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### D3.2.3 Monitoring plan to evaluate the impact of plastic pollution

Activity 3.2

WP 3

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## PROJECT MARLESS

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## 1. Adriatic sea

The Adriatic Sea is an elongated semi-enclosed basin within the Mediterranean Sea, extending for 138,600 km<sup>2</sup> and surrounded by six nations, namely Albania, Montenegro, Bosnia, and Herzegovina, Croatia, Slovenia, and Italy. The shape can be approximated as a tilted rectangle, about 800 km long and 200 km wide (Ferrarese et al., 2009). Due to its geographical position and surrounding orography, the Adriatic Sea can be considered a unique testbed where a number of processes important for driving the circulation of the Eastern Mediterranean Sea happen (Malanotte-Rizzoli et al., 2014).

The Adriatic Sea's bathymetry is characterised by latitudinal and longitudinal asymmetries. Notably, longitudinal asymmetries are largely due to the presence of a significant number of islands along the eastern coast and their absence along the west coast. An additional contributing factor to longitudinal asymmetries is the difference in orographic features between the Dinaric Alps close to the eastern sea and the Apennines westwards, resulting in a different topography of the coastal area.

Considering the bathymetric configuration, the Adriatic Sea is divided into three distinct sub-areas: Nordic, Middle, and South Adriatic. The average depth ranges from about a maximum depth lower than 100 m in the North section and a maximum depth of 1200 m in the South Adriatic Pit. The northern part consists of sediment-loaded beaches, where sediments are mainly carried in the area by many Italian rivers discharging into the sea. Instead, the Middle and South areas are rugged and rocky and lack substantial riverine inputs.

Furthermore, the Adriatic Sea is one of the three Mediterranean sites where density currents can be originated and can be classified as such: the North Adriatic Dense Water (NAdDW), cold and dense shelf water that forms in the northern sector during intense and cold outbreaks in winter, and the Adriatic Deep Water (AdDW) which forms by open ocean convection between late winter and early spring in the center of the permanent cyclonic gyre of the southern Adriatic and vertically mixes the water column up to a variable depth (Paladini de Mendoza et al., 2022). The NAdDW is considered the densest waters of the Eastern Mediterranean, flowing along the western shelf of the Central Adriatic Sea till the Gargano Peninsula after 2–4 months since it has been produced. Once it reaches the edge of the continental shelf it sinks toward the center of the Southern Adriatic along the slope in front of the Gargano promontory or through the Bari canyon, carrying dissolved oxygen, nutrients, particulate matter, and pollutants to deep benthic

ecosystems (ISP). Instead, the AdDW is generated through deep vertical convection, caused by surface heat losses following cold continental wind events occurring in late winter (ISP).

The Adriatic Sea is dominated by the circulation of two main currents, namely the West Adriatic Currents (WAC) and the East Adriatic Currents (EAC) along with two main cyclonic gyres, Bora (from North-East) and Sirocco (from South-East), representing the two principal winds blowing over the Adriatic. The Adriatic basin is characterized by an intense presence of human activities such as marine traffic, recreational activities, fishing, and aquaculture, which represent fundamental economic sources for the surrounding countries. Accordingly, these activities negatively impact the marine ecosystem and significantly contribute to the dispersion of marine litter. Remarkably, marine litter refers to any object which has been artificially manufactured or processed that reaches the marine environment after its use, and marine litter reduction and prevention is part of descriptor 10 of the Marine Strategy Framework Directive (MSFD), designed to achieve Good Environmental Status (GES) in European Waters by 2020.

A considerable portion of marine litter enters the Adriatic basin through the rivers, coastal urban populations, and the remaining through shipping and fishing activities. Indeed, rivers largely contribute to marine litter dispersion in the Adriatic Sea as well as land-based activities. Moreover, microplastic pollution, which poses a high risk to the marine environment, has been found in all abiotic compartments, including beaches, surface waters, sediments, and biota (Schmid et al., 2021). According to Fortibuoni et al. (2021), the Adriatic Sea was the most polluted subregion (590 items/100 m) among the Italian marine subregions between 2015 and 2018. Notably, a number of studies revealed that the spatial distribution of marine litter has targeted the Adriatic region as a preferential area for plastic accumulation within the Mediterranean Sea, due to transboundary effects caused by sea currents (Schmid et al., 2021).

## 2. Sources of litter pollution

### Veneto region

Veneto region has a population of about five million and covers a total area of 18,345 km<sup>2</sup>. City of Venice is the region capital with around 255,000 inhabitants. The city is built on a group of 118 small islands that are separated by expanses of open water and canals. The Venetian Lagoon is an enclosed bay lying between the mouths of Brenta and Sile rivers but also influenced by nearby Po and Piave rivers. Local economy is mainly based on agriculture and tourism, but also textile and glass production while agricultural industry is dominant in the region. The Veneto region in Italy is a popular tourist destination, known for its beautiful cities, canals, and countryside. However, the region also faces significant anthropogenic pressure for litter, due to its large population, high tourism rates, and agricultural activity. One of the main sources of litter in the Veneto region is tourism. Millions of visitors come to the region each year, and many of them leave behind litter, such as plastic bottles, food wrappers, and cigarette butts. This litter can pollute the region's waterways and countryside and can also harm wildlife. Another major source of litter in the Veneto region is agriculture. The region is home to a large agricultural industry, which produces a variety of crops, including fruits, vegetables, and grains. Agricultural activities can generate a significant amount of litter, such as plastic mulch, fertilizer bags, and pesticide containers. Fisheries are a significant source of marine litter, which can have a devastating impact on marine life and ecosystems. In addition to tourism, fishery and agriculture, other sources of litter in the Veneto region include industry, construction, and transportation. These activities can generate a variety of litter, such as plastic bags, metal cans, and glass bottles. This litter can also pollute the region's waterways and countryside. The anthropogenic pressure for litter in the Veneto region is a serious problem. Litter can pollute the region's waterways and countryside, harm wildlife, and reduce the region's aesthetic appeal. To address this problem, it is important to reduce the amount of litter that is generated and to improve waste management practices. The Venetian Lagoon is a UNESCO World Heritage Site, but it is also one of the most polluted lagoons in the world. Plastic pollution is a major problem in the lagoon, and it is estimated that there are over 300 million pieces of plastic floating in the water. This plastic pollution is harming the lagoon's marine life and ecosystems. The cities of the Veneto region, such as Venice and Padua, are also facing a problem with litter. Tourists and residents alike often litter the streets and canals of these cities. This litter is unsightly and can also pollute the cities' waterways.

## Friuli Venezia Giulia Autonomous Region

Friuli-Venezia Giulia is a region in northeastern Italy with a population of about 1.2 million people. The regional capital is Trieste, which has a population of about 204,000 inhabitants. The region is known for its beautiful scenery, including the Dolomites Mountain range and the Adriatic Sea. Friuli-Venezia Giulia is also a popular tourist destination, with visitors coming to enjoy the region's natural beauty, culture, and cuisine. However, Friuli-Venezia Giulia also faces significant anthropogenic pressure for litter. This pressure is due to a number of factors, including the region's population, tourism industry, and agricultural activity. One of the main sources of litter in Friuli-Venezia Giulia is tourism. Millions of visitors come to the region each year, and many of them leave behind litter, such as plastic bottles, food wrappers, and cigarette butts. This litter can pollute the region's waterways and countryside, and can also harm wildlife. Another major source of litter in Friuli-Venezia Giulia is agriculture. The region is home to a large agricultural industry, which produces a variety of crops, including fruits, vegetables, and grains. Fisheries are a major contributor to marine pollution. This pollution can come from a variety of sources, such as lost fishing gear, waste generated during fishing operations, and waste generated on fishing vessels. Agricultural activities can generate a significant amount of litter, such as plastic mulch, fertilizer bags, and pesticide containers. This litter can also pollute the region's waterways and countryside. In addition to tourism and agriculture, other sources of litter in Friuli-Venezia Giulia include industry, construction, and transportation. These activities can generate a variety of litter, such as plastic bags, metal cans, and glass bottles. This litter can also pollute the region's waterways and countryside. The anthropogenic pressure for litter in Friuli-Venezia Giulia is a serious problem. Litter can pollute the region's waterways and countryside, harm wildlife, and reduce the region's aesthetic appeal. To address this problem, it is important to reduce the amount of litter that is generated and to improve waste management practices.



## Emilia-Romagna Region

Emilia-Romagna located in the northern Italy covers an area of 22,446 km<sup>2</sup> with a population of 4.4 million. Emilia-Romagna considered one of the richest European regions and the third wealthiest Italian region with its developed agricultural and car industry inland while tourism is dominant on the coast, especially in Rimini. Emilia-Romagna is a region in northern Italy that is known for its beautiful scenery, delicious food, and rich culture. It is also one of the wealthiest regions in Italy, with a thriving agricultural and car industry. However, Emilia-Romagna also faces a number of environmental challenges, including anthropogenic pressure for litter.

One of the main sources of litter in Emilia-Romagna is tourism. The region attracts millions of visitors each year, many of whom leave behind litter, such as plastic bottles, food wrappers, and cigarette butts. This litter can pollute the region's beaches, countryside, and waterways.

Another major source of litter in Emilia-Romagna is agriculture. The region is home to a large agricultural industry, which produces a variety of crops, including grapes, tomatoes, and wheat. Agricultural activities can generate a significant amount of litter, such as plastic mulch, fertilizer bags, and pesticide containers. Fishing is a major contributor to the problem of marine plastic pollution. This pollution can come from lost fishing gear, packaging materials, and other sources. This litter can also pollute the region's environment.

In addition to tourism and agriculture, other sources of litter in Emilia-Romagna include industry, construction, and transportation. These activities can generate a variety of litter, such as plastic bags, metal cans, and glass bottles. This litter can also pollute the region's environment.

The anthropogenic pressure for litter in Emilia-Romagna is a serious problem. Litter can pollute the region's environment, harm wildlife, and reduce the region's aesthetic appeal. To address this problem, it is important to reduce the amount of litter that is generated and to improve waste management practices.

Plastic pollution on the Adriatic coast, the coast of Emilia-Romagna is a popular tourist destination, but it is also a major source of plastic pollution. A recent study found that over 80% of the litter found on the Adriatic coast is made of plastic. This plastic pollution is harming the coast's marine life and ecosystems. The Po River Valley is the agricultural heartland of Emilia-Romagna.

However, the river valley is also facing a growing problem with litter. Agricultural activities are a major source of litter in the river valley, but litter from industry, construction, and transportation is also a problem. This litter is polluting the Po River and its tributaries, and is harming the river's aquatic life.



## Apuglia Region

Puglia has a population of about four million people and an area of 19,345 km<sup>2</sup>. It is in the south of Italy where it stood out as the region with the most thriving economy that expanded between 2007 and 2013 which put a pressure on the hydrogeological system of the region. Industries are specializing areas such as food processing and vehicles in Foggia; footwear and textiles in the Barletta province, wood and furniture in the Murge area to the west, steel and oil production in Taranto and Chemical industrial park in Brindisi. One of the main generators of waste in the Puglia region is tourism. Tourism is an important economic activity in the Puglia region and therefore an important source of waste. Tourists often leave litter on beaches, in public parks and on the streets. Apuglia region is also an important agricultural region, and agricultural activities can generate a significant amount of waste. This includes plastic mulch, fertilizer bags, and pesticide containers. Industry is also an important source of waste in the Apuglia region. Fishing is a significant source of marine litter. This litter can include abandoned, lost, or discarded fishing gear, as well as waste from fishing operations and fishing vessels.

Industrial waste includes plastic bags, metal cans, and glass bottles. Construction activities can also generate a significant amount of waste. These wastes include scrap metal, wood scraps, and concrete waste. Transportation activities can also generate waste such as cigarette butts, fast food packaging, and plastic bottles. In addition to these major contributors, there are several other waste generators in the Puglia region, such as illegal dumping and littering by individuals.

## Istria Region

Istria region is a region located in West Croatia, covering an area of 2,813 km<sup>2</sup> with a population of about 208,000 people. Regional economy is mostly based on tourism (especially in Poreč, Rovinj and Pula) but also fisheries, agronomy, cement industry and shipyard industry in Pula which is also the region capital.

There are several different litter generators in the Istra region. One of the main generators is tourism. The region attracts millions of visitors each year, many of whom leave behind litter, such as plastic bottles, food wrappers, and cigarette butts. This litter can pollute the region's beaches, countryside, and waterways. Fisheries are a major source of litter in the marine environment. This litter can come from a variety of sources, including abandoned, lost, or otherwise discarded fishing gear, operational waste, and vessel waste. Another source of litter in the Istra region is agriculture. The region is home to a large agricultural industry, which produces a variety of crops, including grapes, olives, and wheat. Agricultural activities can generate a significant amount of litter, such as plastic mulch, fertilizer bags, and pesticide containers. This litter can also pollute the region's environment.

Other sources of litter in the Istra region include industry, construction, and transportation. These activities can generate a variety of pollutants, including air pollution, water pollution, and noise pollution. Additionally, these activities can lead to habitat destruction and fragmentation.

The litter generators in the Istra region are having a significant impact on the region's environment. It is threatening the region's biodiversity, water resources, and coastal ecosystems. To address this problem, it is important to reduce the amount of litter generated by human activities and to protect the region's remaining natural habitats.

## Dubrovnik-Neretva County

Dubrovnik is the southernmost larger city of Croatia. The city with its surrounding villages covers the area of 143.35 km<sup>2</sup> and has around 41,500 inhabitants. Tourism and maritime industry have the largest contribution to the local economy. The city is known for hosting the largest number of cruise ships in Croatia.

Dubrovnik Neretva County is a popular tourist destination, with a thriving agricultural and industrial sector. However, this economic activity also generates a significant amount of litter, from tourism-related waste such as plastic bags and food wrappers, to agricultural waste such as fertilizer bags and pesticide containers, to industrial waste such as metal cans and glass bottles. Construction activities also generate a significant amount of litter, such as scrap metal, wood scraps, and concrete debris. Transportation activities can also generate litter, such as cigarette butts, fast food wrappers, and plastic bottles. Finally, fishery is also a major source of litter in Dubrovnik Neretva County, with lost or discarded fishing gear and other operational waste polluting the marine environment. It is important to note that litter can have a significant impact on the environment, even in small amounts. For example, litter can pollute waterways and soil, harm wildlife, and reduce the aesthetic appeal of an area.

### 3. Assess marine litter pollution

To assess the impact of litter pollution in each specific region, a comprehensive monitoring plan should be developed and implemented. This plan should include the following elements:

- Identify sources and types of plastic pollution: the first step is to identify the main sources and types of plastic pollution in the region. This can be done through surveys, interviews, and field observations.
- Selection of monitoring sites: Once the sources and types of plastic pollution are identified, representative monitoring sites should be selected. These sites should be located in areas where plastic pollution is likely to be highest, such as beaches, rivers, and urban areas.
- Data collection and analysis: data should be collected and analyzed regularly to identify trends in the extent and nature of plastic pollution. These data can be used to assess the impact of plastic pollution on the environment and evaluate the effectiveness of mitigation measures.
- Reporting and dissemination of results: The results of the monitoring program should be shared with relevant stakeholders, such as government agencies, businesses, and the public. This information can be used to raise awareness of the plastic pollution problem and support decision-making.

In addition to the above elements, the monitoring plan should also be flexible enough to be adapted to the specific needs of the region. For example, it may be necessary to modify the plan to address different types of plastic pollution, such as microplastics or marine beach litter.

By implementing a comprehensive monitoring plan, we can better understand the impacts of plastic pollution in each specific region and develop effective mitigation measures.

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