public within hours of collection. However, today there are still some areas of the ocean that are overcrowded, while others have gaps that need to be saturated with additional Argo buoys.

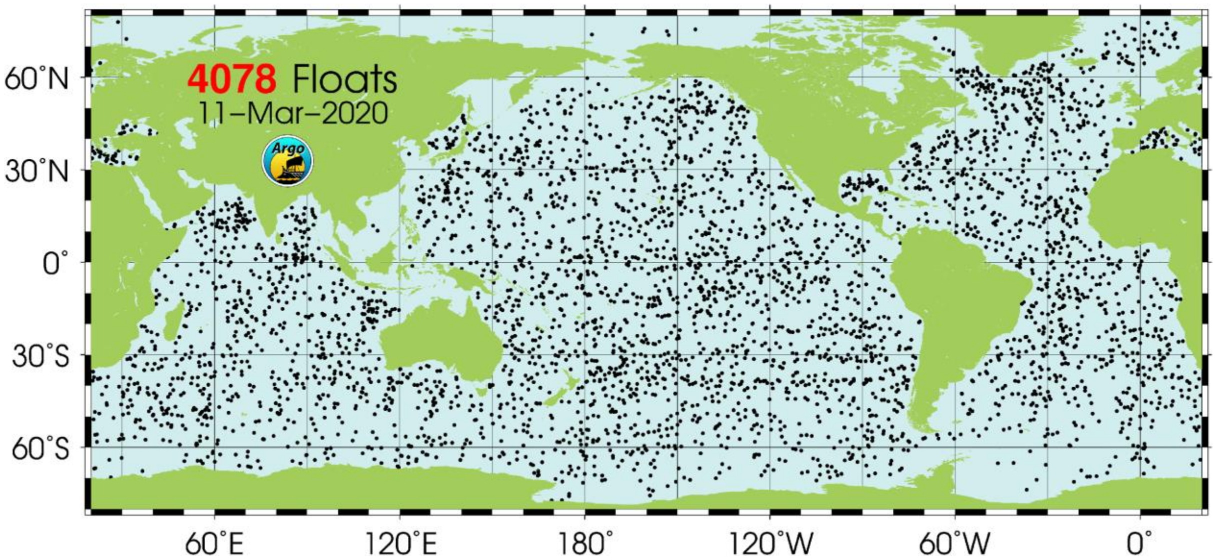


Fig. 2.7 Location of buoys globally, according to data from February 2020 (source: https://directory.eoportal.org/web/eoportal/satellite-missions/a/argo)

Although the main task of the buoy network is to measure the physicochemical parameters of the marine environment, by applying algorithms to smooth their trajectories during their free movement in the aquatic environment, they are successfully used to analyze marine currents.

2.3. Copernicus Marine Environmental Monitoring Service

The Copernicus Marine Environmental Monitoring Service performs daily analyzes and forecasts of and for the Black Sea. In this context, Argo buoy measurements are routinely adopted in the real-time data assimilation system, which applies a variation scheme to estimate the optimal initial conditions for forecasts made at a horizontal resolution of approximately 3 km.

Regarding the geographical scope of the data, they are divided into 7 groups (see Fig. 2.8), and in terms of time range they are of three types: re-analyses, real-time data and forecast data.

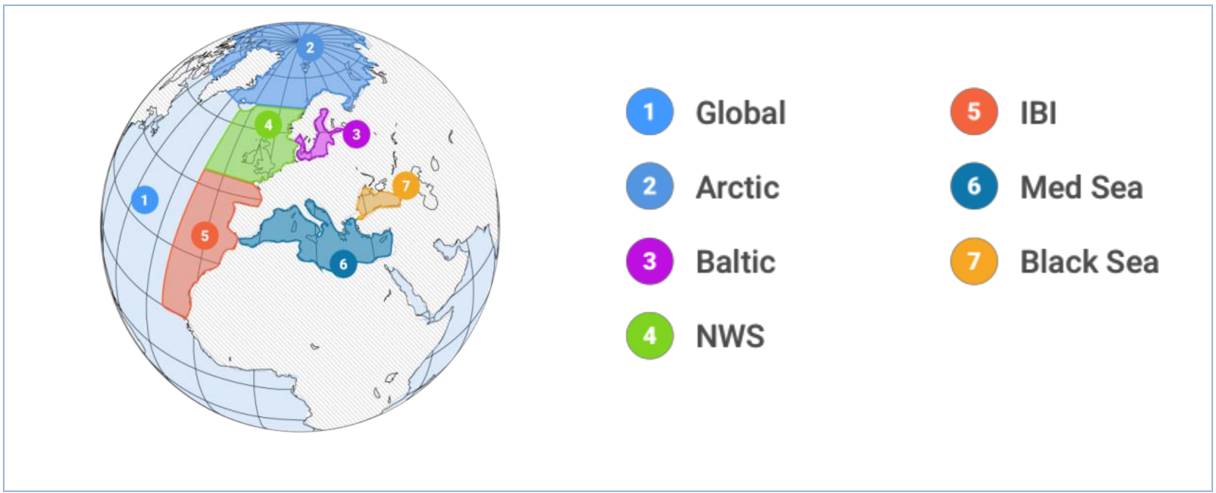


Fig. 2.8 Geographical scope thematic grouping of data

The analyzed data are both global and regional. Their purpose is to provide reference data for the last decades, using optimal resolution and coverage of observations, as well as using an analysis system corresponding to that which produces real-time analyzes and forecasts. Regional realizations usually offer either better physical data due to the configuration of the model, which is specially tuned for the given region (eg Black Sea), and/or higher resolution.

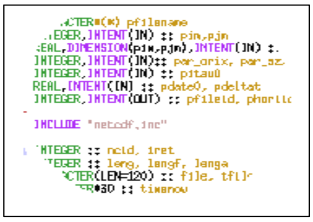
In order to generate the targeted data types daily, the so-called "supercomputers" start the algorithms of the global and regional oceanographic models for calculating the circulation of water masses in the given water basin, sampled in time for each point of the reference network, located in the three-dimensional space.

Equations mechanics of fluids | Algorithms | Supercomputers

$$\frac{\partial T}{\partial t} = -u \cdot \nabla T + D_T + F_T$$

$$\frac{\partial S}{\partial t} = -u \cdot \nabla S + D_S + F_S$$

$$\frac{\partial u}{\partial t} = -u \cdot \nabla u + fv - \frac{1}{\rho_0}\frac{\partial P}{\partial x} + D_u + F_u$$



The Ocean Models transform the ocean through numerical modeling into a "discrete ocean" by solving millions of equations in a strict time sequence for each point in the grid of the 3D spatial network of the ocean.

For the needs of the study, the data on the surface sea currents for the Black Sea are of interest.

The model used to analyze and predict water circulation is called NEMO, and its current version is 3.4. The model is powered by data from other models (air mass circulation model and bathymetric model of the seabed / trough), satellite data (from all satellites that have flown and collected data for the Black Sea: Jason 2 / 2N / 3, Cryosat2, AltiKa, Sentinel3) and the so-called. In-Situ data (data measured on site) supplied mainly by the Argo buoy system in the form of vertical seawater temperature and salinity profiles and additionally by other monitoring systems drifting or anchored buoys, ships, platforms, etc.).

This version of the NEMO model provides an opportunity to take into account the impact of river flows and circulation through the Bosphorus Strait on the overall circulation of water masses in the Black Sea, which are set as boundary conditions at the start of the model.

The targeted system is started daily as a result of which are generated: 3-day analyzes, 1-day simulations and 10-day forecasts.

Once a week, the system is run in a longer analysis cycle mode to generate a 14-day analysis, a 1-day simulation, and a 10-day forecast.

Georeferenced maps materials of the surface currents speed and directions data sets (depth up to 5 meters) are attached in Annex 1 to this report.

2.4. Reliable sources of data on the direction and speed of sea currents in the surface layer in the target area.

In order for the data related to the direction and speed of sea currents to be used as input data for creating an interactive computer model - a map of the movement of pollutant flows (solid marine floating waste) in the Bulgarian Black Sea area, it must meet the following basic requirements:

- data accuracy (data based on real research)

- provision with metadata

representativeness of the data (geospatial coverage, resolution, etc.)

- density of time series

Such data for the target area can be obtained only in the presence of systematic observations - monitoring of the marine environment in terms of parameters of interest (direction and speed of surface water currents to a depth of 5 m).

The following reliable data sources for the direction and velocity of sea currents in the surface layer in the target area have been identified:

- Global system of free-floating buoys Argo - in the part "Black Sea"
- Copernicus Marine Monitoring Service - in the Black Sea section
- NEMO model for analysis and forecasting of water circulation (for the Black Sea)

For the purpose of creating an interactive computer model - a map of the movement of pollutant flows under the influence of water and air currents, the input data should be those of the Marine Environment Monitoring Service of the Copernicus program for the Black Sea.

The data available through the Copernicus program integrates the data obtained from the global system of free-floating buoys Argo, which are input data for the NEMO model. Given the level of integrity of the data and information accumulated in the Copernicus program on marine currents, it should be used to develop an interactive model map of the flow of pollutants in the section "under the influence of water currents".

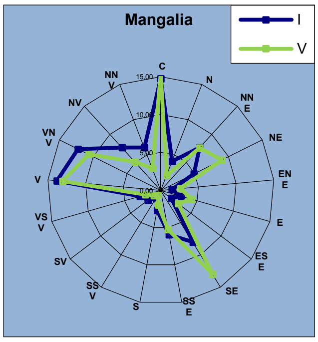
This data was used as input data in combination with data on the direction and speed of the winds over the specified water area and data from own observations (conducting an experiment - simulations implemented within the RedMarLitter project).

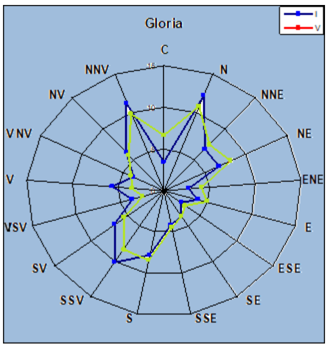
3. Analysis of the available data sources for the direction and speed of air currents (on height up to 10 m.)

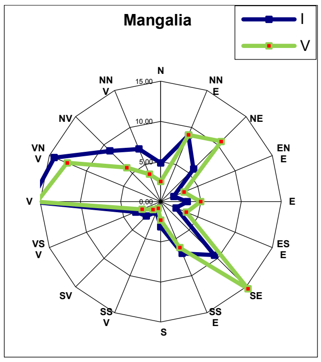
Numerous oceanographic centers (around 80) worldwide collect environmental data in oceanographic stations on vertical columns of water in all seas and oceans around the world, the main parameters being temperature, salinity, oxygen, phosphate, nitrate, and silicate. They are analyzed at standard depths. The main interest is this work is towards the analysis of wind, wave and current data. These environmental factors, in particular waves and currents, are interdependent on the action of the wind.

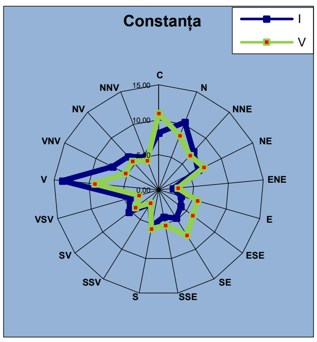
The wind regime is characterized by the local physio-geographical conditions, the topography having the most important role. The dynamics of the air masses in the coastal area of Romania is characterized by seasons.

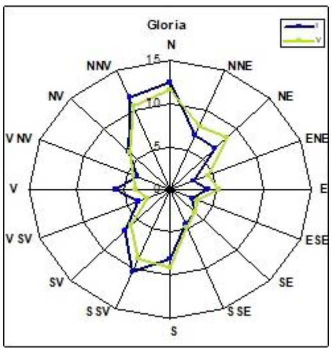
Wind rose (%) (including v=0)	Wind rose (%) Gloria (including v=0) Gloria (without calm)	Wind rose (%) (without calm)

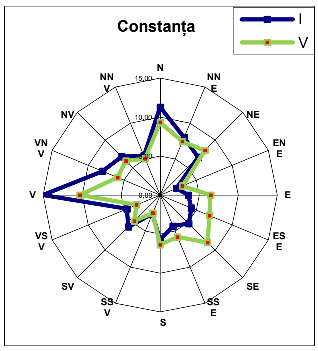


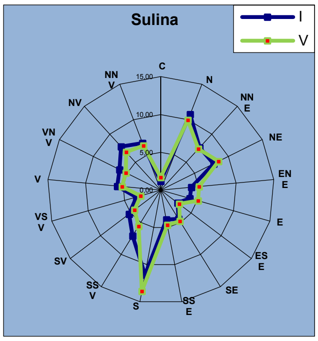












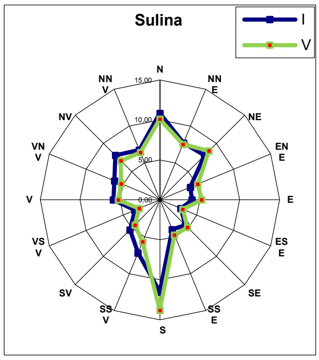
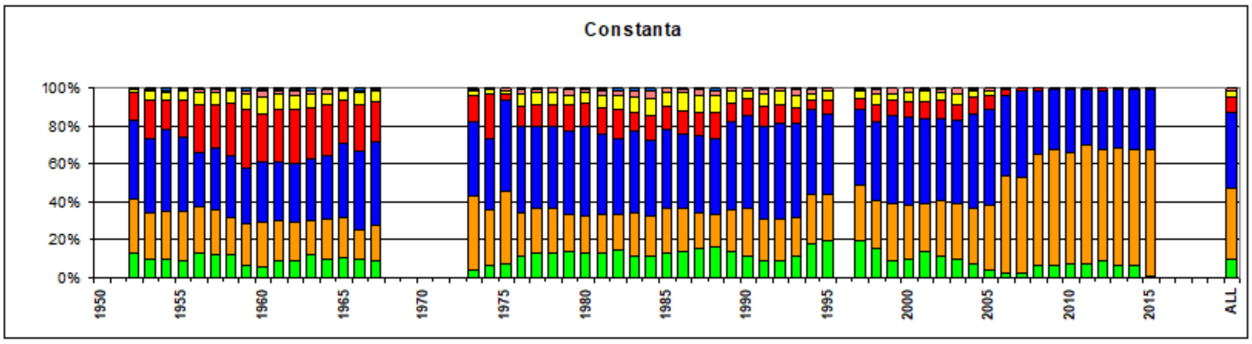


Fig. 3. 1 – Wind direction distribution (winter - I and summer - V) with calm period and no calm period from total records [7]

Complete or partial analyzes were performed on several data rows:

- sets from the stations Mangalia, Constanța, Sulina and Gloria [5] [6] [8], according to the standard international weather reports of the weather stations. The periods of the data sets are, in order:1975-2013,1964-2002, 1952-2016, 1952-2016, 1953-2016, 1983-2002, the sets having respectively, 62291, 138946, 286056, 256792, 535137, 62283, 627594 values.

The analysis was performed for the distribution according to the wind direction (winter and summer) (Fig. 2.1). The unusual appearance of the roses for Mangalia and Constanta, in relation to the stations Sulina and Gloria Platform, suggest particular local conditions. The study brings together four sets of data, three along the shore, giving a spatial image of how wind values can vary from north to south, not only offshore (Fig. 3.2.).



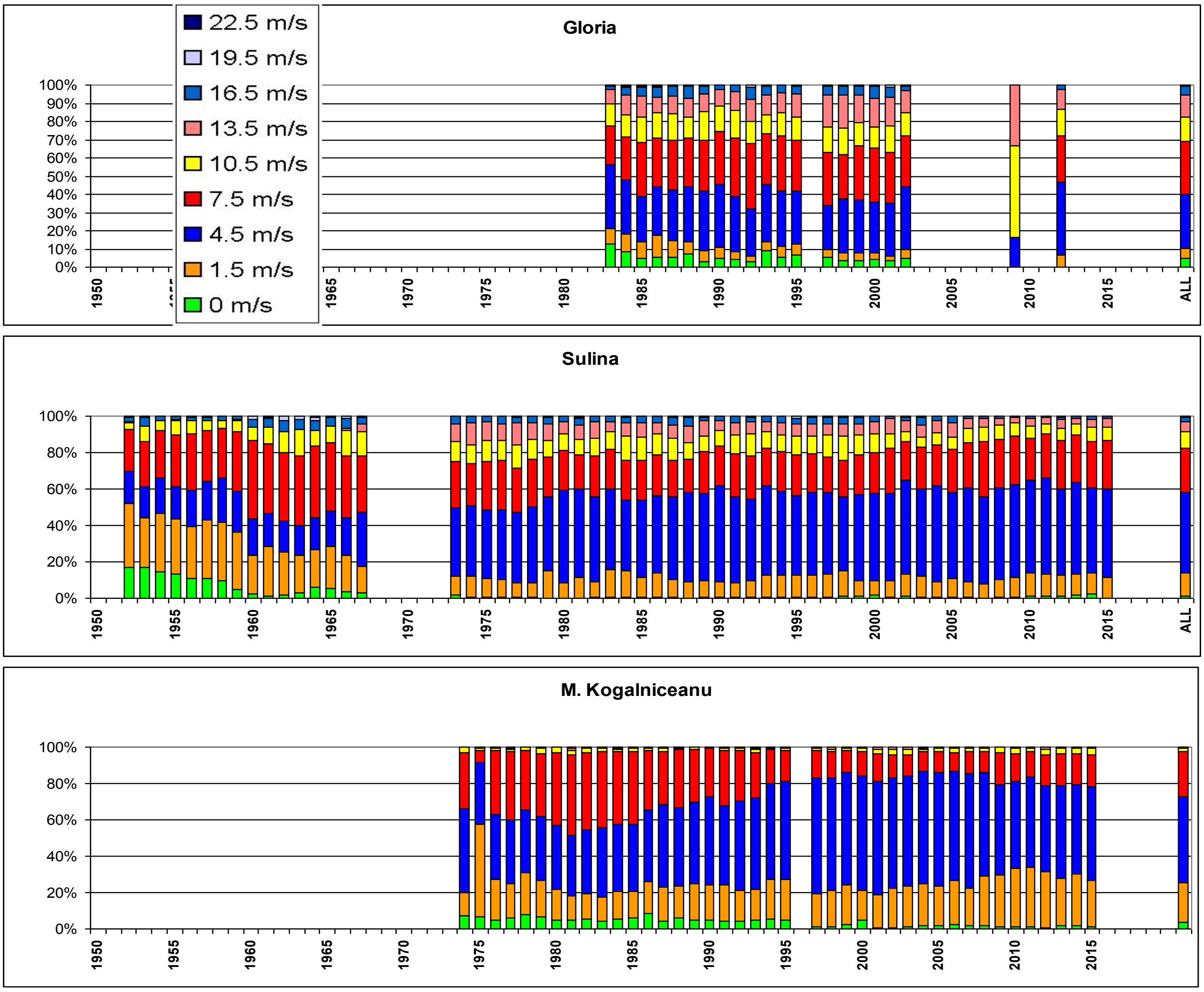


FIG. 3. 2 – Multi-annual wind speed distribution (average values) for each set of data (1950 - 2015) [7]

3.1. Space-based Earth observation systems

One source of data on the direction and speed of air currents up to 10 meters above sea level are the raw radar data of various space-based Earth observation systems.

Nowadays, remote sensing methods are widely applied globally to the world's oceans and the marine environment in general, which allows the extraction and collection of data on the movement of air masses over land and sea surface.

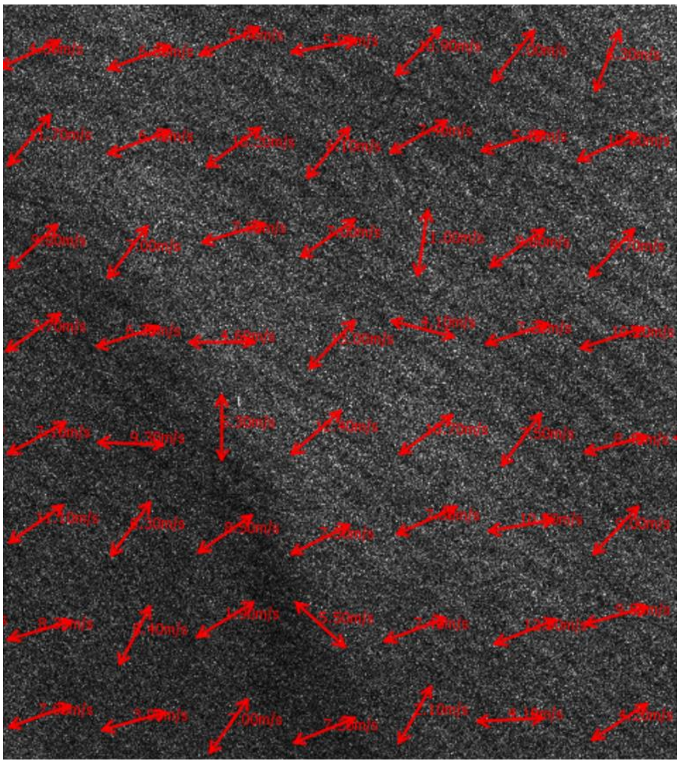


FIG. 3.3. Example of the application of the method
(source: European Space Agency)

Figure 3.3 shows an example of the use of this method. It can be used in applications to determine the parameters of air currents for a past period of time and for the so-called near-real-time when satellite data is used immediately after the satellite flies over the area of interest. **As a disadvantage of the method, it can be noted that it does not allow the necessary time density of the time series of data required for the needs of the present study.**

3.2. Copernicus Marine Environment Monitoring Service

Another source of data on the direction and speed of air currents is the Copernicus Marine Environment Monitoring Service.

Figure 3.4 shows a visualization of **averaged 6 hour wind direction and wind speed data of product WIND_GLO_WIND_L4_REP_OBSERVATIONS_012_006** for random selected date and height 10 meters.

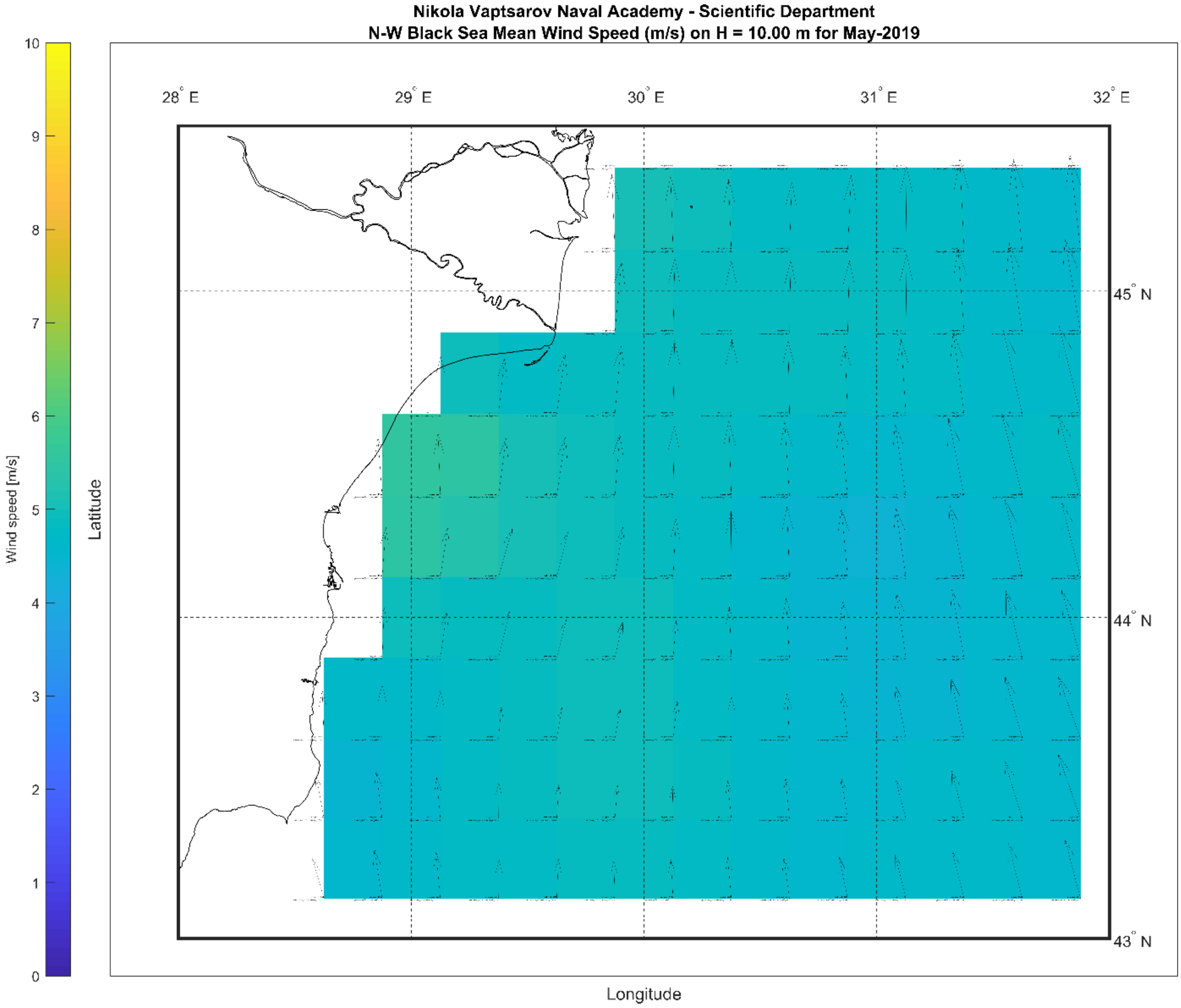


FIG. 3.4 Averaged 6-hour wind direction and speed data (m/s)

The data is calculated and a product is generated **WIND_GLO_WIND_L4_REP_OBSERVATIONS_012_006** for a network consisting of one layer 10 meters above sea level and a horizontal resolution of 0.125 or 0.25.

Although data on wind characteristics over the target area obtained from research projects are available, they are relatively short in duration and not suitable for 'entering' a model with forecasting capabilities.

3.3. Identified reliable data sources for the direction and speed of air currents at a height of up to 10 m in the target area.

In order for the data related to the direction and speed of air currents to be used as input data for creating an interactive computer model - a map of the movement of pollutant flows (solid marine floating waste) in the Bulgarian Black Sea area, it is necessary to meet the following general requirements:

- data accuracy (data based on real measurements)
- metadata provision
- data representativeness (geospatial coverage, resolution, etc.)
- time series density

The following **reliable data sources for direction and speed of air currents (up to 10 m altitude) above the target water area have been identified:**

- World Meteorological Organization (WMO)
- Copernicus Marine Environment Monitoring Service - in the Black Sea part
- Space-based Earth observation systems

For the purpose of creating an interactive computer model - a map of the flow of pollutants under the influence of water and air currents, the input data should be those from the Marine Copernicus Monitoring Service of the Black Sea Program.

This conclusion is necessary because, although the data of space-based Earth observation systems are reliable and accurate, they are instantaneous data and do not provide the necessary time density. On the other hand, WMO data are successfully applied in modeling the transport of atmospheric pollutants mainly over land, but their applicability as input data for determining the direction and speed of movement of drifting objects is limited.

The data obtained from the Marine Environment Monitoring Service of the Copernicus program on wind direction and speed up to 10 m altitude are highly similar to those on the direction and speed of sea currents, which is a prerequisite for obtaining high quality simulations with different nature input data.

For the purposes of developing an interactive computer model map for the movement of pollutant flows in the target area, averaging of the data for wind direction and speed from the Copernicus program for 24 hours was performed.

4. Analysis of the available sources of information on the loading of solid marine litter in the target area, including the one collected through a study for such under this project.

The main sea-based source of plastic litter is discarded fishing gear (mainly traps and nets); Another possible source of plastic waste might come from the shipping activities, the intense marine traffic concentrates at the Romanian shore, in front of the Danube Delta and at in the south part of the coast, which consist of three ports (Midia Port, Constanta Port and Mangalia Port). The ship routes traveling the Romanian Exclusive Economic Zone have a high density of ship traffic, which can be approximated to be more the 350000 routes/5km^2/year (Fig. 4.1).

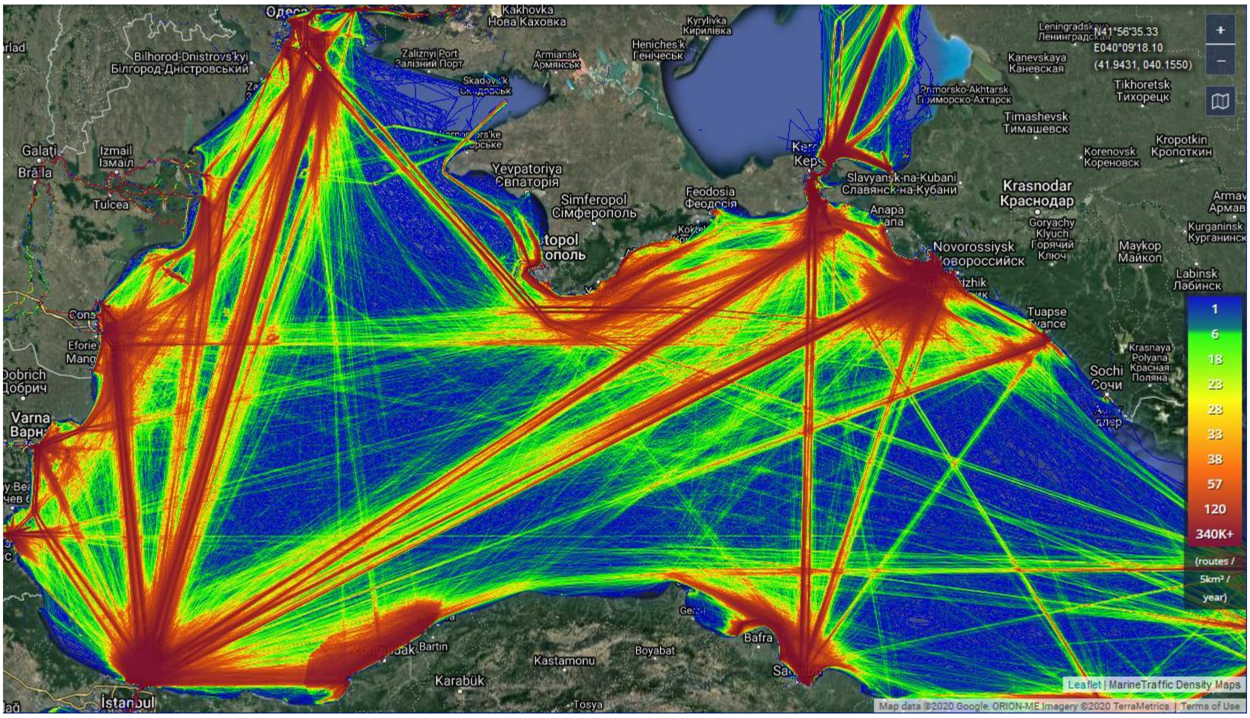


FIG. 4. 1 – Marine traffic intensity in 2017 [10]

The amount of waste variations that can be found in rivers may be linked to the weather, implying that vast quantities of rain runoff play an important role in the transport of plastics into freshwater systems. In recent years, more and more studies sampled plastics in the surface waters of rivers. In Europe, studies estimated that only the Danube River releases 530–1500 tons of plastic into the Black Sea annually. [11]

Based on several reports from 2016 to 2019 [12], 8 beach sectors were monitored. The number of wastes items inventoried and disposed (by hand) of was 115592, weighing in total about 1400 kg, most of the waste was collected in the Navodari sector (496.7 kg), and the minimum waste was collected in Vama Veche (59 kg) and Corbu (65 kg) sectors. From the perspective of abundance, the waste recorded a frequency was of 0.11 items/m^2.

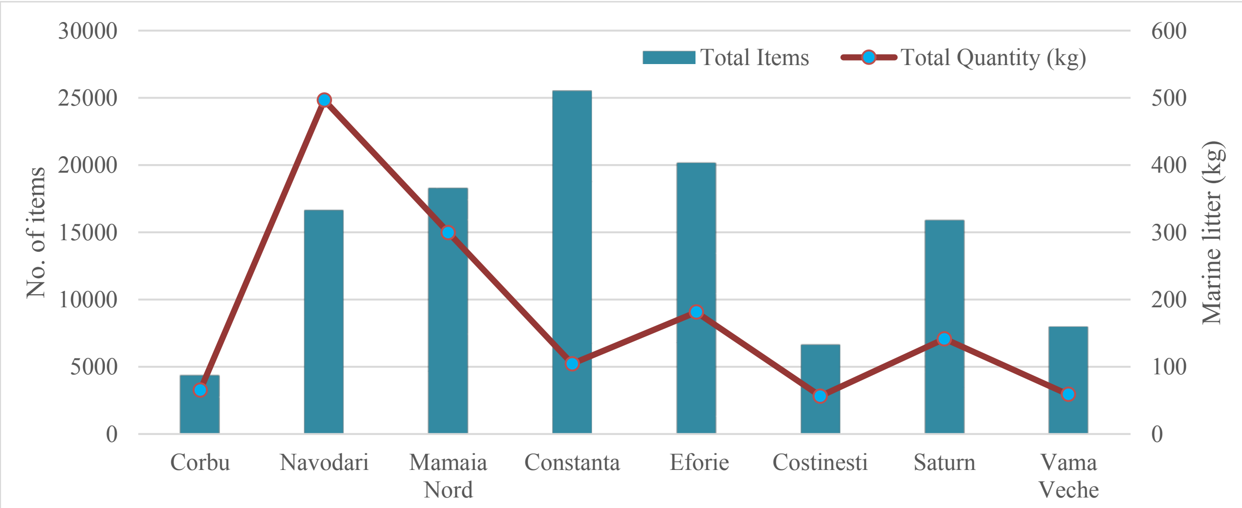


FIG. 4. 2 – The situation of marine waste on the Romanian coast 2016 - 2019

Regarding the categories of waste for 2016 - 2019, artificial polymeric material prevailed, accounting for 77% of the total (Fig. 4.2). The least identified category waste is rubber (0.56%).

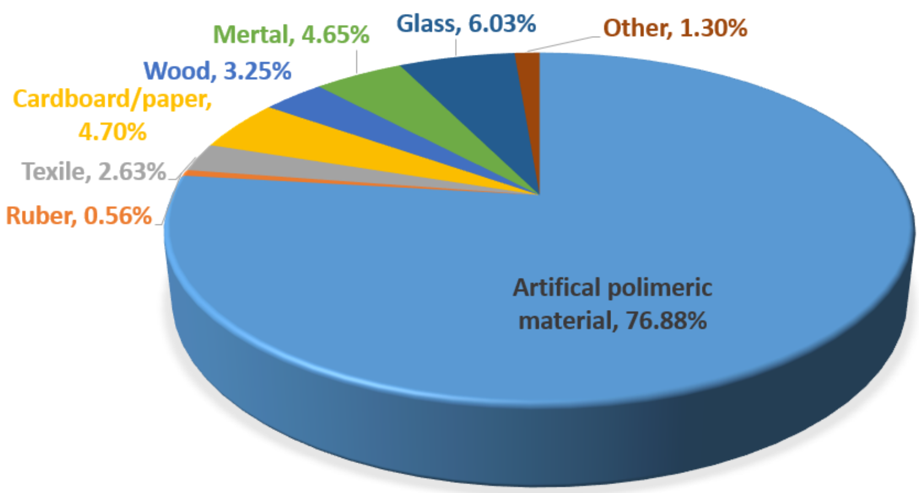


FIG. 4. 3 – Situation of waste by categories 2016 - 2019

In the case of artificial polymeric material, most of the inventory items were cigarette butts. In addition to cigarette butts, there were numerous plastic pieces larger than 2.5 cm, plastic bags, plastic packages, as well as plastic caps that came from beverage bottles.

From the perspective of quantity, the waste collected summed up to 1404 kg (Fig. 4.3).

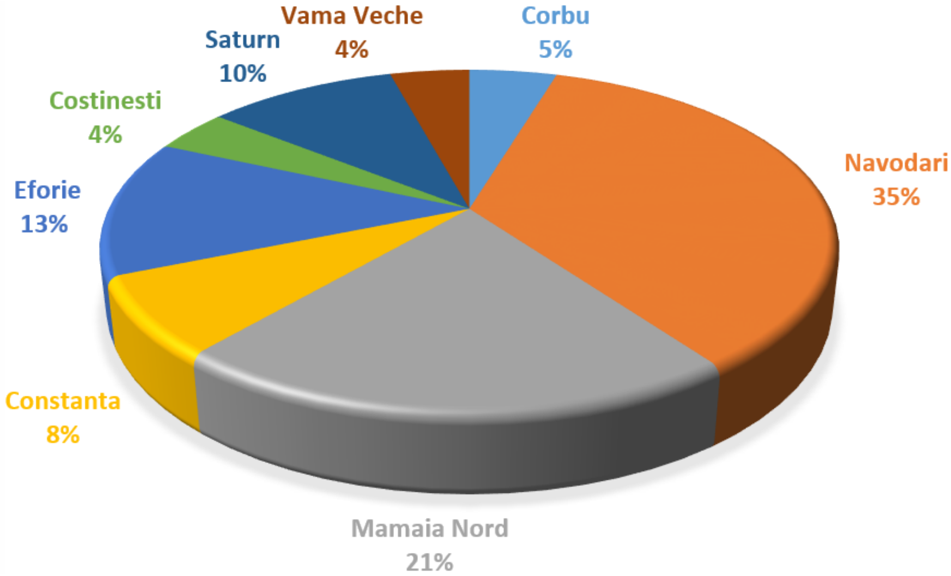


FIG. 4. 4 – Marine litter - by sector (kg) 2016 - 2019

The number of waste items by year and categories is shown in table 4.1, where the difference between the polymeric materials that dominate the other categories can be easily observed.

Category	**2016**	**2017**	**2018**	**2019**
Artificial polymeric material	84.01	69.84	74.79	76.40
Rubber	0.60	0.74	0.75	0.34
Clothing / Textiles	1.87	2.58	3.05	2.95
Paper / Cardboard	4.13	2.26	6.12	5.40
Processed wood	1.85	4.02	4.37	3.19
Metal	2.79	7.58	5.97	3.78
Glass / Ceramics	4.48	11.42	3.65	6.03
Other	0.26	1.56	1.29	1.91
TOTAL	**31060**	**20639**	**26405**	**43805**

Table 4.1 – Distribution of marine waste by years and categories [12]

Because every sector is different, it is not proper to decide just based on the available data, as not only the shape of the coast plays an important role of where and how the marine litter winds up on the shore. Depending on the sector, more or less tourists are drawn to the area or based on the activity that can be done in a specific sector, different types of tourists can be found there. In this respect, the marine litter found in these areas do not necessarily represent spots where the litter concentrates due to the weather, wind, marine currents or waves.

Based on the data collected from each beach, (Fig. 4.5) shows which sector has a greater accumulation of marine litter through the years, to be noted that every sector has a different number of squared meters, the sectors are not equal as a surface.

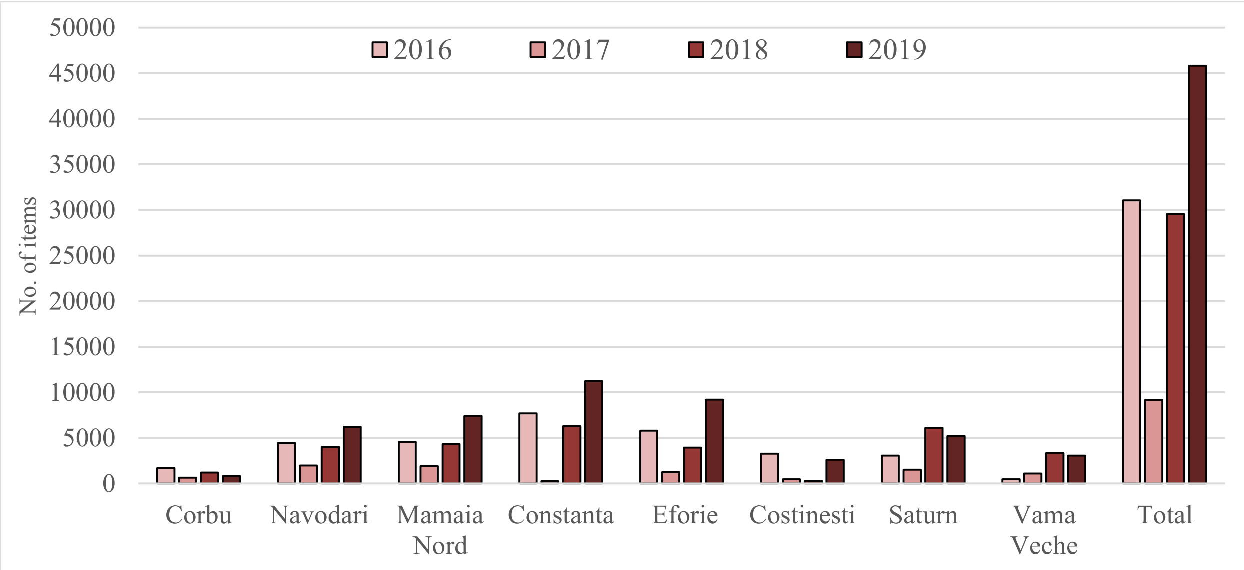


FIG. 4. 5 – Marine litter (items) by year for every sector

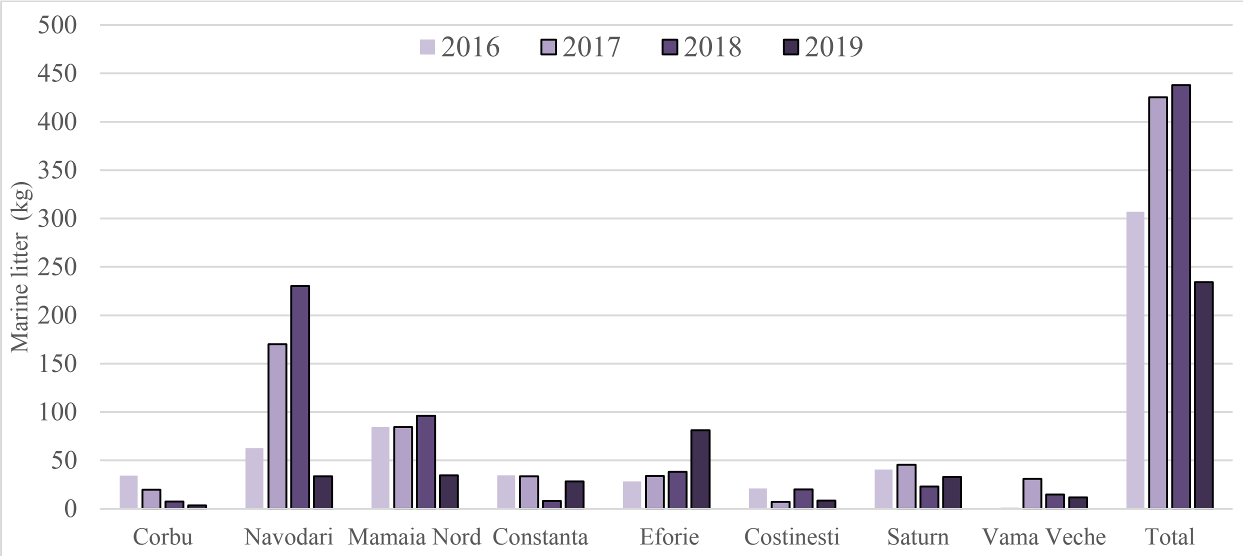


FIG. 4.6 – Marine litter (kg) by year for every sector

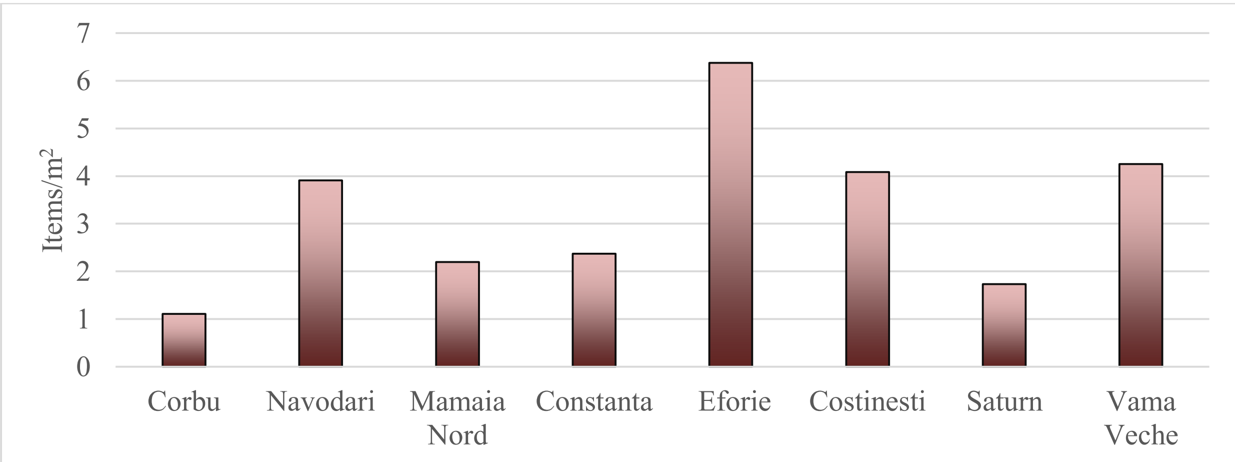


FIG. 4.7 –Marine litter per scanned area (m^2) for every sector (2016-2019)

The number of items found in each sector can be seen in Fig. 4.6, and it can be noted that Constanta beach is has the most marine litter because it has the greatest area scanned, and when the items are divided to the scanned area (Fig. 4.6), Eforie beach is more polluted because it has more marine litter per square meter.

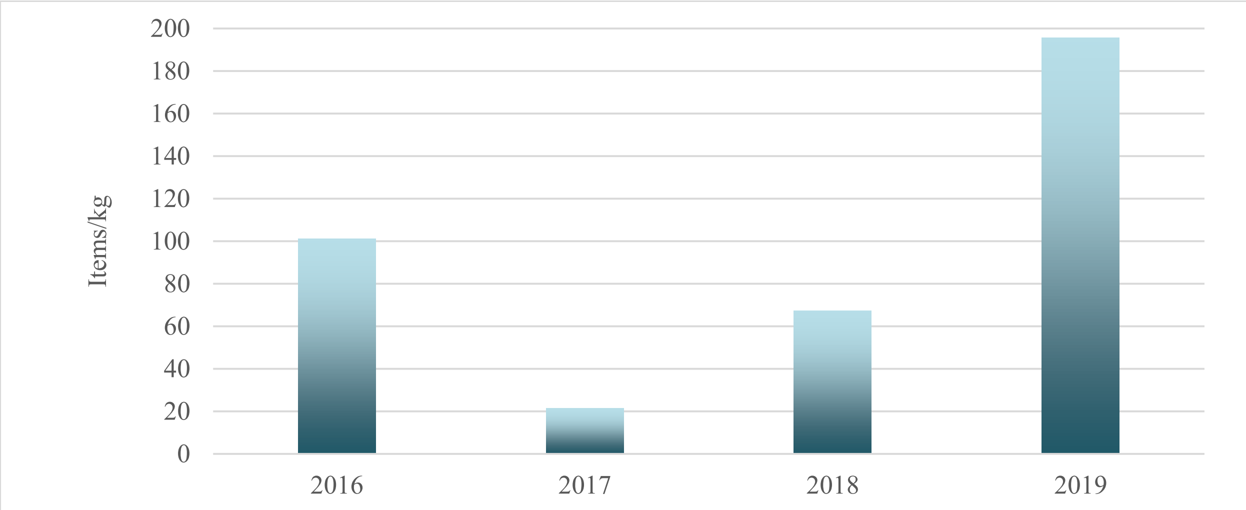


FIG. 4.8 – The ratio between Marine litter (items) and their weight (kg) (2016 – 2019)

The coastline sectors saw in 2019 a rise in marine litter (Fig. 4.8), most of it as polymeric artificial materials. The year 2017 had the least number of marine litter items collected form the beaches, making it the cleanest year, but as the result shows, in fig 4.9 the weight of the marine litter is almost double then the one from 2019. This means smaller pieces in 2019 with less weight and less pieces with greater wight in 2017.

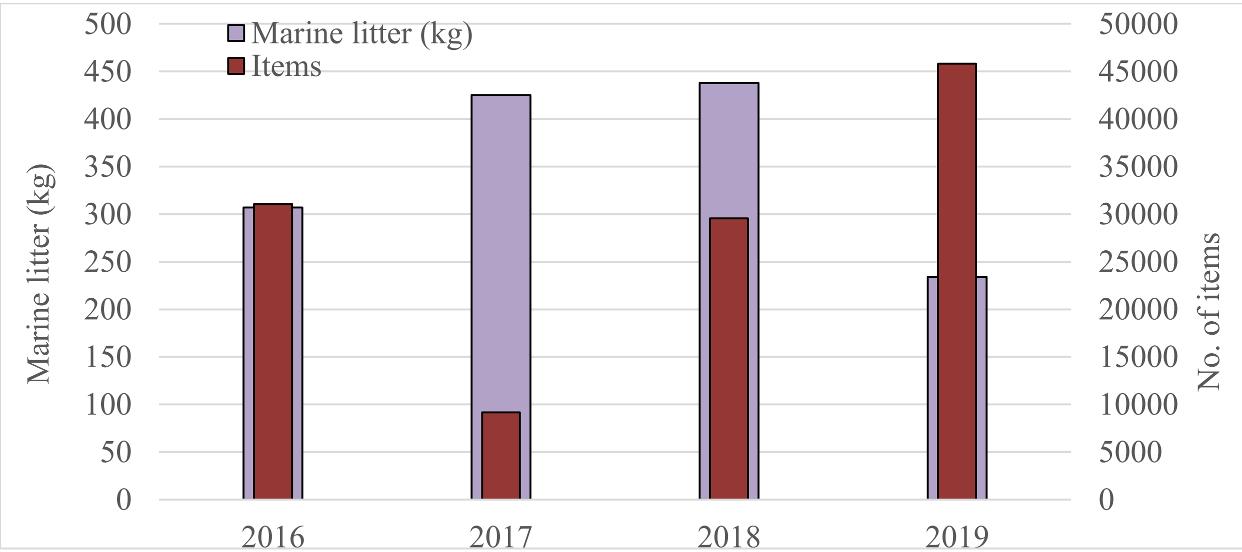


FIG. 4.9 – Marine litter items and their weight comparison through the years

The results (Fig. 4.9) show a clear picture of how the marine litter has trended in these four years, note that in 2019 the items collected from the beaches reached a maximum high, even if their weight is lower then previous years, this is due to the cigarette buds which are found in overwhelming quantities. [12,13]

In the course of realization of the project RedMarLitter and filling with data and information in the open database of the project https://map.redmarlitter.eu/en/database, the project database can be considered as a separate information resource regarding the load of the target area with solid floating waste (Fig. 4.10).

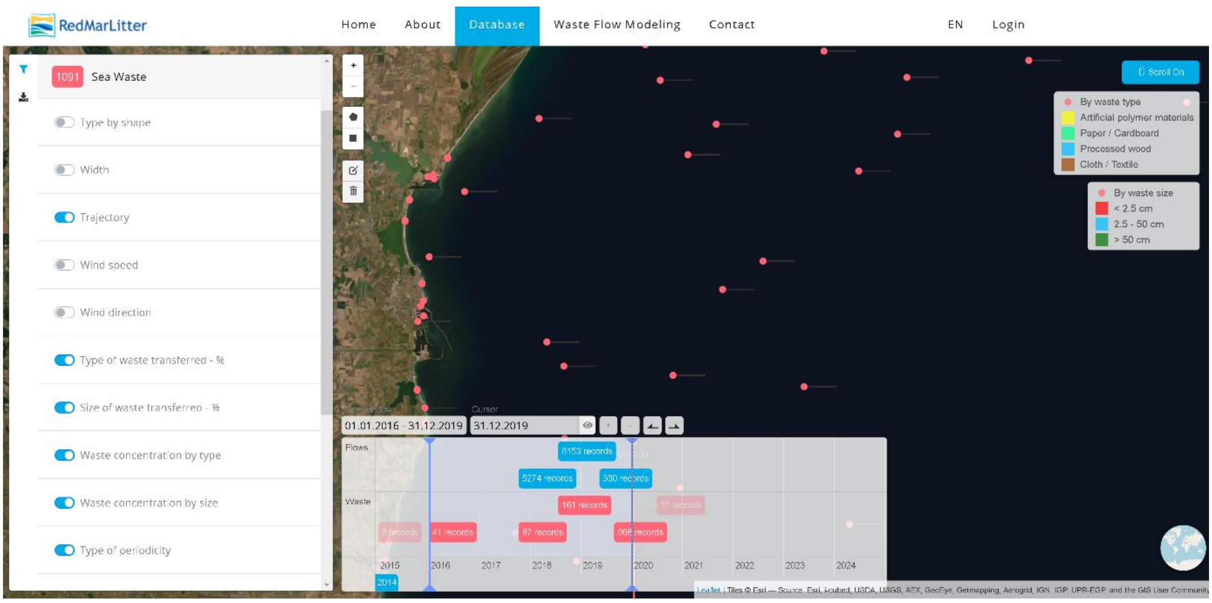


FIG. 4.10 Open database of the RedMarLitter project

(source: https://map.redmarlitter.eu/en/database)

As a result of the analysis of the collected data, it can be concluded that the data on floating solid waste on the sea surface with dimensions larger than 2.5 cm do not meet the requirements for the needs of modeling water flows and solid waste distribution **periodicity**, as both temporally and spatially. In practice, they can be considered only as "snapshots" of separate (different) waters of the target area.

Taking into account the above facts, for the purposes of modeling water flows and the distribution of solid waste in the target area, an approach based on mathematical modeling by simulations of floating solid waste on the sea surface should be used.

5. Development of algorithms and software code for import and processing of the collected data (according to tasks 1, 2, 3) and derivation of models of water flows in the surface layer and models of motion distribution and waste distribution.

Based on the analyzes made in sections 2 and 3 of this report, and taking into account that only the Marine Environment Monitoring Service of the Copernicus Program systematically develops, maintains and provides data on the Black Sea area, and in particular on the direction and speed of sea and air currents, algorithms and software code were developed for import and processing of the data collected by it in the environment of the software product MatLab.

Figure 5.1 shows data on sea currents in the surface layer of the Black Sea (horizon/depth of 2.5 m.) for 29.10.2018

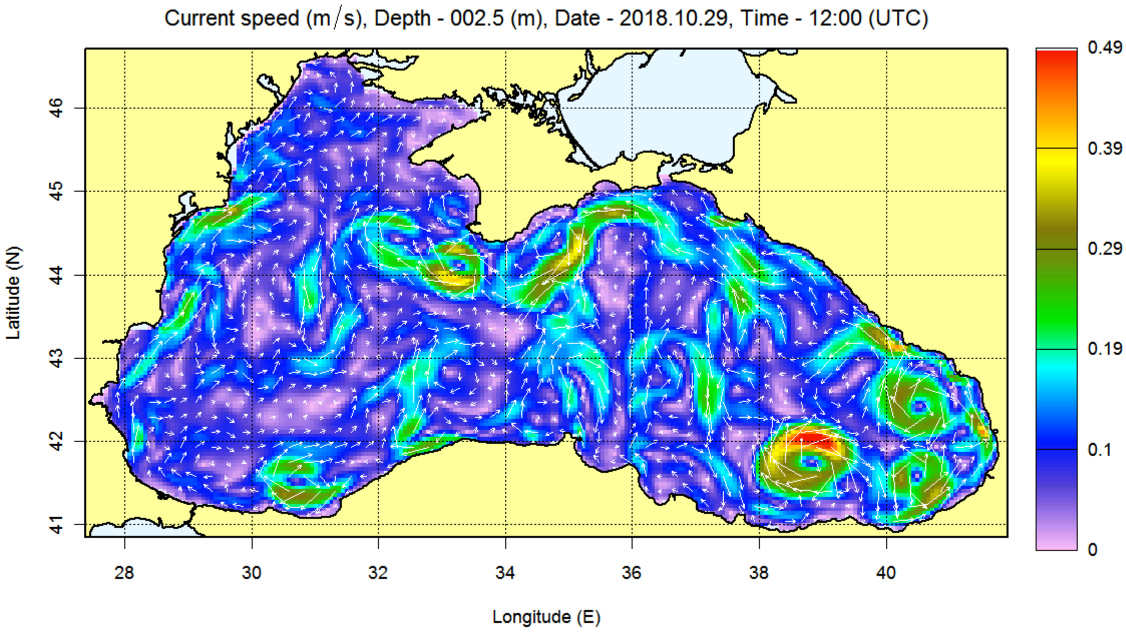


FIG. 5.1 Sea currents in the surface layer of the Black Sea (horizon 2.5 m.) for 29.10.2018 (source: http://bsmfc.net/Year_analysis.php)

For the derivation of the models of water flows in the surface layer were used the data for average monthly values of the surface marine currents of the Marine Environment Monitoring Service of the Copernicus Program for the period from 2015 to 2019.

The average monthly data for the sea currents in the surface layer of the Black Sea (horizon 2.5 m) of the product **BLKSEA_REANALYSIS_PHYS_007_004**, which is characterized by the highest accuracy among the products of this class, are referred to.

Solid floating waste in the surface layer can be conditionally divided into two groups, as announced in the introduction of this report: solid waste floating in the water column at shallow depths (see Fig. 5.2) and solid waste floating on the water surface (see Fig. 5.3).

The conditional division is made in order to take into account mostly the influence of the so-called ground wind, if any, on the movement and distribution of solid waste on the sea surface.

As far as the data referred to in Section 4 for **floating** solid marine litter are episodic, the application of a simulation model based on marine current data from the Copernicus Marine Environmental Monitoring Service described in section 2 and airflow data described in section 3 of this report, **which are characterized by the required spatial coverage, resolution and time range**, is considered to detect their movement and distribution.

FIG. 5.2 Solid waste floating in the water column at shallow depths

Fig. 5.3 Solid waste floating on the sea surface

For the detection of the movement and distribution of solid marine waste from the **first conditional group** it is assumed that the surface wind does not have a direct impact on their movement because they are in the water column, but the influence of air masses / forces was taken into account in the generation of data on the direction and speed of surface marine currents from the model of the Marine Environment Monitoring Service of the Copernicus.

Using this innovative approach and taking into account the derived data on water flows by mathematical modeling in MatLab environment, again by mathematical modeling in the same environment are generated simulations of the movement and distribution of floating solid waste (conditionally called drifters) at shallow depths (up to 5 meters) in the water column for all months from 2015 to 2019 inclusive, under the following conditions: virtual solid waste (drifters) are located on the three lines as follows:

Line 1 is between points:

Lat_1 = 44.265018°N, Lon_1 = 28.661670°E

Lat_2 = 44.265018°N, Lon_2 = 30.095196°E

Line 2 is between points:

Lat_1 = 43.897218°N, Lon_1 = 28.651404°E

Lat_2 = 43.897218°N; Lon_2 = 30.027281°E

Line 3 is between points:

Lat_1 = 44.855378°N, Lon_1 = 29.643821°E

Lat_2 = 44.855378°N, Lon_2 = 30.794544°E

and they are equally distributed along the line on every 30 seconds (approximately 1 km).

In FIG. 5.3 in red shows the location of the starting line of the virtual drifters in the target area.

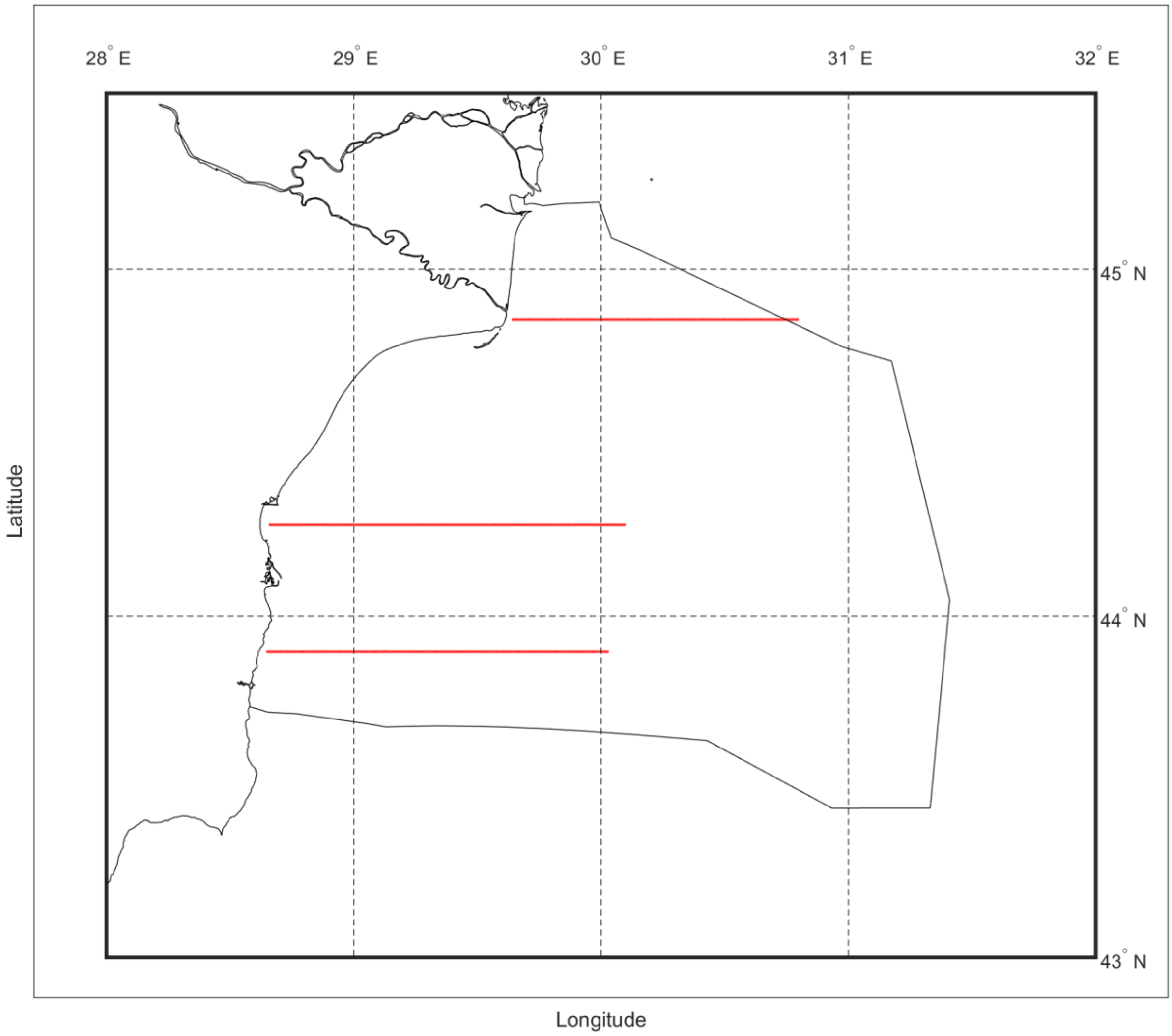


FIG. 5.3 Starting lines of virtual drifters in target area

Numerical modeling for the derivation of water flows is performed according to the algorithm shown in Figure 5.4.

The georeferenced map material, for each of the targeted months, visualizing the water flows is attached in Annex 2 to this report.

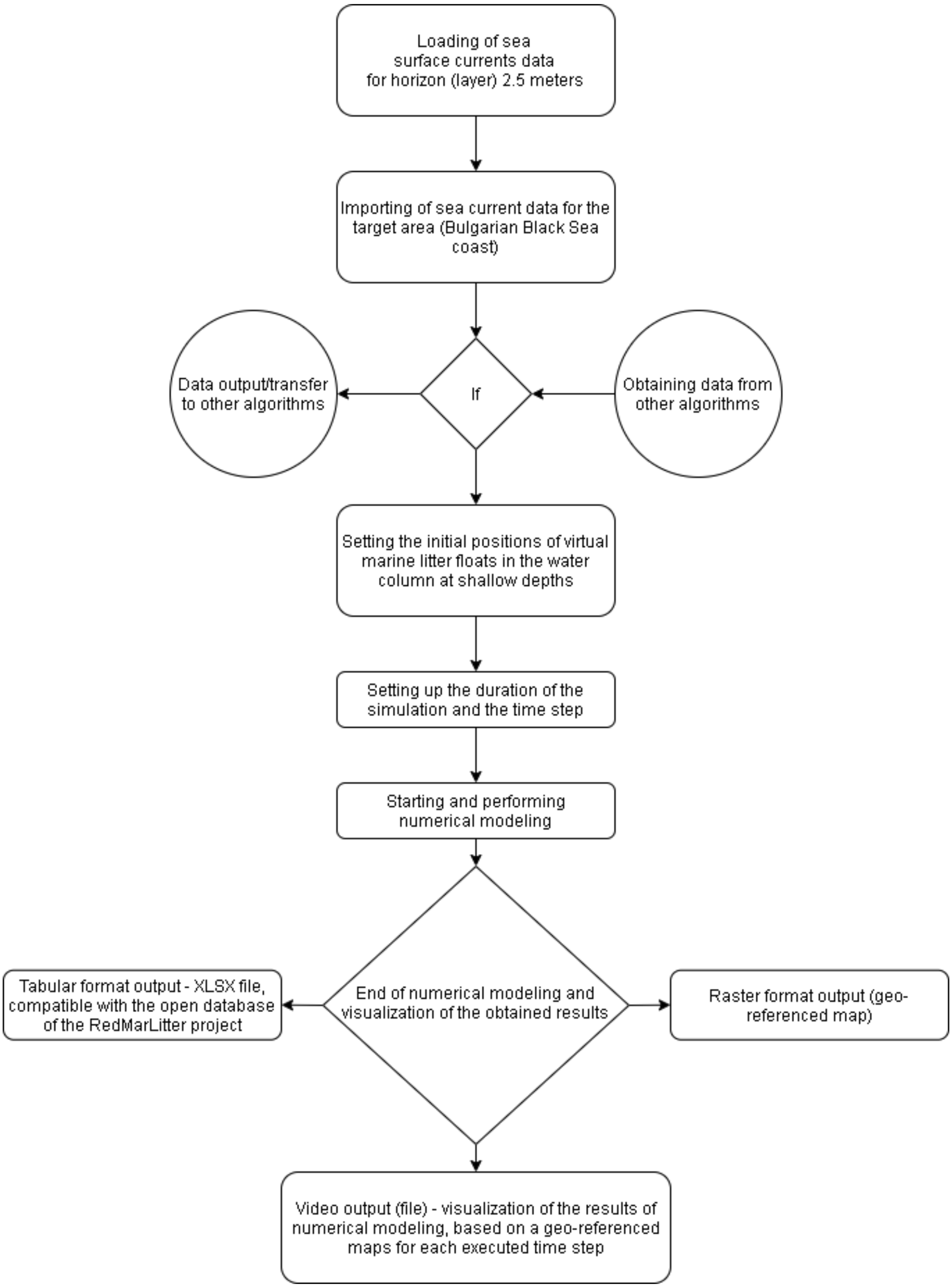


FIG. 5.4 Algorithm of mathematical modeling for derivation of water flows in the surface layer in the target area (Bulgarian Black Sea coast), based on product data of product **BLKSEA_REANALYSIS_PHYS_007_004**

As a result of mathematical modeling for the needs of RedMarLitter project generators from for the period 2015-2019 (for which the respective results are presented in the form of video materials, georeferenced data in raster format and in tabular format XLSX files compatible with the open database of the RedMarLitter project), showing the movement and distribution in time of the floaters at shallow depths in the water column solid waste.

The full volume of the video materials from the mathematical modeling, including the georeferenced map material for the movement and distribution of the solid floating waste are attached on optical media Annex 3 to this report and published with free access on the project page https://map.redmarlitter.eu/en/waste-flow-modeling (see Fig. 5.5). A sample of georeferenced map materials of the distribution of solid floating waste in the surface layer of the Bulgarian Black Sea for every tenth day of the month for the period from 2015 to 2019 as a result of simulations through mathematical modeling are attached in this report.

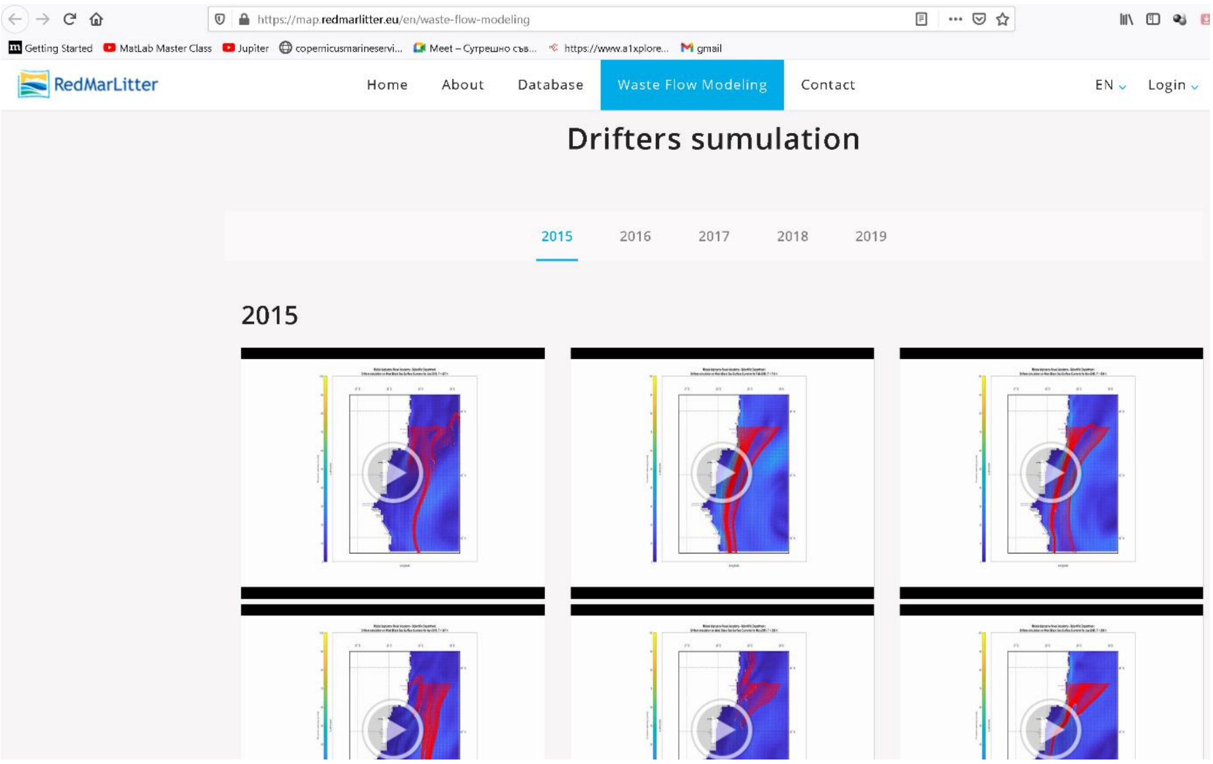


FIG. 5.5 Visualization of the video materials published on

https://map.redmarlitter.eu/en/waste-flow-modeling

For the detection of the movement and distribution of the solid marine waste from the **second conditional group,** data on the direction and speed of the air currents from the Marine Environmental Monitoring Service of the Copernicus Program (product **WIND_GLO_WIND_L4_REP_OBSERVATIONS_012_006**) described in section 3 of this study, **which are also characterized by the required spatial coverage, resolution and time range, are also used.**

During the study, no information was found in the scientific literature on research in the field of determining the degree of impact of air currents on floating surface solid waste of mixed type, as shown in Figures 5.2 and 5.3.

One option for assessing the impact of the direction and speed of air currents on floating solid waste is the use of established methods for predicting the movement and spread of oil spills on the sea surface. They assume that the impact of air currents is within a **maximum of 3.0% to 3.5%** of the resultant force (resultant vector), formed by the sum of the forces (vectors) of sea and air currents.

The algorithm used to derive the direction and velocity data from product **WIND_GLO_WIND_L4_REP_OBSERVATIONS_012_006** of the Copernicus Marine Environment Monitoring Service is shown in Figure 5.6. It should be noted that the product concerned contains a single layer with data at a height of 10 meters above sea level.

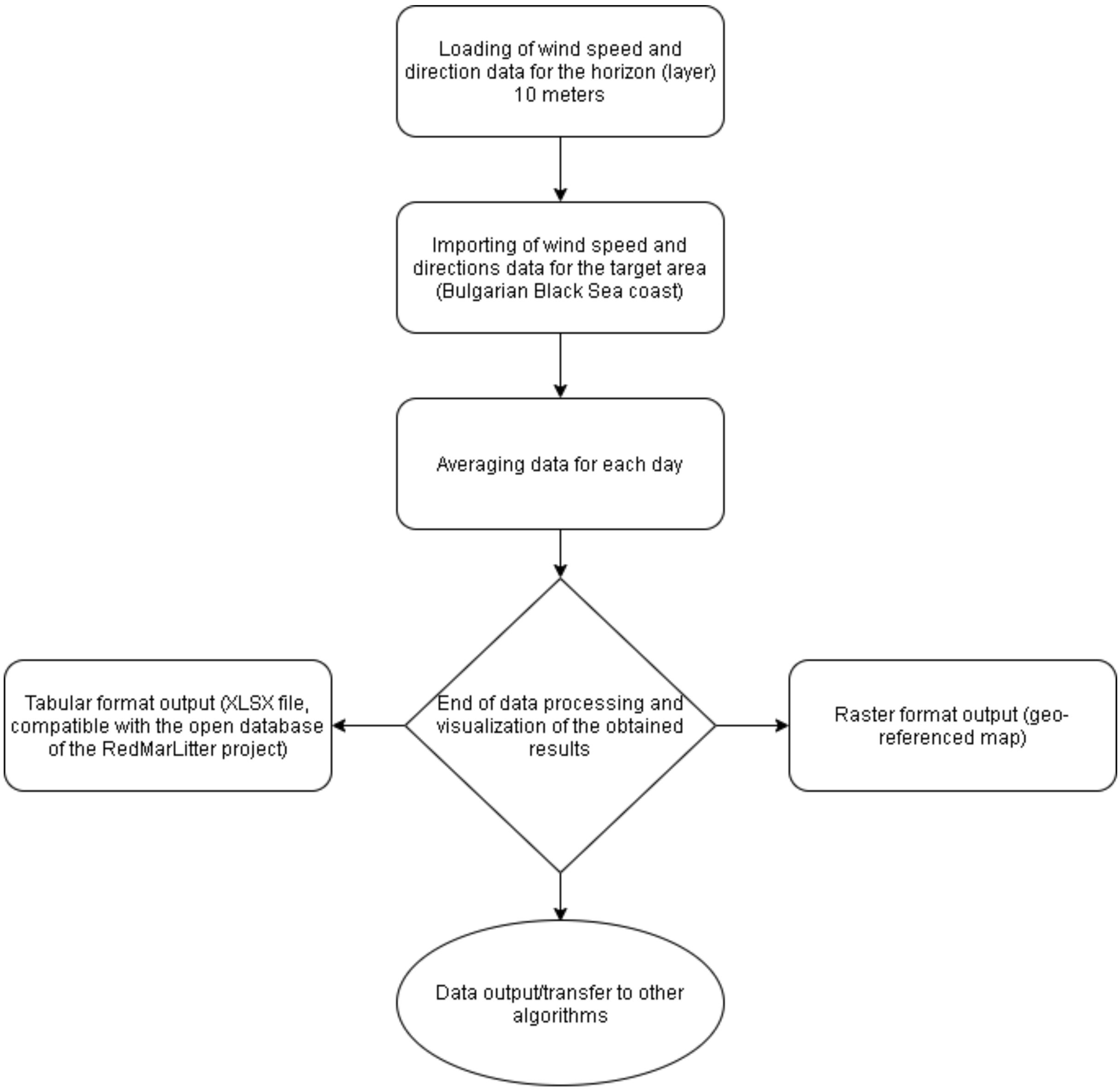


FIG. 5.6 Algorithm for deriving data on the direction and velocity of air currents from product **WIND_GLO_WIND_L4_REP_OBSERVATIONS_012_006** of the Marine Environment Monitoring Service of the Copernicus Program

As a result of the analyzes, the lack of specific data from studies on the degree of impact of air currents on the multivariance of the second conditional group, mathematical modeling and simulations for floating solid waste in the target area, it can be assumed that the direct impact of wind flows on of the second conditional group does not have a significant influence in determining the most endangered coastal areas.

For the needs of the mathematical modeling for definition of the water flows (carriers of floating solid waste on the sea surface) in the target area additional algorithms and software code in MatLab environment have been developed, by which the ***density of the distribution of the floating solid waste on the sea surface, with dimensions larger than 2.5 cm, in the target area is calculated.***

Figure 5.7 shows a georeferenced map of water flows in the target area for 2015-2019, based on mathematical modeling of floating solid waste on the sea surface and the obtained water flows according to the density of distribution of floating solid waste on the sea surface started on Line 1.

Figure 5.8 shows a georeferenced map of water flows in the target area for 2015-2019, based on mathematical modeling of floating solid waste on the sea surface and the obtained water flows according to the density of distribution of floating solid waste on the sea surface started on Line 2.

Figure 5.9 shows a georeferenced map of water flows in the target area for 2015-2019, based on mathematical modeling of floating solid waste on the sea surface and the obtained water flows according to the density of distribution of floating solid waste on the sea surface started on Line 3.

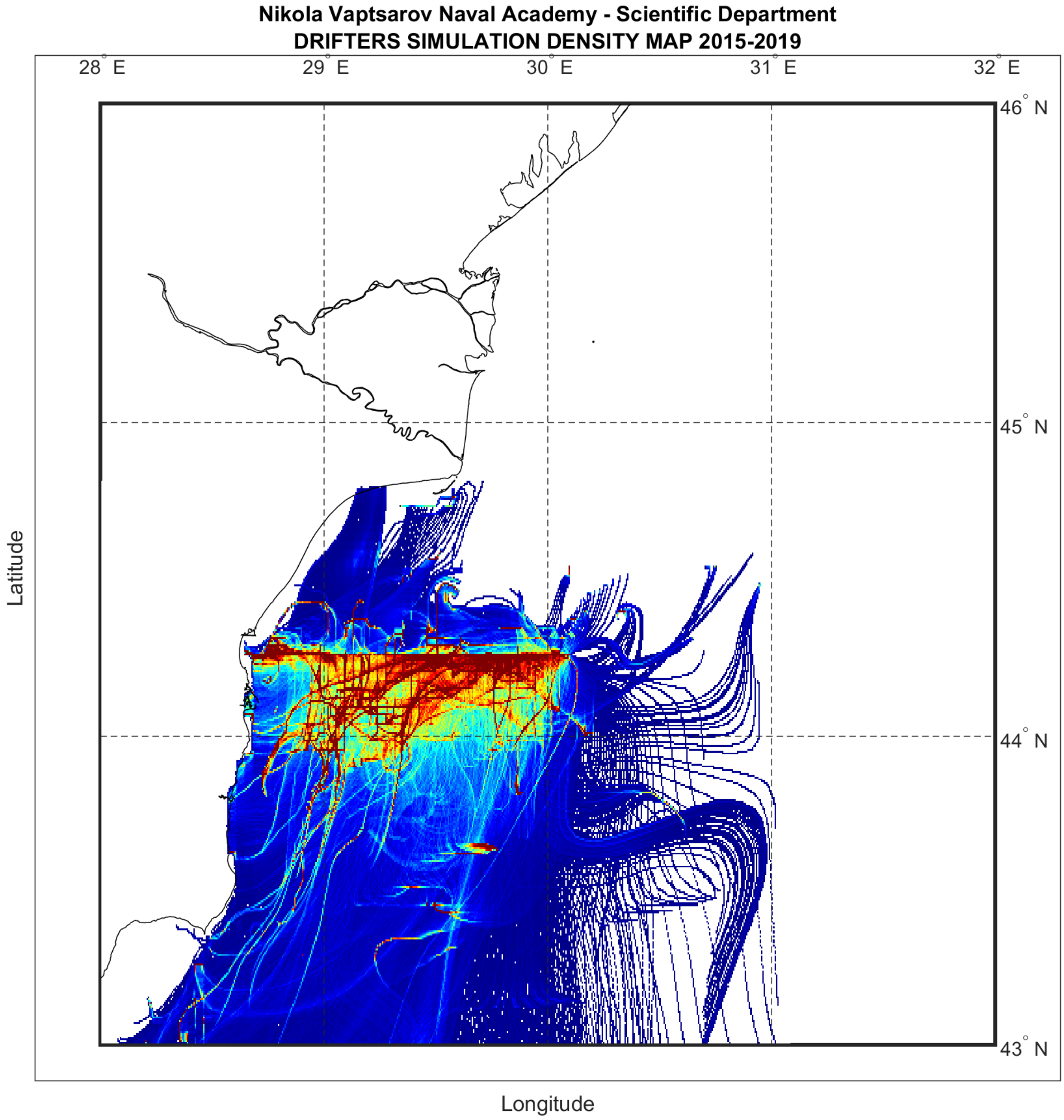


FIG. 5.7 Model of water flows in the surface layer of the target area for 2015-2019 (Line 1)

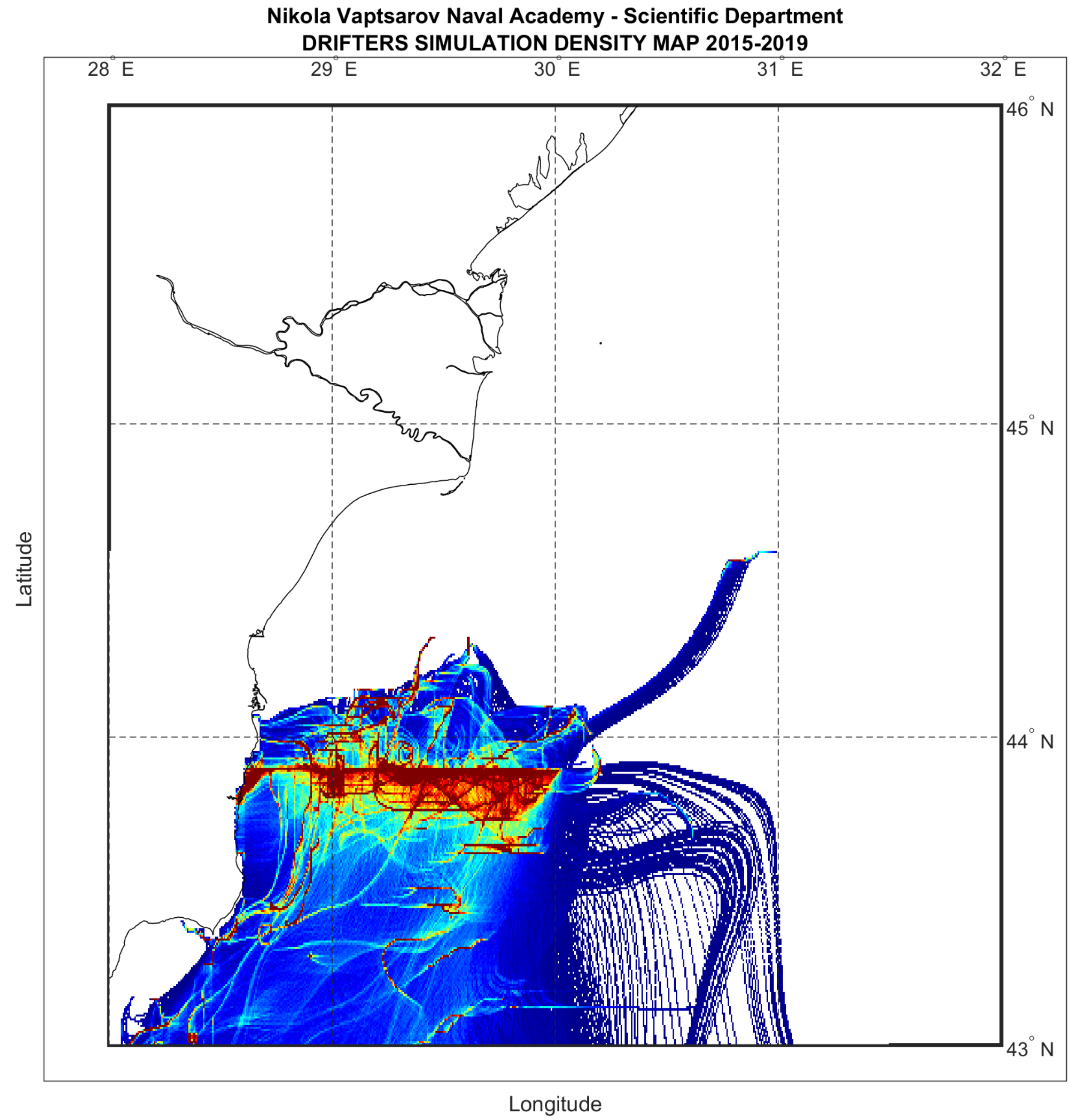


FIG. 5.8 Model of water flows in the surface layer of the target area for 2015-2019 (Line 2)

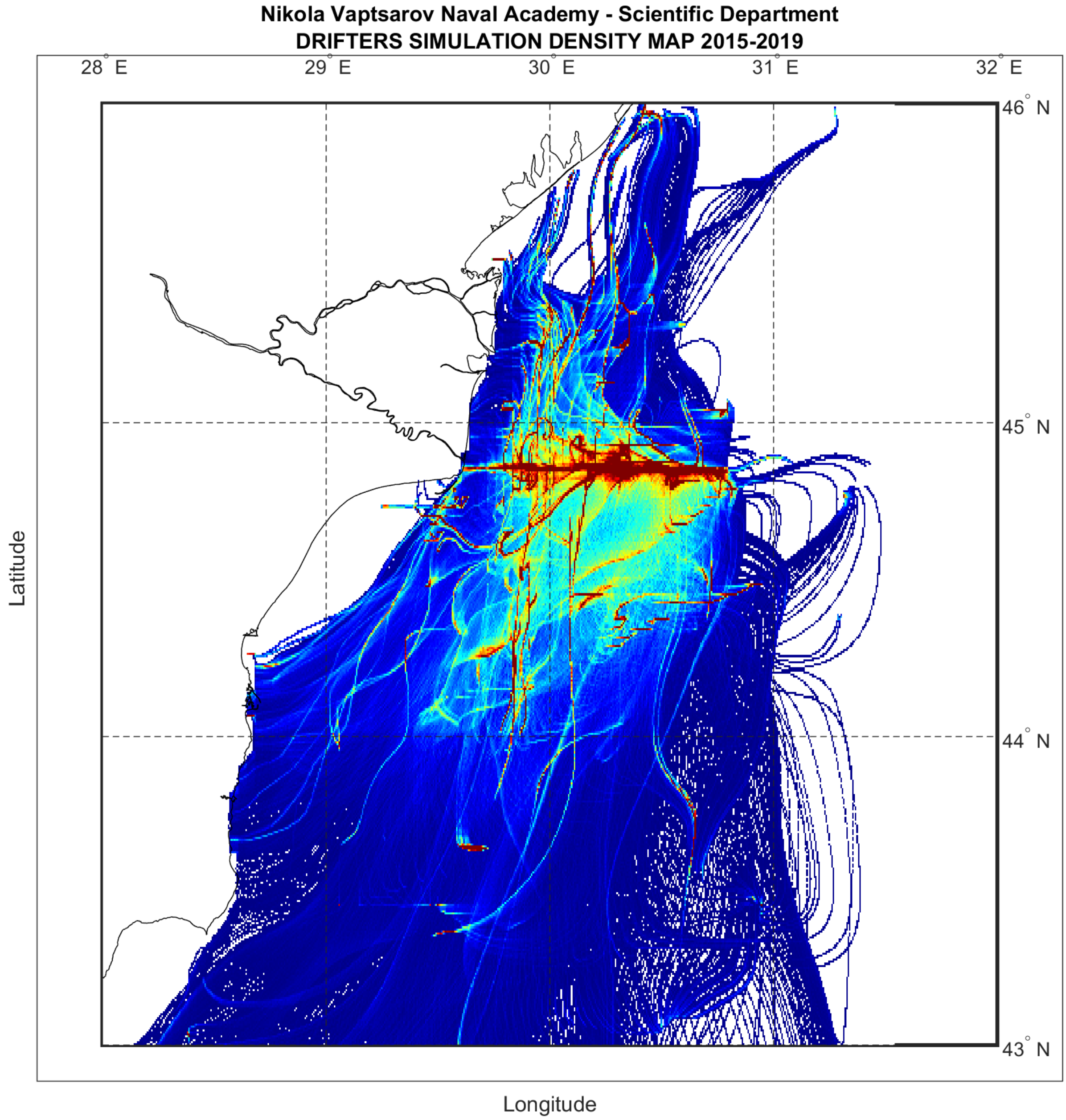


FIG. 5.9 Model of water flows in the surface layer of the target area for 2015-2019 (Line 3)

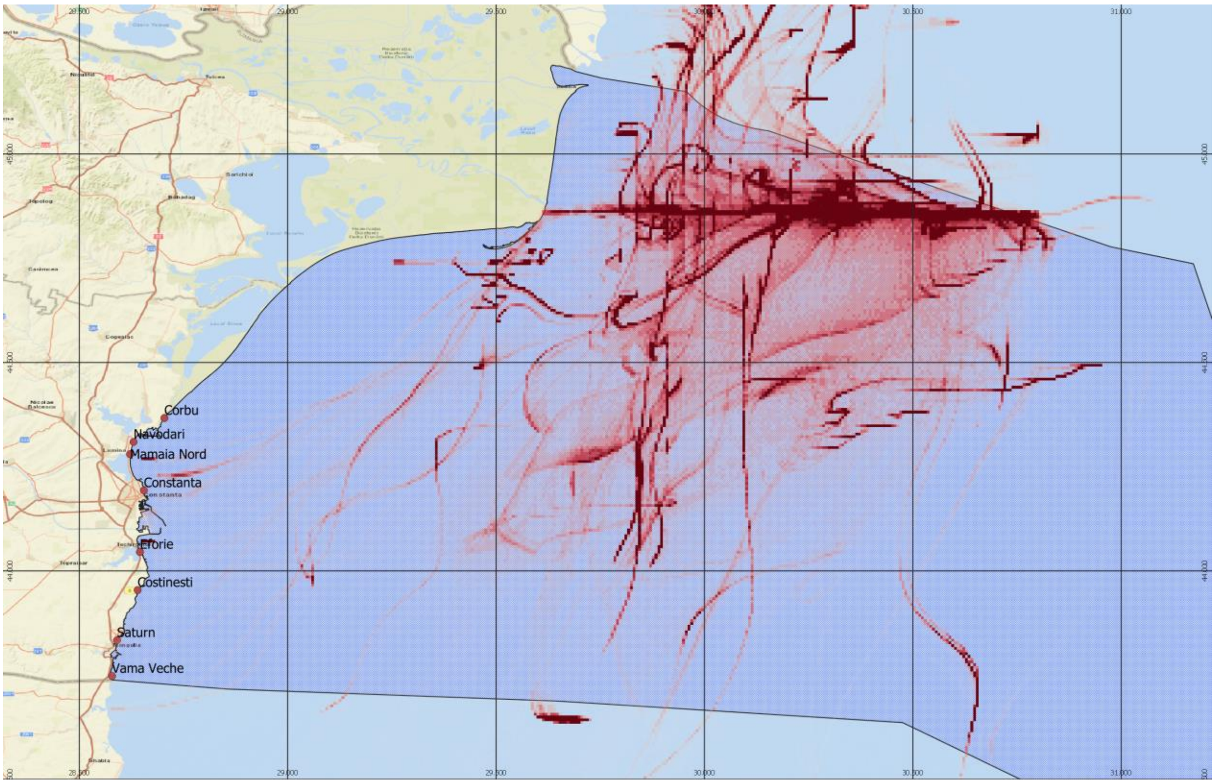


FIG 5.10 Line 3 SCALE 1:500000

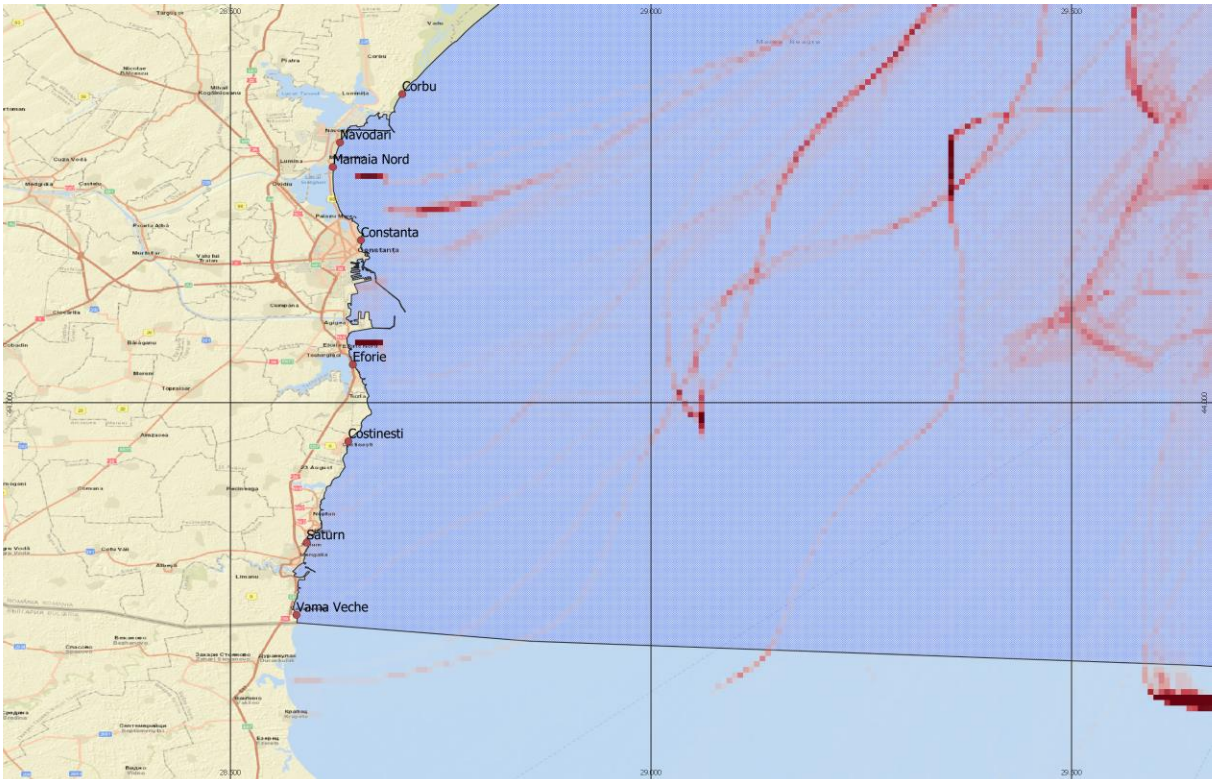


FIG 5.11 Line 3 SCALE 1:250000

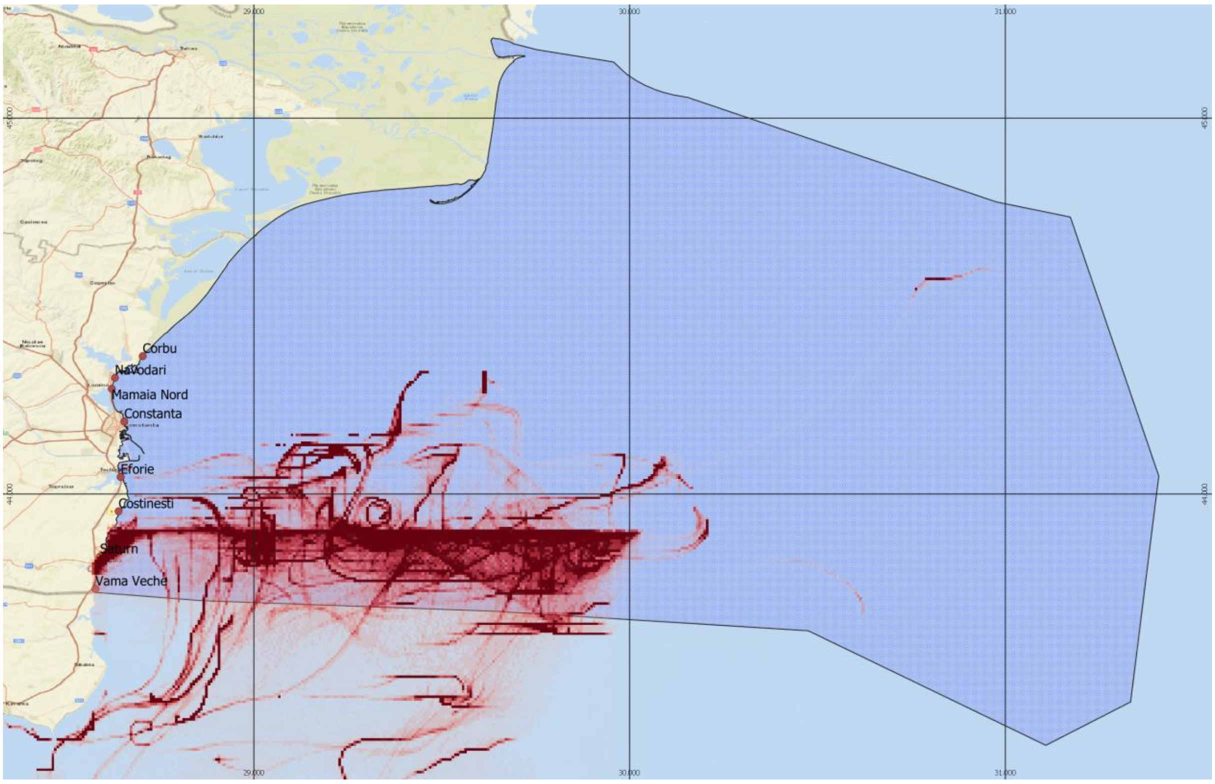


FIG 5.12 Line 2 SCALE 1:500000

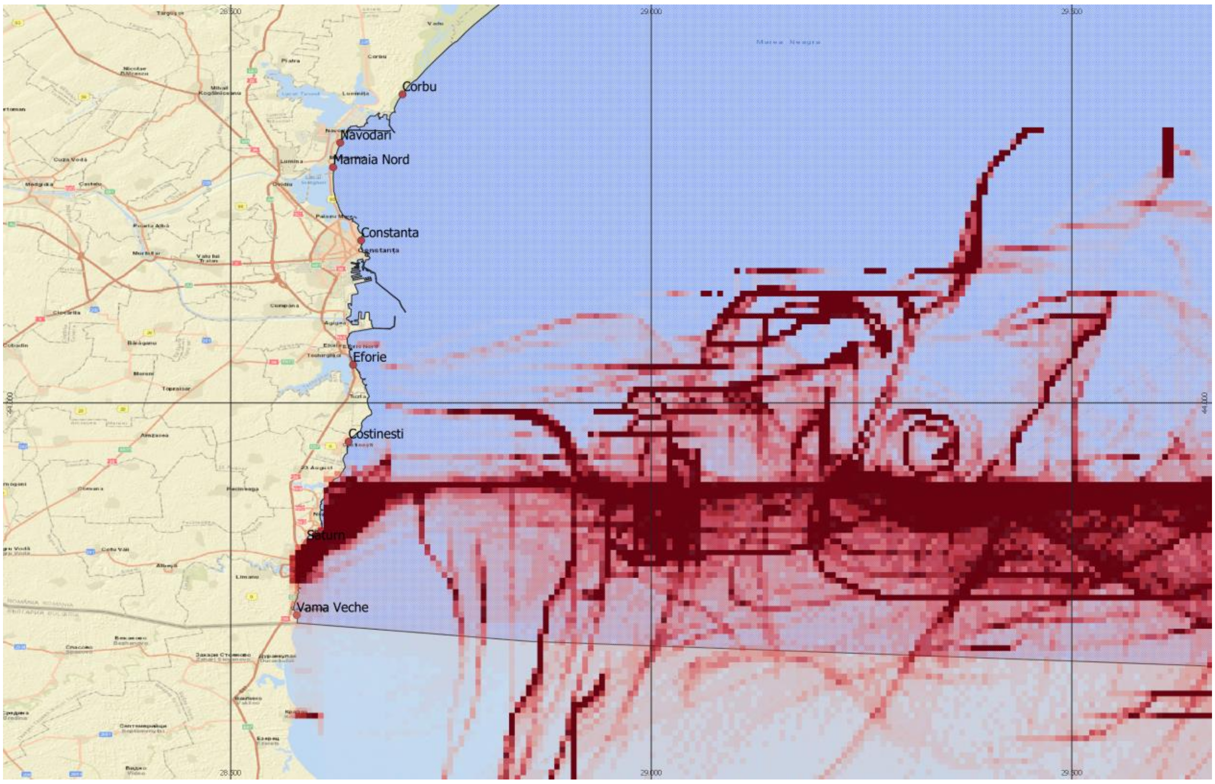


FIG 5.13 Line 2 SCALE 1:250000

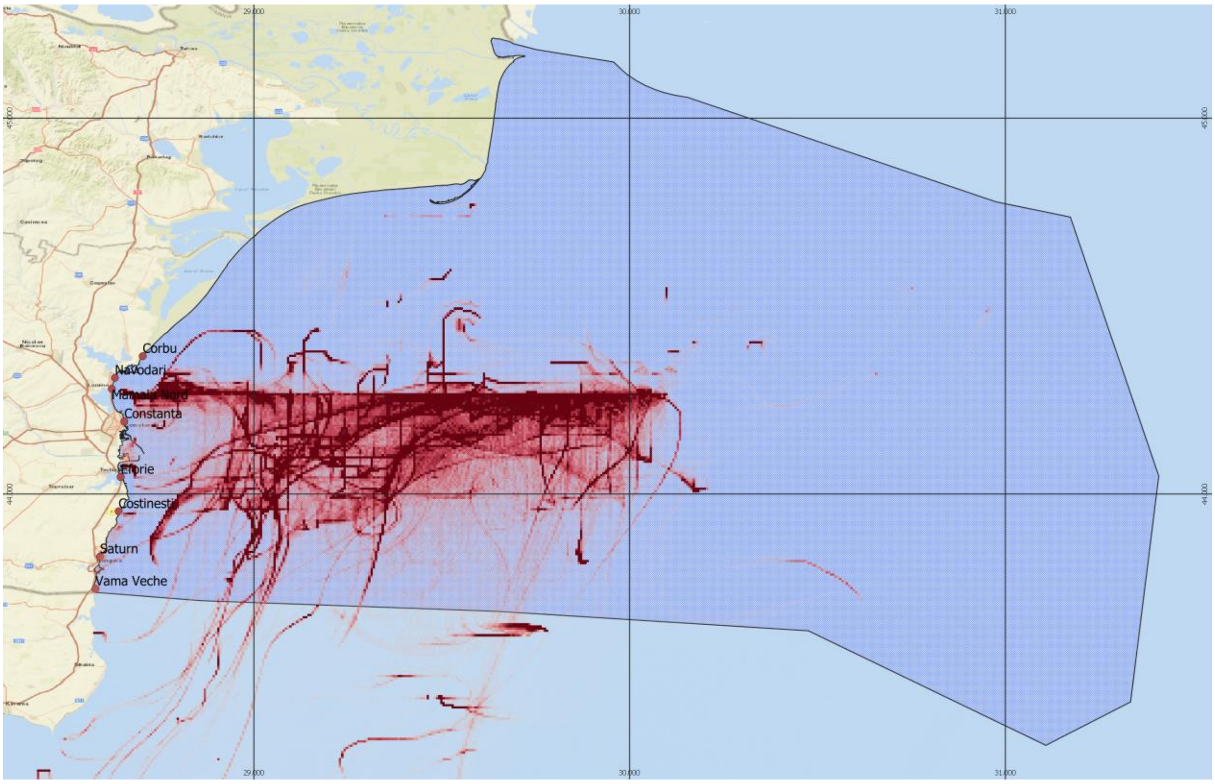


FIG 5.14 Line 1 SCALE 1:500000

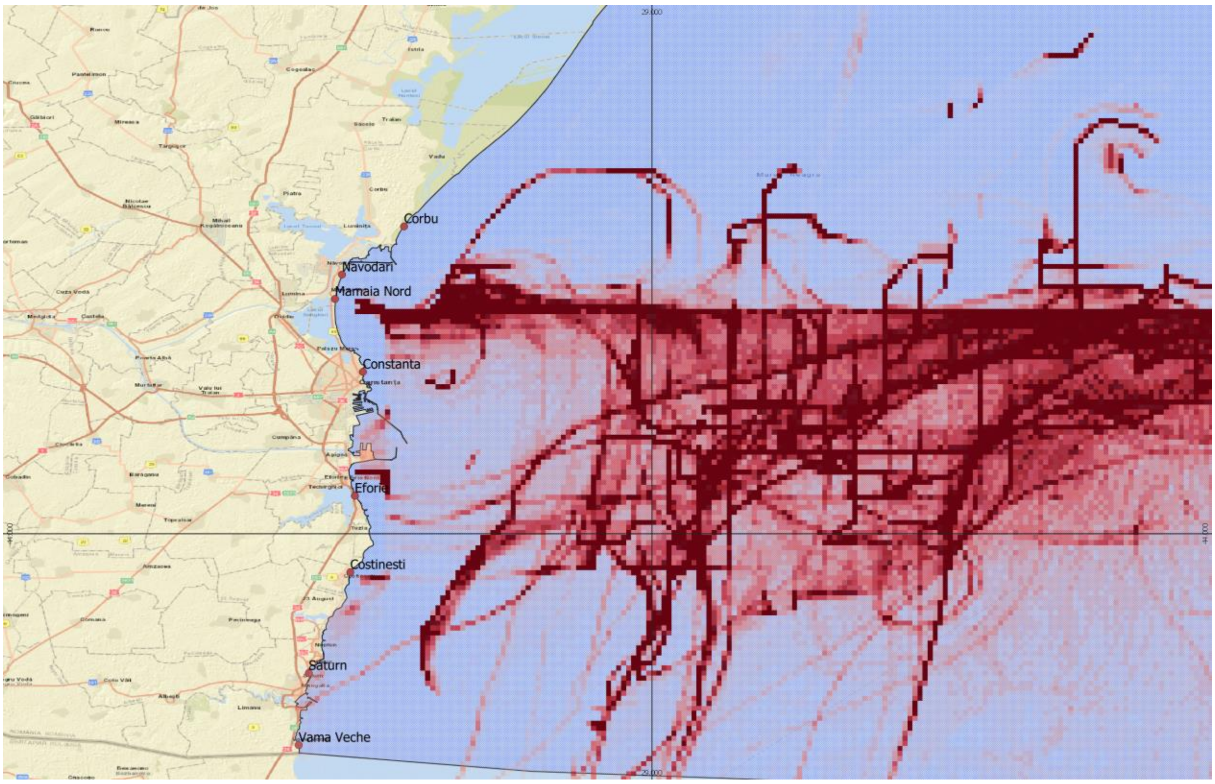


FIG 5.15 Line SCALE 1 1:250000

The rising impact of the marine litter crisis on sea ecosystems and marine species has encouraged a global concern and increasing calls for directives at the local, national, and international levels. Increasing evidence establishes that the plastic lifecycle brings a lot of risks not only to the environment, but also to the human health. In order to stop the harm to our ecosystems an immediate and dramatic reductions in plastic production must be done.

The data used in this study was collected from multiple monitoring sessions, carried out over 4 years on 8 beaches, with a total analyzed area of 43000 m^2. The total number of marine litter collected and identified on the coastline was approximately 116000 items of artificial polymeric material, rubber, textiles, paper, cardboard, processed wood, glass, ceramics, and metal. The largest amount of waste in terms of weight was registered in Navodari in 2018, but the largest number of objects was registered in Constanta in 2019, approximately 11300.

The ratio between the items and their weight, shows that in 2019 the analyzed beaches were the most affected by marine litter (195 items per kg); The abundance recorded in this 4th year of monitoring was 2.91 items/m^2.

Per total, from 2016 to 2019, Eforie had the highest recorded value of 6.37 items/m^2, followed by Vama Veche with 4.25 items/m^2 and the lowest value recorded was at Corbu 1.11 items/m^2.

Constanța sector was the least affected when it comes to the weight of the marine waste 9.69 g/m^2, followed by Saturn sector with 15.1 g/m^2 and Corbu sector with 16.54 g/m^2. At the opposite end, Navodari sector is the most affected with 116.59 g/m^2, followed by Eforie sector with 57.32 g/m^2.

The tourists the enjoy a nice vacation at the sea side play an important role when it comes to marine litter, maybe with years to come, with adequate education at national level, the awareness of the public will grow.

Another important part in creating the marine litter hot sports is played by the shape of the coastline, in this case the southern dike structures of the ports create a “pocket” like mechanism were debris from the sea and marine litter in general can concentrate.

6. Development of algorithms and software code for creating an interactive computer model-map for the movement of pollutant flows under the influence of water and air currents.

The interactive computer model-map for the movement of pollutant flows under the influence of water and air currents was developed in MatLab's environment, as a standalone application, based on the algorithms for importing these types of data from the Copernicus Marine Environmental Monitoring Service. and algorithms for modeling water flows in the surface layer and algorithms for modeling the distribution and distribution of floating solid waste.

Additionally, in this task, algorithms and software code have been developed for the creation of a graphical user interface for the operation of the application in the environment of MS Windows.

The graphical user interface of the application consists of seven interactive panels for data input and output, and control of its operation. Additionally, an uneditable information panel is placed at the top of the interface.

1 - Panel “Currents (monthly mean data)”

2 - Panel “Winds (daily mean data)”

3 - Panel “Flows”

4 - Panel “RedMarLitter Database File (* .XLSX)”

5 - Panel “Flows forecast (based on)”

6 - “Progress Information”

panel 7 - “Controls”panel

The graphical user interface (GUI) of the interactive map for the modeling of movement of waste flows under the influence of water and air currents is shown in fig. 6.1.

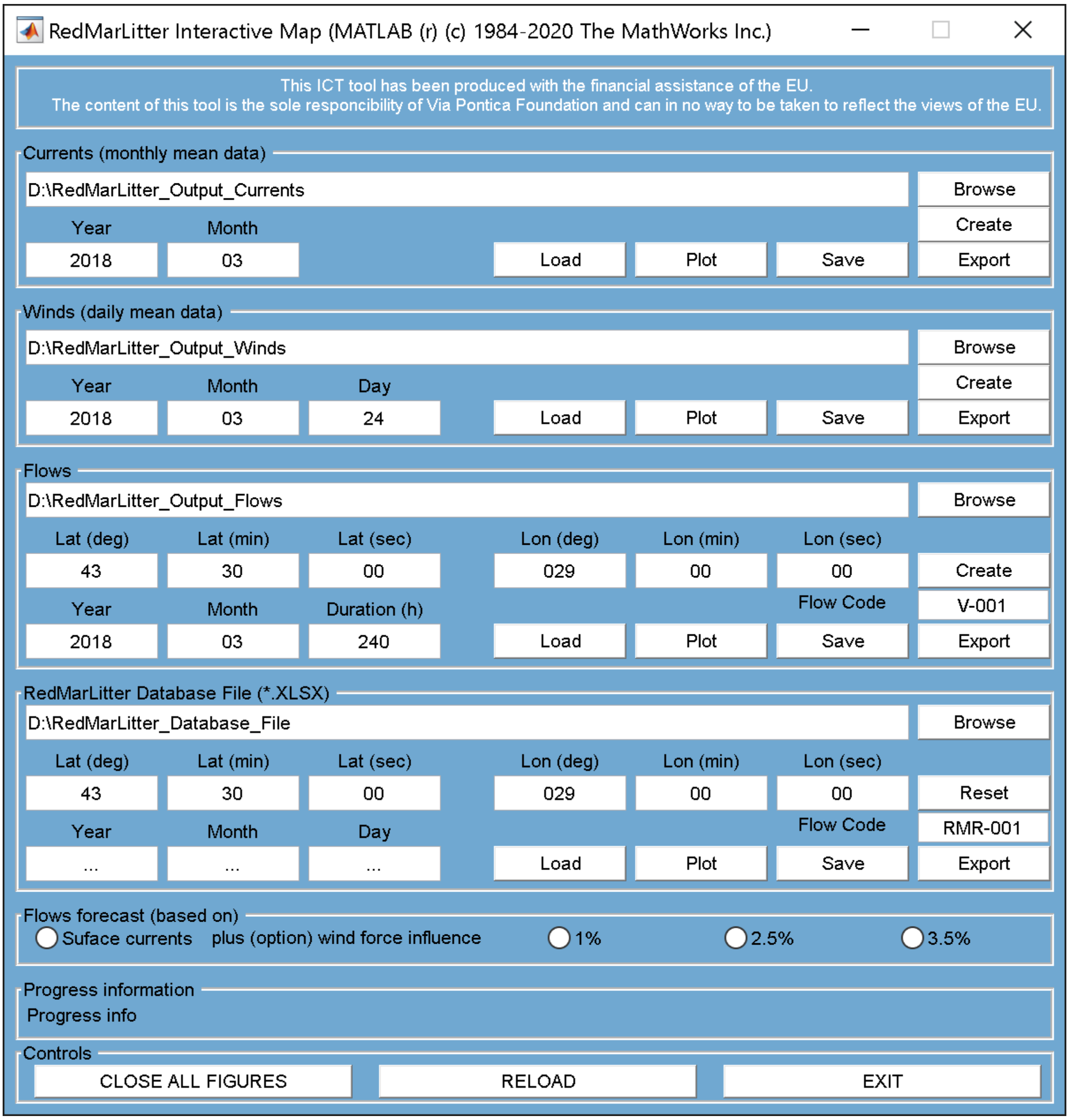


FIG. 6.1 Graphical user interface of the interactive computer model-map for the movement of pollutant flows under the influence of water and air currents

Panel "Currents (monthly mean data)"

The application integrates the data for the average monthly values of surface sea currents (per product BLKSEA_REANALYSIS_700) for all months for the period 2015-2018 inclusive, collected within the project for the target territory. The panel is shown in Figure 6.2.

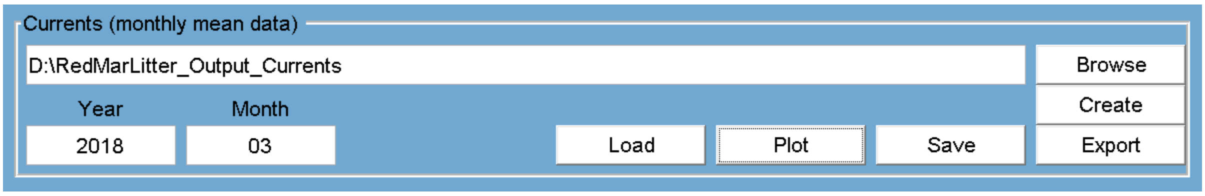


FIG. 6.2 Visualization of the "Currents (monthly mean data)"

Panel The "Currents (monthly mean data)" is designed for the purposes of managing this data. It consists of:

- "Browse" button with the help of which a directory / folder is selected in which to save the output files generated by the application according to parameters set by the user;
- Button "Create" with which to create a directory / folder with address (path) entered in the field in front of the button "Browse" in which to save the output files generated by the application by user-defined parameters;
- Fields "Year" and "Month" in which the user enters the desired month and year for visualization and display of data on average monthly values of surface sea currents;
- "Load" button with which the user after setting the time period loads the data into the computer's memory;
- "Plot" button with the help of which the user generates a georeferenced map in raster format visualizing the direction and speed of the surface sea currents (see Fig. 6.3);

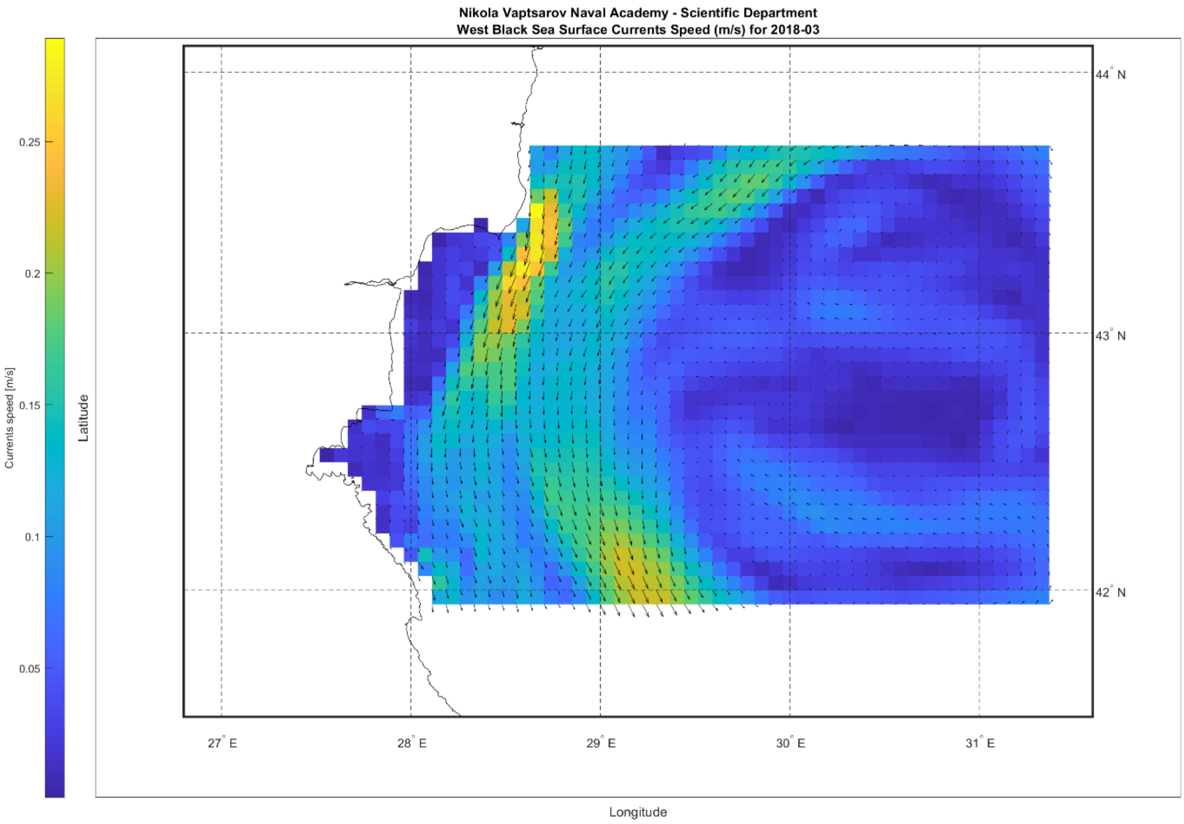
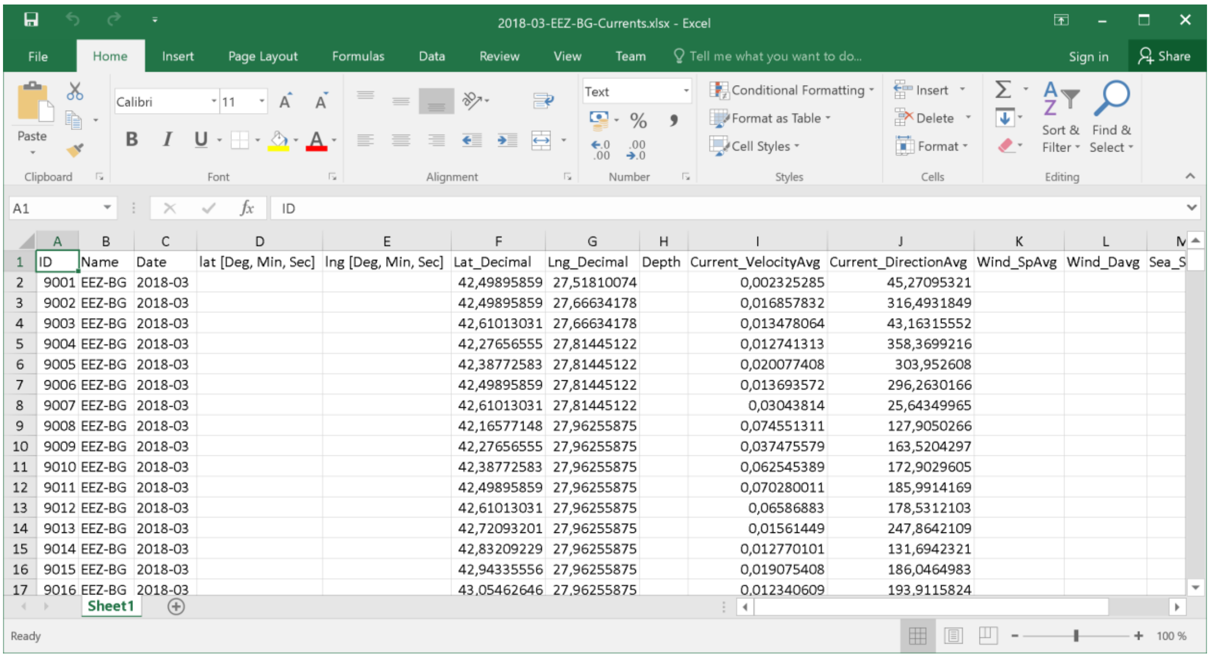


FIG. 6.3 Visualization of the direction and speed of surface sea currents in the form of a georeferenced map in raster format

- “Save” button with the help of which the user saves the map generated by the application in the predefined directory / folder;
- "Export" button with which the user stores the data on the direction and speed of surface sea currents in tabular form in XLSX format, compatible with the open database of the RedMarLitter project. This functionality is based on a specially developed additional algorithm for transforming the data on the direction and speed of marine currents by the Marine Environment Monitoring Service of the Copernicus Program in a format suitable for the open project database (see Fig. 6.4). Files of this type are entered into the open project database https://map.redmarlitter.eu/en/database using the “Import XLSX” functionality (see Figures 6.5 and 6.6);



ID	Name	Date	lat [Deg, Min, Sec]	lng [Deg, Min, Sec]	Lat_Decimal	Lng_Decimal	Depth	Current_VelocityAvg	Current_DirectionAvg	Wind_SpAvg	Wind_Davg	Sea_S
9001	EEZ-BG	2018-03			42,49895859	27,51810074		0,002325285	45,27095321			
9002	EEZ-BG	2018-03			42,49895859	27,66634178		0,016857832	316,4931849			
9003	EEZ-BG	2018-03			42,61013031	27,66634178		0,013478064	43,16315552			
9004	EEZ-BG	2018-03			42,27656555	27,81445122		0,012741313	358,3699216			
9005	EEZ-BG	2018-03			42,38772583	27,81445122		0,020077408	303,952608			
9006	EEZ-BG	2018-03			42,49895859	27,81445122		0,013693572	296,2630166			
9007	EEZ-BG	2018-03			42,61013031	27,81445122		0,03043814	25,64349965			
9008	EEZ-BG	2018-03			42,16577148	27,96255875		0,074551311	127,9050266			
9009	EEZ-BG	2018-03			42,27656555	27,96255875		0,037475579	163,5204297			
9010	EEZ-BG	2018-03			42,38772583	27,96255875		0,062545389	172,9029605			
9011	EEZ-BG	2018-03			42,49895859	27,96255875		0,070280011	185,9914169			
9012	EEZ-BG	2018-03			42,61013031	27,96255875		0,06586883	178,5312103			
9013	EEZ-BG	2018-03			42,72093201	27,96255875		0,01561449	247,8642109			
9014	EEZ-BG	2018-03			42,83209229	27,96255875		0,012770101	131,6942321			
9015	EEZ-BG	2018-03			42,94335556	27,96255875		0,019075408	186,0464983			
9016	EEZ-BG	2018-03			43,05462646	27,96255875		0,012340609	193,9115824			

FIG. 6.4 Export file with data on the direction and speed of surface sea currents in tabular form (XLSX format), compatible with the open database of the RedMarLitter project

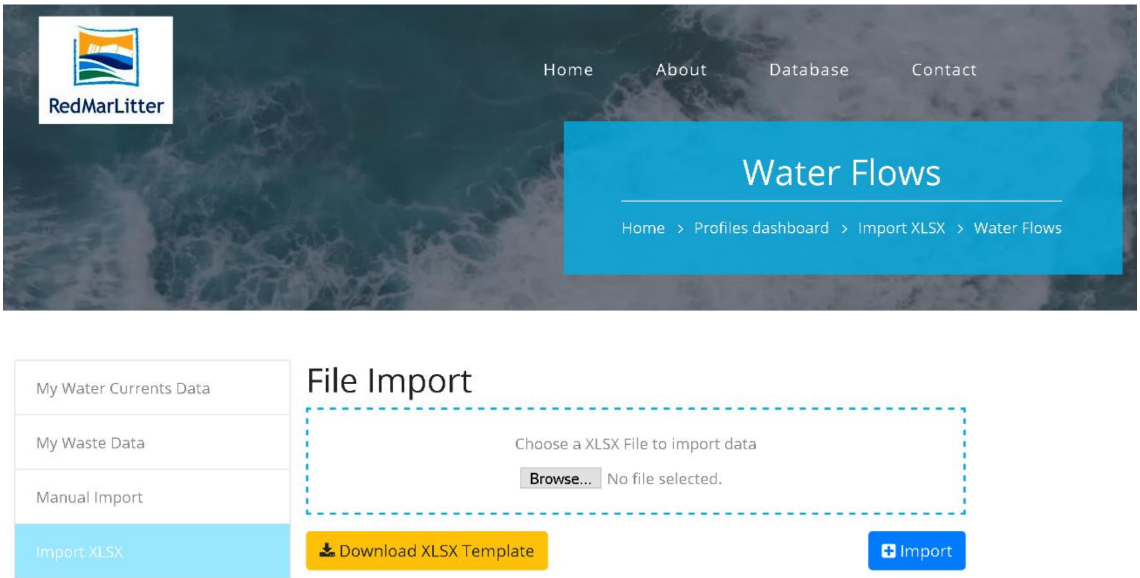


Fig. 6.5 “Import XLSX” functionality of the open project database

https://map.redmarlitter.eu/en/database

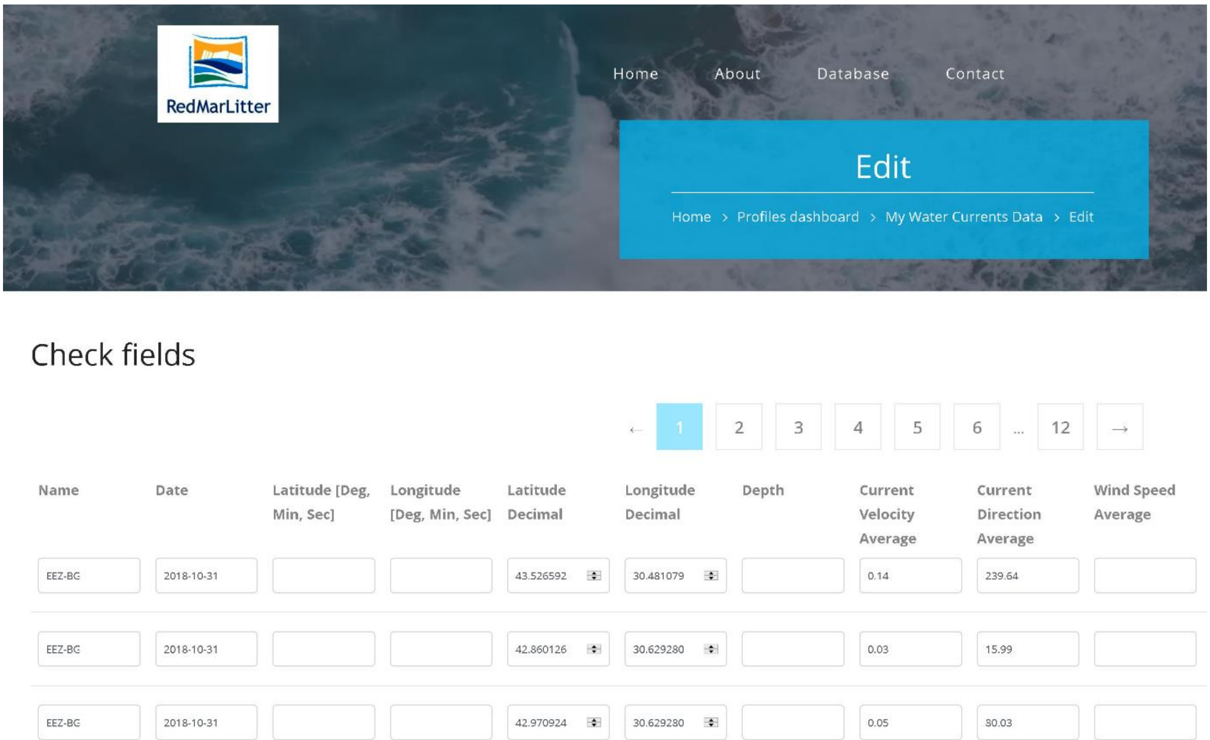


Fig. 6.6 Visualization of the functionality for viewing and editing the imported data in the open database of the RedMarLitter project

After importing the data in https://map.redmarlitter.eu/en/database they can be visualized and accessed using the interactive filters, buttons and tools on the website (see Fig. 6.7).

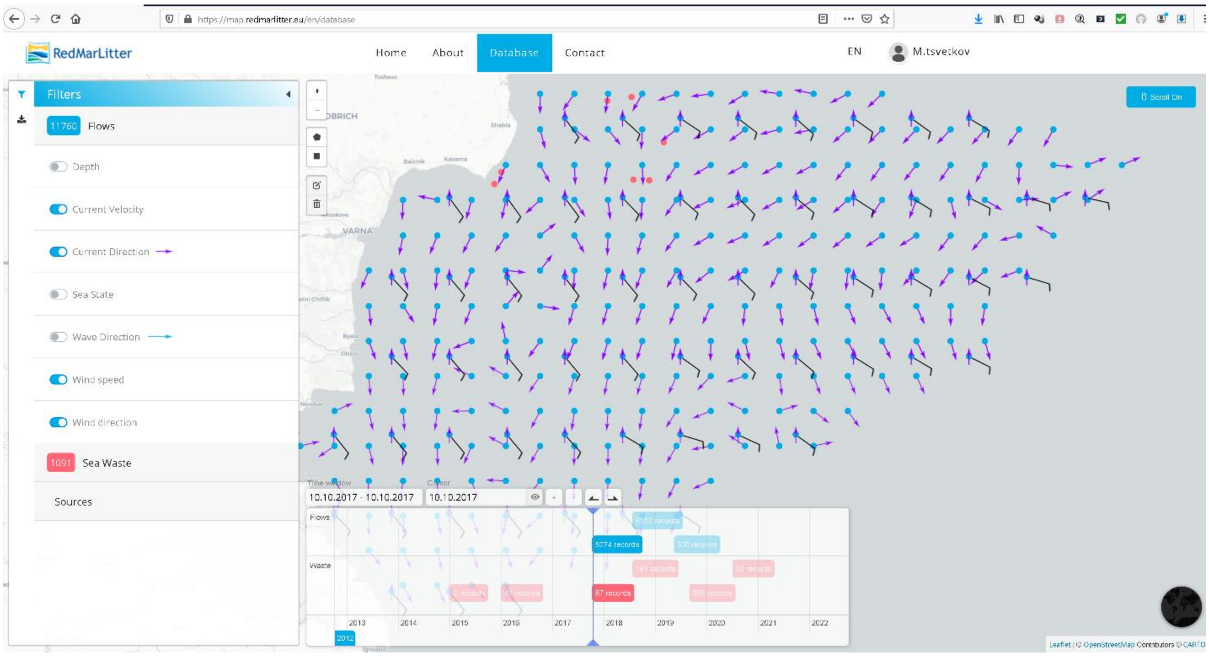


FIG. 6.7 Visualization of data on sea currents in the open database of the RedMarLitter project

Panel "Winds (daily mean data)"

The application integrates the data on the average daily values for the direction and wind speed at a height of 10 meters above sea level (on product WIND_GLO_WIND_L4_REP) for all days for the period 2015-2018 inclusive, collected within the project for the target territory. The panel is shown in Figure 6.8.

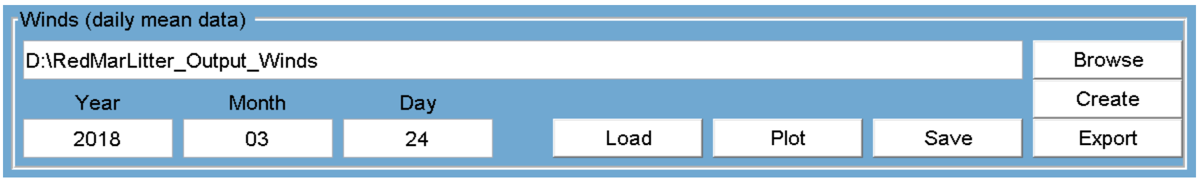


FIG. 6.8 Visualization of the "Winds (daily mean data)" panel

The "Winds (daily mean data)" panel is designed for the needs of the management of the wind direction and speed data integrated in the application. It is analogous to the already described Panel "Currents (monthly mean data)" and consists of the same fields, buttons and functionalities with an added field "Day" providing the ability to enter a day (date) by the user.

Preview of the direction and speed of the air currents in the form of a georeferenced map in raster format, generated by the application according to parameters set by the user is shown in fig. 6.9. Figure 6.10 shows an application-generated export file in XLSX format compatible with the open RedMarLitter project database.

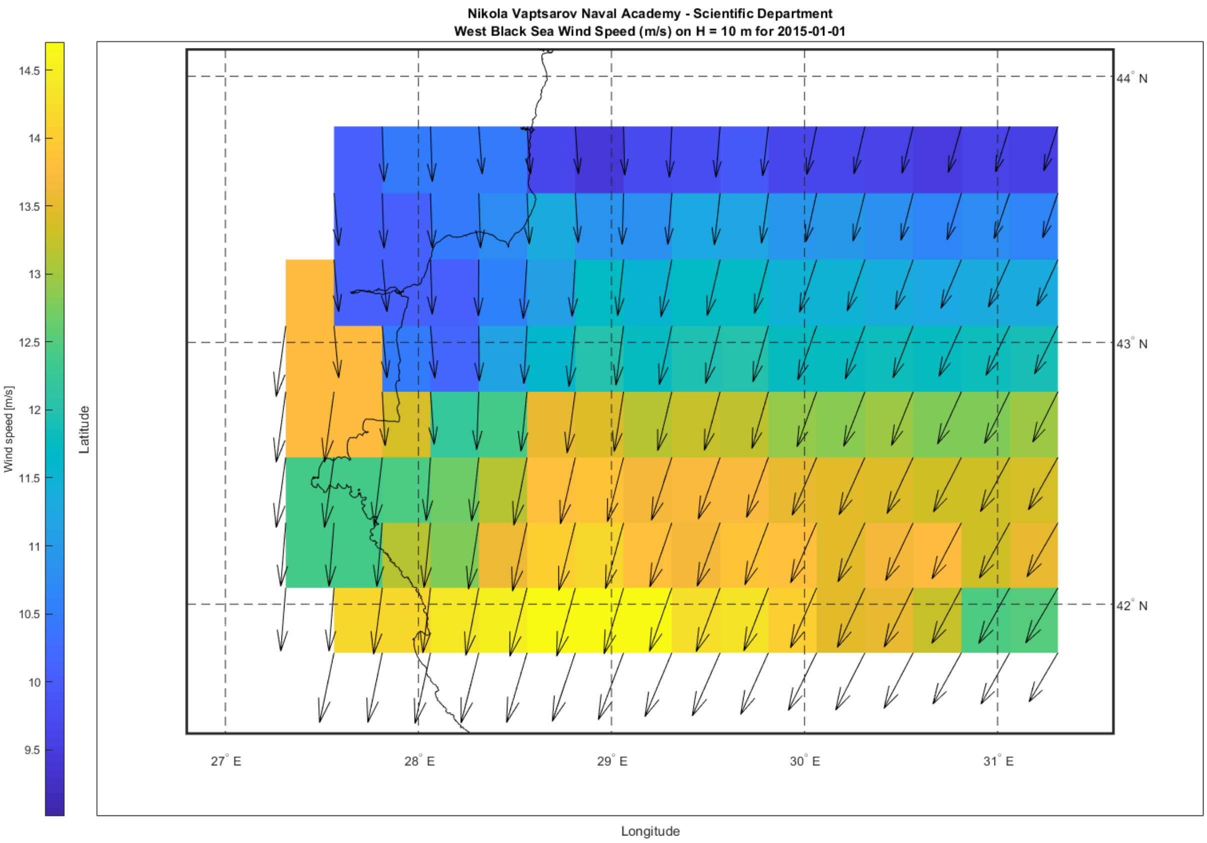
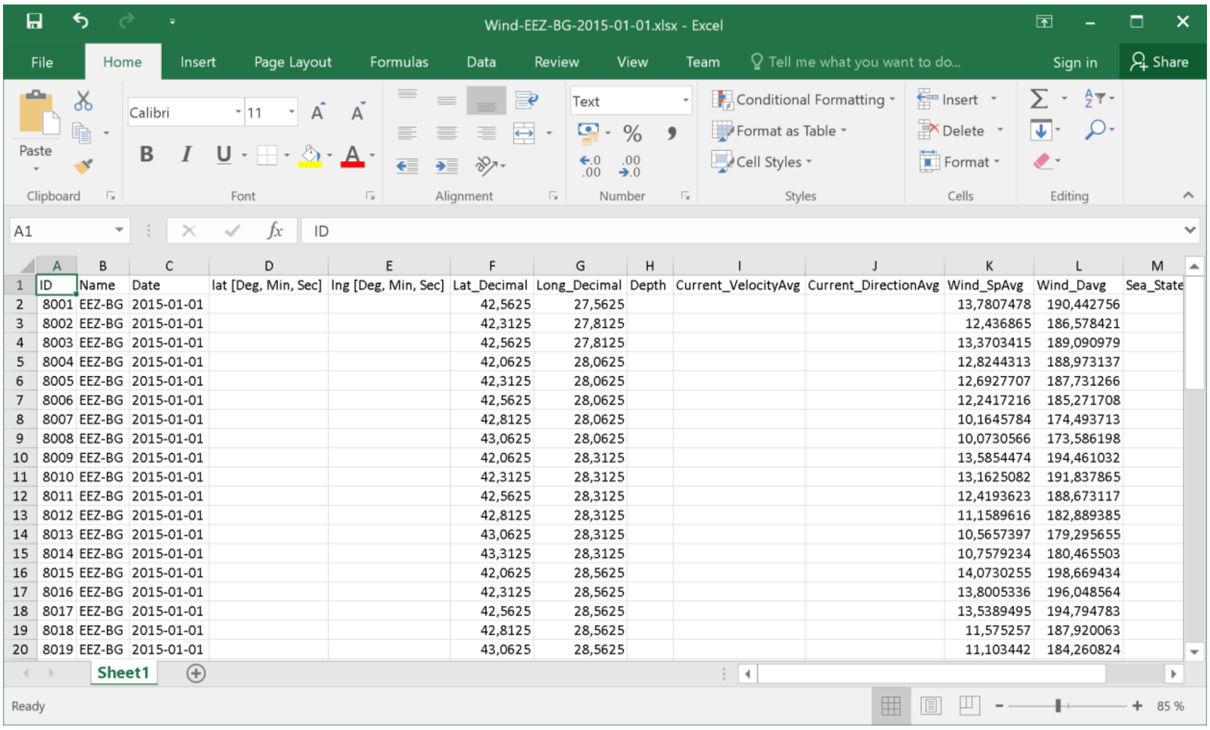


FIG. 6.9 Visualization of the direction and speed of the air currents in the form of a georeferenced map in raster format



Wind-EEZ-BG-2015-01-01.xlsx - Excel

	ID	Name	Date	lat [Deg, Min, Sec]	lng [Deg, Min, Sec]	Lat_Decimal	Long_Decimal	Depth	Current_VelocityAvg	Current_DirectionAvg	Wind_SpAvg	Wind_Davg	Sea_State
2	8001	EEZ-BG	2015-01-01			42,5625	27,5625				13,7807478	190,442756	
3	8002	EEZ-BG	2015-01-01			42,3125	27,8125				12,436865	186,578421	
4	8003	EEZ-BG	2015-01-01			42,5625	27,8125				13,3703415	189,090979	
5	8004	EEZ-BG	2015-01-01			42,0625	28,0625				12,8244313	188,973137	
6	8005	EEZ-BG	2015-01-01			42,3125	28,0625				12,6927707	187,731266	
7	8006	EEZ-BG	2015-01-01			42,5625	28,0625				12,2417216	185,271708	
8	8007	EEZ-BG	2015-01-01			42,8125	28,0625				10,1645784	174,493713	
9	8008	EEZ-BG	2015-01-01			43,0625	28,0625				10,0730566	173,586198	
10	8009	EEZ-BG	2015-01-01			42,0625	28,3125				13,5854474	194,461032	
11	8010	EEZ-BG	2015-01-01			42,3125	28,3125				13,1625082	191,837865	
12	8011	EEZ-BG	2015-01-01			42,5625	28,3125				12,4193623	188,673117	
13	8012	EEZ-BG	2015-01-01			42,8125	28,3125				11,1589616	182,889385	
14	8013	EEZ-BG	2015-01-01			43,0625	28,3125				10,5657397	179,295655	
15	8014	EEZ-BG	2015-01-01			43,3125	28,3125				10,7579234	180,465503	
16	8015	EEZ-BG	2015-01-01			42,0625	28,5625				14,0730255	198,669434	
17	8016	EEZ-BG	2015-01-01			42,3125	28,5625				13,8005336	196,048564	
18	8017	EEZ-BG	2015-01-01			42,5625	28,5625				13,5389495	194,794783	
19	8018	EEZ-BG	2015-01-01			42,8125	28,5625				11,575257	187,920063	
20	8019	EEZ-BG	2015-01-01			43,0625	28,5625				11,103442	184,260824	

Fig. 6.10 Export file with airflow direction and velocity data in tabular form (XLSX format), compatible with the open database of the RedMarLitter project

Similarly, by using the functionalities and tools of the open database of the RedMarLitter project, the imported data can be viewed , edited and visualized (see Fig. 6.7).

Flows panel

This panel is designed for calculation by mathematical modeling and visualization of water flow input based on userdata and by using the integrated in the application data on the direction and speed of surface sea currents and the direction and speed of air currents.

The panel is shown in fig. 6.11.

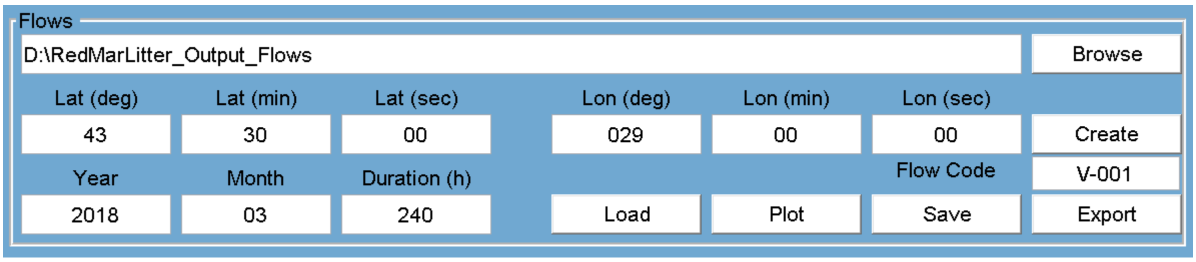


FIG. 6.11 Visualization of the “Flows” Panel

The panel consists of:

- “Browse” button with the help of which a directory / folder is selected in which to save the output files generated by the application according to parameters set by the user;
- Button "Create" with which to create a directory / folder with address (path) entered in the field in front of the button "Browse" in which to save the output files generated by the application by user-defined parameters;
- Fields “Year” and “Month” in which the user enters the desired month and year for use of the data for the average monthly values of the surface sea currents;
- "Duration" field with which the user sets the duration of the mathematical modeling in the form of the number of hours counted from the beginning of the calendar month. For example: a value of 240 means ten full days;
- The fields “Lat (deg, min, sec)” and “Lon (deg, min, sec)” are used by the user to enter the geographical coordinates of the starting position of the floating object for which the mathematical modeling will be performed and will be calculated. the trajectory of movement under the influence of surface sea currents forming a water flow;
- Field "Flow code" with which the user sets his own identification code of the flow. The identification code is integrated in the name of the source files generated by the application;
- "Load" button with which the user after setting all the input parameters loads the data into the computer's memory;
- The “Plot”, “Save” and “Export” buttons have the same purpose and functionality as their analogues described in the previous panels;

Flows forecast panel

The panel and its supporting algorithms are designed to enable the user to generate water flow forecasts. The panel works with input data from the "Flows" Panel or with input data from the "RedMarLitter Database File (* .XLSX)" panel. The panel is shown in fig. 6.12.

For the needs of mathematical modeling in the first case, the user can choose one of the four options:

- Forecast based only on the average monthly data on surface sea currents for the four years (2015-2018);
- Forecast based on the average monthly data for surface sea currents for the four years (2015-2018) plus wind impact reporting within 1%;
- Forecast based on the average monthly data for surface sea currents for the four years (2015-2018) plus wind impact reporting within 2.5%;
- Forecast based on average monthly data for surface sea currents for the four years (2015-2018) plus wind impact reporting within 3.5%;
-

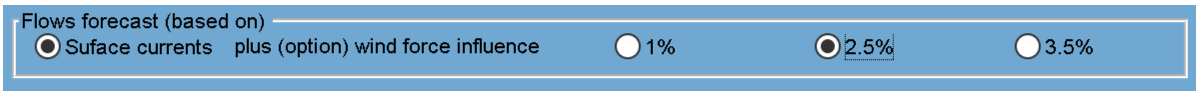


FIG. 6.12 Preview of the "Flow forecast" panel

The panel consists of four "radio" buttons with the help of which the desired combination (option) is selected by the user. The remaining input parameters are entered by using the "Flows" Panel as described above or by using the "RedMarLitter Database File (* .XLSX)" Panel. The results are displayed using the "Plot", "Save" and "Export" buttons on the respective "Flows" panel or respectively on the "RedMarLitter Database File (* .XLSX)".

The next four figures (6.13 to 6.16) show the results generated by the application for the four options with the same other input parameters.

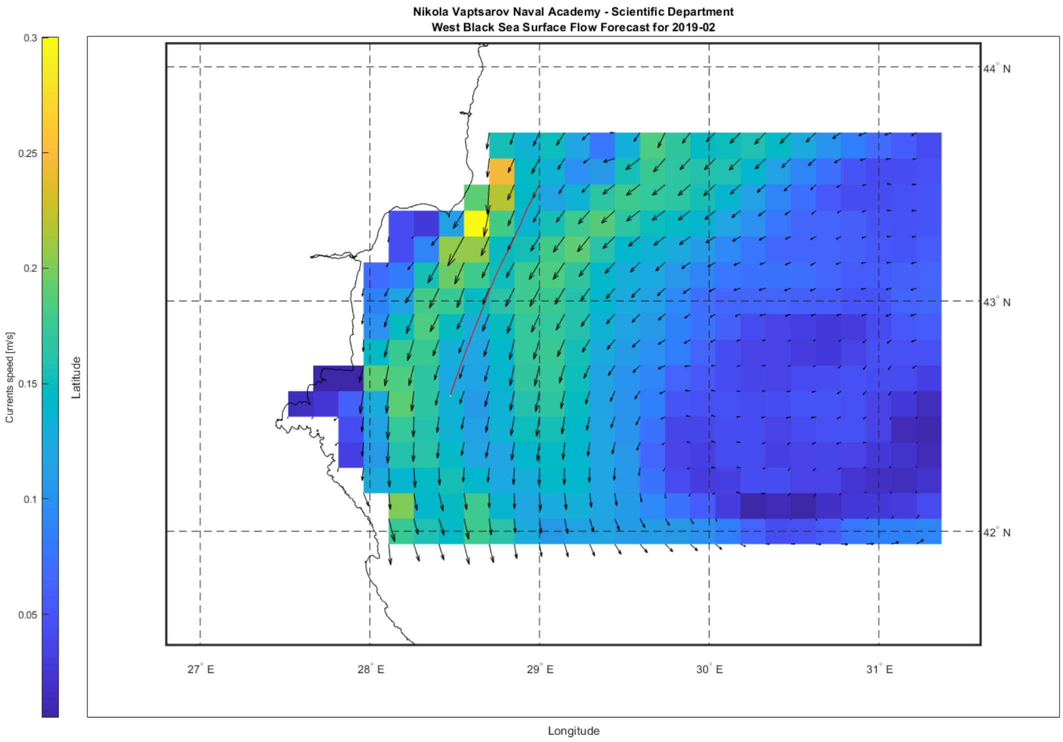


FIG. 6.13 Forecast based only on the average monthly data for the surface sea currents, without taking into account the influence of the wind

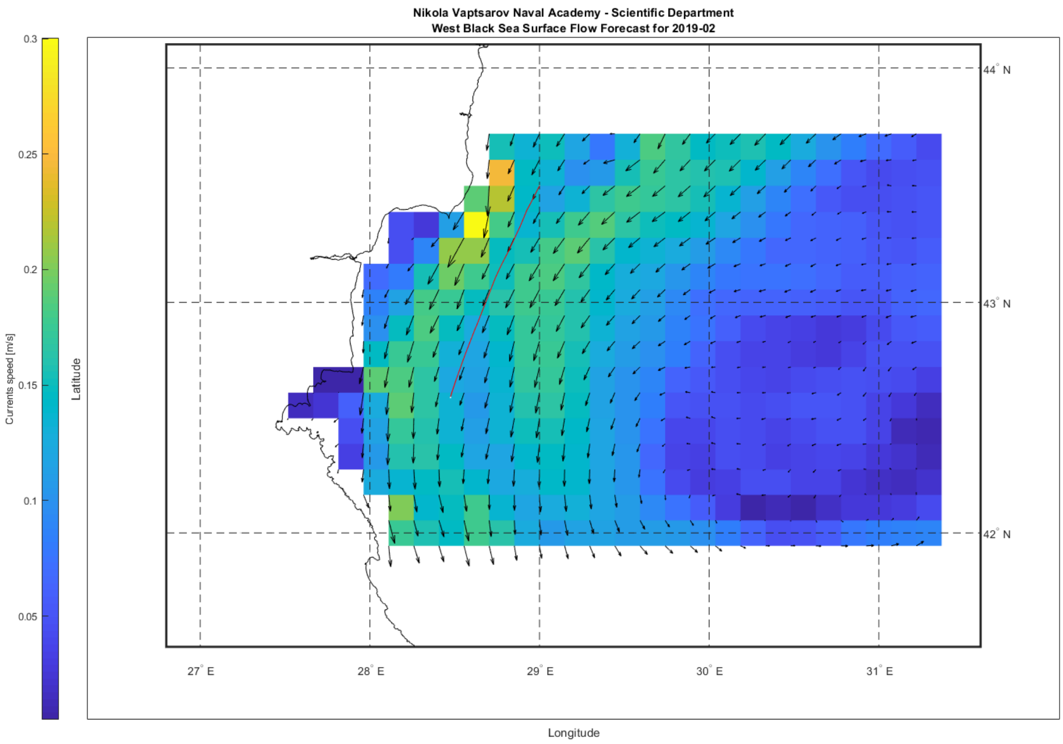


Fig. 6.14 Forecast based on the average monthly data for the surface sea currents taking into account the influence of the wind within 1%

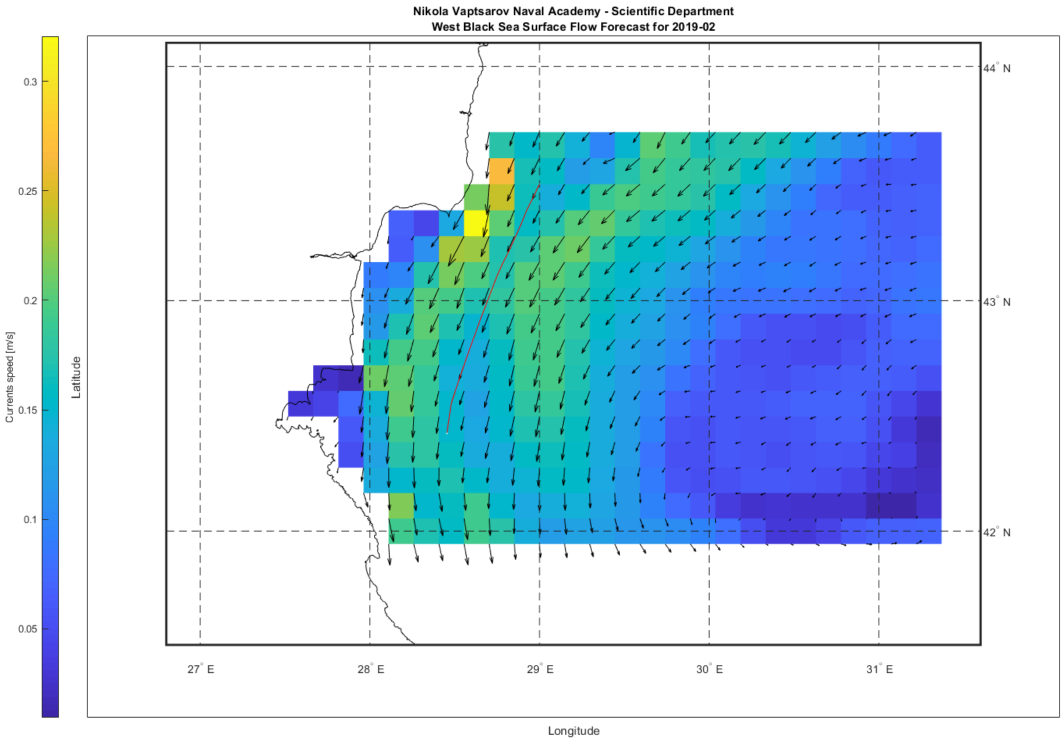


Fig. 6.15 Forecast based on the average monthly data for the surface sea currents taking into account the influence of the wind within 2.5%

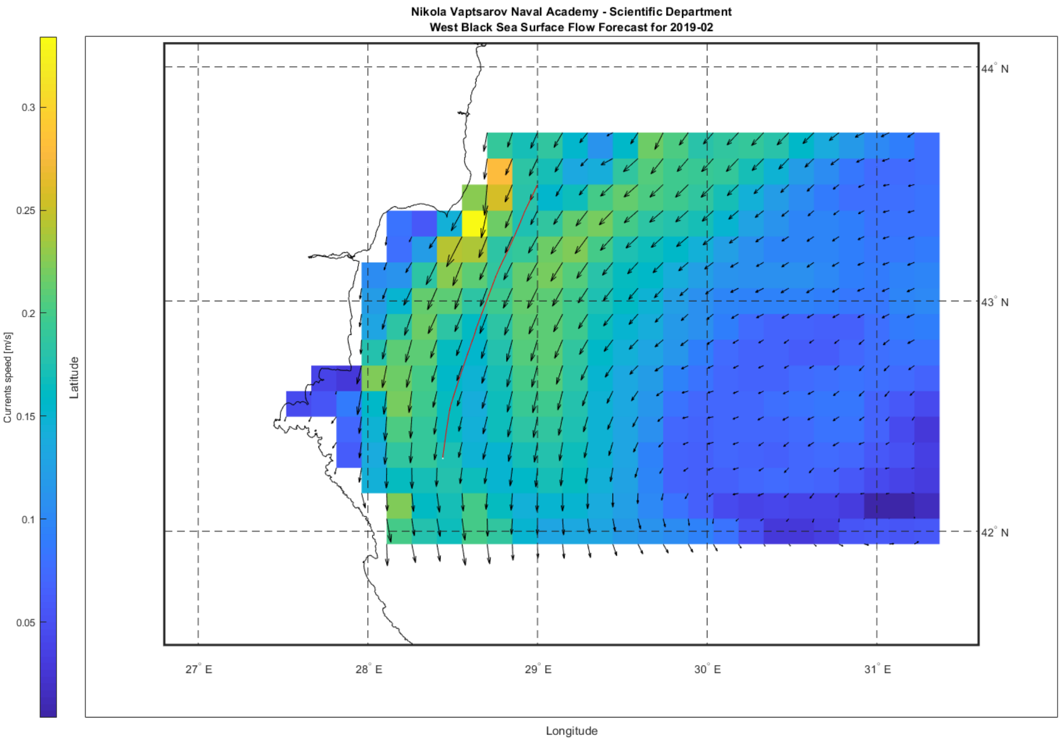


Fig. 6.16 Forecast based on average monthly data for surface sea currents taking into account the influence of wind within 3.5%

Panel "RedMarLitter Database File (* .XLSX)"

As far as the interactive computer model-map for the movement of flows from pollutants under the influence of water and air currents mainly generate data with the ability to integrate and visualize in the open database of the RedMarLitter project, then this panel is designed to enable the user to use downloaded from https://map.redmarlitter.eu/en / database data on the direction and speed of surface sea currents and wind, on the basis of which to perform mathematical modeling. The panel is shown in fig. 6.17.

Assuming that sea and air currents with the required spatial coverage, resolution and time range can be downloaded from the open project database for a future period of time (up to several days), this panel can be successfully used to forecast the movement of floating solid waste on the sea surface for the target area.

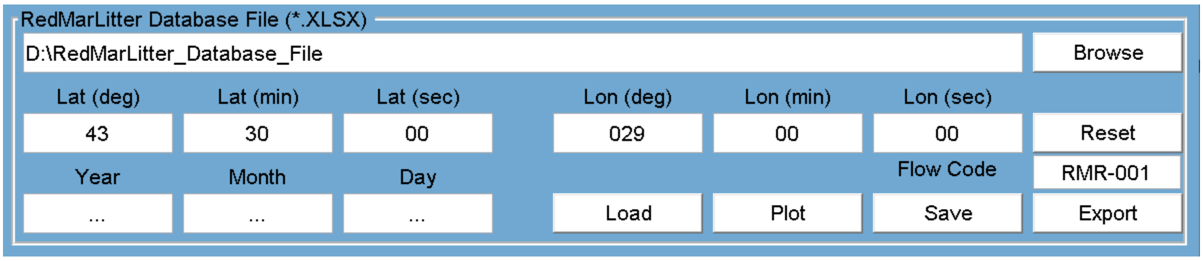


FIG. 6.17 Preview of the “RedMarLitter Database File (* .XLSX)”Panel

The panel is built similarly to the “Flows” Panel, except that using the “Browse” button it is selected downloaded from https://map.redmarlitter.eu/en / database and a file with the extension XLSX stored in the personal computer, and containing data on the direction and speed of the water currents or data on the direction and speed of the water and air currents.

The second difference is in the use of the fields "Year", "Month" and "Day", which in this case visualize the date to which the data in the downloaded file refer. The data is displayed after pressing the "Load" button.

The third difference is in the replacement of the "Create" button with the "Reset" button, which is used to reset the input parameters.

For clarity, the RedMarLitter Database File (* .XLSX) panel algorithm is described textually and illustrated visually in the following figures.

In the open database https://map.redmarlitter.eu/en/database in the menu "Flows" the data on the direction and speed of the sea and air currents are activated (see Fig. 6.18).

By using the “Time window” and “Cursor” tools, the user selects the time range for which he wishes to download data (see Fig. 6.18). The figure shows an example dated October 10, 2017.

Using the “Draw a rectangle” tool, the area for which the user wishes to download data is selected (see Fig. 6.19).

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RedMarLitter

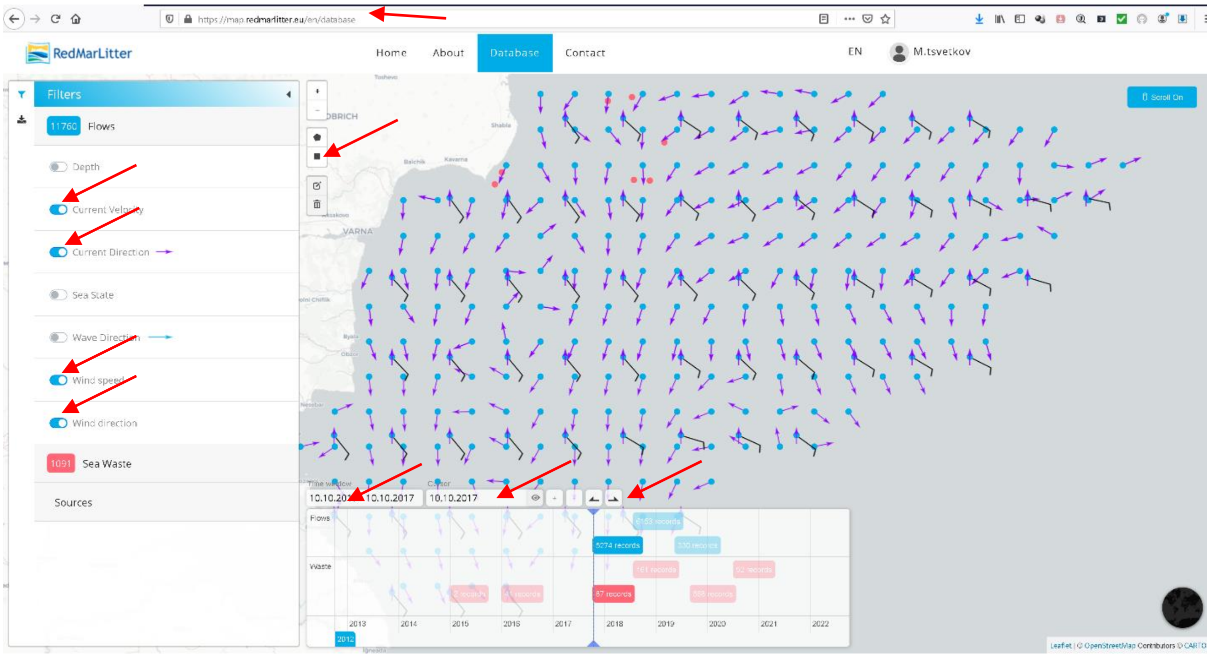


FIG. 6.18

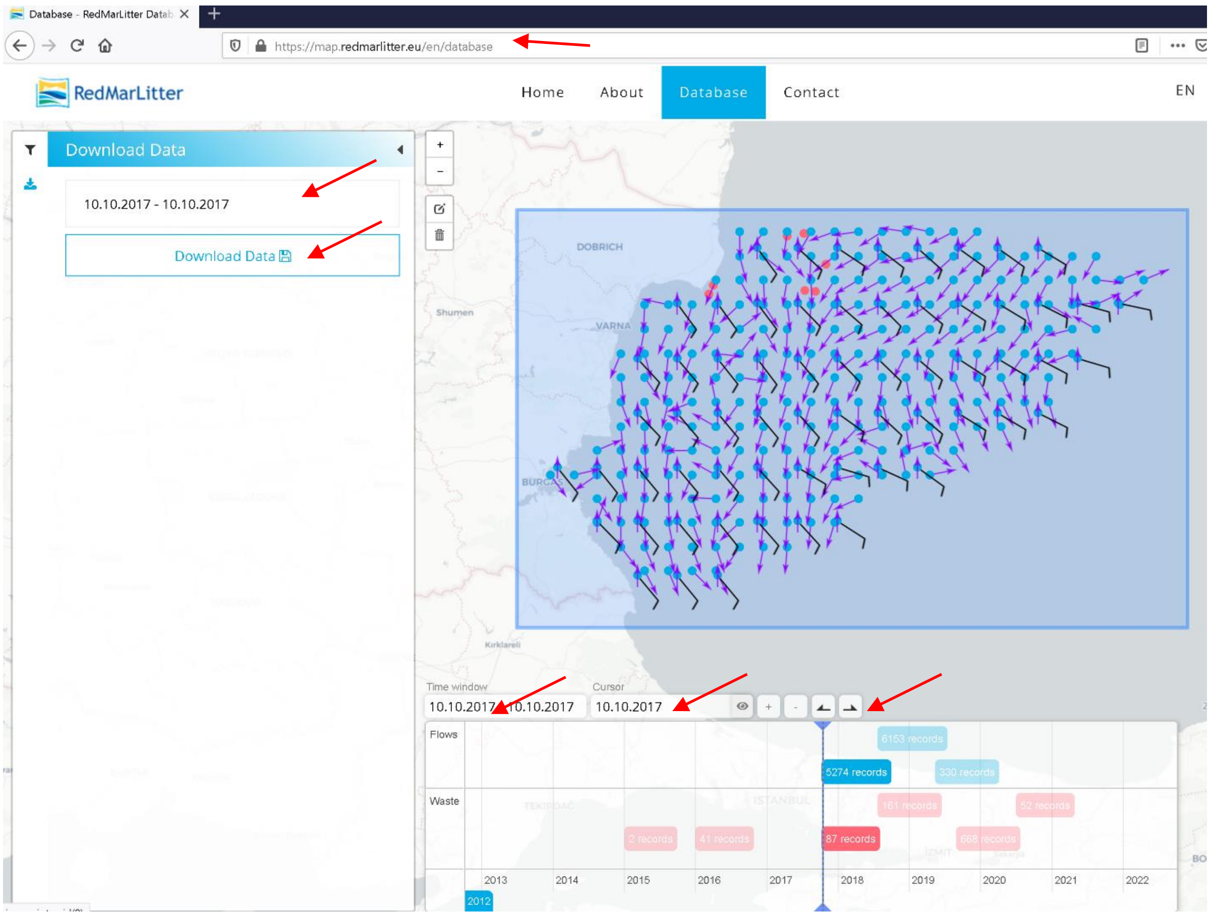


FIG. 6.19

Once the user has defined a geographical area and time range, he is able to download the data activated by him by using the "Download data" button from the open database of the RedMarLitter project (see Fig. 6.19).

The data is then downloaded as an XLSX file to the user's personal computer.

By using the "Browse" button on the panel "RedMarLitter Database File (* .XLSX)" the user selects the data file (see Fig. 6.20). The file name is displayed in the Progress information panel (see Fig. 6.21).

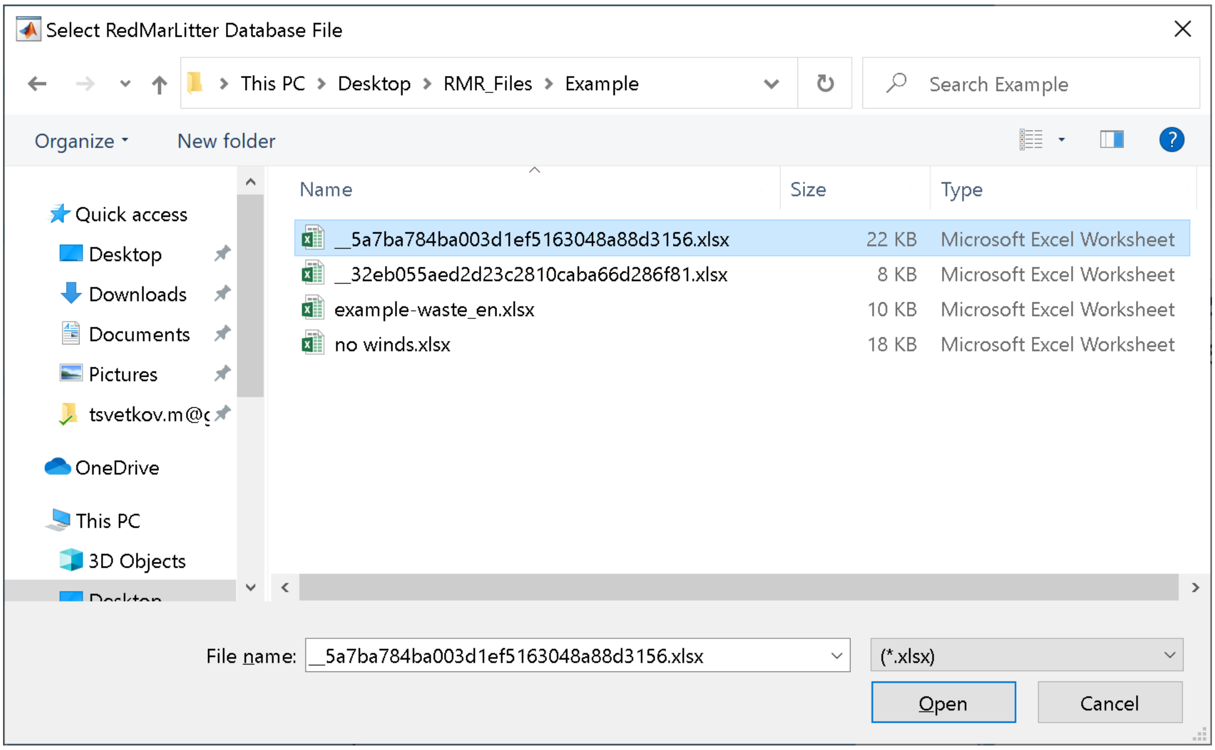


FIG. 6.20

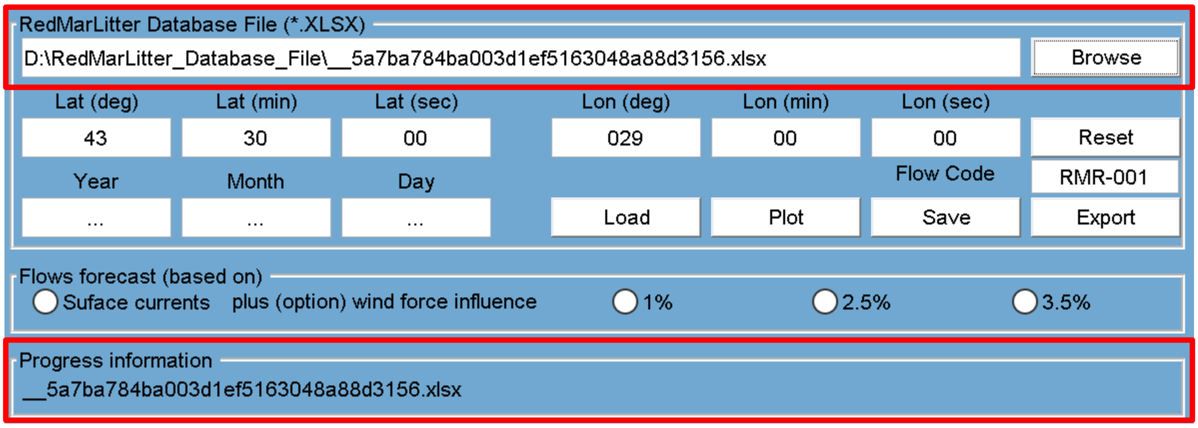


FIG. 6.21 The user sets the geographical coordinates of the starting position of the floating object for which the mathematical modeling will be performed and will calculate the trajectory under the influence of surface sea currents forming a water flow from the data downloaded from [https: //map.redmarlitter. eu / en / database](https://map.redmarlitter.eu/en/database) .

Using the "Load" button from the selected panel, the user loads the data from the downloaded file into the **RedMarLitter Interactive Map application**.

In the fields "Year", "Month" and "Day" the data for the date to which the data for the direction and speed of the sea and air currents are visualized (see Fig. 6.22).

An information message also appears in the Progress information panel (see Fig. 6.22).

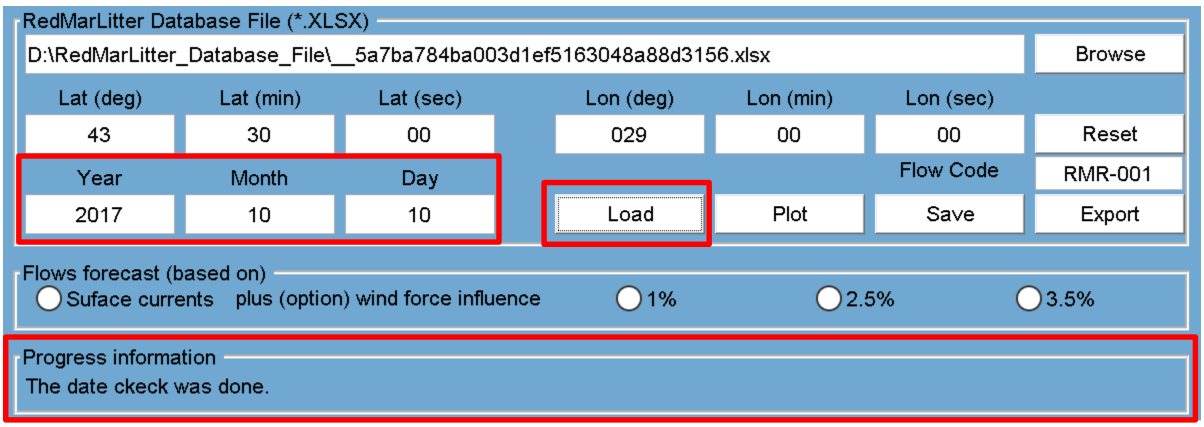
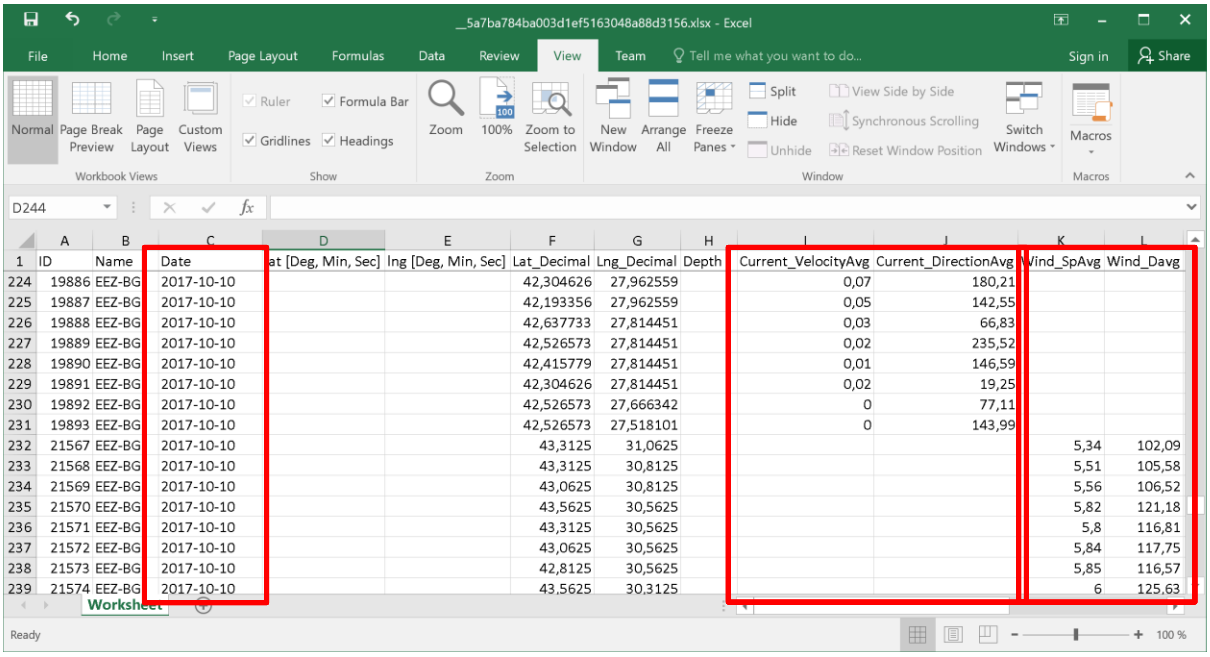


FIG. 6.22

Using the "Plot", "Save" and "Export" buttons, the user starts the mathematical modeling, saves in raster format a georeferenced map depicting the results of the modeling and generates an export XLSX file, compatible with the open database of the RedMarLitter project and ready for import into https://map.redmarlitter.eu/en/database .

The data is stored in the same directory / folder as thedownloaded from https://map.redmarlitter.eu/en/database file with data on the direction and speed of the sea / air currents.

As noted earlier in the presentation, this panel can work in conjunction with the Flows forecast panel. The full functionality of this combination is achieved when the downloaded from https://map.redmarlitter.eu/en/database files contain direction and speed data for both sea currents and air currents (see Fig. 6.23). To be used as input for mathematical modeling, water and air flow data must have the required resolution and geospatial coverage (range).



1	ID	Name	Date	at [Deg, Min, Sec]	lng [Deg, Min, Sec]	Lat_Decimal	Lng_Decimal	Depth	Current_VelocityAvg	Current_DirectionAvg	Wind_SpAvg	Wind_Davg
224	19886	EEZ-BG	2017-10-10			42,304626	27,962559		0,07	180,21		
225	19887	EEZ-BG	2017-10-10			42,193356	27,962559		0,05	142,55		
226	19888	EEZ-BG	2017-10-10			42,637733	27,814451		0,03	66,83		
227	19889	EEZ-BG	2017-10-10			42,526573	27,814451		0,02	235,52		
228	19890	EEZ-BG	2017-10-10			42,415779	27,814451		0,01	146,59		
229	19891	EEZ-BG	2017-10-10			42,304626	27,814451		0,02	19,25		
230	19892	EEZ-BG	2017-10-10			42,526573	27,666342		0	77,11		
231	19893	EEZ-BG	2017-10-10			42,526573	27,518101		0	143,99		
232	21567	EEZ-BG	2017-10-10			43,3125	31,0625				5,34	102,09
233	21568	EEZ-BG	2017-10-10			43,3125	30,8125				5,51	105,58
234	21569	EEZ-BG	2017-10-10			43,0625	30,8125				5,56	106,52
235	21570	EEZ-BG	2017-10-10			43,5625	30,5625				5,82	121,18
236	21571	EEZ-BG	2017-10-10			43,3125	30,5625				5,8	116,81
237	21572	EEZ-BG	2017-10-10			43,0625	30,5625				5,84	117,75
238	21573	EEZ-BG	2017-10-10			42,8125	30,5625				5,85	116,57
239	21574	EEZ-BG	2017-10-10			43,5625	30,3125				6	125,63

FIG. 6.23

In this case, the options from the “Flows forecast” panel can be selected (see Fig. 6.12) for the degree of influence of the air currents on the floating object.

Visualization of the results for 24 hour forecast (georeferenced map) with selected option: mathematical modeling based on sea currents plus 3.5% influence of air currents and geographical coordinates of the starting position of the surface floating object Latitude: 43deg. 30 min. 00 sec. North and Longitude: 029deg. 00min. 00sec. East is shown in fig. 6.24.

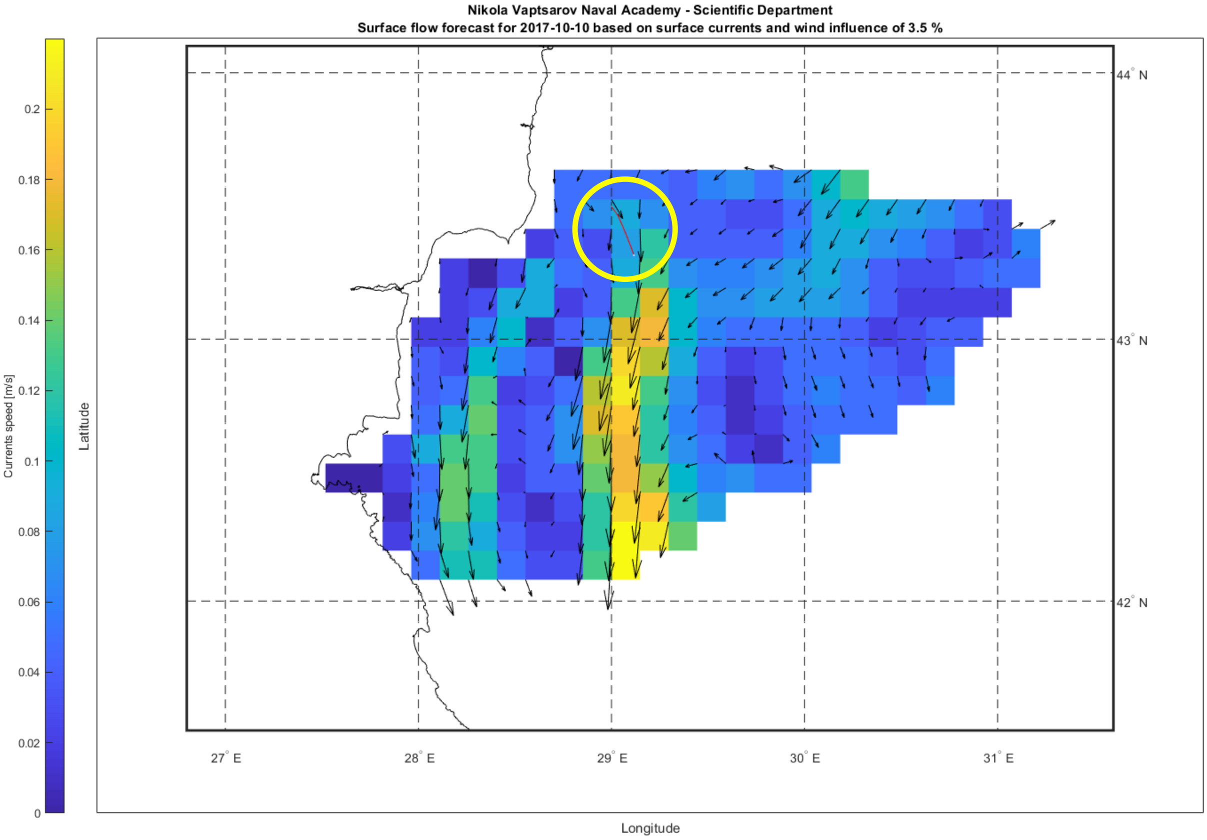


FIG. 6.24

Using the other panels: Progress Information Panel and Controls Panel, the user operates the standalone application.

An interactive computer model-map for the movement of pollutant flows under the influence of water and air currents is attached on an optical medium (Appendix 5) to this report.

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