Iceland
Liechtenstein
Norway grants

WOSUP

# Removing rubbish from the oceans

Direção-Geral de Política do Mar

REPÚBLICA PORTUGUESA
MAR

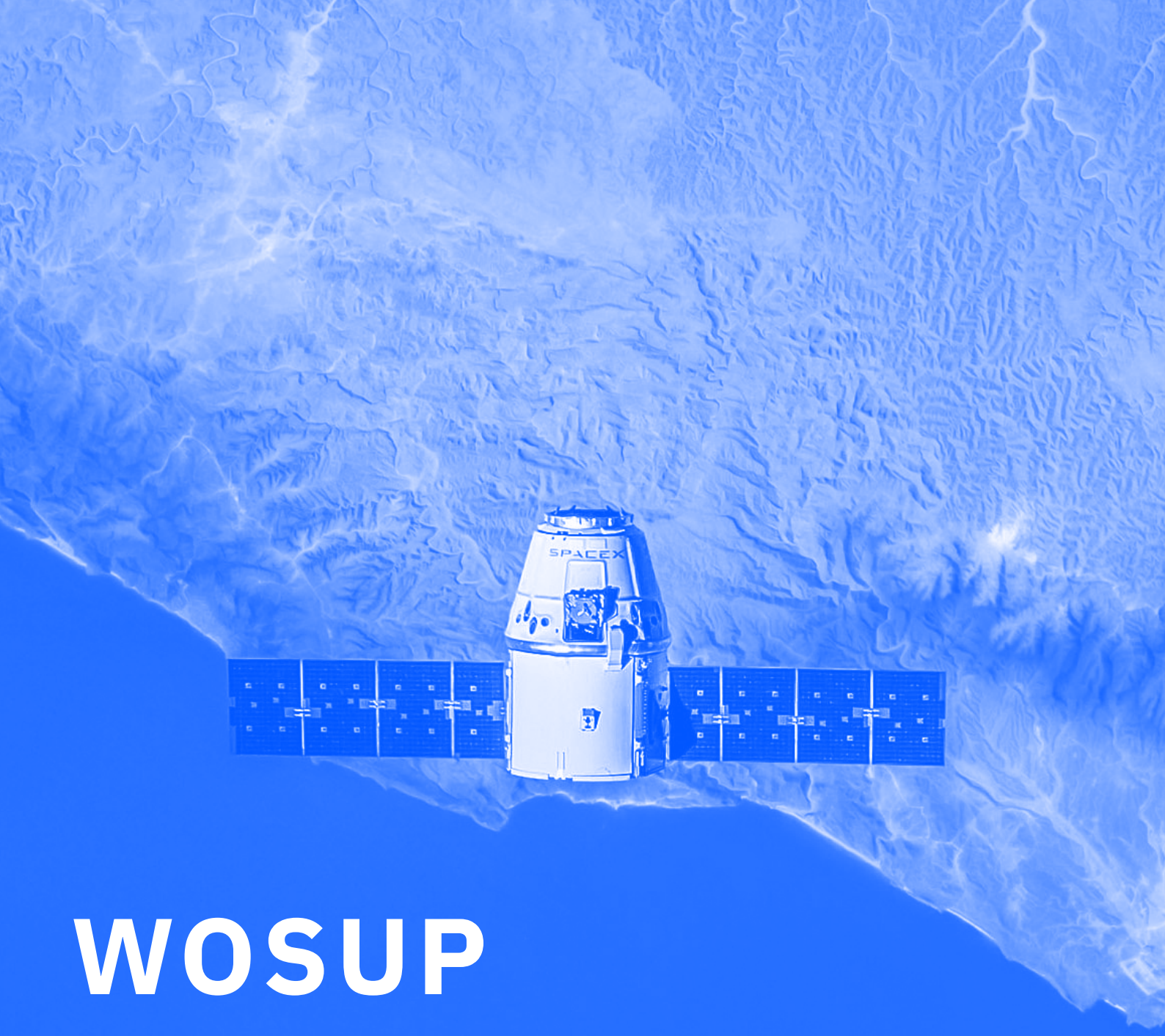
# INTRODUCTION

## The oceans face several threats, pollution being one of the biggest. More than 80% of the pollution that reaches the oceans originates on land and is transported to the oceans through rivers and streams resulting from intentional or unintentional discharges.

It is estimated that at least 5 million tonnes of waste are dumped into the oceans every year, with most of it (80%) originating in cities as a result of poor solid waste management.

Plastic is one of the main wastes that has been polluting the oceans. The most recent estimates of the United Nations Organisation (UNO), point to something like 8 million tons of plastic entering the oceans every year. According to the UN, 60 to 80% of all the rubbish in the sea is plastic, and by 2050, there may be more plastic than fish in the sea. Litter in the marine environment is already a global challenge similar to climate change. And the problem, which goes far beyond what is visible, is present in almost all coastal areas of the world, bringing imbalance to both flora and fauna and compromising this vital resource for humanity.

**Thousands of marine animals every year are killed or affected by the plastic waste in the oceans, either by strangulation or ingestion of this debris. Nets, fishing gear and abandoned pieces of plastic can suffocate and crush coral reefs and sensitive marine plant ecosystems.**




# WOSUP - A POSSIBLE SOLUTION

Plastic, unlike organic materials, does not disintegrate in nature, accumulating in the environment, especially in the oceans. Plastic undergoes fragmentation processes through sunlight, salt water and even waves, breaking it down into smaller and smaller pieces.
A simple plastic water bottle can take up to 500 years to break down into microscopic fragments. Microplastics are also present in products that we consume daily as well as cosmetics and personal care products that many times end up in the oceans.

WOSUP aims to promote the removal of rubbish from the oceans, more precisely the removal of plastic and its derivatives, based on the development of a technological solution that intends to enhance and leverage the discovery and processing of the location and size of waste accumulations, so that, subsequently, specialised vessels can be notified to collect the plastic, considering its location, size and the best route to optimise its journey, taking into account the waste it can carry.

**The aim is to integrate and process satellite images, drones and information from maritime probes, to build algorithms for the detection of types of plastics in the oceans and to generate operational reports and optimised collection routes, promoting the rapid and serial collection of waste for later reuse or recycling.**

With a more assertive identification of the large concentrations of litter in the ocean and creating the necessary conditions to increase the efficiency of the collection activity, it is expected that the volume of plastic collected based on the solution being developed will be much higher than the one collected today, also ensuring a higher volume of plastic whose destination will be recycled or reused.

In order to ensure that the solution is scalable and has coverage across the globe, satellite images will be used to scan the oceans. Subsequently, a second scan is carried out, where necessary, using drones, in order to complement the first scan with a focus on image detail to determine an approximation of the size of the detected debris island and to understand what type of waste was found, with the purpose of being catalogued to optimise the collection process.

**All these algorithms will produce succinct and easy-to-understand reports that will be very close to what the logistics operation of waste collection is, identifying the most critical locations that need waste removal and the respective composition in terms of types of waste.**

# EMPLOYED TECHNOLOGIES

# Overview of multimodal data processing flow

One of the differentiating factors of this project is its ability to analyse multimodal data to classify, detect and infer details about waste present in the ocean.

**In order to achieve the main goal of facilitating waste collection and decreasing the costs of these operations, we have developed a multi-stage processing, analysis and forecasting flow. The first step of the flow consists in the periodic analysis of the most recent satellite images provided by Sentinel 2 and at geographical coordinates of interest, in order to detect islands of debris.**

In the event of detection of a debris island on a satellite image, we proceed to the second step of the flow, which consists of using drone and sonar imagery both to perform a more detailed analysis of the detected debris and to confirm the detections on the satellite image. To do this, it is necessary to first search for drone and sonar images collected within a pre-configured radius, centred at the geographical coordinates of the satellite image, and within a certain time interval. These drone and sonar datasets are obtained through periodic patrols on predefined routes that pass through the geographical coordinates of interest used in the satellite imagery collection.

The existence of drone images is essential to the further execution of the flow, as it is from these that the prediction of the debris weight is made. If they are not present, sonar images are used to assess whether or not there is plastic on the detected island in the satellite image. If waste is detected in the sonar image, the flow is paused until the drones perform another patrol and pass again through that region. If debris are detected in the new drone imagery, the flow is resumed. In contrast, if there is no sonar and drone imagery, the flow is terminated.

If there are drone images corresponding to the satellite image, we use a Machine Learning algorithm to detect and classify the waste, which then allows us to determine the approximate material properties for inferring the weight. Weight prediction is important for calculating efficient routes for waste collection.

**After this processing, we obtain the data needed to create a new report for the collection of the detected island, and enable the calculation of the most efficient routes and waste movement prediction at the time the operator views the operational report.**

# Integration and processing of satellite, drone and sonar images

For the development of this project, the integration with various data sources was done using satellite images (Fig. 1), drone (Fig. 2) and sonar (Fig. 3).

Given that one of the objectives is the detection of waste (in this case, plastic, marine litter, styrofoam boxes, etc.), in images collected by the different sources. We selected the YOLOv5 architecture for this task as it is currently the most popular object detection algorithm. Furthermore, due to the inherent differences between images obtained from the previously mentioned sources, we opted to separately train a ML model for each of them.

**Thus, taking into account the type of source from which the image was captured , the respective model performs the detection of waste (placing the bounding boxes around the detected objects) in each image and classifies them as plastic, marine debris, etc.**

Fig.1 Satellite image

Fig. 2 Drone image

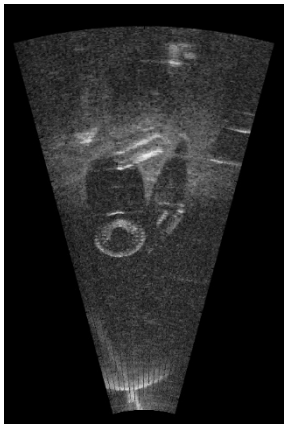


Fig. 3 Sonar image

# Classifying and predicting the weight of waste

After the detection and classification of waste at sea, another of the project's objectives is to predict the weight of this waste.

Of the three data sources available, only drone images allow this task to be carried out, since it is in this type of image that the dimensions of the detected waste and its material can be more accurately predicted. In addition, it is also necessary to know some characteristics of the drone model (altitude from which the images were obtained, focal length, sensor height and sensor width) from which the images were taken, as well as their geographical location.

Thus, after detecting and classifying the various residues, knowing the drone characteristics (altitude, focal length, sensor height, sensor width), and in order to estimate the weight of the detected objects, the following steps were taken:

**1. To know the dimensions (height, width) of the bounding box for a given object;**

**2. Determine the actual size of the target (height/width) according to the formula,**

$$\textit{real height/width (cm)} = \frac{\textit{object height/width (px)} \times \textit{altitude (mm)} \times \textit{sensor height/width (mm)}}{\textit{focal length (mm)} \times \textit{image height/width (px)}} \times 0.1$$

**3. Determine the area of the object:**

$A\ (cm^2) = real\ height\ (cm) \times real\ width\ (cm)$;

**4. Assuming a value for the density, *p*, according to the type of material detected, and an approximation for the thickness, *e*, determine the weight:**

$P\ (kg) = p \times A \times e \times 0.001$

# Forecasting the movement of waste in the ocean

The focus of WOSUP is the removal of rubbish from the oceans, where weather factors such as sea currents, wind, waves, etc. influence the movement of waste at the surface. Thus, from the moment data is collected by a satellite, drone or sonar until the moment the vessel goes to collect the waste, it ends up moving to a different location from where it was originally detected.

Thus, in order to speed up the operation of waste collection at sea by the vessels, it was necessary to develop an algorithm that predicts a possible final location for the detected waste.

**The algorithm used predicts a possible final location based on the initial location of the waste, the information on the currents for that location and the time elapsed between the moment when the data was collected identifying the waste and the moment when the waste was collected.**

# Calculation of the most efficient routes for waste collection by boat

Ambitioning the removal of litter from the oceans, one of the most relevant tasks is indeed the notification of specialised vessels for litter collection.

**Thus, it is important to create the necessary conditions for an efficient collection activity, in order to allow the collection to have an economic return, where the vessel collects the maximum amount of debris it can, covering the shortest possible path.**

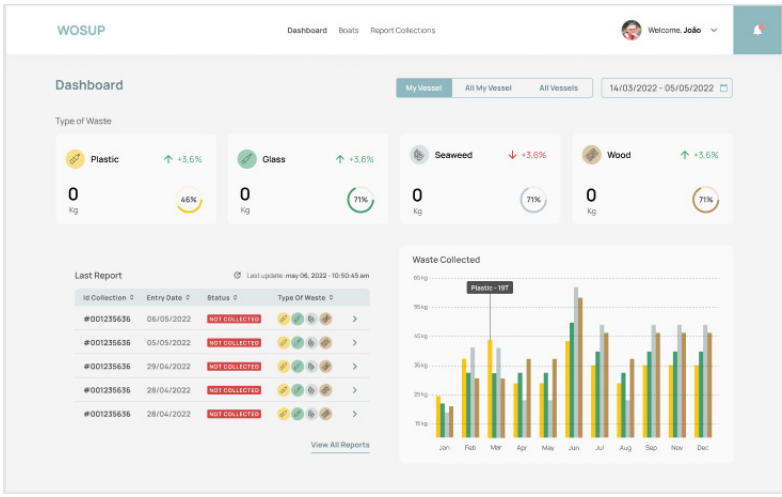
With the aim of satisfying this need, we used the OpenDrift project to plot an optimised route.
To perform this task, we need to know the debris collection location, as well as the location of the boat and the boat capacity (amount of debris it can collect).


55+
23+
THE PLATFORM

**The interaction with the solution will be done through a web platform by the waste collection entities. The images below summarise the main functionalities of the platform.**

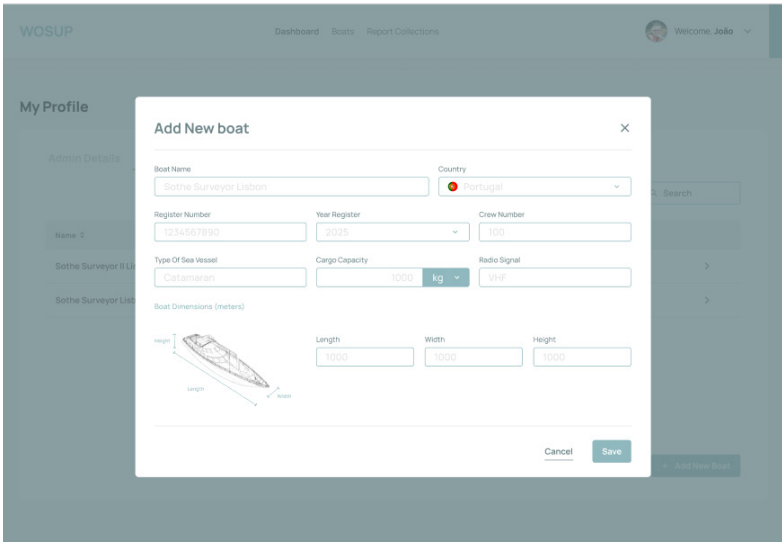
# Dashboard

The dashboard displays detailed information on the type of plastic that has already been collected by the entity that is logged on, it also allows the amount of waste collected over the months in Kg and by type to be displayed, as well as the latest operating reports.



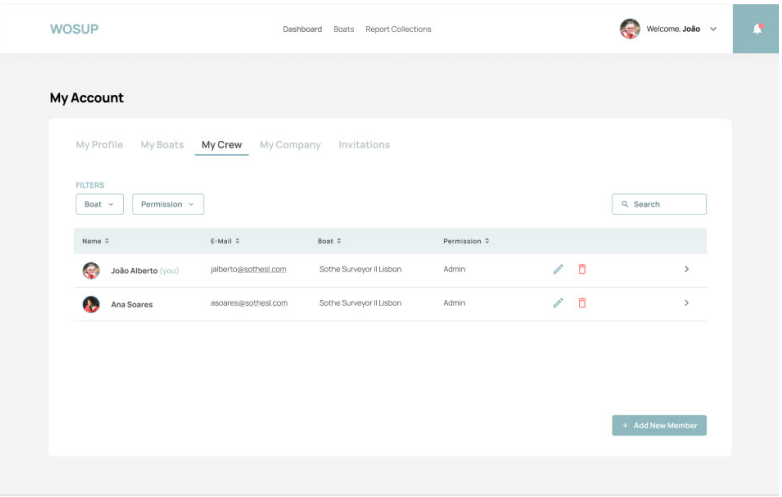

# Registering Vessels

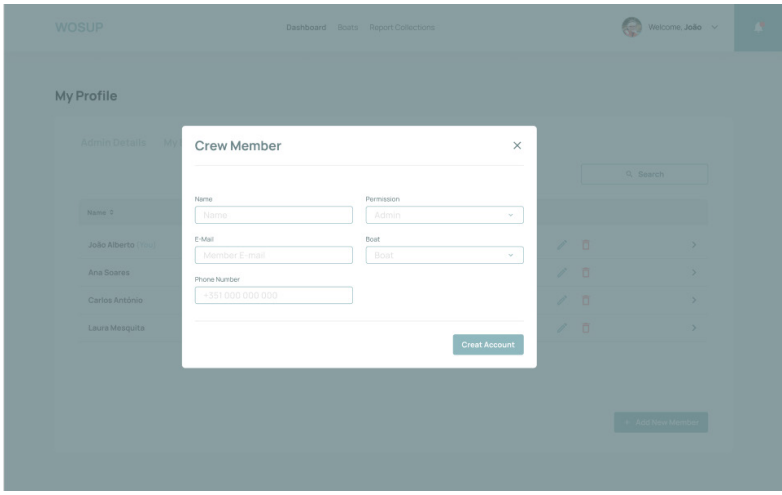
Registration of the boats is mandatory in order to carry out waste collections. It is the responsibility of the entity's manager to register his or her boats.



# Registering Workers

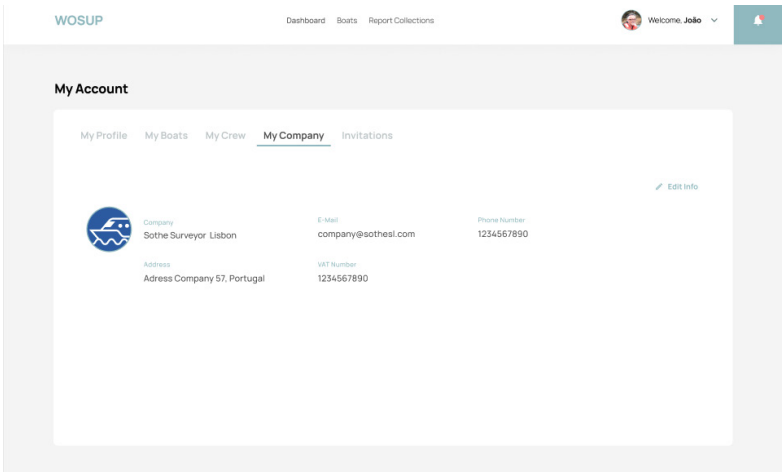
The waste collection by the entities is carried out by people, thus the registration of the crew that uses the boats for waste collection is mandatory.



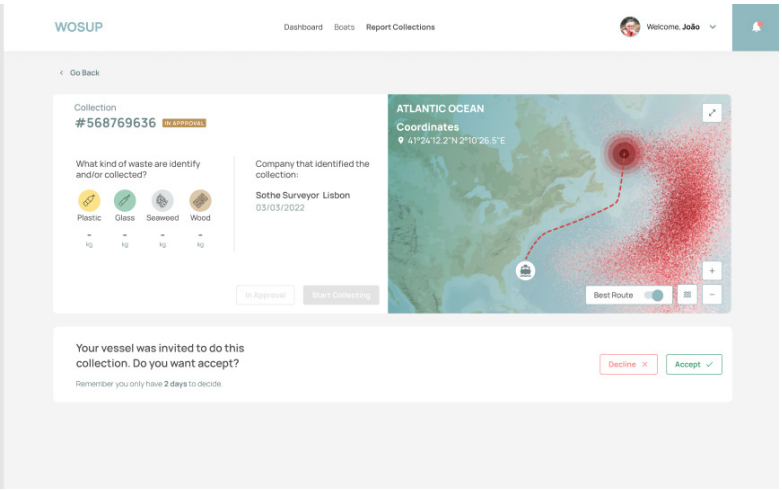

# Company registration

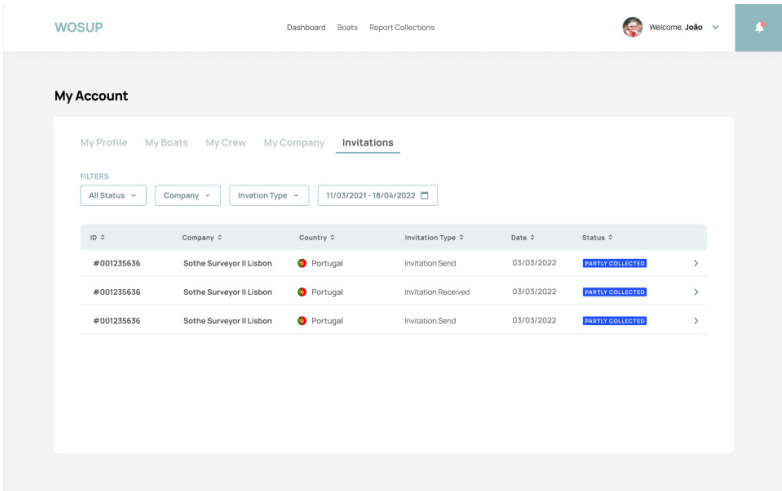
When registering on the platform or later, the waste disposal company must register the company so that it can make use of information such as operational reports and can use the platform as a whole.



# Invitation to collections

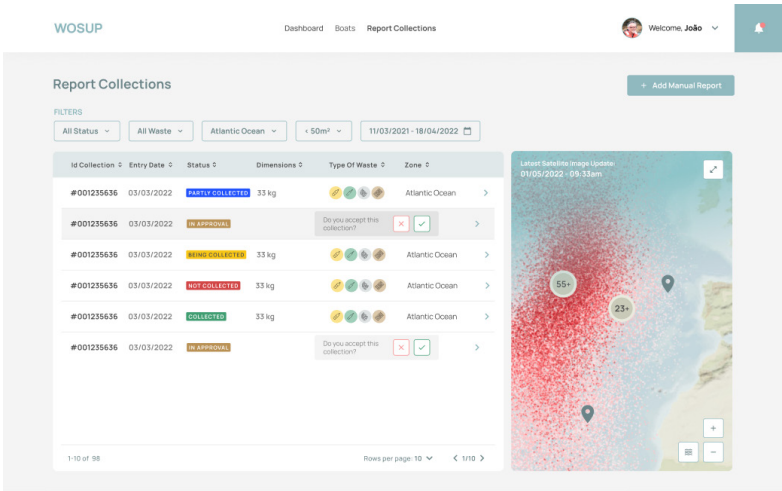
The sharing of rubbish collections is possible in WOSUP. A vessel of one entity can recommend another entity to perform a collection or share the same collection in order to help it in the removal of waste.



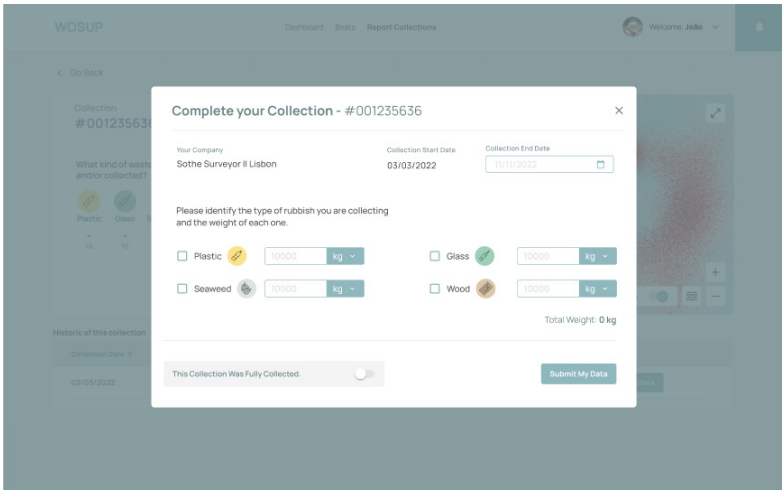

# Operational reports

Operational reports are created when a rubbish island is found in the ocean, either automatically or manually, and contain all the necessary information for the rubbish collection entities to be able to proceed with the removal of these islands.



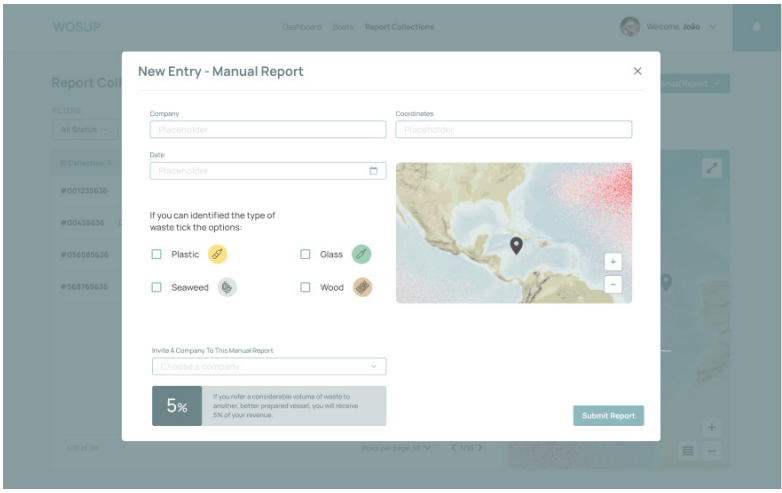
# Recording of collections

The collections that are made must be registered by the boats responsible for the collection. The date the collection took place, the type of waste collected and its weight must be filled in.




# Manual Reporting

The manual reporting allows a vessel to register on the platform if it finds drifting rubbish. Entities registered on the platform will have access to this reporting and will be able to perform the collection if they wish.



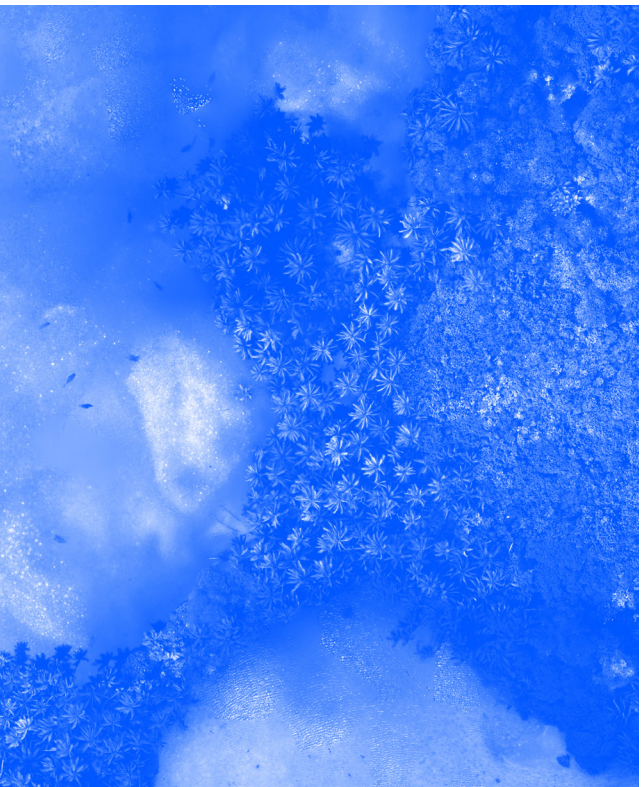
# APPLICABILITY

The WOSUP project aims to solve some challenges such as to leverage the discovery and processing of the location and size of waste, to support the increase of resource efficiency linked to companies in the maritime sector and the reduction of ocean pollution.

**The entities that have access to the WOSUP platform will be able to use it in any type of vessel that is destined to collect waste in the seas and oceans, this way the use of the platform will be transversal and will be possible to use anywhere in the world.**

As mentioned previously in chapter 4, where the presentation of the WOSUP platform was made, this solution is intended for all entities involved in waste collecting.

**They will have at their disposal a solution that will allow them to know the location of the waste islands, make their respective collections, register new clusters found, among others, as already mentioned.**



# IMPACT

**Several studies already point out that the pollution generated by microplastics is one of the main risk factors for health.**

The University of Osnabrück in Germany, points out that microplastics have the ability to absorb toxic products found in the oceans such as pesticides, heavy metals and other types of organic pollutants. These contaminated microplastics, over time, end up being ingested by plankton and small animals that when eaten by larger fish, spread the intoxication. When we get to the end of the food chain, humans by feeding on these fish, are themselves ingesting the plastic and the pollutants that have accumulated along the chain. Having said this, the impacts of microplastics in nature are highly harmful not only because of the previous question but also because these microplastics block the digestive tract of small animals and the intoxication itself by products present in the plastic might even result in death.

## This solution aims not only to raise society's awareness to preserve the planet but also to directly help in the removal and reduction of plastic that reaches the seas and oceans.

The consequent reduction of plastic makes it possible to reduce the number of animals frequently suffocated by rubbish, reducing the ingestion of these plastics and preventing death by malnutrition which results from having their stomachs full of plastic and the consequent inability to ingest food. Besides for animals, the intoxication that exists along the food chain as a result of the ingestion of plastics will be diminished as a result of this reduction of plastics in the oceans.

**It will improve the quality of life of marine species, the cleanliness of the oceans and the risks to human health, through the removal of plastic and its derivatives.**

# CONCLUSION AND FUTURE WORK

The rubbish that is currently polluting the seas and oceans is a problem that is being fought against. For years the rubbish in the seas and oceans has been accumulating, part of it ends up sinking and depositing on the bottom of the oceans and other is circulating in ocean currents creating difficulty for the rubbish collecting entities to track it. The WOSUP platform tries to solve this difficulty that collection companies have, increasing their efficiency.

**It is necessary to take measures on land, it is essential to think of a solution that minimises the maximum rubbish that reaches our oceans. It is estimated that 1.15 to 2.41 million tonnes of plastic arrive in the oceans every year, mainly from rivers.**

There are now policies and legislation in the European Union aimed at improving waste management, reducing packaging and increasing recycling rates mainly for plastics, improving waste water treatment and generally using resources more efficiently.

**Ocean pollution does not only occur from land based waste but also from ship and port waste to which there are also directives to reduce their pollution. It is necessary to improve the implementation of these waste prevention and reduction policies, which could bring huge benefits.**

# Contributors

Stefan Loureiro

Diogo Guedes

ubiwhere