Interreg Italy - Croatia EUROPEAN UNION

FROM SHARED RESOURCES
TO JOINT SOLUTIONS

D.5.3.2 “Pilot action final report”

STRATEGIC PROJECT

FRAMESPORT

Framework initiative fostering the sustainable development of Adriatic small ports

1. Introduction

The Port of Šibenik Authority has planned pilot action aimed at improving navigation safety and reducing pollution. The pilot action consists of two parts:

1. Feasibility study on alternative moorings for ship and on the use of electric ro-ro passenger ships
2. IT system for the forecast of possible geographical dispersion of the pollutants in case of accident

2. Pilot action description

2.1. Aim of pilot action

PILOT 1. Feasibility study on alternative moorings for ship and on the use of electric ro-ro passenger ships

The study will define the possibilities of applying alternative methods of mooring for ships in order to increase the level of operability and safety in the port of Šibenik. Furthermore, the study will analyze and describe the possibilities of introducing RO-RO services to the islands of the Šibenik archipelago using electrically powered boats. It is necessary to analyze the possibilities and necessary steps for the implementation of the use of alternative fuels that have a lower impact on the environment in order to ensure sustainability. The technologies and lessons learned from the study, as well as the pronounced advantages of applying new technologies, are applicable in all ports in Croatia and Italy and there should be a possibility that they will become the standard in the Adriatic. The study is the first step and basis for future investments and application of these technologies.

PILOT 2. Testing IT system for the forecast of possible geographical dispersion of the pollutants in case of accident

Second part of the project pilot plan is focused on the forecasts of possible geographical spread of pollution: buoys with sensors will be installed and an IT tool for predicting possible geographical spread of pollution will be tested. The Adriatic is a very sensitive area and its protection is a priority for all regions. In case of pollution, the installed system will enable Šibenik Port Authority to predict the geographical spread of pollution and to react properly, which results in benefits for the entire Adriatic coast area.

2.2. Start date - End date

PILOT 1. 04/05/2023 – 30/06/2023

PILOT 2. 22/12/2022 – 30/06/2023

2.3. Achieved results

PILOT 1: The tender for the pilot was realized in March 2023, and the contract was signed on April 5, 2023. As a result, the study is completed within two months of signing the contract. The study is a practical demonstration of planning further development of the port and is in line with the "Development of a strategic 'umbrella' framework addressing the further development and planning of small ports along the Adriatic coasts." The technologies and lessons learned from the study are applicable to all ports in Croatia and Italy, and there is a possibility that they may become the standard in the Adriatic.
The main purpose of the Feasibility Study of alternative ways of mooring ships in the port of Šibenik is to create strategic documentation that will be an integral part of the comprehensive project of sustainable development of the port infrastructure and superstructure in the port area under the administration of the Port of Šibenik Authority. The increased intensity of cruise ship arrivals and the limited mooring capacity on the available operating shores in the passenger part of the Šibenik port require the Port of Šibenik Authority, which manages the port area, to establish alternative mooring methods that would enable faster and safer mooring and provide additional port capacity to accommodate a larger number of cruisers. In addition, the limited sea passage to the city of Šibenik through the channel of Sv. Ante on the maximum length of ships of 230 meters directly affects the impossibility of accepting larger cruise ships that today already sail on the Croatian side of the Adriatic towards or from Dubrovnik. Therefore, the basic need to create this feasibility study was primarily due to the need to improve the existing mooring model for cruise ships that moor in the passenger part of the port of Šibenik, but also to analyze possible models that would further increase the mooring capacity and ensure the acceptance of larger cruise ships.

PILOT 2: The pilot action for PILOT 2 focused on the forecasts of possible geographical spread of pollution. The pilot installed buoys with sensors and an IT tool to predict the possible geographical spread of pollution, allowing the Port of Šibenik Authority to predict the geographical spread of pollution and respond properly in case of pollution. The goal of the pilot was to ensure timely and adequate response solutions to preserve the sensitive Adriatic Sea and protect the entire Adriatic coast area.

The tender for the pilot was realized in December 2022, and the contract was signed on December 22, 2022. Two drones and two buoys with sensors were acquired. In May 2023, the buoys were completely installed, but, as the location permits were still missing, could not be situated in the sea. Finally, in June 2023, the buoys were installed in the sea, on the planned location in order to give the information from the optimal sea location.

The two types of drones (air and underwater) were tested in May 2023. The air drone can produce precise photos in a length of few hundred meters, which is significant in order to detect possible dangerous vehicle and to document it from the air side. The underwater drone was also tested in May 2023, and is significant in order to create precise photos in very high resolution, which is important for detecting the pollutants on the seabed and to react promptly.

Two buoys with sensors for pollutants detection were tested in June 2023. Two types of simulations were held in order to show the speed of the pollutants movement through the channel. During the simulations, the analysis involved two different types of pollutants, meteo data (wind direction and strength) and time. The analysis showed that the pollutants can move very fast all overall the Šibenik channel and can cause significant damage, if there is no prompt reaction to prevent pollution.

2.4. Description of activities carried out

PILOT 1: The pilot action for PILOT 1 focuses on conducting a feasibility study on the possibilities of applying alternative methods of mooring for ships, and introducing RO-RO services to the islands of the Šibenik archipelago using electrically powered boats.
The study of the feasibility of alternative ways of mooring ships in the port of Šibenik includes office and field research on the needs of the Port of Šibenik Authority in the area of the ship mooring system primarily intended for the mooring of ships on cruises. The inadequacy of the existing mooring system in terms of technical performance and the impossibility of accepting large cruise ships encouraged the Port of Šibenik Authority to find alternative ways of mooring in the passenger part of the Šibenik port.
Based on the analysis, the basic guidelines with which a better ship mooring system can be achieved and models for improving the existing mooring capacities of the passenger part of the Šibenik port were determined.
The existing mooring system can be upgraded with a new automatic mooring system and better light marking of operational shores, while the total mooring capacity can be increased by placing mooring buoys in the area of the Martinska anchorage and implementing a mobile floating jetty that will allow passengers to disembark from large cruise ships at a location outside the Šibenik Bay.
This will significantly increase the total passenger traffic of the port of Šibenik, but also contribute economically to the economic growth of the City of Šibenik and Šibenik-Knin County.

PILOT 2: For PILOT 2, the pilot action involves the installation of buoys with sensors and an IT tool for predicting possible geographical spread of pollution. The aim of this pilot is to enable the Šibenik Port Authority to predict the geographical spread of pollution in the Adriatic Sea and to react properly, thus protecting the sensitive area and the entire Adriatic coast area.
The pilot action for PILOT 2 consists of several steps. First, two buoys with sensors will be installed in the sea, which will be used to detect pollutants. The sensors will be able to provide real-time data on the quality of the sea, which will be transmitted to the land base. Additionally, two drones (air and underwater) will be used to provide information about the sea quality and meteorological data to the land base. The data will be analyzed using an IT tool that will predict the possible geographical spread of pollution in case of an incident. Two info kiosks and two smart waiting stations are set up on the land base to provide information to the public about the system and the sea quality.

The two types of drones (air and underwater) were tested in May 2023. The air drone can produce precise photos in a length of few hundred meters, which is significant in order to detect possible dangerous vehicle and to document it from the air side. The underwater drone was also tested in May 2023, and is significant in order to create precise photos in very high resolution, which is important for detecting the pollutants on the seabed and to react promptly.

Two buoys with sensors for pollutants detection were tested in June 2023. Two types of simulations were held in order to show the speed of the pollutants movement through the channel. During the simulations, the analysis involved two different types of pollutants, meteo data (wind direction and strength) and time. The simulation of the oil spill was carried out using various parameters, including the location, amount, duration of the spill, type of substance and other data. After that, winds and currents, or oceanographic and hydrometeorological data collected in real time from various sensor systems, were included in the simulation.

The analysis showed that the pollutants can move very fast all overall the Šibenik channel and can cause significant damage, if there is no prompt reaction to prevent pollution.

2.5. Actors/Beneficiaries/ Stakeholders involvement

Šibenik Port Authority - the main actor responsible for implementing the pilot projects and ensuring their success.

Ministry of the Sea, Transport and Infrastructure - the institution that engaged the Faculty of Maritime Studies of the University of Rijeka to draft a 'National Plan for the Development of Coastal Liner Maritime Transport,' which serves as the basis for future investments in new generations of liner ships using alternative fuels and electricity.

Faculty of Maritime Studies of the University of Rijeka - the institution responsible for drafting the 'National Plan for the Development of Coastal Liner Maritime Transport' as per the request of the Ministry of the Sea, Transport and Infrastructure.

Croatian and Italian experts - these experts will contribute their knowledge and experience to the study to ensure that the technologies and lessons learned from the project are applicable in all ports in Croatia and Italy and can hopefully become standard in the Adriatic.

Ships and cruise boats - the beneficiaries of the alternative mooring methods that will be studied and developed in the project pilot. They stand to benefit from the reduced cost of mooring/unmooring, among other advantages.

Passengers - the beneficiaries of the improved port services, particularly the RO-RO services that will be introduced to the islands of the Šibenik archipelago using electrically powered boats. This will offer them a more sustainable and efficient means of transportation.

Local communities - the stakeholders who stand to benefit from the protection of the Adriatic Sea, which is a very sensitive area. The installation of buoys with sensors and an IT tool for predicting possible geographical spread of pollution will enable the Port of Šibenik Authority to predict the geographical spread of pollution and respond properly, resulting in benefits for the entire Adriatic coast area.

Furthermore, the Port of Šibenik Authority regularly consults with industry-relevant stakeholders, such as shipping companies, cruise operators, and port service providers, to ensure that their needs and concerns are addressed in the development of future projects. The authority plans to hold one or two more stakeholder meetings in the near future to discuss the results and potential implications of the pilot actions, and to gather feedback for future projects.

2.6. Use of thematic equipment

The air drone can produce precise photos in a length of few hundred meters, which is significant in order to detect possible dangerous vehicle and to document it from the air side. The underwater drone was also tested in May 2023, and is significant in order to create precise photos in very high resolution, which is important for detecting the pollutants on the seabed and to react promptly. Drones will help capture video, monitor waves and weather, and inspect ships or infrastructure to spot damage that could cause pollution.

Two buoys with sensors for pollutants detection were tested in June 2023. Two types of simulations were held in order to show the speed of the pollutants movement through the channel. During the simulations, the analysis involved two different types of pollutants, meteo data (wind direction and strength) and time. The analysis showed that the pollutants can move very fast all overall the Šibenik channel and can cause significant damage, if there is no prompt reaction to prevent pollution.

2.7. Problems encountered

There were no detected problems.

3. Monitoring of activities

PILOT 1.

Indicator	Unit of measure	Target value	Achieved value	Time horizon for monitoring (June ‘21/ Dec. ‘21/ June ‘22)
Procurement process for external expertise	*Procurement procedure*	*1*	*1*	*February – April 2023*
Draft of the Feasibility study	*Document draft*	*1*	*1*	*June 2023*
Final version of the Feasibility study	*Final document*	*1*	*1*	*June 2023*

PILOT 2.

Indicator	Unit of measure	Target value	Achieved value	Time horizon for monitoring (June ‘21/ Dec. ‘21/ June ‘22)

Procurement process for external expertise	*Procurement procedure*	*1*	*1*	*August – December 2022*
Installation phase of equipment (2 buoys + 2 drones)	*Equipment*	*4*	*4*	*January – June 2023*
Testing phase	*Testing of the equipment*	*2*	*2*	*May – June 2023*

4. Pilot action outcomes

PILOT 1.

The FRAMESPORT project is based on the formation of the basic foundations of integrated and sustainable development of smaller ports located on both sides of the Adriatic coast. With such an approach, Adriatic ports as active stakeholders become social and economic drivers of the development of the coastal areas where they are located. For this reason, one of the main objectives of the pilot activity of the Port of Šibenik Authority follows, namely the creation of strategic documentation whose main purpose is the development of maritime infrastructure and superstructure in the port area under the administration of the Port of Šibenik Authority following the direction of social and environmental responsibility.

The implementation of the FRAMESPORT project aims to support a homogeneous and integrated improvement of the sustainability, competitiveness and attractiveness of Adriatic ports through:

- creating a strategic framework that guides their future development in the long term,
- the realization of an ICT platform as a virtual space accessible to users and stakeholders, which contains the results of the implementation of pilot actions, examples of good practices and proposals and ideas for the development of Adriatic ports and their management, and
- increasing competences for coordinated planning and management of ports, thereby contributing to the stimulation of their role as drivers of sustainable growth of coastal areas.

The increased intensity of cruise ship arrivals and the limited mooring capacity on the available operating shores in the passenger part of the Šibenik port require the Port of Šibenik Authority, which manages the port area, to establish alternative mooring methods that would enable faster and safer mooring and provide additional port capacity to accommodate a larger number of cruisers. In addition, the limited sea passage to the city of Šibenik through the channel of Sv. Ante on the maximum length of ships of 230 meters directly affects the impossibility of accepting larger cruise ships that today already sail on the Croatian side of the Adriatic towards or from Dubrovnik. Therefore, the basic need to create this feasibility study was primarily due to the need to improve the existing mooring model for cruise ships that moor in the passenger part of the port of Šibenik, but also to analyze possible models that would further increase the mooring capacity and ensure the acceptance of larger cruise ships. The main purpose of the Feasibility Study of alternative ways of mooring ships in the port of Šibenik is to create strategic documentation that will be an integral part of the comprehensive project of sustainable development of the port infrastructure and superstructure in the port area under the administration of the Port of Šibenik Authority.

The available options that the port of Šibenik can provide to its users on operational shores that are intended for mooring ships on cruises include various models of newer mooring devices and equipment and additional security lighting of the coastal wall. The proximity of the anchorage Martinska, which is located in the Šibenik Bay opposite the city of Šibenik, enables additional mooring capacity for cruise ships in such a way as to provide them with appropriate mooring buoys to avoid the harmful effects of ship anchors on marine flora and fauna. By implementing a mobile floating jetty at a location where large cruise ships would not be restricted by passing through the channel of Sv. Ante would create the basic prerequisites for the inclusion of the city of Šibenik in the itineraries of all the world's companies that organize round trips.

The expected result of the implementation of the feasibility study of alternative ways of mooring ships in the port of Šibenik is the achievement of the goals of the FRAMESPORT project, which is the upgrading of the existing mooring system in the passenger part of the port of Šibenik in order to meet higher safety standards and improve the level of port service for cruise ships and their passengers. and increased the total capacity of the passenger part of the port of Šibenik.

PILOT 2.

The pilot action for PILOT 2 focused on the forecasts of possible geographical spread of pollution. The pilot installed buoys with sensors and an IT tool to predict the possible geographical spread of pollution, allowing the Port of Šibenik Authority to predict the geographical spread of pollution and respond properly in case of pollution. The goal of the pilot is to ensure timely and adequate response solutions to preserve the sensitive Adriatic Sea and protect the entire Adriatic coast area.

Two drones, air and underwater, and two buoys with sensors for detection of pollution, are of significant importance for pollution prevention in the overall Šibenik area. Buoys process measurements of various indicators from the environment using built-in sensors. It also uses sensor units to detect pollutants in the sea, such as oil and petroleum, and other substances dissolved in water.
Constantly raising the level of sea safety, especially in the context of protection against pollution, is among the priority goals of the Port of Šibenik Authority, which has recognized the importance of applying modern technologies to improve efficiency and reduce operational costs of surveillance at sea. For this reason, drones and sensor buoys were acquired, in order to strengthen prevention and timely suppress sea pollution, protect assets at sea, and ensure timely reactions in the

event of maritime accidents, search and rescue, as well as other extraordinary events at sea.

5. Conclusion

PILOT 1.

The expected result of the implementation of all researched and analyzed elements of the Feasibility Study of alternative ways of mooring ships in the port of Šibenik is the realization of the goals of this project, which is the upgrading of the existing mooring system in the passenger part of the port of Šibenik in order to meet higher safety standards and improve the level of port service for ships on cruises and their passengers and increased the total capacity of the passenger part of the port of Šibenik. Thus, the Feasibility Study of alternative ways of mooring ships in the port of Šibenik fully meets the objectives of the FRAMESPORT project, and the port of Šibenik receives quality guidelines for the implementation of its sustainable development projects. Likewise, the port of Šibenik and the Port of Šibenik Authority become active stakeholders in the economic development of the City of Šibenik, Šibenik-Knin County and the Republic of Croatia.

PILOT 2.

Constantly raising the level of sea safety, especially in the context of protection against pollution, is among the priority goals of the Port of Šibenik Authority, which has recognized the importance of applying modern technologies to improve efficiency and reduce operational costs of surveillance at sea. For this reason, drones and sensor buoys were acquired, in order to strengthen prevention and timely suppress sea pollution, protect assets at sea, and ensure timely reactions in the event of maritime accidents, search and rescue, as well as other extraordinary events at sea.

Annex 1 The process of installing buoys with sensors in the port of Šibenik

Figure 1. The process of preparing the buoys for transport to the anchoring location

Figure 2. The process of placing and securing the buoy for transport to the anchoring location

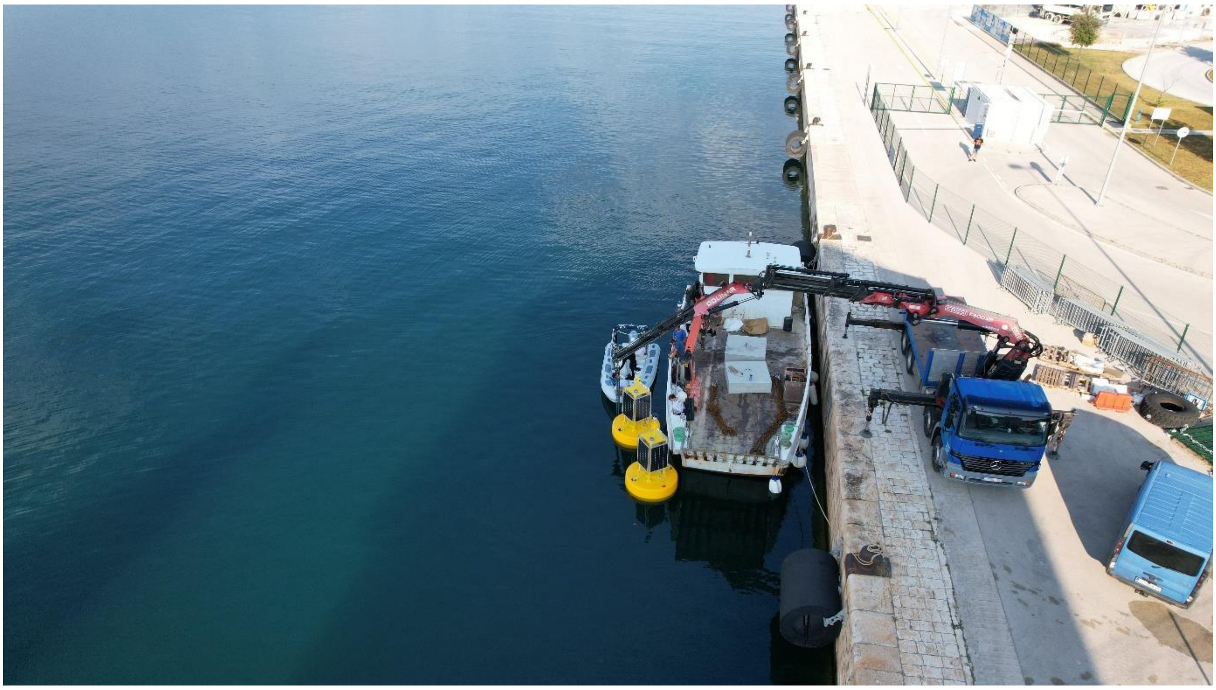


Figure 3. The process of placing and securing the buoy for transport to the anchoring location (photo made by air drone)

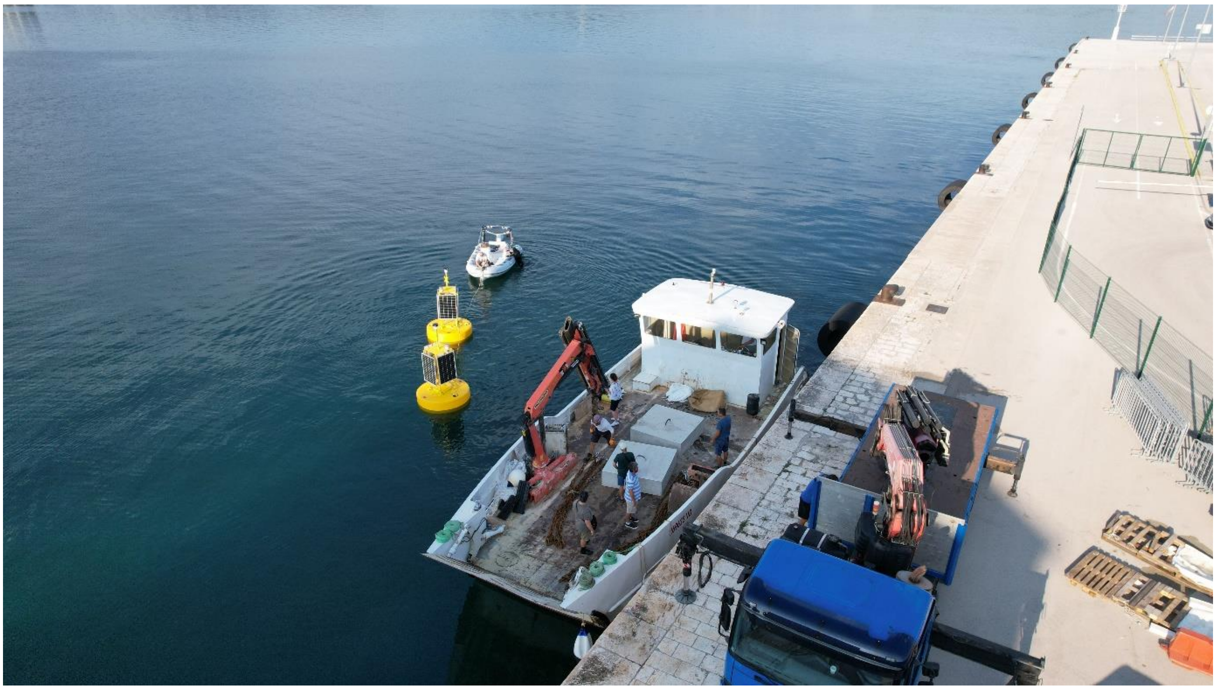


Figure 4. Taking the buoy to the anchoring place 1 (photo made by air drone)

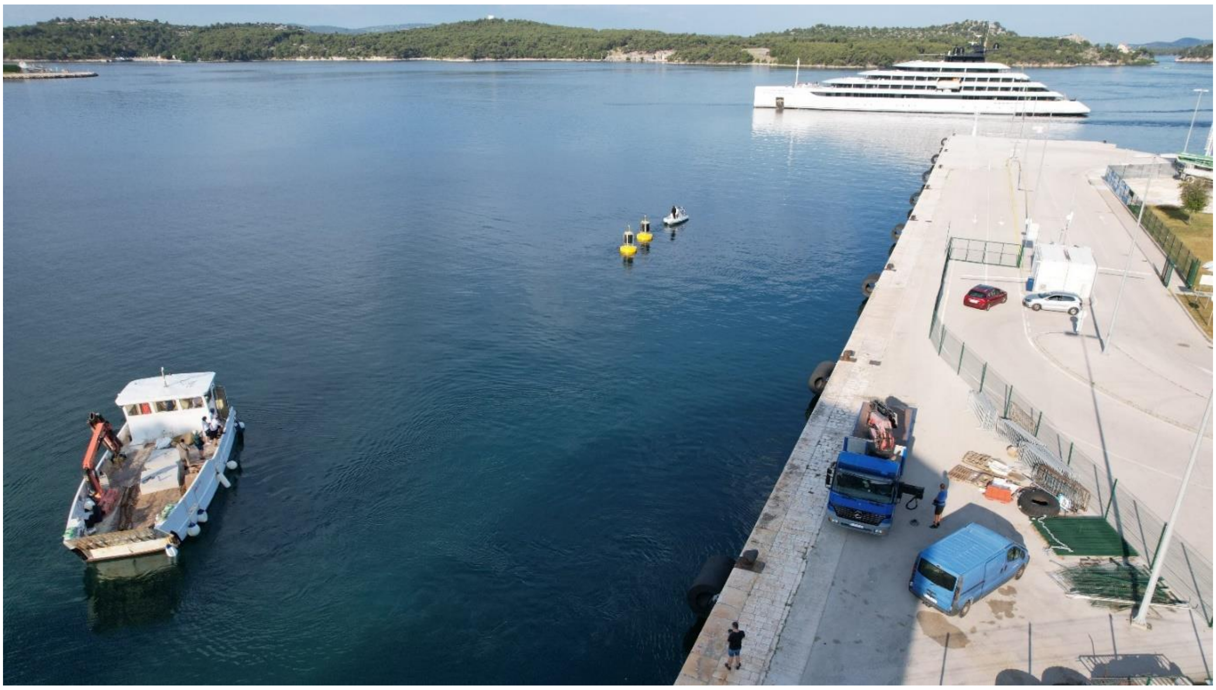


Figure 5. Taking the buoy to the anchoring place 2 (photo made by air drone)

Figure 6. Delivery of buoys to anchoring locations (photo made by air drone)

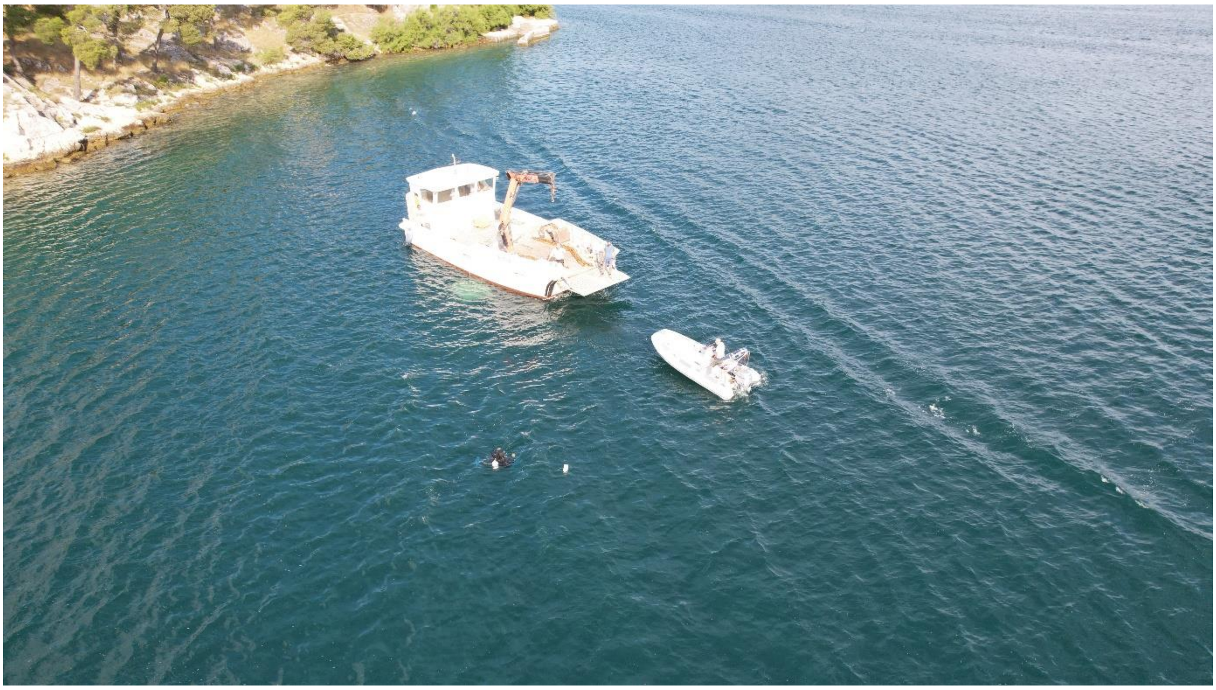


Figure 7. Anchoring preparation procedure 1 (photo made by air drone)

Figure 8. Anchoring preparation procedure 2

Figure 9. Anchoring preparation procedure 3

Figure 10. A buoy installed on one side of the entrance to the port of Šibenik (photo made by air drone)

Figure 11. Installed buoy

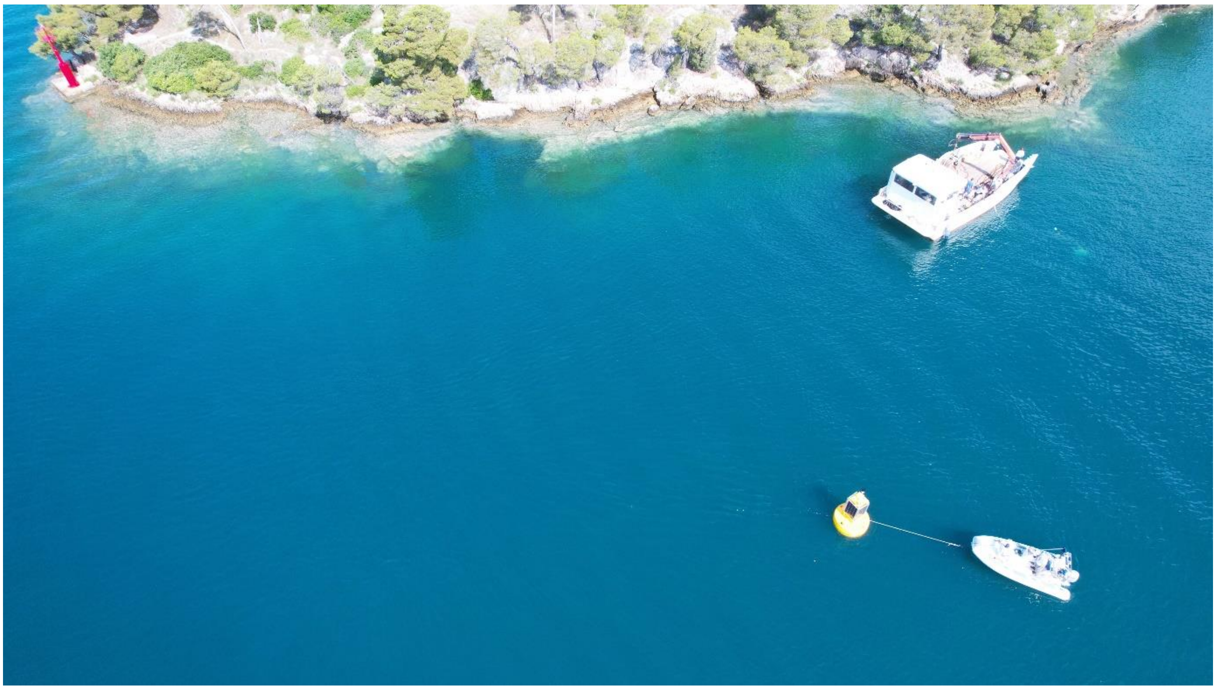


Figure 12. Installation of second buoy on the other side of the entrance in a channel of st. Ante (photo made by air drone)

Figure 13. Installed second buoy on the other side of the entrance in a channel of st. Ante

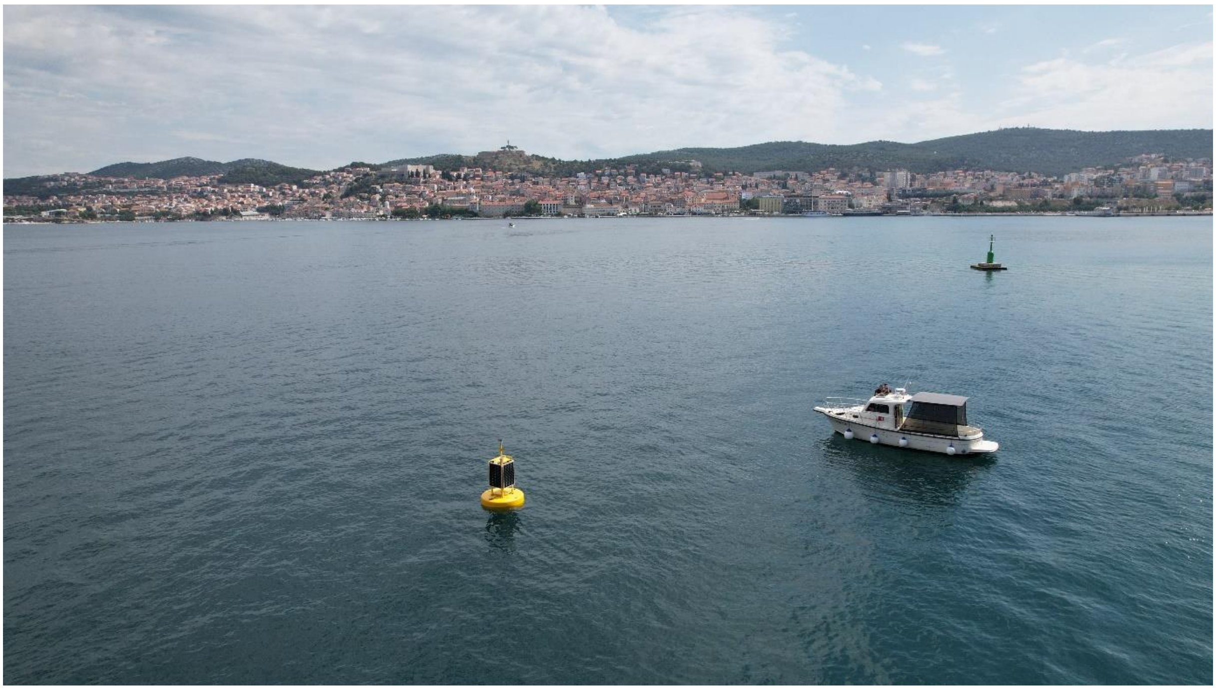


Figure 14. The position of the buoy in relation to the coast (photo made by air drone)

Figure 15. Land sensors for receiving information from buoys 1 (photo made by air drone)

Figure 16. Land sensors for receiving information from buoys 2 (photo made by air drone)

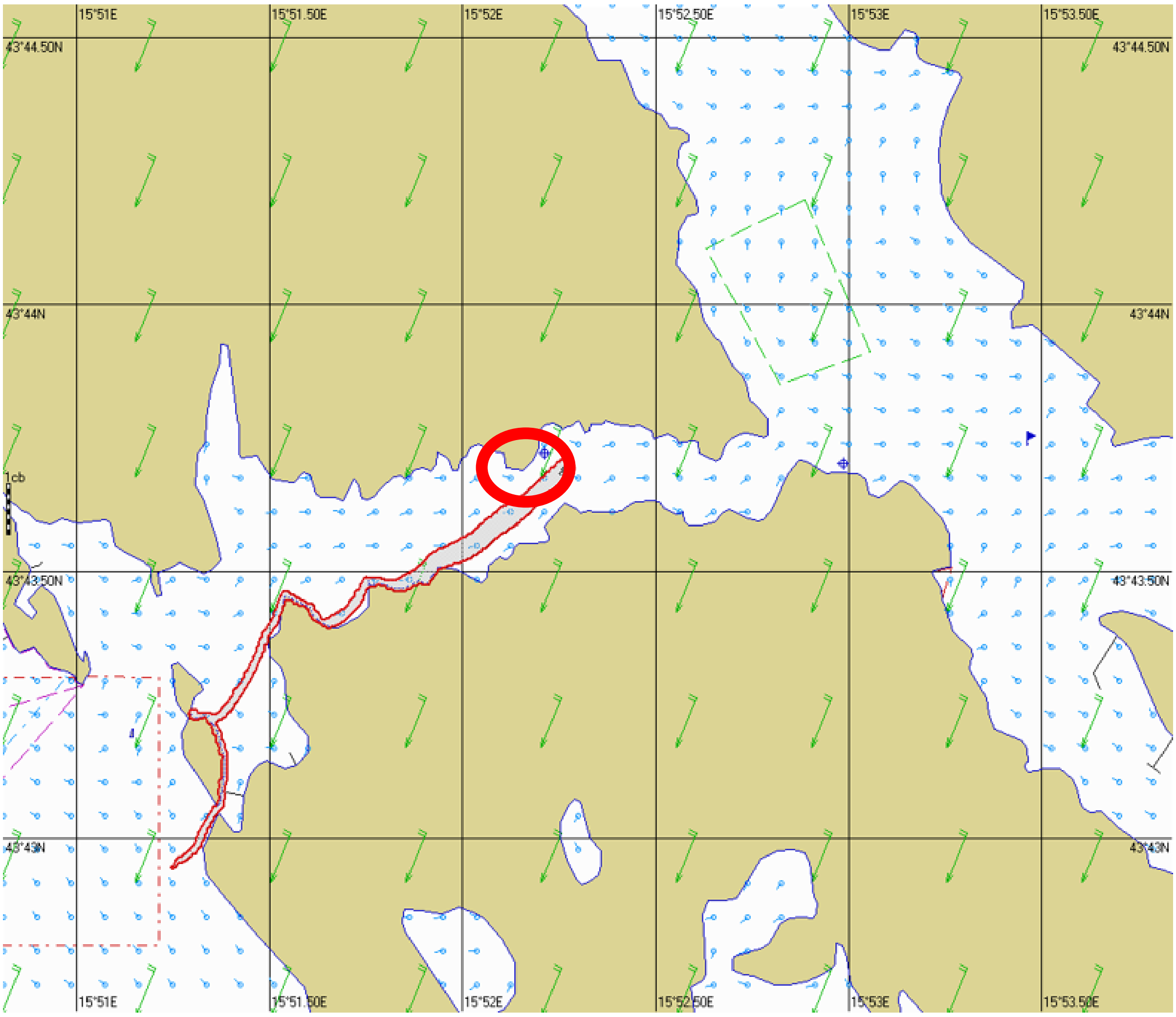
Figure 17. Land sensors for receiving information from buoys 3 (photo made by air drone).

Annex 2 Description of the simulation of the pollution of the port of Šibenik with meteorological and hydrological display

SIMULATION 1

Situation 1:

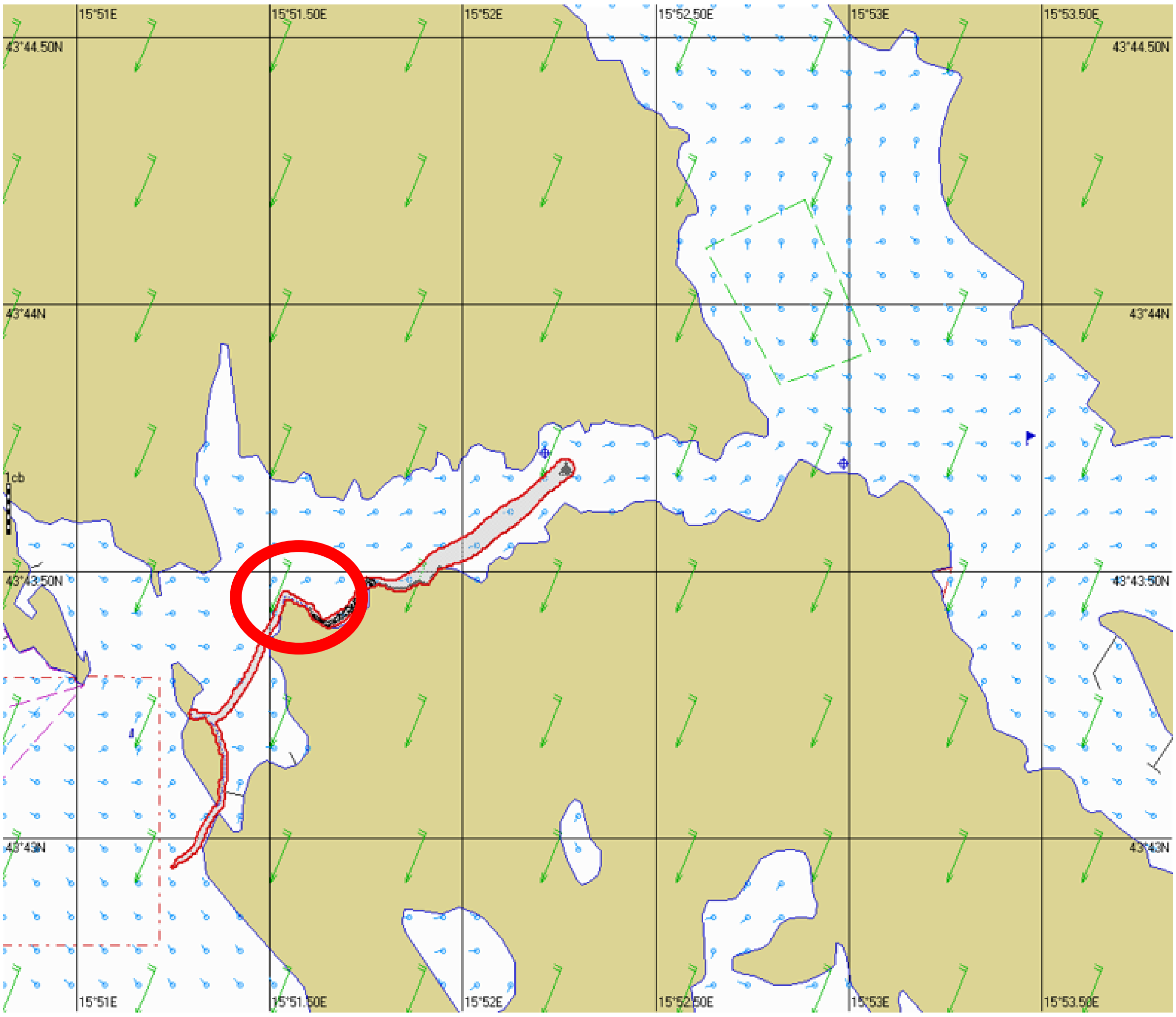
Amount of pollutant in the sea: 15 m3 of diesel
Wind speed and direction: 20 knots NNE
Time: 8.00 AM



Diesel engines are mostly used as fuel for ships, therefore the risk of sea pollution with diesel is expected. On the photo there is a 15m3 of diesel located near buoy situated in the channel of St. Ante, and the wind is NNE (cro. *burin*), the wind that blows at night from the land.

Situation 2:

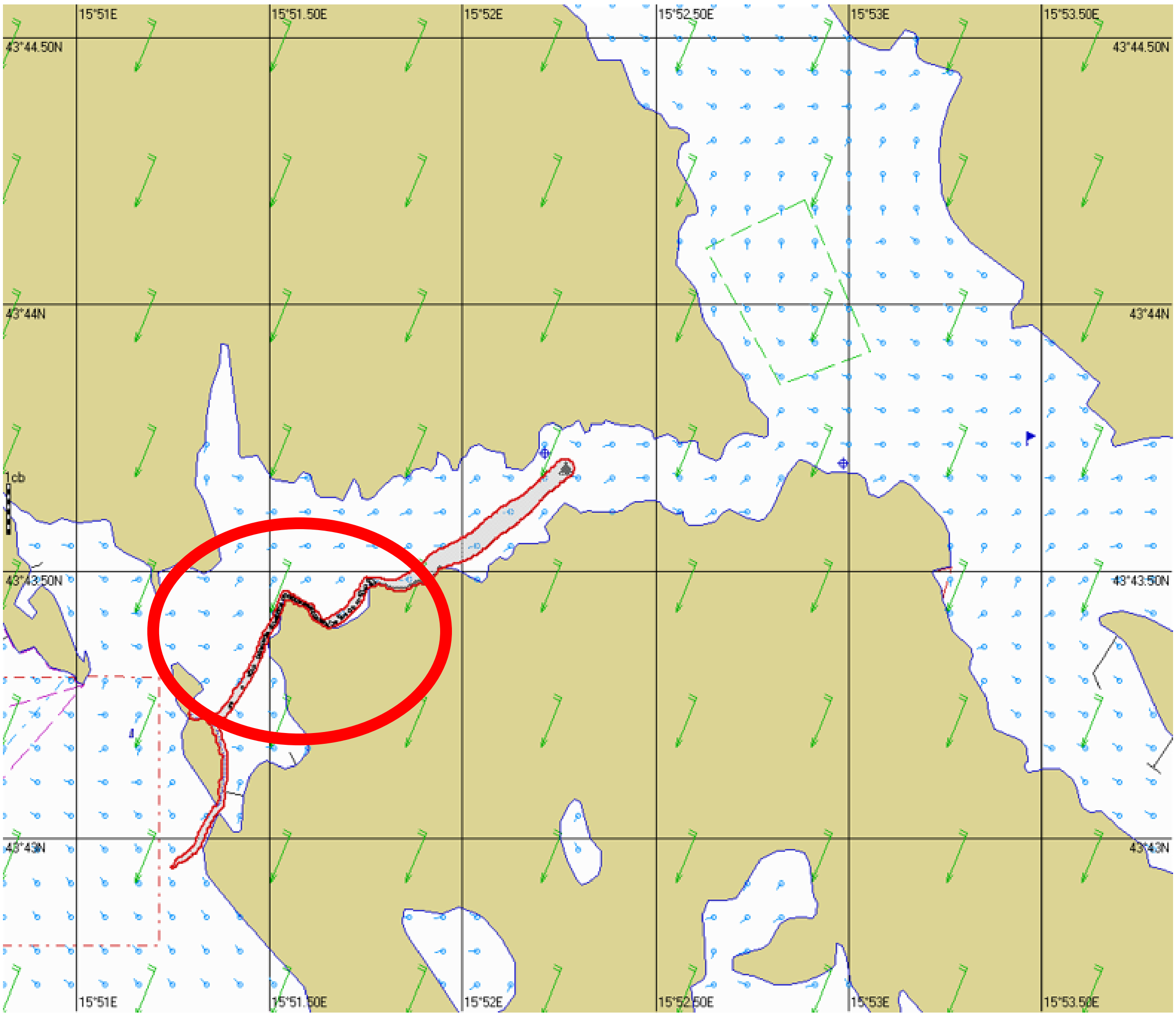
Amount of pollutant in the sea: 15 m3 of diesel
Wind speed and direction: 20 knots NNE
Time: 8.30 AM



Within half an hour, the pollution spread to part of the St. Ante and, due to the action of sea currents and wind direction, spread along the coastal part containing a large number of plant species.

Situation 3:

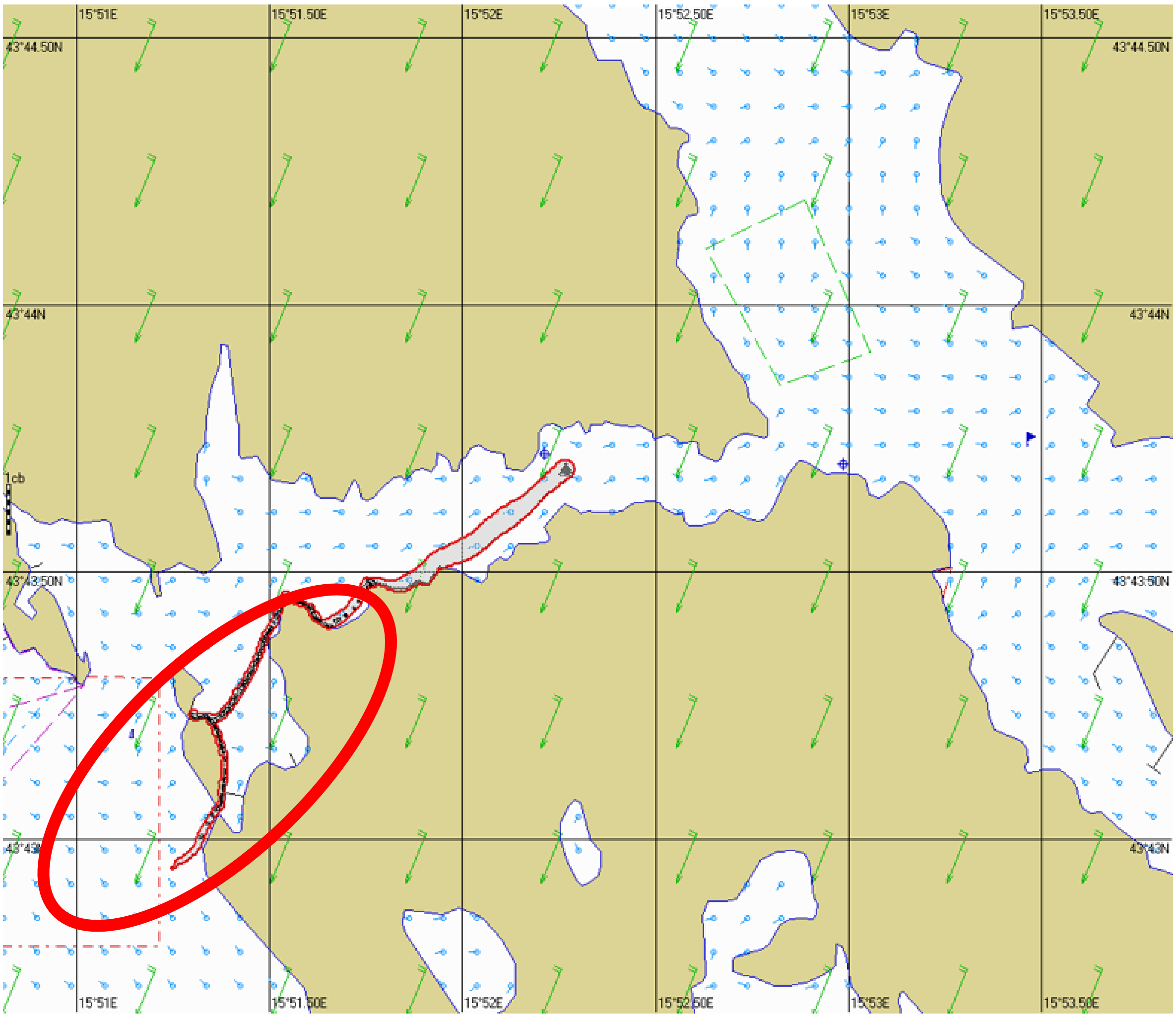
Amount of pollutant in the sea: 15 m3 of diesel
Wind speed and direction: 20 knots NNE
Time: 9.00 AM



The pollutant spreads along the coast.

Situation 4:

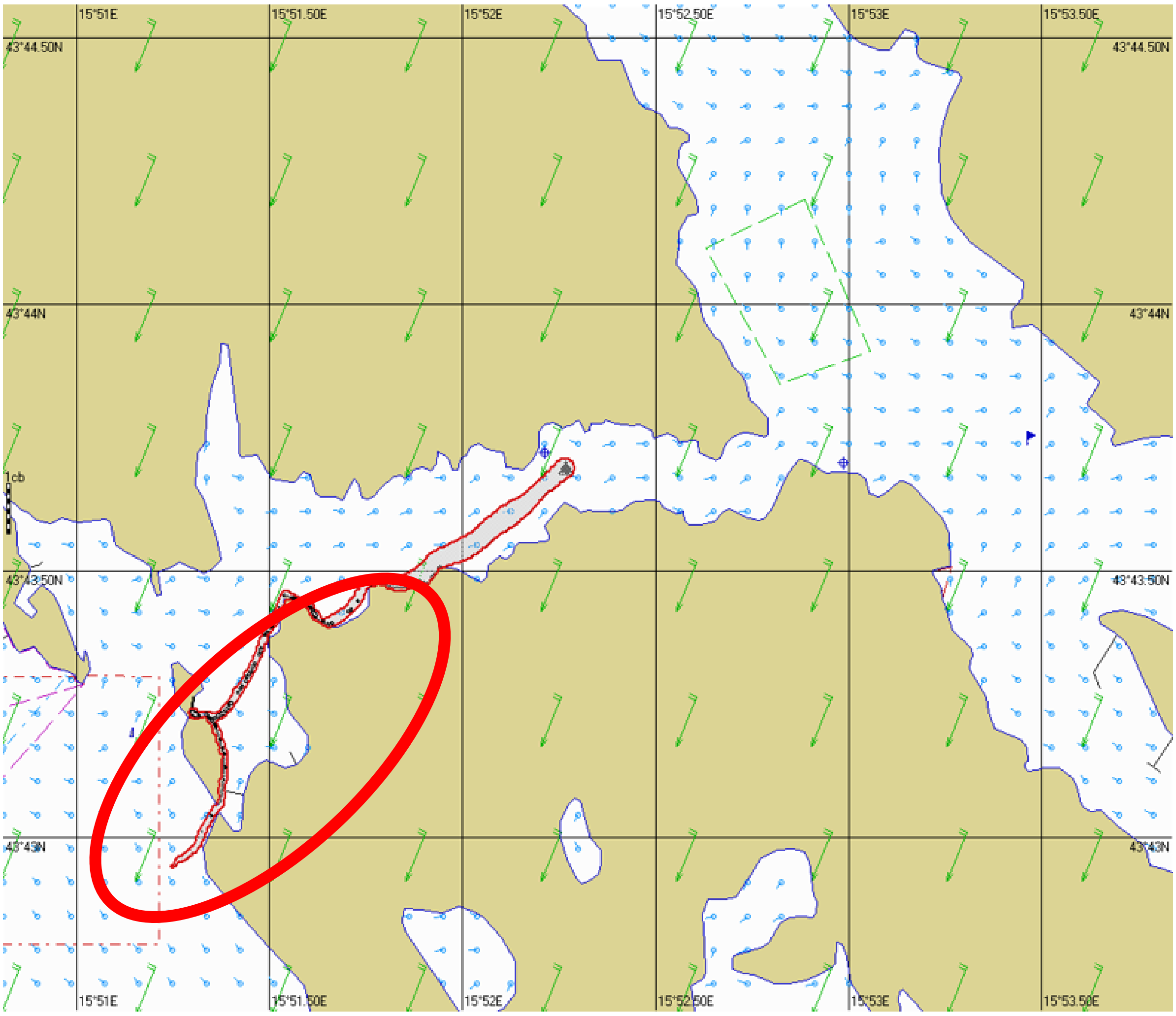
Amount of pollutant in the sea: 15 m3 of diesel
Wind speed and direction: 20 knots NNE
Time: 10.00 AM



Within an hour, the pollutant spread considerably along the coastal part of the channel and reached the entrance to the open sea - at this moment, the pollution also threatens the outer part of the Šibenik sea area.

Situation 5:

Amount of pollutant in the sea: 15 m3 of diesel
Wind speed and direction: 20 knots NNE
Time: 11.00 AM



At this point, the pollution has already caused considerable damage to the coastal area and to the flora and fauna, and floating particles of pollutants continue to float towards the open sea.

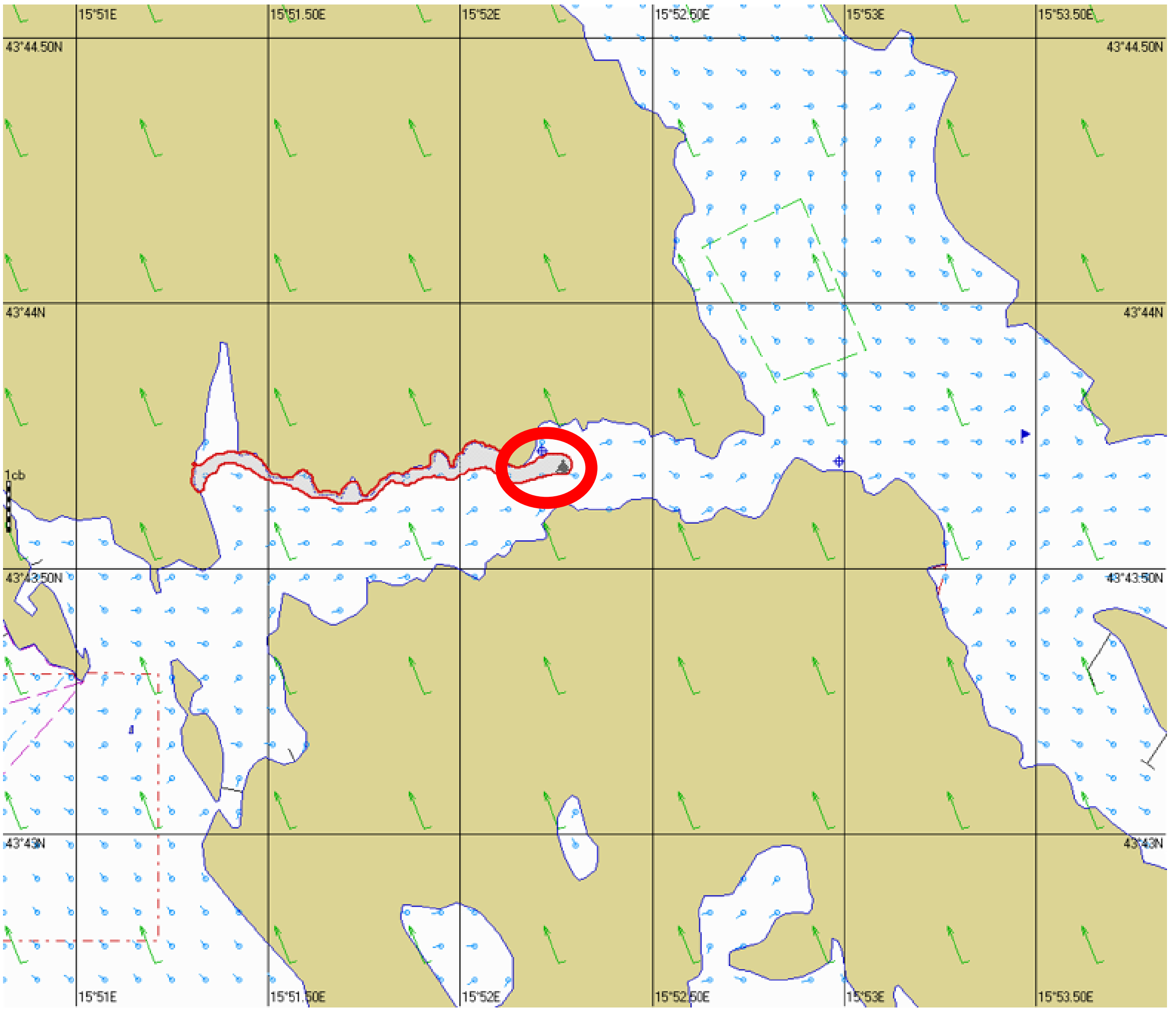
Pollution statistics for simulation 1:

Oil		
Amount spilled	12463 kg	100 %
Amount floating	6428 kg	51.6 %
Amount evaporated	412 kg	3.3 %
Amount dispersed	5199 kg	41.7 %
Amount stranded	425 kg	3.41 %
Amount burned	0.0 kg	0 %
Amount sunk	0.0 kg	0 %
Amount recovered	0.0 kg	0 %
Recovered oil on shore	0.0 kg	0 %
Recovered soil and oil on shore	0.0 kg	
Emulsion		
Amount floating mixture	9039 kg	
Amount recovered mixture	0.0 kg	
Slick		
Max thickness	94.2 mm	
Slick area	0.0 km2	
Viscosity	3.0 cSt	

SIMULATION 2

Situation 1:

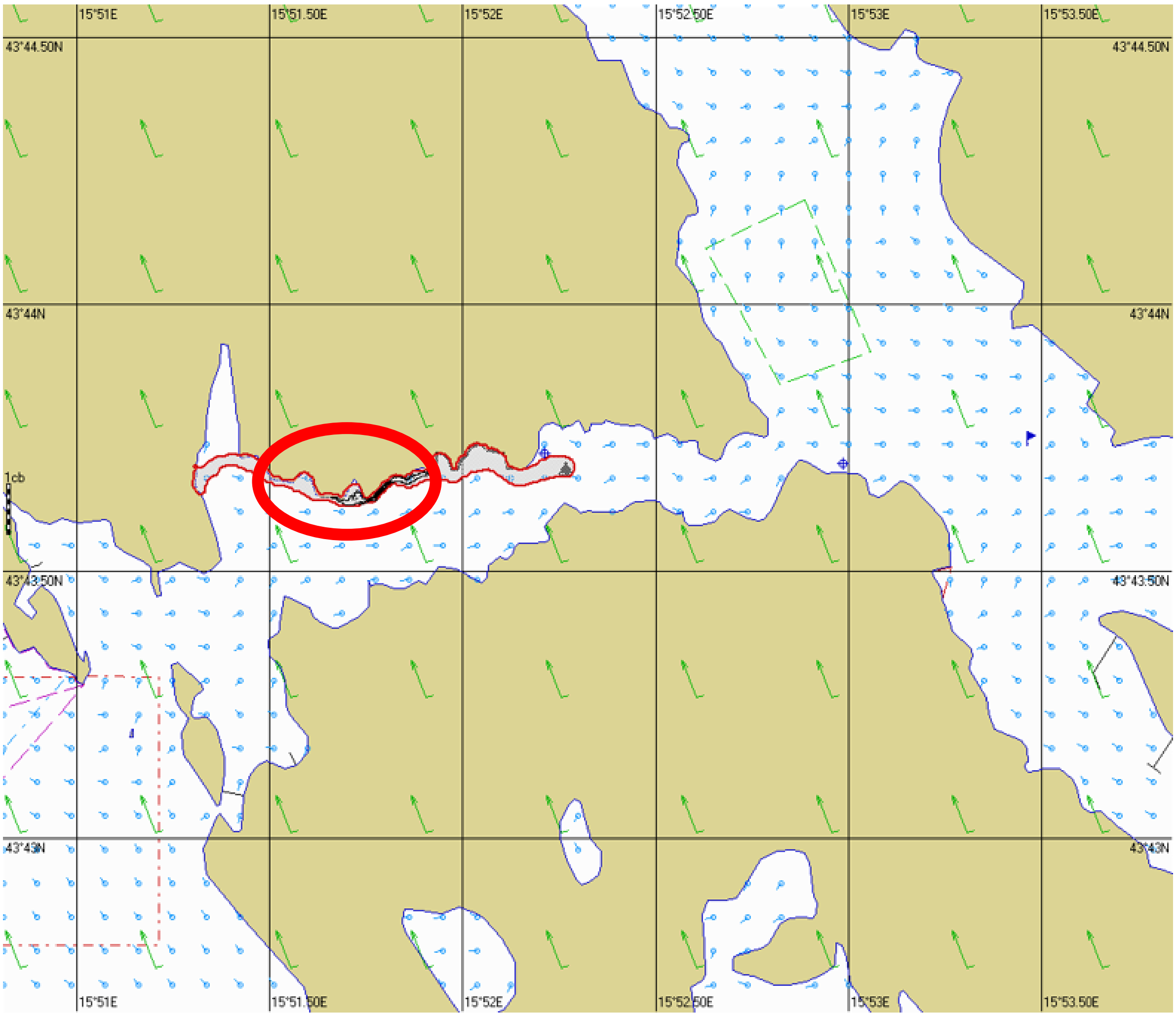
Amount of pollutant in the sea: 15 m3 of diesel
Wind speed and direction: 10 knots SSE
Time: 08.00 AM



On the photo there is a 15m3 of diesel located near buoy situated in the channel of St. Ante, and the wind is SSE (cro. *levant and south wind scirocco*), warm and humid wind of greater strength.

Situation 2:

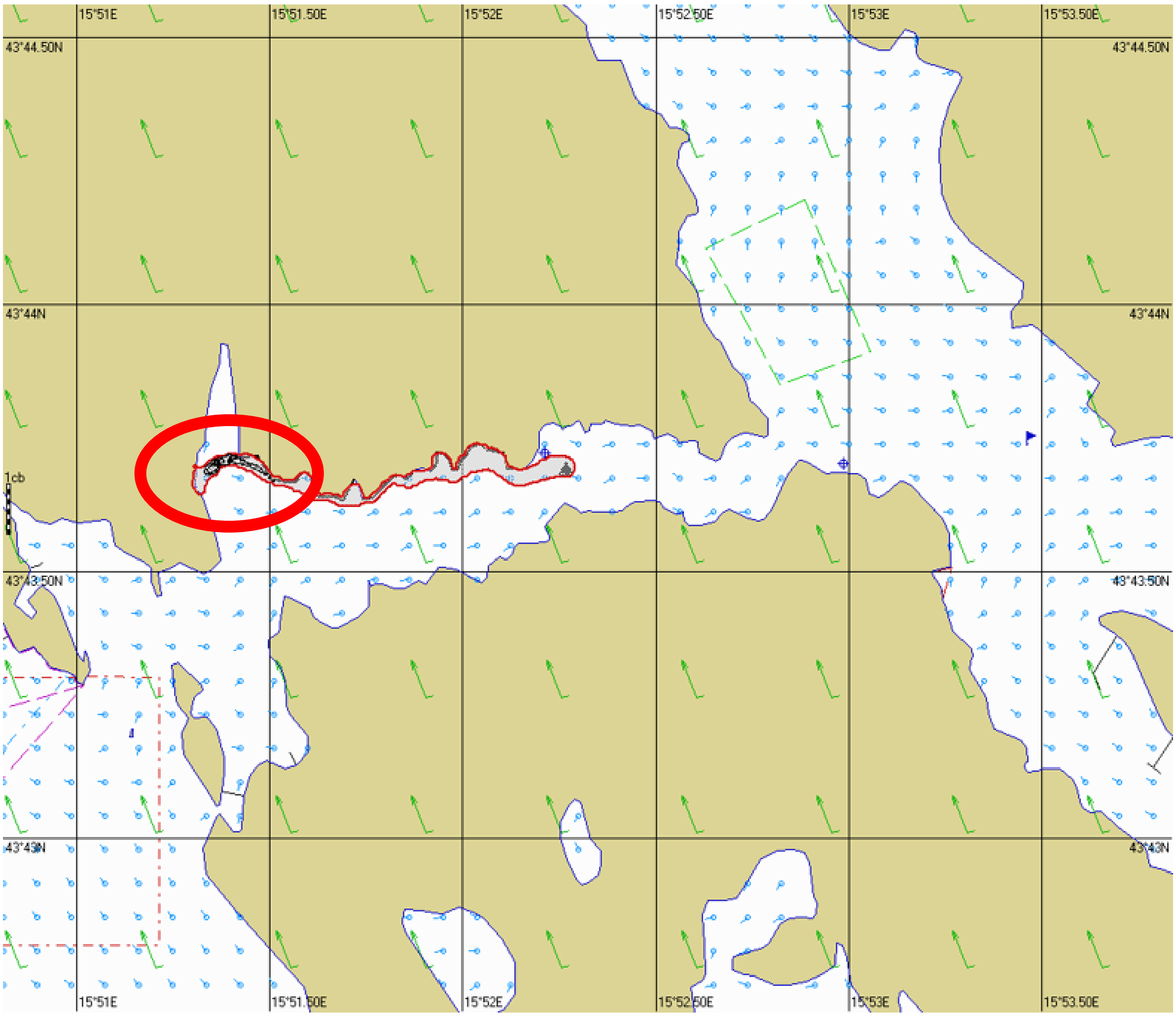
Amount of pollutant in the sea: 15 m3 of diesel
Wind speed and direction: 10 knots SSE
Time: 08.30 AM



Within half an hour, the pollution spread to part of the St. Ante and, due to the action of sea currents and wind direction, spread along the coastal part containing a large number of plant species on the narrow part of the channel.

Situation 3:

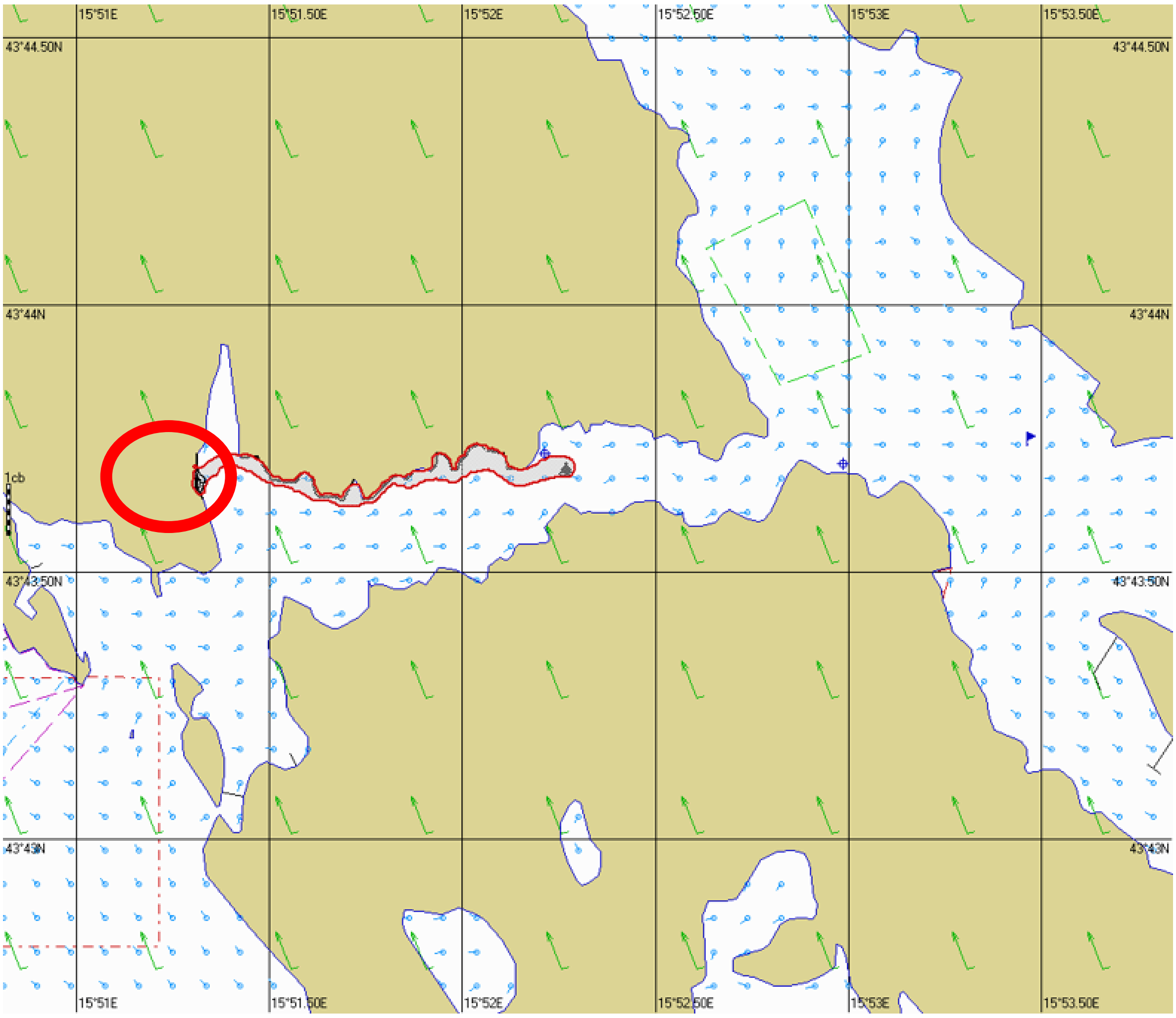
Amount of pollutant in the sea: 15 m3 of diesel
Wind speed and direction: 10 knots SSE
Time: 09.00 AM



Pollutants, under the influence of the SSE wind, are distributed faster and more densely along the coast compared to the NNE wind.

Situation 4:

Amount of pollutant in the sea: 15 m3 of diesel
Wind speed and direction: 10 knots SSE
Time: 10.00 AM



Pollutants are retained on a smaller surface in a compact form, causing pollution with a larger amount of pollutants on a smaller surface. Although the pollutant was stationed on a smaller coastal part, in its path it caused the pollution of the entire coastal part through which it passed.

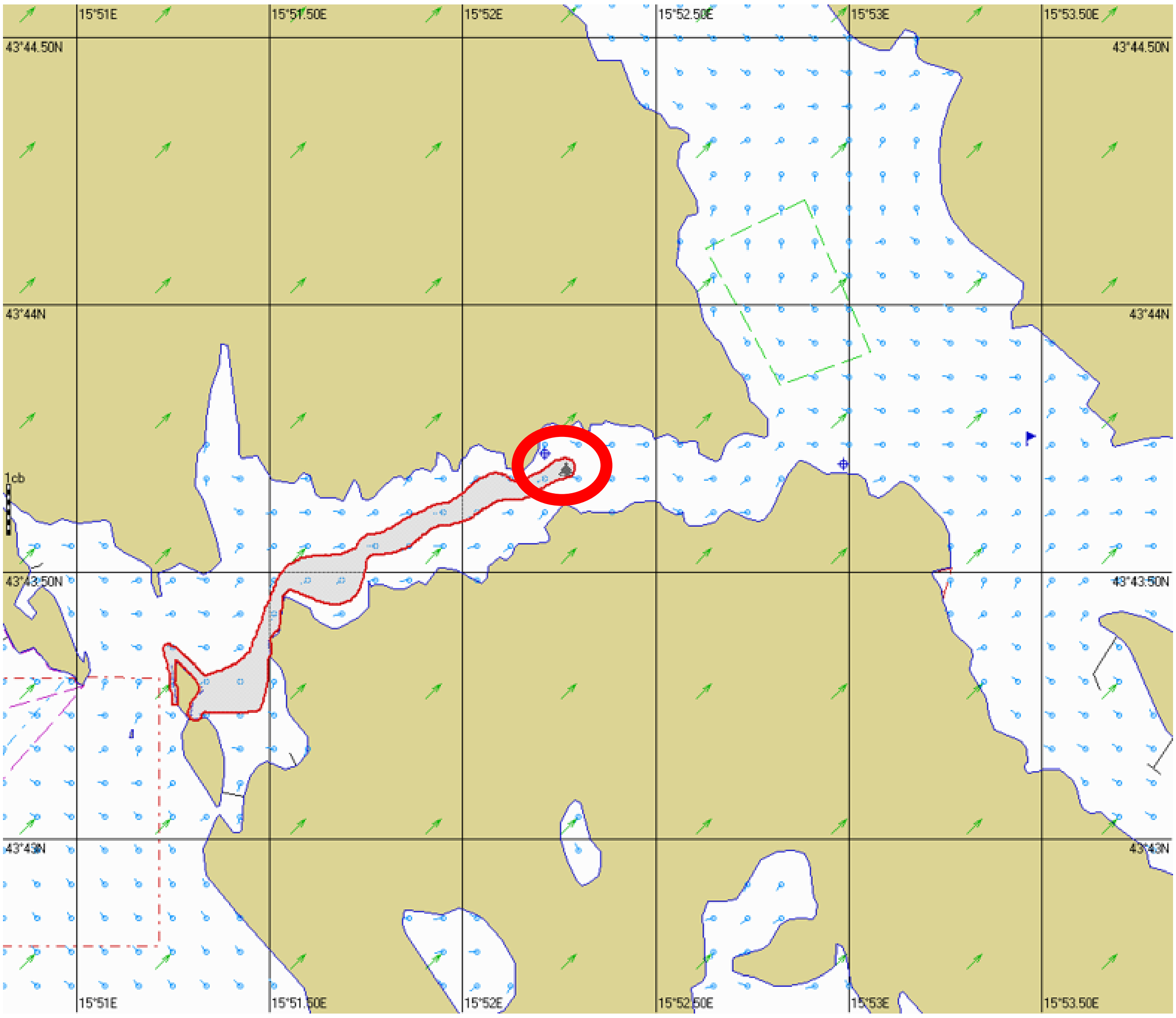
Pollution statistics for simulation 2:

Oil		
Amount spilled	12463 kg	100 %
Amount floating	11578 kg	92.9 %
Amount evaporated	149 kg	1.2 %
Amount dispersed	158 kg	1.27 %
Amount stranded	579 kg	4.64 %
Amount burned	0.0 kg	0 %
Amount sunk	0.0 kg	0 %
Amount recovered	0.0 kg	0 %
Recovered oil on shore	0.0 kg	0 %
Recovered soil and oil on shore	0.0 kg	
Emulsion		
Amount floating mixture	16154 kg	
Amount recovered mixture	0.0 kg	
Slick		
Max thickness	34.6 mm	
Slick area	0.0 km2	
Viscosity	2.4 cSt	

SIMULATION 3

Situation 1:

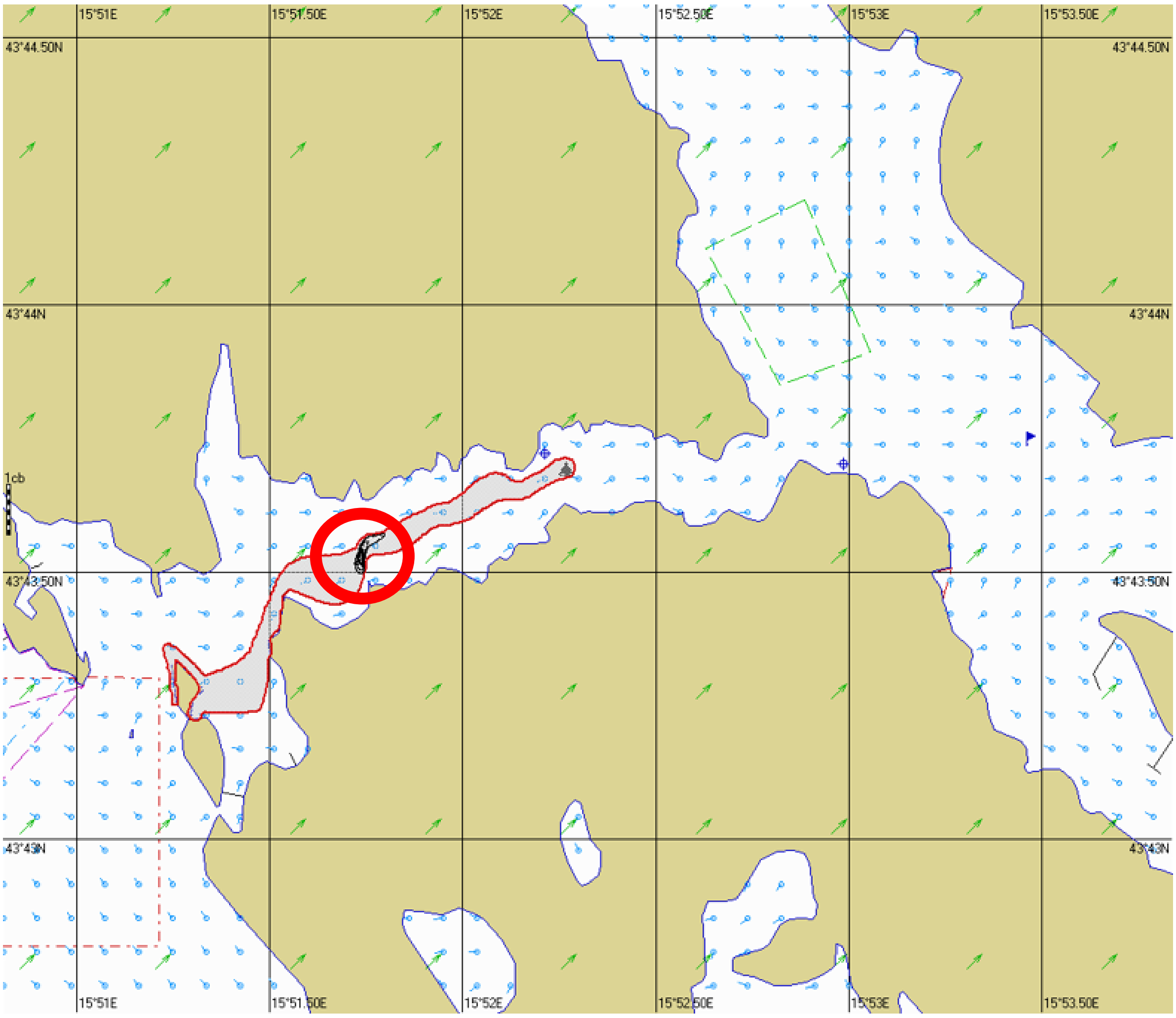
Amount of pollutant in the sea: 15 m3 of diesel
Wind speed and direction: 3 knots SW
Time: 08.00 AM



On the photo there is a 15m3 of diesel located near buoy situated in the channel of St. Ante, and the wind is SW (southwest wind, cro. *lebić* or *gerbin*), warm and humid wind of greater strength.

Situation 2:

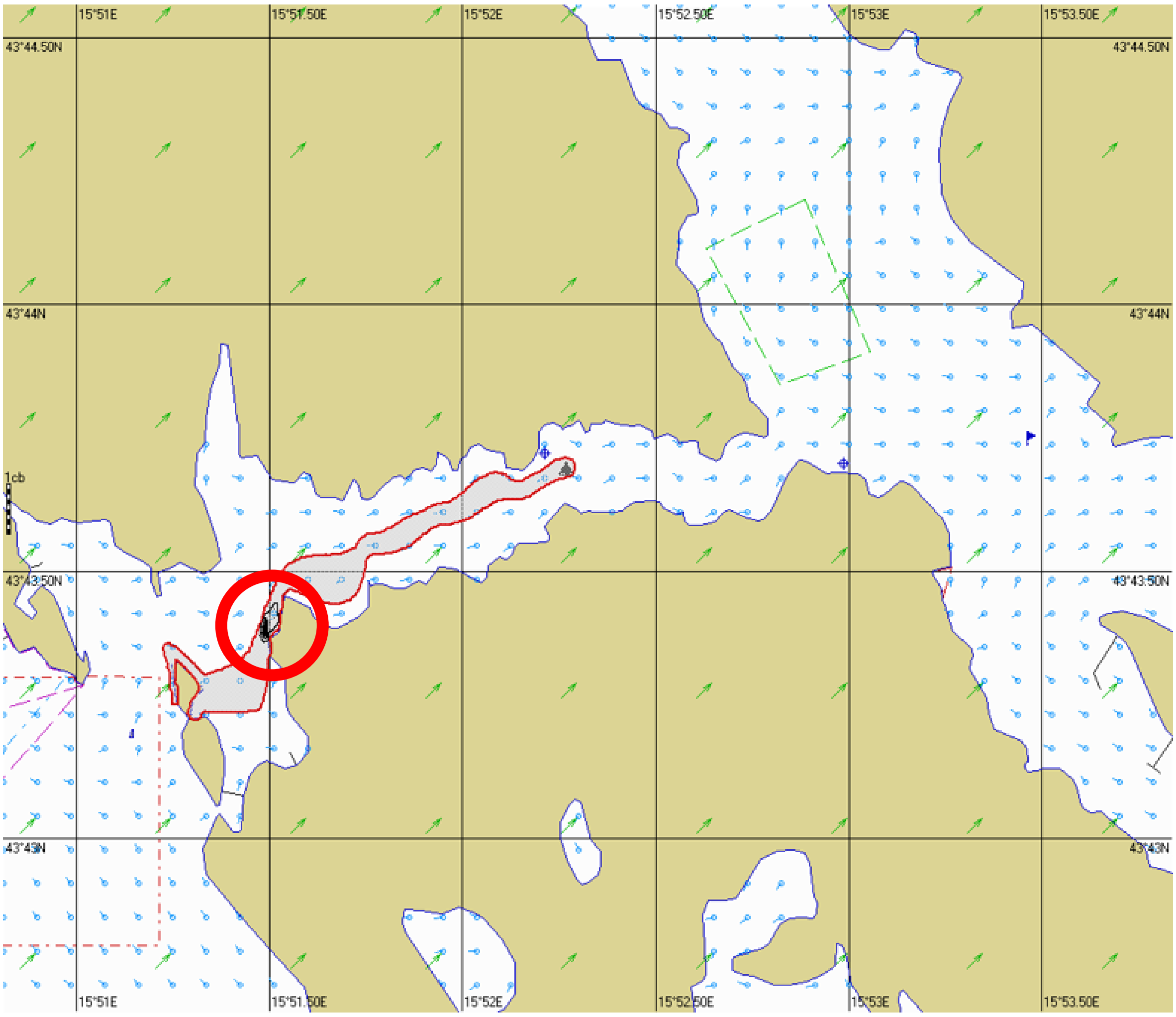
Amount of pollutant in the sea: 15 m3 of diesel
Wind speed and direction: 3 knots SW
Time: 08.30 AM



Within half an hour, the pollution spread to part of the St. Ante and, due to the action of sea currents and wind direction, spread along the marine part of the channel.

Situation 3:

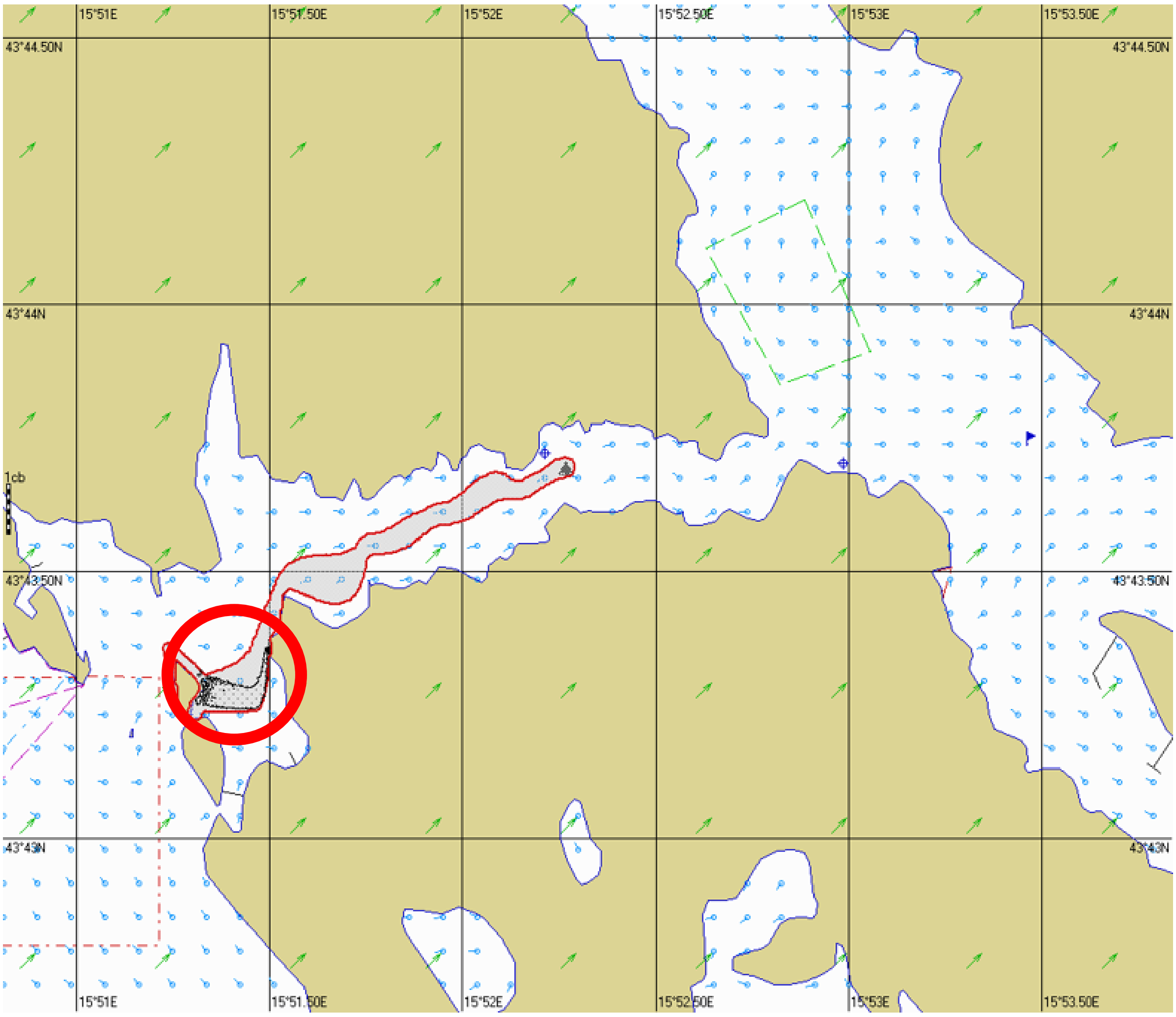
Amount of pollutant in the sea: 15 m3 of diesel
Wind speed and direction: 3 knots SW
Time: 09.00 AM



An hour after the start of the pollution, the pollution spread by sea to the protruding part of the coast.

Situation 4:

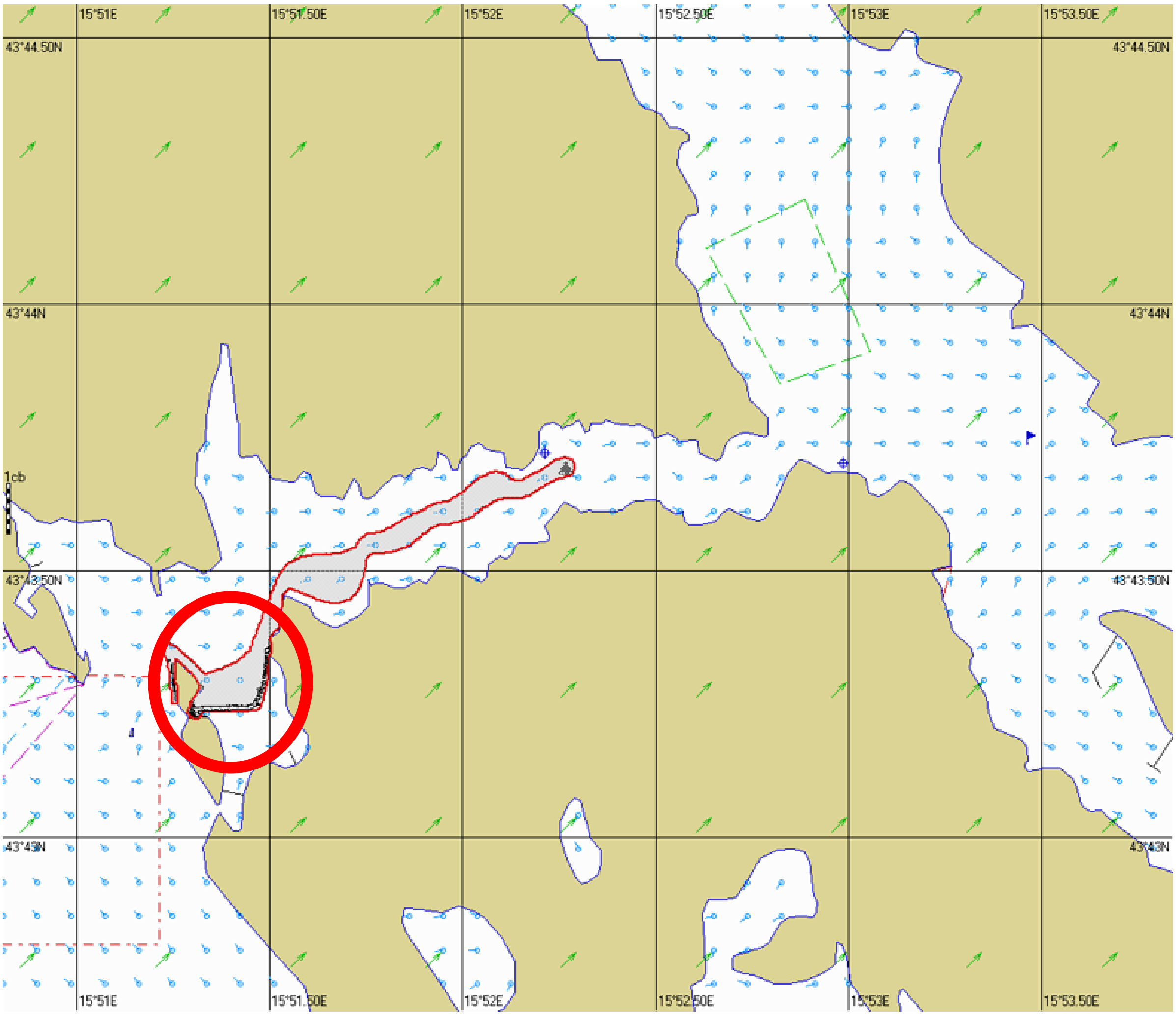
Amount of pollutant in the sea: 15 m3 of diesel
Wind speed and direction: 3 knots SW
Time: 09.30 AM



After half an hour, the pollution spreads towards the open sea with greater pressure and remains on the coastal part where it is carried by the sea currents and the direction of the wind.

Situation 5:

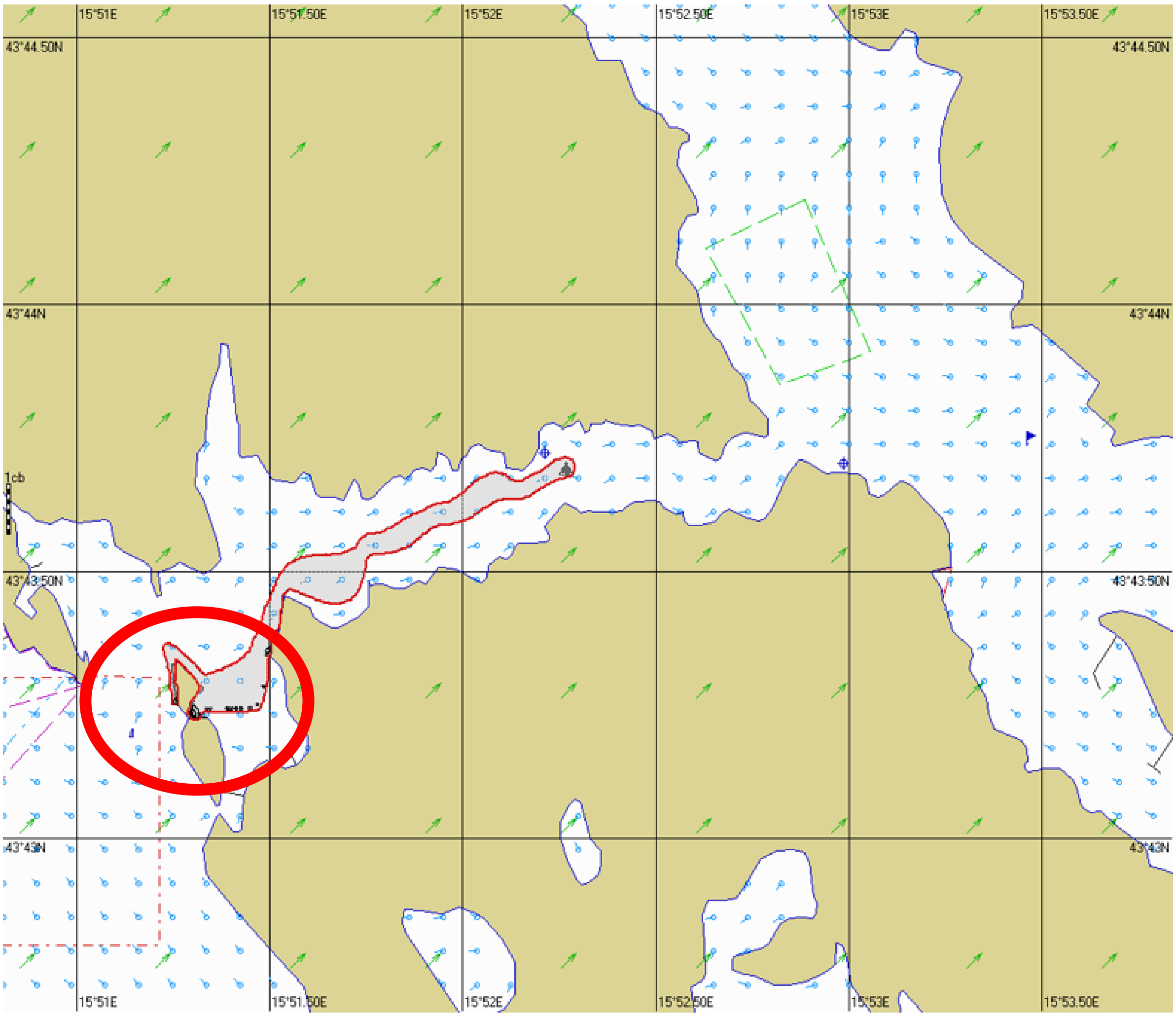
Amount of pollutant in the sea: 15 m3 of diesel
Wind speed and direction: 3 knots SW
Time: 10.00 AM



Sea currents carry pollution to a smaller coastal area, where it accumulates in a larger volume.

Situation 6:

Amount of pollutant in the sea: 15 m3 of diesel
Wind speed and direction: 3 knots SW
Time: 11.00 AM



Location of the pollutant.

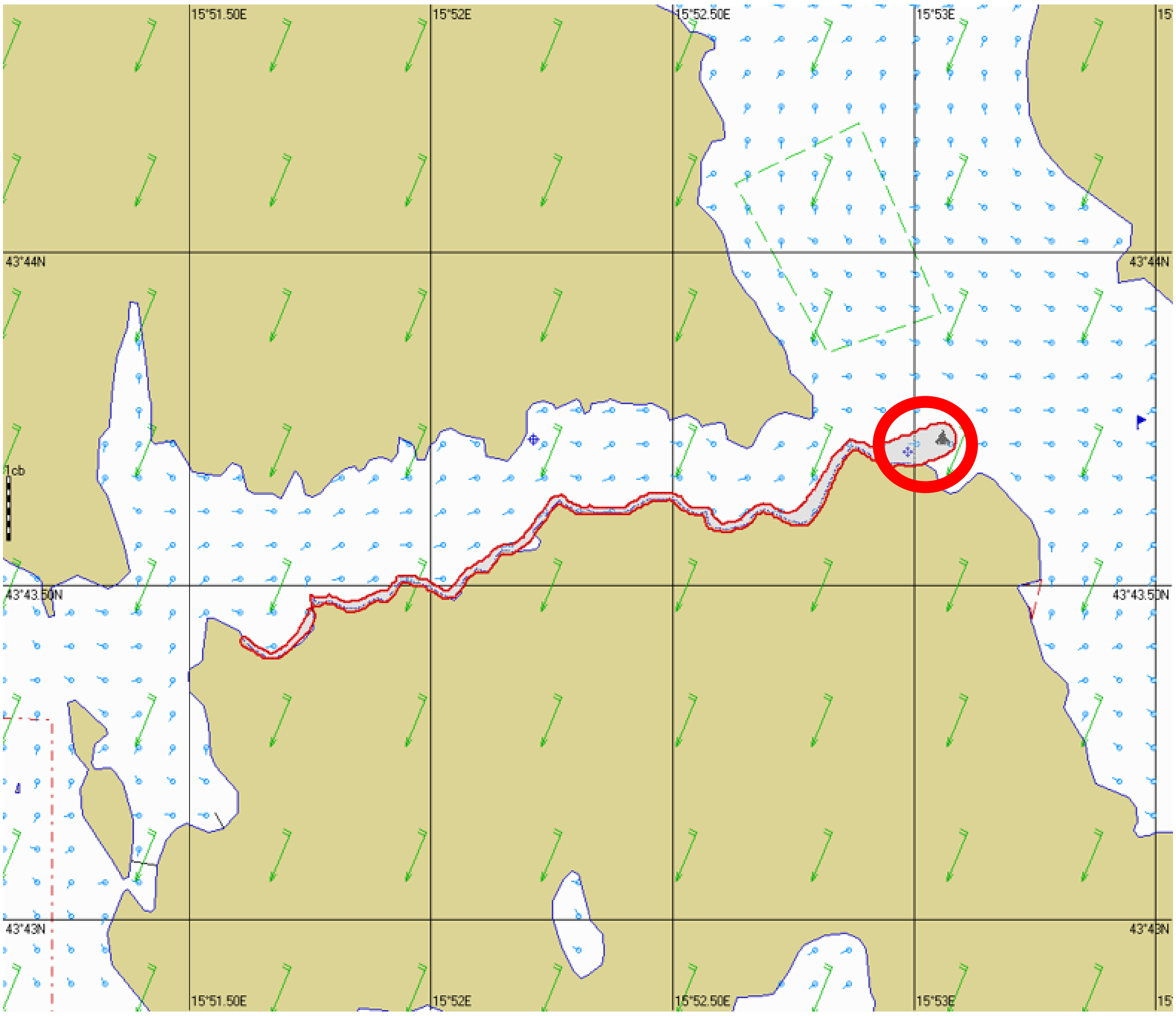
Pollution statistics for simulation 3:

Oil		
Amount spilled	12463 kg	100 %
Amount floating	12095 kg	97 %
Amount evaporated	197 kg	1.58 %
Amount dispersed	1.6 kg	0.01 %
Amount stranded	170 kg	1.36 %
Amount burned	0.0 kg	0 %
Amount sunk	0.0 kg	0 %
Amount recovered	0.0 kg	0 %
Recovered oil on shore	0.0 kg	0 %
Recovered soil and oil on shore	0.0 kg	
Emulsion		
Amount floating mixture	14120 kg	
Amount recovered mixture	0.0 kg	
Slick		
Max thickness	59.5 mm	
Slick area	0.0 km2	
Viscosity	1.6 cSt	

SIMULATION 4

Situation 1:

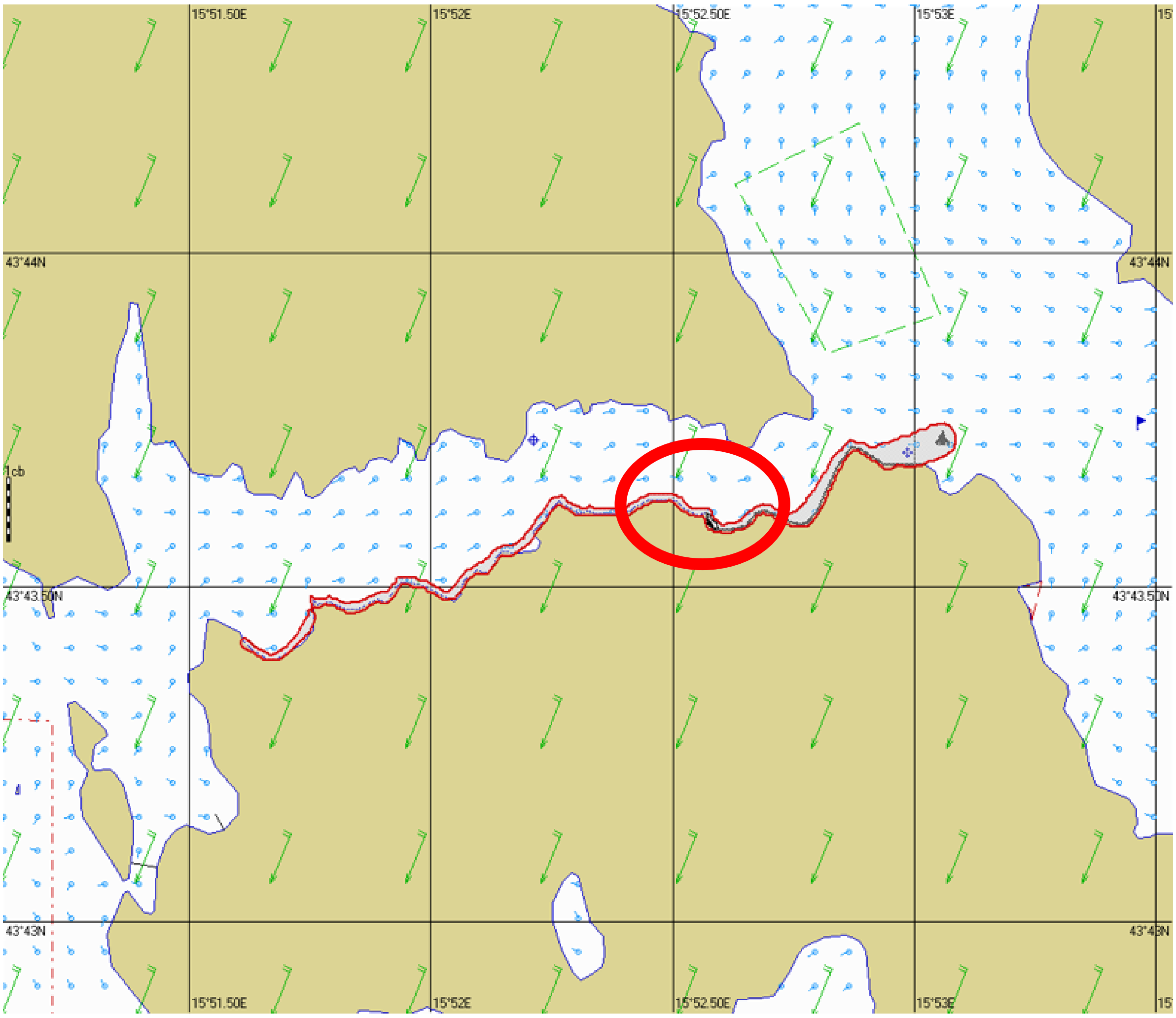
> Amount of pollutant in the sea: 40 m3 of IFO
> Wind speed and direction: 20 knots NNE
> Time: 08.00 AM



The simulated pollutant is Intermediate Fuel Oil (IFO).
On the photo there is a 40m3 of IFO located near buoy situated in the entrance/exit of the channel of St. Ante, and the wind is NNE (cro. *burin*), the wind that blows at night from the land.

Situation 2:

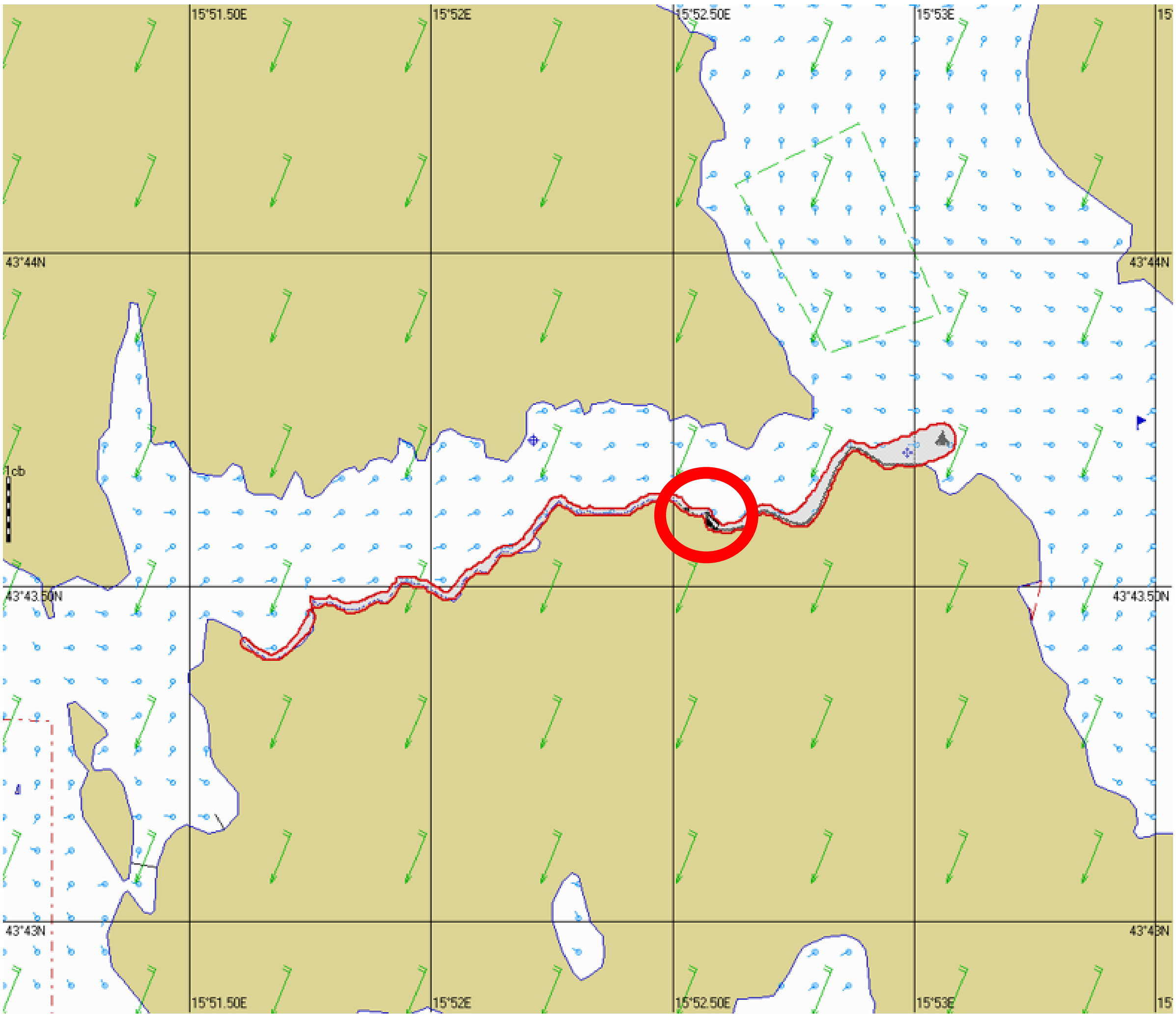
Amount of pollutant in the sea: 40 m3 of IFO
Wind speed and direction: 20 knots NNE
Time: 08.30 AM



Half an hour after the beginning of the pollution, the pollution spreads along the coastal part, according to the sea currents and the direction of the wind.

Situation 3:

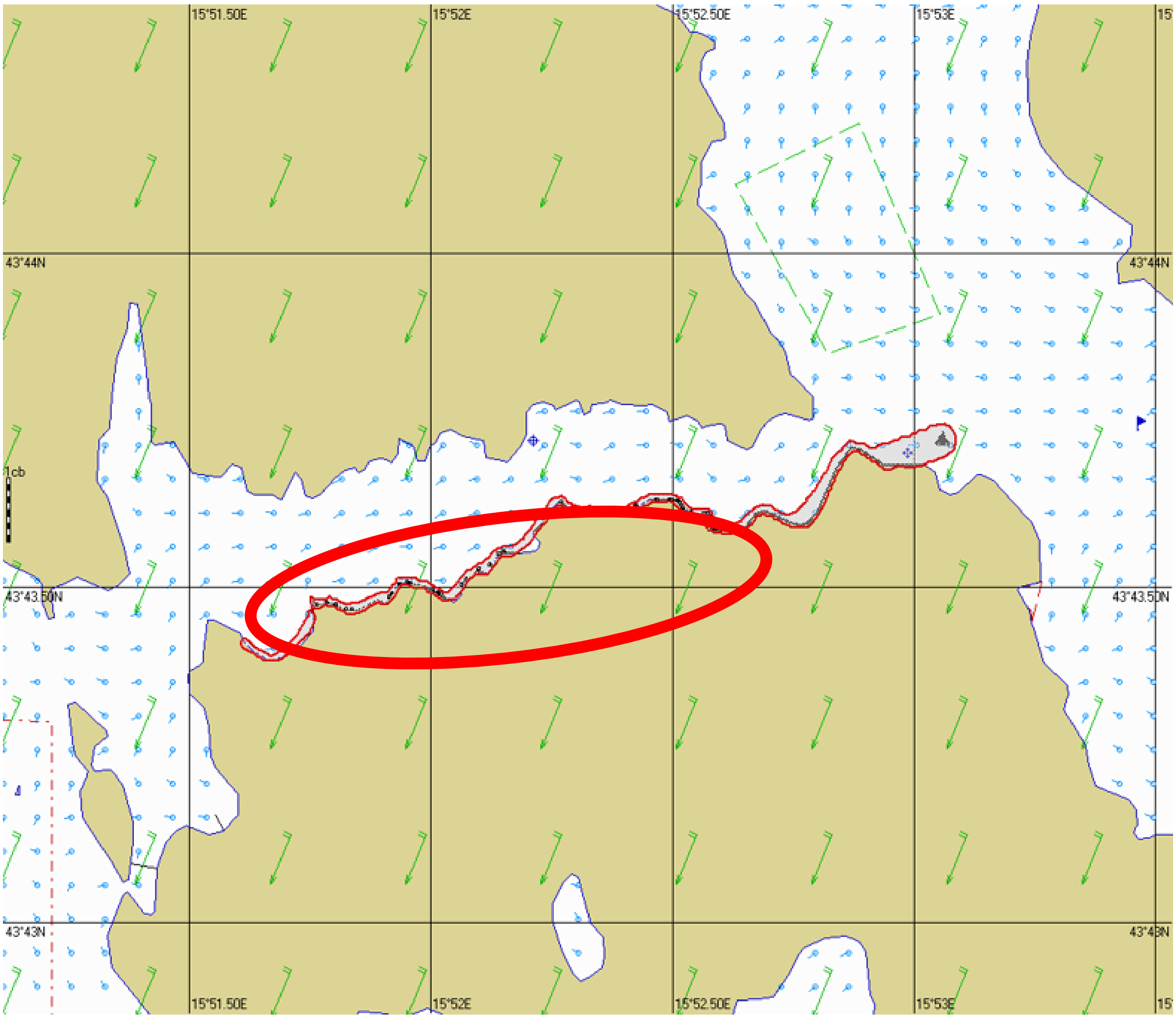
Amount of pollutant in the sea: 40 m3 of IFO
Wind speed and direction: 20 knots NNE
Time: 09.00 AM



The pollution spreads more slowly and remains on the part of the coast in a denser composition.

Situation 4:

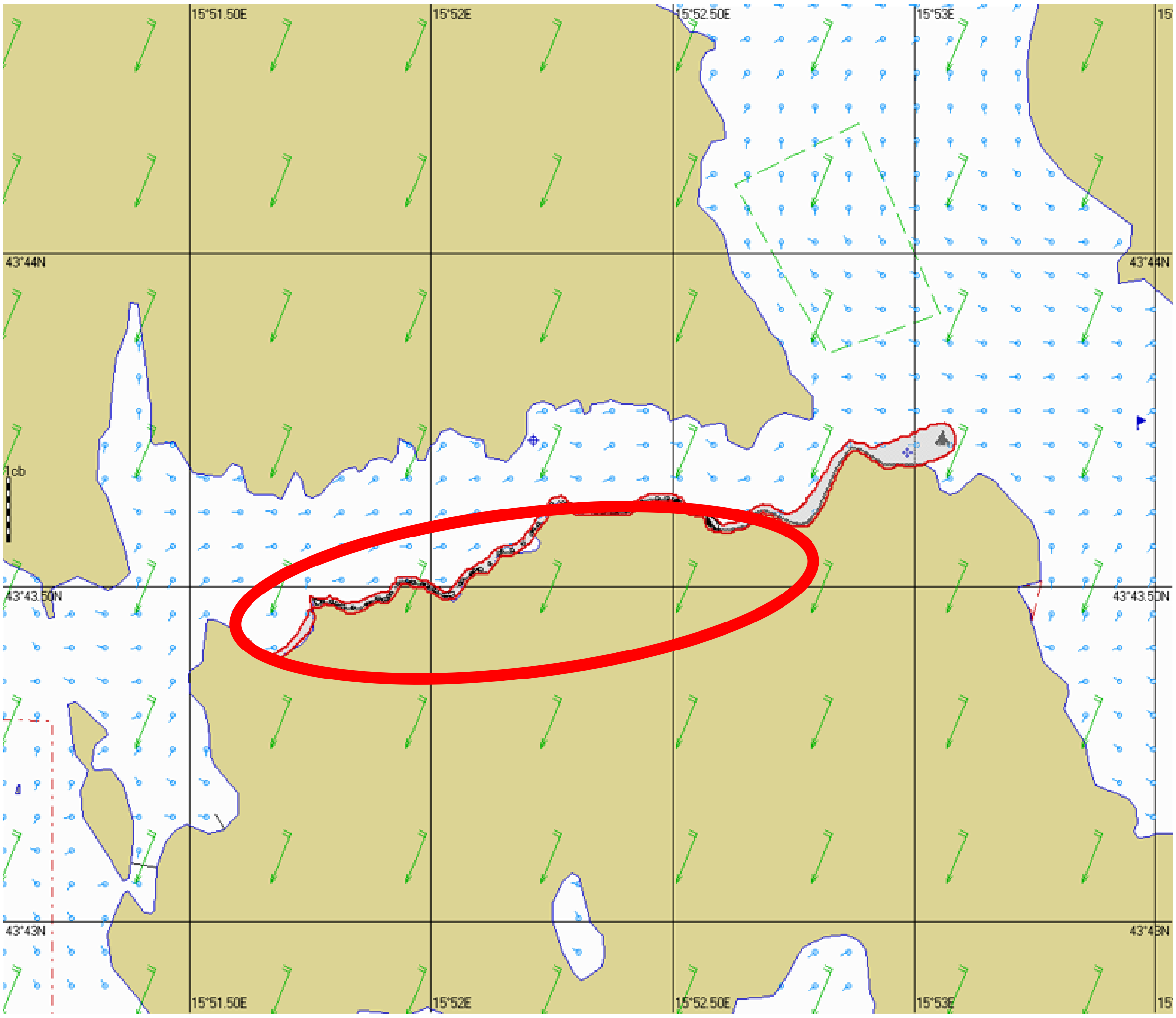
Amount of pollutant in the sea: 40 m3 of IFO
Wind speed and direction: 20 knots NNE
Time: 10.00 AM



Within an hour, the polluting particles spread over almost the entire length of the southern part of the St. Ante.

Situation 5:

Amount of pollutant in the sea: 40 m3 of IFO
Wind speed and direction: 20 knots NNE
Time: 11.30 AM



The pollutant is constantly present on the southern coastal part of the St. Ante channel.

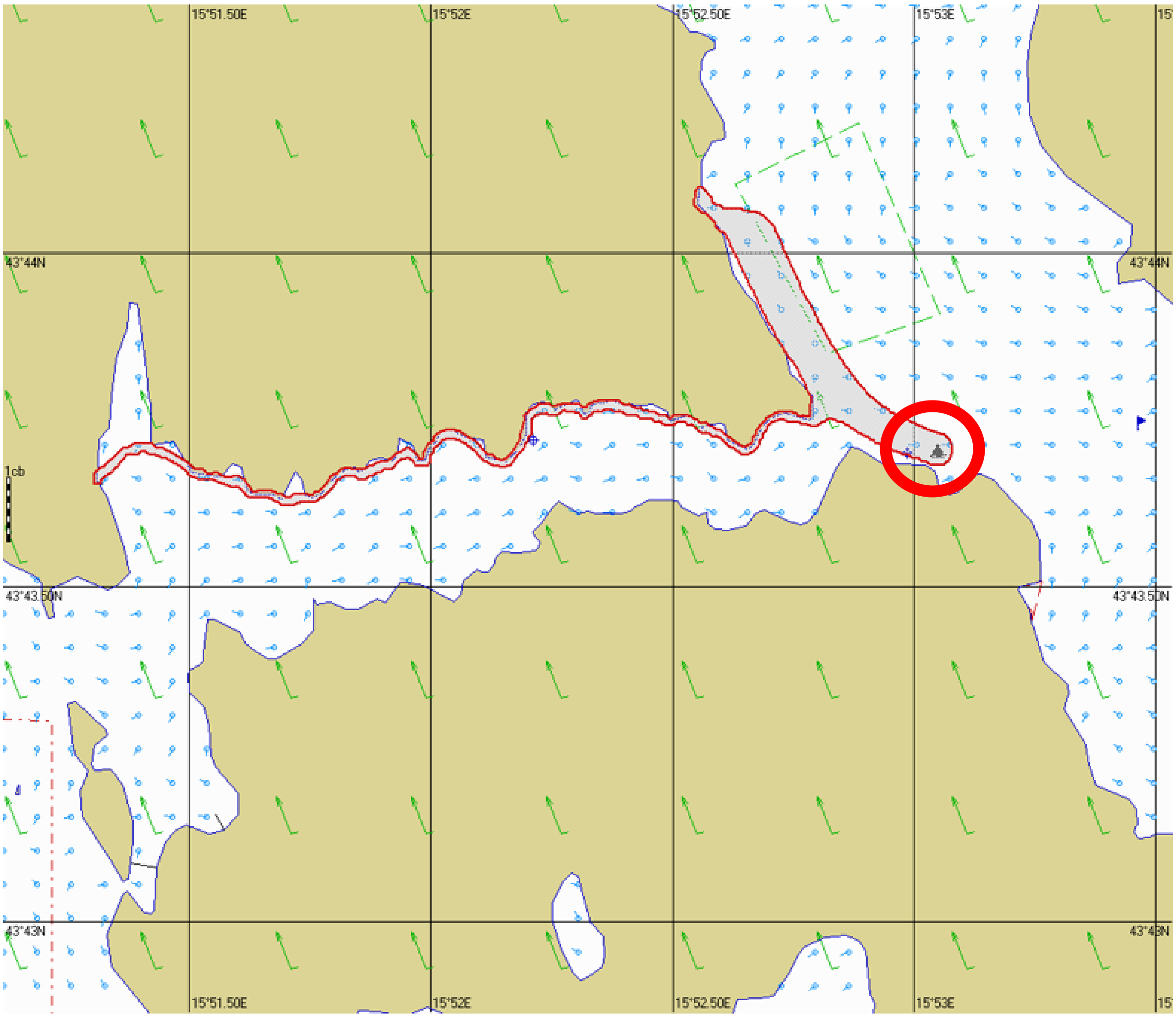
Pollution statistics for simulation 4:

Oil		
Amount spilled	38714 kg	100 %
Amount floating	37652 kg	97.3 %
Amount evaporated	19.2 kg	0.05 %
Amount dispersed	182 kg	0.47 %
Amount stranded	860 kg	2.22 %
Amount burned	0.0 kg	0 %
Amount sunk	0.0 kg	0 %
Amount recovered	0.0 kg	0 %
Recovered oil on shore	0.0 kg	0 %
Recovered soil and oil on shore	0.0 kg	
Emulsion		
Amount floating mixture	50878 kg	
Amount recovered mixture	0.0 kg	
Slick		
Max thickness	235 mm	
Slick area	0.0 km2	
Viscosity	2131 cSt	

SIMULATION 5

Situation 1:

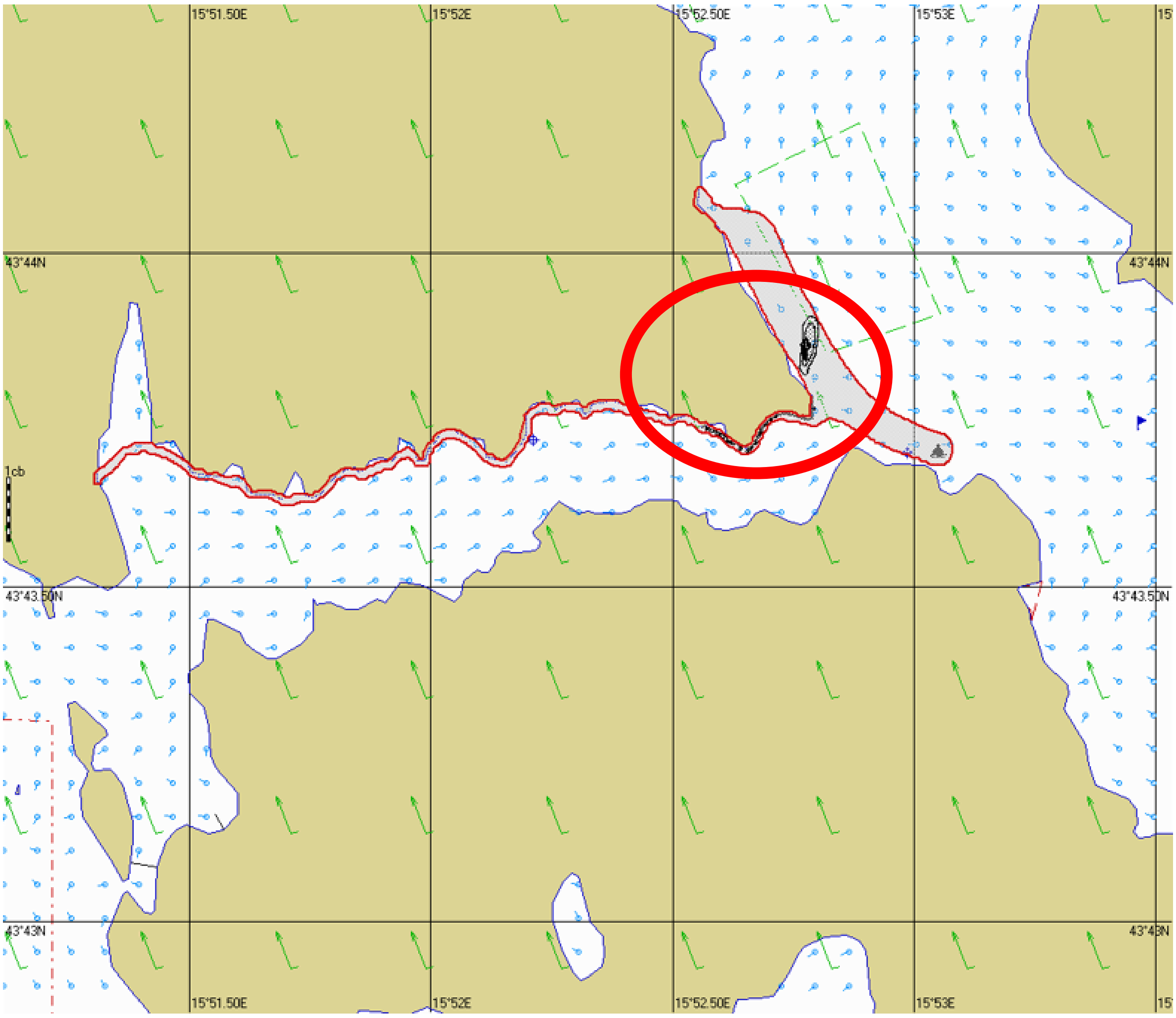
Amount of pollutant in the sea: 40 m3 of IFO
Wind speed and direction: 10 knots SSE
Time: 08.00 AM



On the photo there is a 40m3 of IFO located near buoy situated in the entrance/exit of the channel of St. Ante, and the wind is SSE (cro. *levant and south wind scirocco*), warm and humid wind of greater strength.

Situation 2:

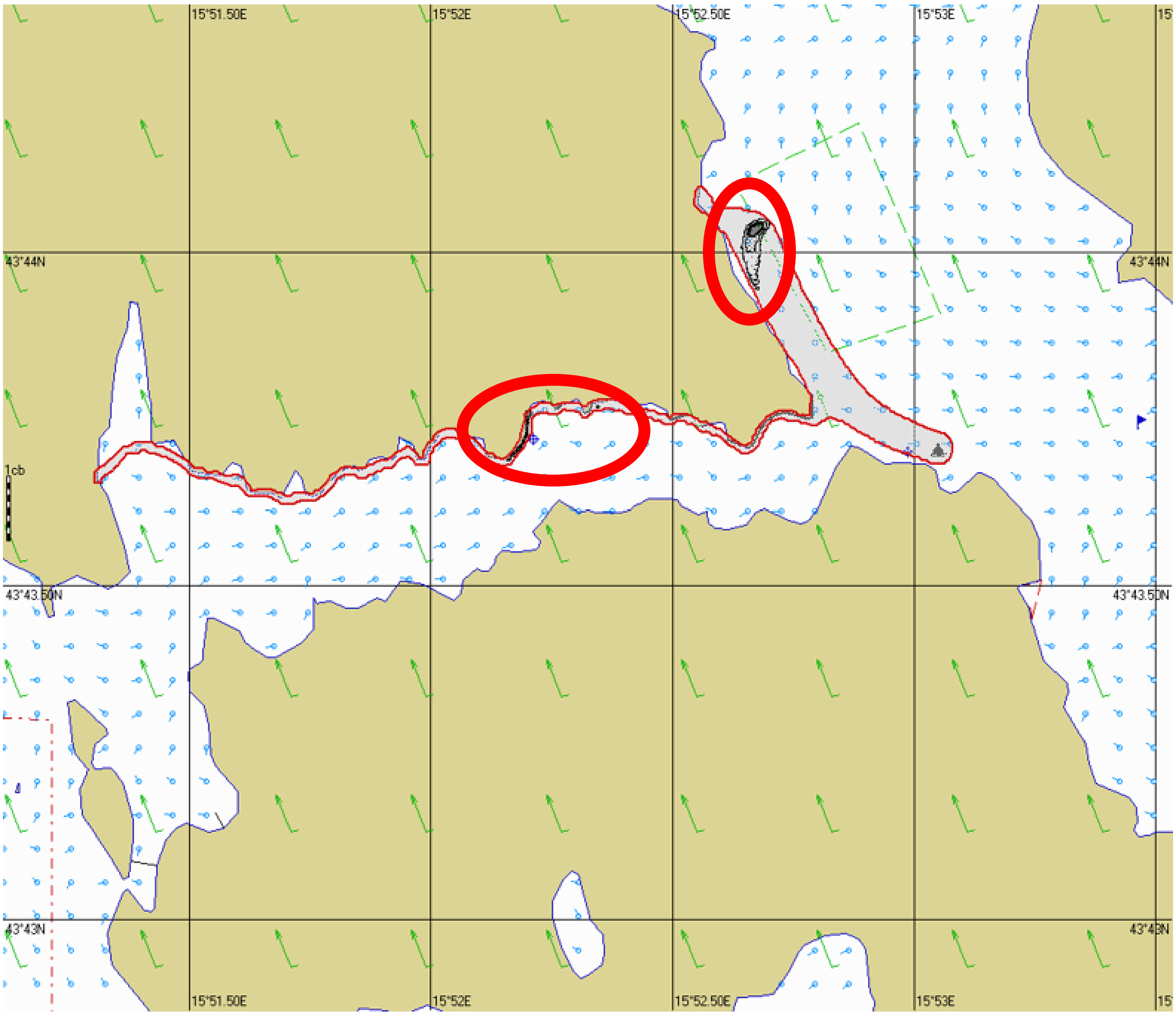
Amount of pollutant in the sea: 40 m3 of IFO
Wind speed and direction: 10 knots SSE
Time: 08.30 AM



Half an hour after the start of the simulation, the pollutant is already spreading along the northern side of the coast in the St. Ante. The specificity of the case is the dispersion of pollutants on two coastal sides.

Situation 3:

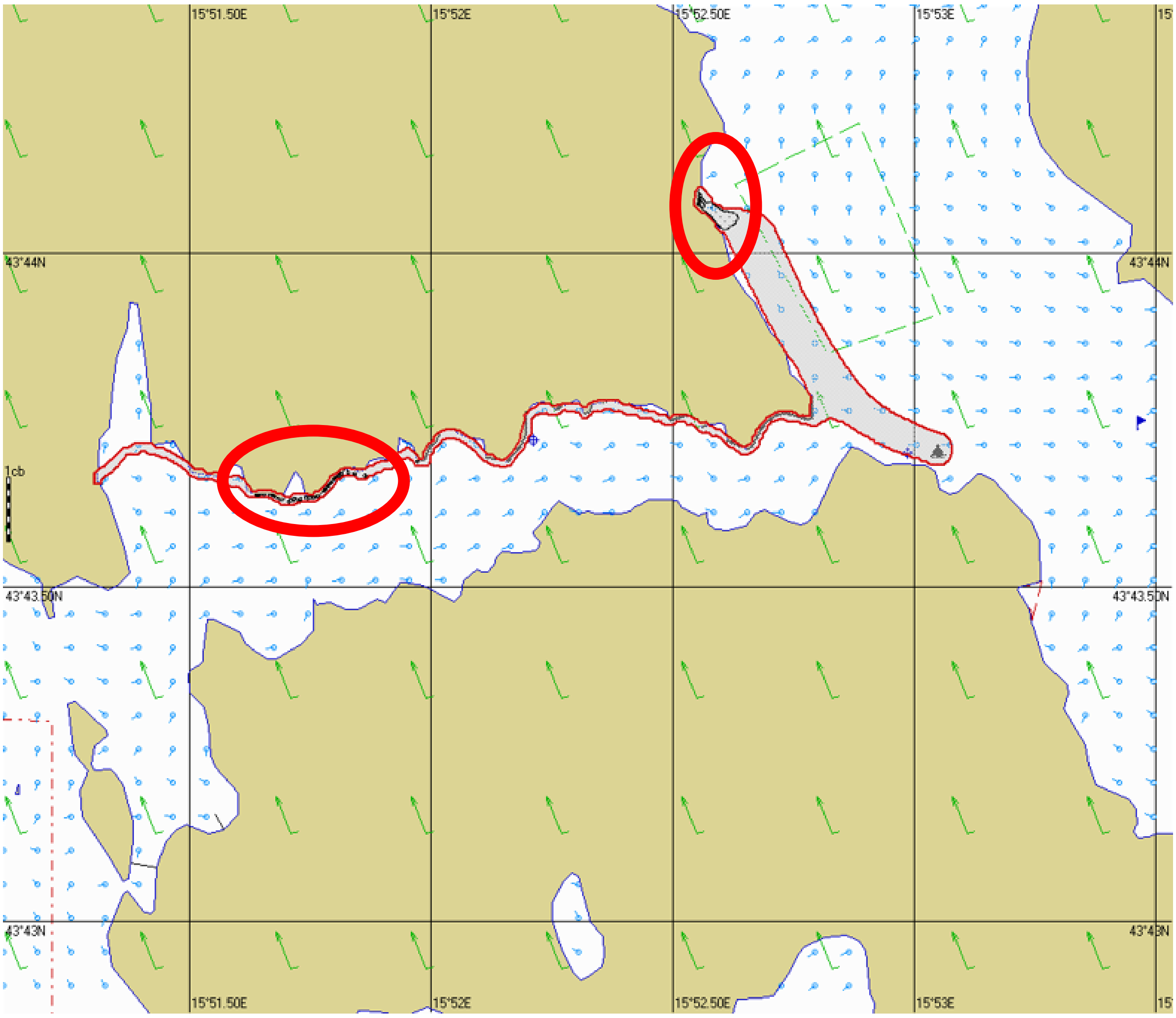
Amount of pollutant in the sea: 40 m3 of IFO
Wind speed and direction: 10 knots SSE
Time: 09.00 AM



Pollution continues to remain on the coastal part, but the pace of expansion is slower.

Situation 4:

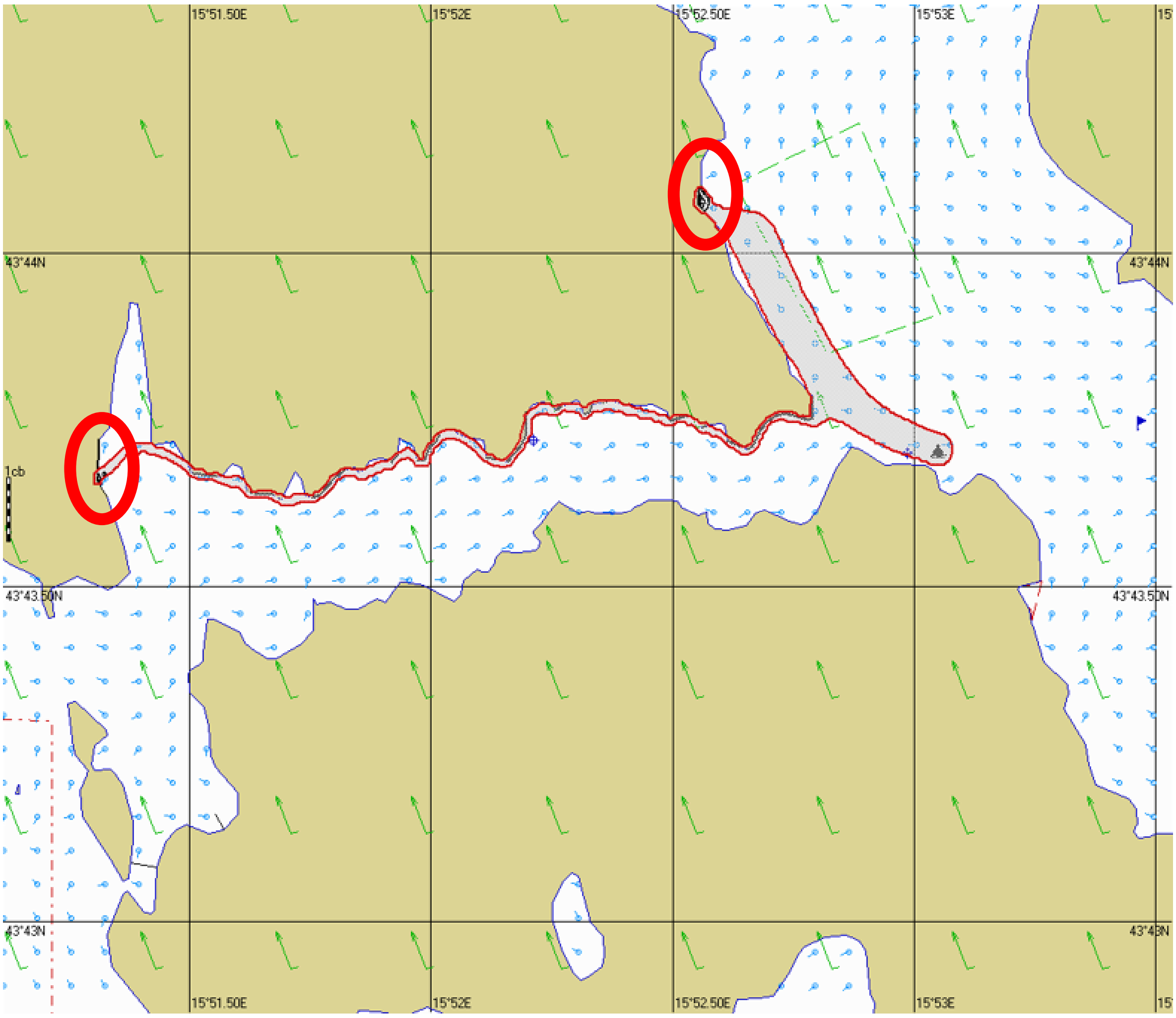
Amount of pollutant in the sea: 40 m3 of IFO
Wind speed and direction: 10 knots SSE
Time: 09.30 AM



The spread of pollutants over a larger coastal area.

Situation 5:

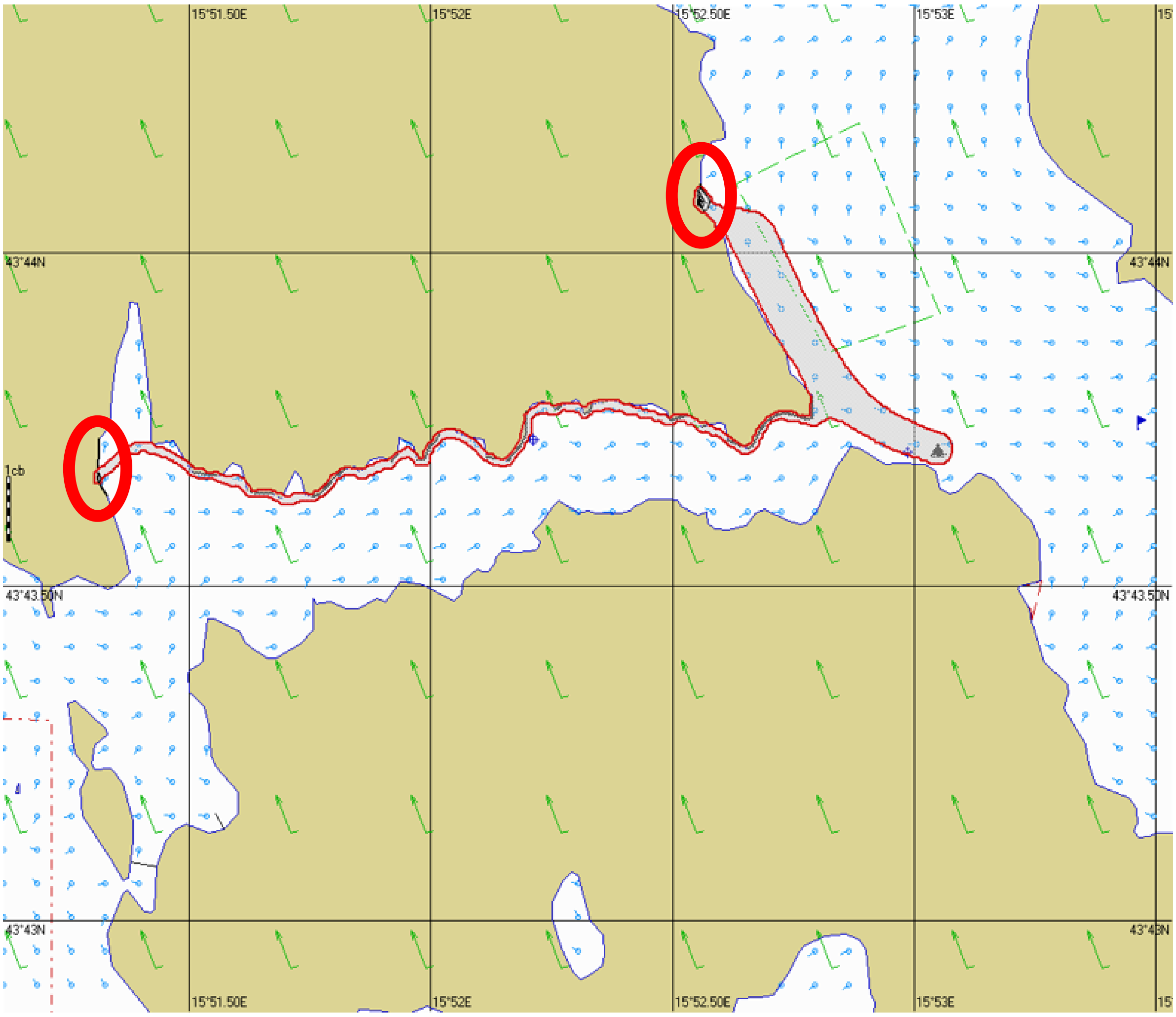
Amount of pollutant in the sea: 40 m3 of IFO
Wind speed and direction: 10 knots SSE
Time: 10.30 AM



After the spread of the pollutants on the two sides of the coast, the pollutants remain in a denser form on the two sides of the coast, depending on the wind direction and currents.

Situation 6:

Amount of pollutant in the sea: 40 m3 of IFO
Wind speed and direction: 10 knots SSE
Time: 11.30 AM



Pollutants linger on two different sides of the coast.

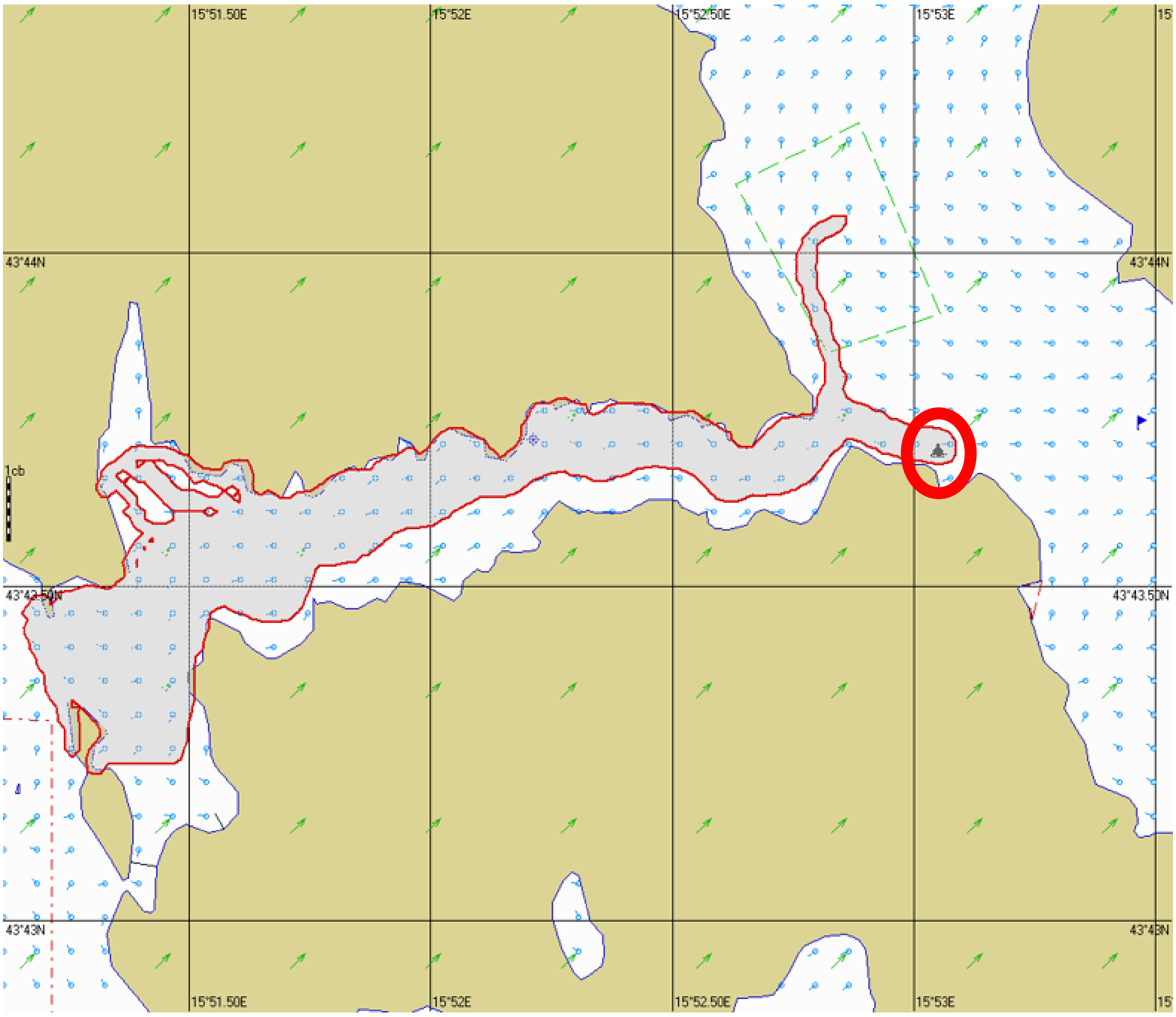
Pollution statistics for simulation 5:

Oil		
Amount spilled	38714 kg	100 %
Amount floating	38032 kg	98.2 %
Amount evaporated	17.4 kg	0.05 %
Amount dispersed	14.8 kg	0.04 %
Amount stranded	650 kg	1.68 %
Amount burned	0.0 kg	0 %
Amount sunk	0.0 kg	0 %
Amount recovered	0.0 kg	0 %
Recovered oil on shore	0.0 kg	0 %
Recovered soil and oil on shore	0.0 kg	
Emulsion		
Amount floating mixture	51016 kg	
Amount recovered mixture	0.0 kg	
Slick		
Max thickness	163 mm	
Slick area	0.0 km2	
Viscosity	2091 cSt	

SIMULATION 6

Situation 1:

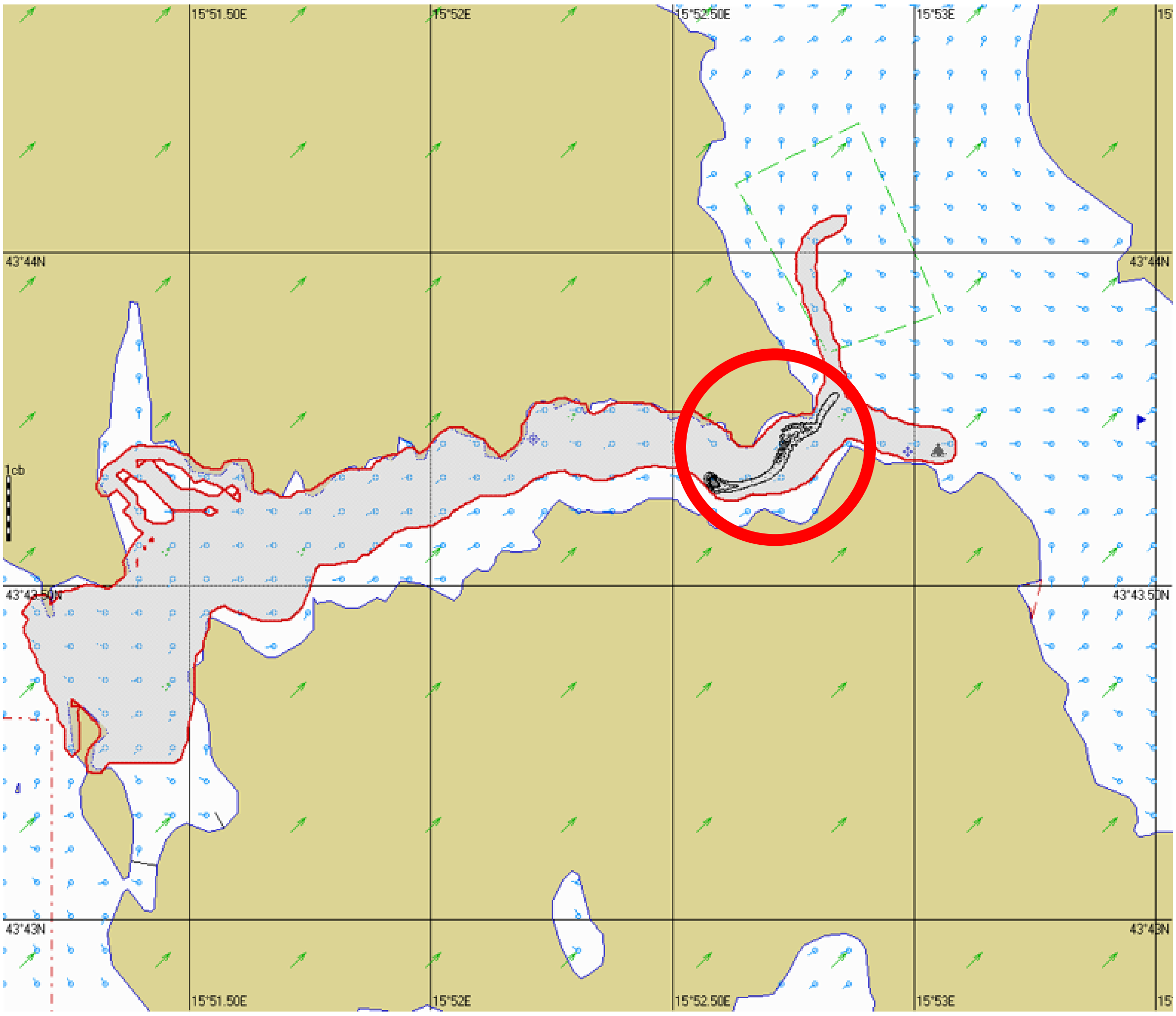
Amount of pollutant in the sea: 40 m3 of IFO
Wind speed and direction: 3 knots SW
Time: 08.00 AM



On the photo there is a 40m3 of IFO located near buoy situated in the entrance/exit of the channel of St. Ante, and the wind is SW (southwest wind, cro. *lebić* or *gerbin*), warm and humid wind of greater strength.

Situation 2:

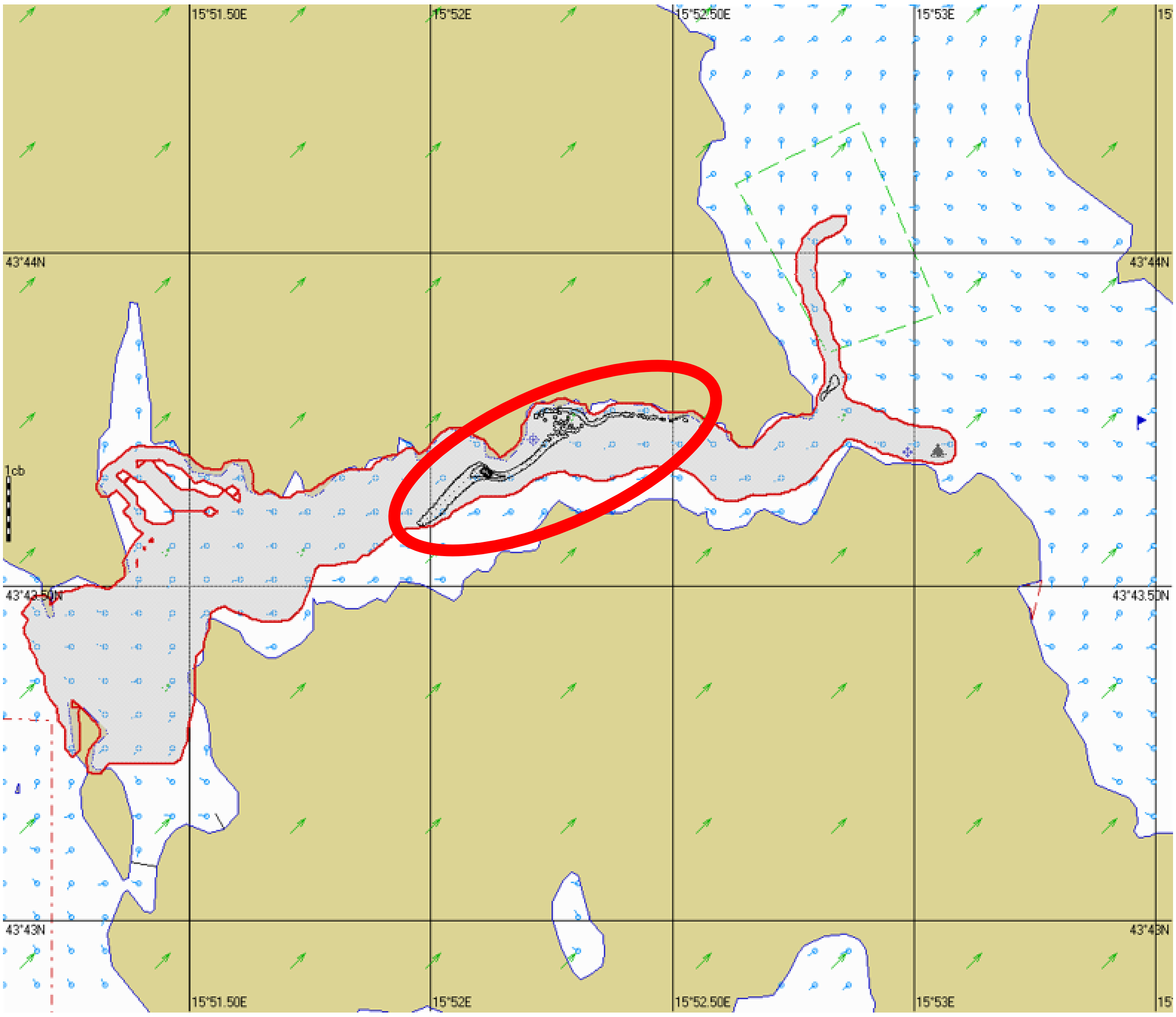
Amount of pollutant in the sea: 40 m3 of IFO
Wind speed and direction: 3 knots SW
Time: 08.30 AM



Pollution spreads in a thick form through the channel of St. Ante, but it does not yet reach the coastal areas.

Situation 3:

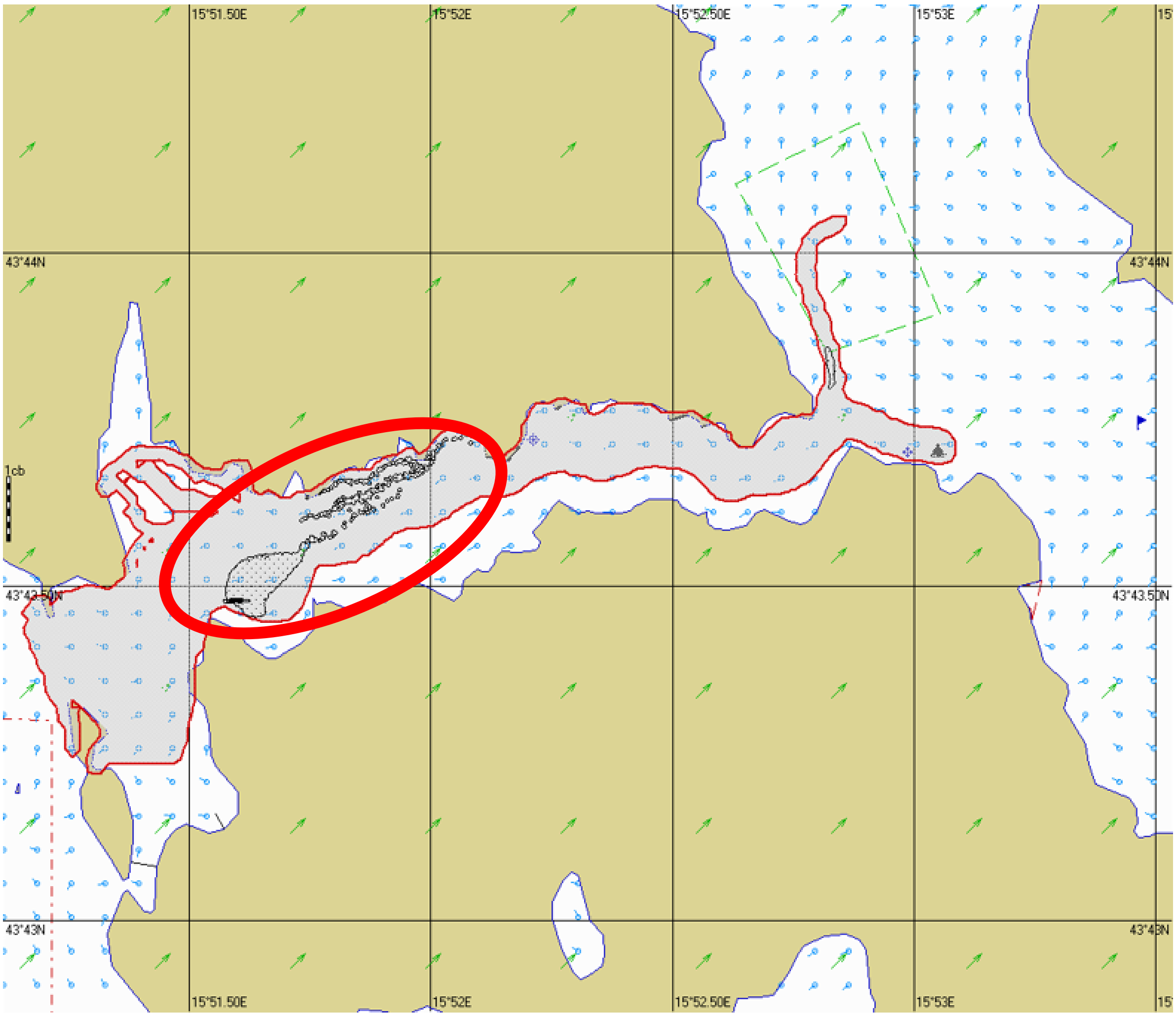
Amount of pollutant in the sea: 40 m3 of IFO
Wind speed and direction: 3 knots SW
Time: 09.00 AM



Pollution spreads and affects coastal areas.

Situation 4:

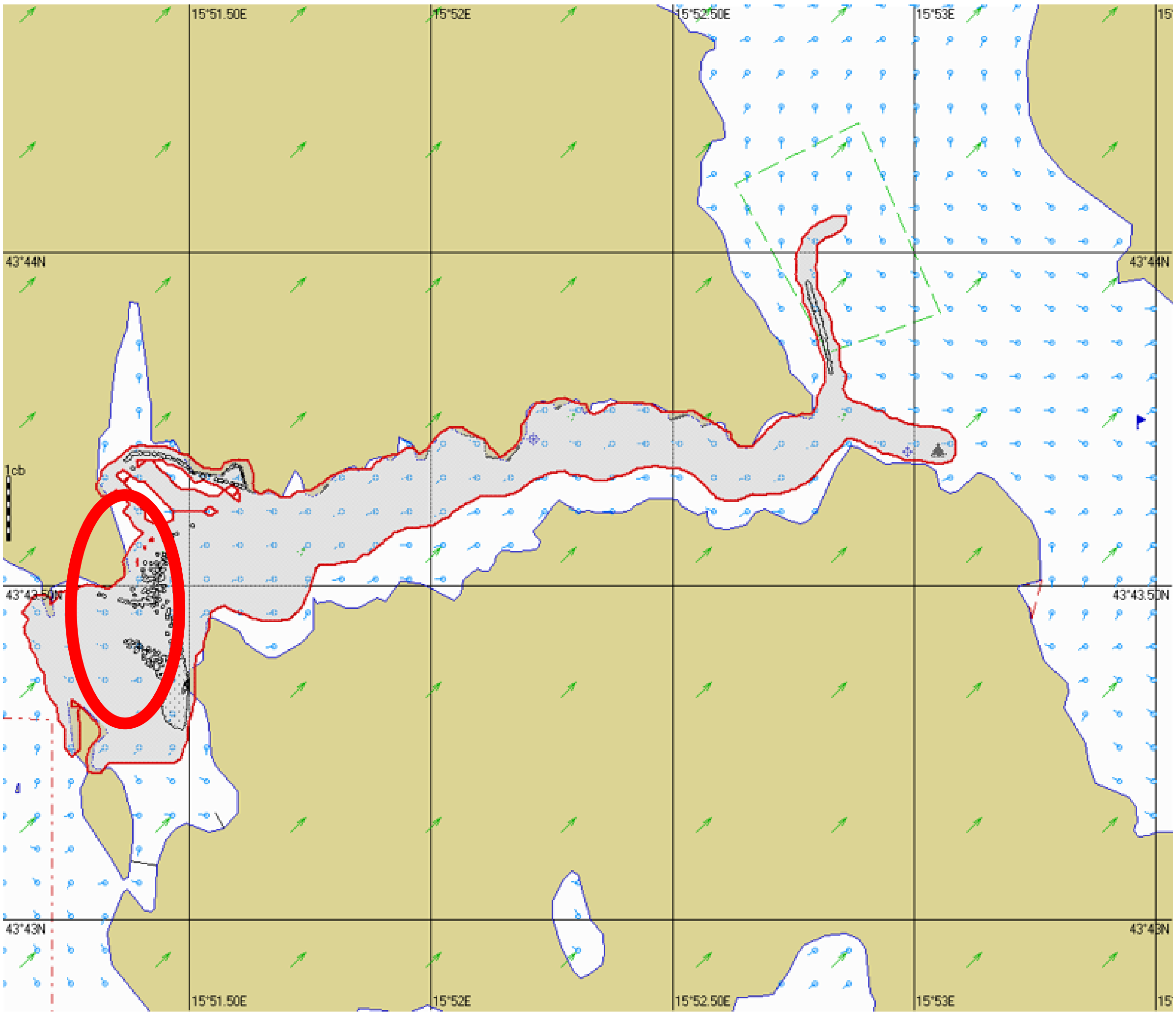
Amount of pollutant in the sea: 40 m3 of IFO
Wind speed and direction: 3 knots SW
Time: 09.30 AM



Pollution spreads through the channel of St. Ante.

Situation 5:

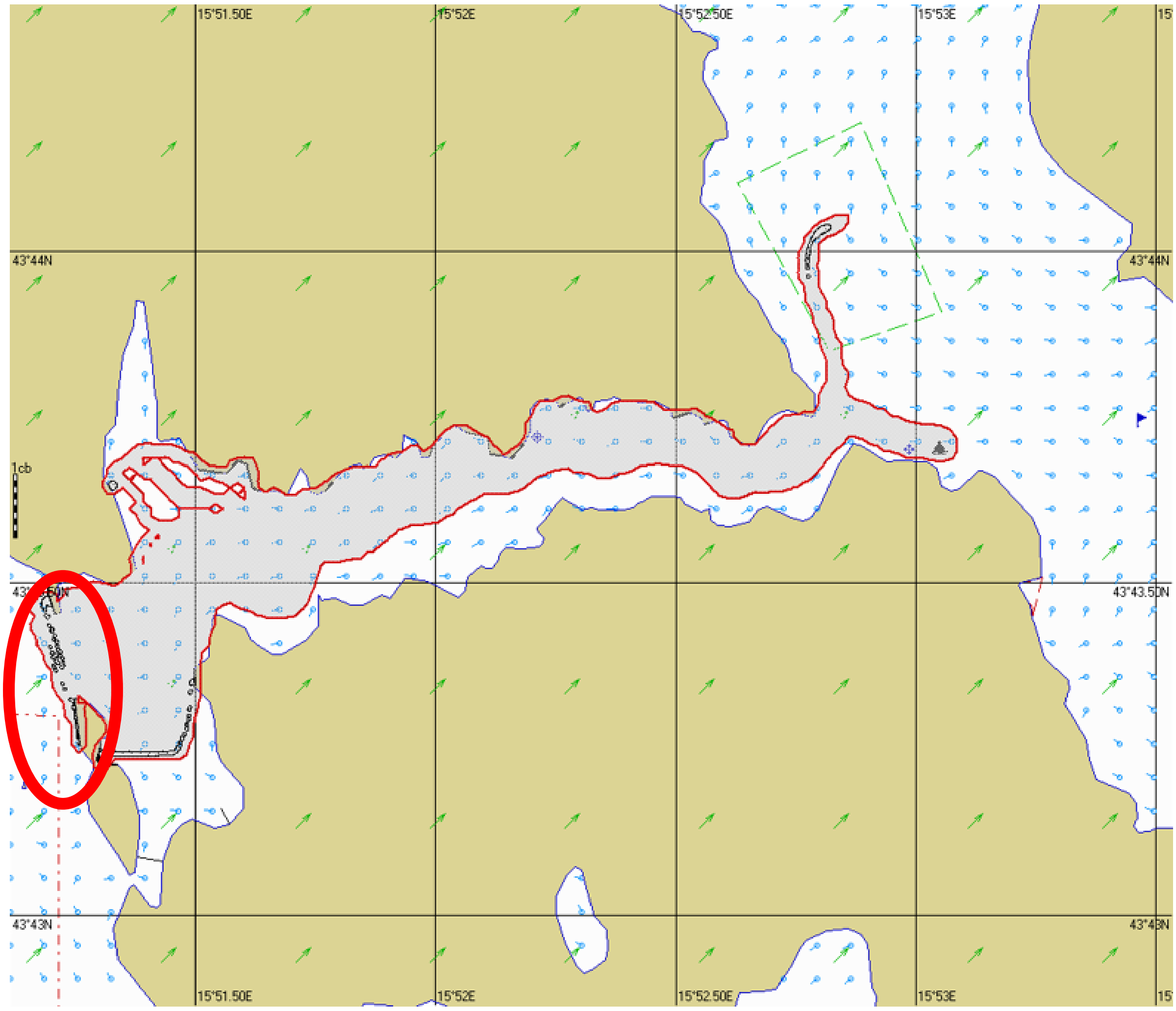
Amount of pollutant in the sea: 40 m3 of IFO
Wind speed and direction: 3 knots SW
Time: 10.00 AM



Pollution spreads rapidly towards the open sea.

Situation 6:

Amount of pollutant in the sea: 40 m3 of IFO
Wind speed and direction: 3 knots SW
Time: 11.00 AM



The pollution spread into the open sea.

Pollution statistics for simulation 6:

Oil		
Amount spilled	38714 kg	100 %
Amount floating	38238 kg	98.8 %
Amount evaporated	54.2 kg	0.14 %
Amount dispersed	0.3 kg	0 %
Amount stranded	421 kg	1.09 %
Amount burned	0.0 kg	0 %
Amount sunk	0.0 kg	0 %
Amount recovered	0.0 kg	0 %
Recovered oil on shore	0.0 kg	0 %
Recovered soil and oil on shore	0.0 kg	
Emulsion		
Amount floating mixture	43784 kg	
Amount recovered mixture	0.0 kg	
Slick		
Max thickness	125 mm	
Slick area	0.0 km2	
Viscosity	1418 cSt	