

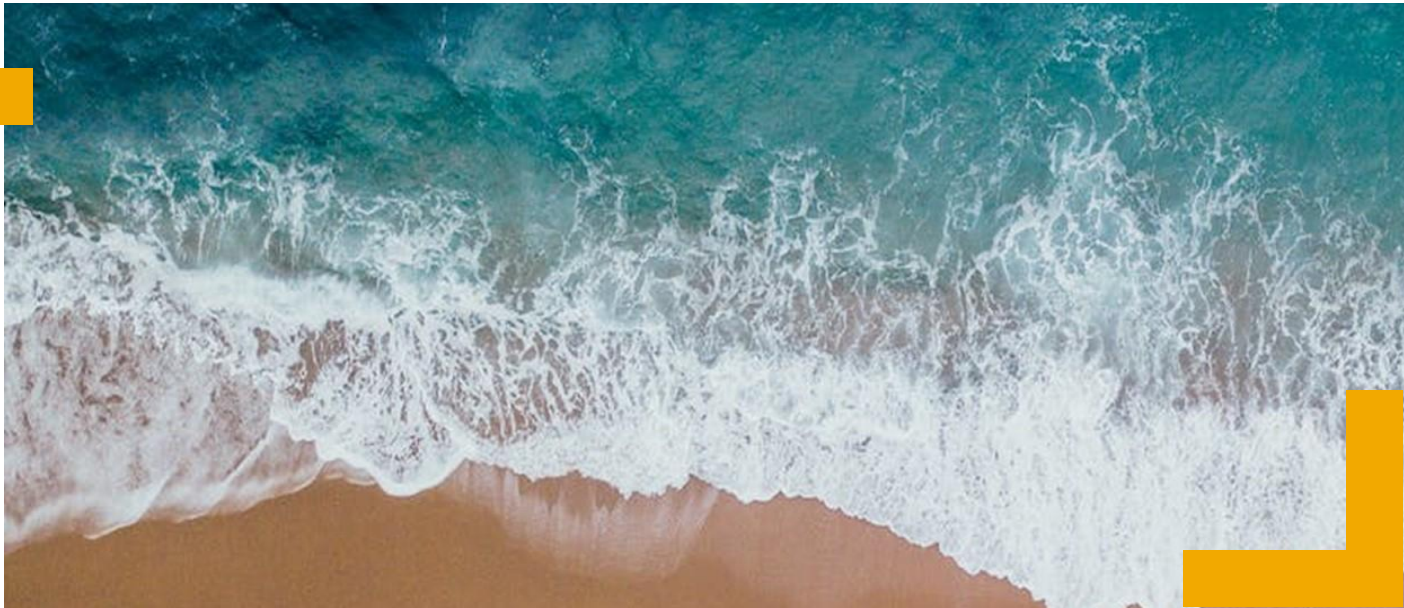


MedSeaRise

Interreg  
Euro-MED



Co-funded by  
the European Union



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## Knowledge and issues on sea level rise scenarios in Mediterranean area



Deliverable 1.1.3.

<https://medsearise.interreg-euro-med.eu/>

## Deliverable ID

|                                   |  |
|-----------------------------------|--|
| <b>Project acronym</b>            | MedSeaRise   |
| <b>Project title</b>              | Supporting Adaptation to Mediterranean Sea Level Rise  |
| <b>Project mission</b>            | Protecting, restoring and valorising the natural environment and heritage  |
| <b>Project priority</b>           | Greener MED  |
| <b>Specific objective</b>         | RSO2.4 Promoting climate change adaptation and disaster risk prevention, resilience, taking into account eco-system based approaches |
| <b>Type of project</b>            | Study project (Thematic Project)   |
| <b>Project duration</b>           | 01/01/2024 – 31/03/2026 (27 months)  |
| <b>Deliverable title</b>          | Knowledge and issues on sea level rise scenarios in Mediterranean area   |
| <b>Deliverable number</b>         | D.1.1.3.   |
| <b>Deliverable type</b>           | Report   |
| <b>Work package number</b>        | 1  |
| <b>Work package title</b>         | Information retrieval, data input and stakeholder awareness  |
| <b>Activity name</b>              | Data and scientific information on future scenarios of sea level rise  |
| <b>Activity number</b>            | 1.1  |
| <b>Partner in charge (author)</b> | ARPA FVG (PP2)   |
| <b>Partners involved</b>          | UoM-IBMK (PP4), UM (PP6)   |

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## 1. Introduction and Objectives

This document presents a specific contribution in the achievement of the general MedSeaRise WPI objective, namely the results obtained in the frame of the Activity 1.1 thanks to efforts focused in describing the state-of-the-art of the scientific community's knowledge on the limits affecting the projections of future sea level trends, due to climate change in the Mediterranean.

To this end, MedSeaRise project has considered mandatory to create personal interactions among the project partners and the experts in the field of sea level variation. In fact, Activity 1.1. foresees the organization of at least one workshop of international scientists and experts of sea level rise, with the objective to discuss about the fundamental physical processes, which are responsible for the increase of the water level along the Mediterranean.

Thanks to the deliverable D.1.1.3 features, the MedSeaRise partnership achieved awareness on how to use the projections of future sea level trends and to which extent our knowledge of current and expected sea level trends is complete.

The awareness gained on the uncertainties still present in the data available for the implementation of the other project activities, it is considered the robust and common background for the planning and the conduction of the case studies on risk related to the sea level rise.

While, according to the original planned involvement of the Project Partners in this activity, only some partners were expected to work on this deliverable,

ad the end the contribution of all partners arose spontaneously thanks to the great interest in the analyzed issues.

In the following, this deliverable reports details on how the MedSeaRise partnership has acquired the information on the limits affecting the projections of future sea level trends due to climate change in the Mediterranean and what are the perspectives for knowledge improvements.

In the following, this deliverable reports the basic knowledge acquired by MedSeaRise partnership on the limits affecting the projections of future sea level trends due to climate change, specifically for the Mediterranean. The two main sources of information cover a section each, namely the experts workshop and the scientific literature analysis.

This deliverable make synergy with deliverables D.1.1.1 and D.2.1.1 [\[1.1\]](#).

## **2. Workshop of Sea Level experts - Kotor 03/10/2024**

In October 2024, thanks to the organizing efforts of PP4, In Kotor, Montenegro, a MedSeaRise workshop took place. The workshop was inserted a side event of the AdriBioPro 2024 conference [\[2.1\]](#).

The choice of having the workshop in the frame of a wider conference gave the expected boost to the discussion of the problems and the strengths in using the sea level trends to assess the impacts on anthropic activities and ecosystems. In fact, besides the project partnership, many interested scientists and experts attended the speeches contributing with stimulating questions and suggestions.

According to the workshop objective and the audience, the number of invited experts was kept at the essential to have contributions to the topic coming from quite different, but complementary, expertise. The main speakers were four and they examined the sea level rise causes and resulting evidences form the pure physical perspective to the biogeochemical interactions, ranging from the large spatial scales to the local peculiarities, without neglecting the uncertainties affecting the measures and the processes simplification required by numerical simulations.

Here, together with the agenda of the workshop, the contribution given to the discussion by each expert is reported.

### **Agenda and Speakers**

The workshop engaged speakers and attendees for half day during the 2<sup>nd</sup> of October 2024, see Appendix A to have a view of the workshop in the frame of the AdriBioPro 2024 conference. The four main speakers and their contributions are listed in figure 2.1.

## KC "Nikola Đurković", Multimedial Hall

12:40-14:00 **Panel session MedSeaRise**

**Angelique Melet:** Sea Level Rise in Europe: 1st Assessment Report of the Knowledge Hub on Sea Level Rise

**Tarzan Legović:** Adriatic Sea level rise until 2099

14:00-15:00 Lunch

15:00-15:30 Networking

15:30-17:30 **Sea level rise: how to exploit climate change scenarios for effective adaptations?**

**Giorgia Verri :** Climate projections of the Adriatic Sea: the role of river release

**Jasmina Obhodaš:** New insights from climate change studies based on the evaluation of temporal trends of marine environmental indicators including impacts on rising sea levels

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*Figure 2.1: the schedule of the workshop reporting invited speakers and the titles of their contributions.*

### **Angelique Melet**

Mercator Ocean Scientific Directorate- Co-chairs of the Physical Science working group of the JPI knowledge hub on sea level rise.

Dr Angelique Melet brought to the workshop an extensive summary of the recent First Assessment Report of the European Knowledge Hub on Sea Level Rise [2.2]. The work of the wide scientific community working on the problems related to sea level variations along all the coasts of the European continent is carried on with an interdisciplinary approach. In her presentation, Dr. Melet summarized all the five main area composing the report and details have been presented on the second one, namely the observations and projections. She stressed the fact that there are still large uncertainties in the future sea level scenarios and there is a scarce capability to use the available information too. One specific note was deserved on the importance to include the short term variations of the sea level, in addition to the long term trends. Those short term variations are mainly caused by tidal forces, generating tides, and atmospheric forcing, generating extreme high and low tides, besides waves and surges. The assessment reveals that the vertical movement of the land with respect of the geoid compensates the sea level increase due to climate change. So in some areas of the European country the level of waters along the coast is decreasing with respect to the land. This is the case of the Scandinavian peninsula. While in other part, as in the northern Adriatic, Venice, the subsidence adds speed to sea level rise. Considering the future projections, according to nowadays available numerical simulations, the sea level rise is faster in Mediterranean Sea than in the northern European basins. It is estimated that at about one century from now the Mediterranean Sea will experience a sea rise, roughly of one meter, for very high emission scenario. There is also a major uncertainty for sea level at long-term due to possible Greenland and

Antarctic ice mass loss and other related tipping points. The speaker completed the focus on the Mediterranean stating that the extreme sea levels at the coast: will be reached more frequently in the future. She referred to the Mediterranean Sea as a hotspot. In particular, high sea level values rarely reached (over past decades) will be reached much more frequently by 2100. So there is need for higher-resolution sea level projections, that have to include also the effects of local drivers of extreme sea levels, such as tides, waves and storm surges.

### **Tarzan Legovic**

Libertas International University and “R. Bošković” Institute (Zagreb)

Prof. Tarzan Legovic focused the attention on the uncertainties affecting the measures of sea level. In particular, he presented a set of time series of sea level records gathered across the Mediterranean and he underlined the combination of the increase of the sea level with the movements of the Earth surface, namely subsidence and uplift, which are caused by many factors, including anthropic actions, such as mining, or natural effects, bradyseism for example. Those results are evident looking at the slope of the time series of records he presented, that are different for each location. Special emphasis was on the Adriatic Sea records because they refer to a basin not large, where it is expected that the steric effect of sea level rise affects all coasts at the same rate. Furthermore, the speaker pointed out the possibility of sudden increases of the sea level due to climate tipping points having a strong impact on sea water volume. One of such events is identified in a rapid melting of the Greenland continental glaciers, besides large areas of the west Antarctic Ices sheet.

### **Giorgia Verri**

CMCC – Euro-Mediterranean Center for Climate Change (CMCC)

Dr. Giorgia Verri presented a specific scientific work on the Adriatic Sea. In particular, she addressed two relevant issues: the rivers discharge conditioning of the Adriatic thermohaline circulation and the role of decreasing river discharge on the Adriatic future climate with consequences on the local sea level rise. The simulations carried on by CMCC to contribute to face those issues have shown that rivers modulate Adriatic dense water formation of about 20% and the river role shows interannual variability depending on other forcing mechanisms, related to atmosphere too. The emphasis was on the approach adopted to conduct the numerical simulations. In fact, to achieve the presented results. It was necessary to have an integrated simulation of the coastal hydrology, that depends on the atmospheric behavior inland too, and the hydrodynamic of the sea. The results allow us to pick up differences between the northern and the southern Adriatic sub basins. Northern Adriatic changes are mainly driven by changes in river release and evaporation, while southern Adriatic are the nonlinear combination of changes in river release, air-sea fluxes and water flow entering through Otranto strait. Taking in account of all the effects, Dr. Verri summarized the results as follow: the sea level trend in the south

Adriatic is driven by the thermosteric effect, that is the water temperature increase, while in the north Adriatic the mass component and the halosteric effect, that is the salinity, are the major responsible. In this latter case, the runoff decrease acts in the opposite direction to the global warming and modulate the sea level rise by reducing mass component and by increasing the halosteric effect.

### **Jasmina Obhodas**

Laboratory for nuclear analytical methods "R. Bošković" Institute (Zagreb)

Dr. Jasmina Obhodas gave a look at the sea level rise from the sea chemistry point of view and she highlighted some evidence. First, recalling the sequestration of atmospheric CO<sub>2</sub> by oceans accounts for about a quarter of the whole Carbon Dioxide removed from the atmosphere and that ocean sequestration capability increases when water temperature decreases.

In fact, cooler water is more effective at dissolving and absorbing gases compared to warmer water. This is because low temperature means the water molecules have a lower kinetic energy and this in turn allows them to form stronger bonds with dissolved molecules.

The sea surface skin temperature can decrease due to evaporation and sensible heat loss, in spite of the overall column, sea water temperature increases. So there could be surface effects that compensate for the overall capability of the sea to remove CO<sub>2</sub> from the air. On the other hand, the concentration of Carbon Dioxide in the atmosphere is progressively increasing, year by year.

There are claims of different signs for the trends in the ability of the oceans to sequester CO<sub>2</sub> in the last 20 years. According to the speaker, most of the information on carbon sequestration by sea refers to the water column only and there is no clear thought about the contribution of sediments.

The sedimentation process regulates climate by mitigating the impact of greenhouse gases. In fact, marine sediments act as a significant carbon sink by storing organic carbon derived from marine organisms for extended periods. Anyway, it is not clear to which extent the contribution can be effective.

But there is another important effect of sediments in climate change consequences too. The role played by the sediments in storing CO<sub>2</sub> is relevant for the mean sea level trends too.

Dr. Obhodas emphasized the relevance of the increase of sedimentation rates due to the increase of CO<sub>2</sub>. The increase of carbon dioxide in seawater can indirectly influence the rate of sediment deposition, though it's not a direct cause-and-effect relationship. Surely, the primary impact of the increased of CO<sub>2</sub> in sea water is sea acidification. Water acidification and CO<sub>2</sub> concentration affect marine life, including those involved in sediment formation. This can lead to changes in sediment composition and, potentially, the rate of sediment accumulation.

The speaker presented the results of recent studies, which have been conducted in the sediments of the Adriatic sea, showing an increase of sedimentation rates, which are of several millimeters per year, concluding that in shallow seas the variations of the sedimentation can play a positive feedback in the observed sea level trends.

## **Results of the workshop**

From the workshop of experts emerged important elements that have been used in the achievement of the project goals.

In particular, it is clear that a reliable simulation of the mean sea level evolution requires to consider all the elements that contribute in the sea water density variation, namely temperature and salinity. Furthermore, the total mass of liquid water in the planet has to be taken in account, but not as constant because climate change can encounter tipping points characterized by the melting of the continental ice sheets, even if a fraction only.

These are the straightforward elements that are requested to generate a reliable simulation of the current and the future mean sea level.

It is also important to consider the dynamical contribution of the circulation of water masses in the sea basin. In fact, the density of the sea water determines the masses movement besides the level. So it is expected that climate simulation integrate all these processes in a simulation run, keeping also the effects of air pressure on the sea surface.

For water temperature, the energy exchanges between atmosphere and the sea is most important set of processes to be considered, including both sensible heat and latent heat exchanges. For water salinity, in addition to the effects due to water evaporation and precipitation, it is extremely important a climate simulation includes the rivers outflow, because of the fresh water input.

As boundary effects that can induce positive or negative feedback on the actual sea level, with respect to the coastal reference level, are the subsidence and the uplift of the coastal areas. Furthermore, the rates of sedimentation of organic matter plays a not negligible role, especially in shallow seas.

Another specific advice spontaneously emerged from the workshop regards the importance to include the short term variations of the sea level, in addition to the long term trends, when computing impacts. The temporary changes of sea level due to the tides and the positive feedback of the forcing of the atmosphere, winds and pressure, may account for sea level oscillations having large amplitudes of with respect the mean sea level.

So sea level rise impacts require the assessment of tides and surges be included directly in the simulations or added to the mean sea level future scenario assuming the astronomical and the atmospheric contributions are independent from the causes of the mean sea level variations.

According to the experts, there are still large uncertainties in the future sea level scenarios and there is a scarce capability to use the available information too.

### 3. Literature analysis

The Project Partners of MedSeaRise got awareness on the issues related to the mean sea level variation through the analysis of the literature collecting during the first phases of the project (see Deliverable D.1.1.1 [\[3.1\]](#)).

From the survey on scientific papers and documents on sea level rise projections, for the XXI century over the Mediterranean [\[3.1\]](#), the mandatory processes that have to be considered for a reliable simulation of sea level evolution match those highlighted in the frame of the MedSeaRise workshop.

Since the model output dataset used in the frame of the project are complemented by scientific papers, describing the features of the numerical model that has generate the output, this deliverable suggests how to evaluate the likelihood of the datasets for future sea level scenarios.

Starting from the processes driving the sea level variations this deliverable has distilled, a set of specific questions on whether the model includes or disregard the specified processes during the simulation run are addressed to the literature, looking for an answer. According to the received answer, a simulation output can be classified to be likely to likely reproduce actual and future sea level.

If the already collected literature, which is detailed in deliverable D.1.1.1 cannot answer to all questions, further scientific papers, specifically tied to the numerical model involved in the datasets generations, will be retrieved and added to the MedSeaRise literature.

### 4. Deliverable indicators

This deliverable is summarized by means of the indicators reported here below. For each of them the expected indicator value and the actual one are presented. In addition, comments are reported too, if any.

| Indicator | Expected value | Actual value | Comments |
|-----------|----------------|--------------|----------|
| Meetings  | 1              | 1            | None     |
| Documents | 1              | 1            | None     |

Further information is available in Google Drive Data area [\[4.1\]](#)

### 5. Conclusions

MedSeaRise Activity 1.1 was conducted from the first project period to the third and in this last period delivered this document. This document acts as

the deliverable describing the knowledge and issues on sea level rise scenarios in Mediterranean area.

This deliverable contributes in achieving the goal of the Activity 1.1 which is summarized as providing the project with data and scientific information on future scenarios of sea level rise, including auxiliary data, suitable to conduct case studies on selected classes of impacts, which are consequences of the sea level rise.

## **6. References to additional material**

- [1.1] Basecamp [Key Production WPI](#)
- [2.1] AdriBioPro 2024, 3rd International Conference: Adriatic Biodiversity Protection 1–4 October 2024 Kotor, Montenegro  
<https://www.adribiopro.ucg.ac.me/>
- [2.2] First Assessment Report of the European Knowledge Hub on Sea Level Rise (2024) by The Knowledge Hub on Sea Level Rise.  
<https://sp.copernicus.org/articles/sp-slre1.pdf>
- [3.1] MedSeaRise deliverable D.1.1.1 [Knowledge and data availability on sea level rise](#) projections
- [4.1] Google Drive MedSeaRise shred area ([MedSeaRise\\_Interreg Euro-MED](#))

## 7. Appendixes

### Appendix A: General program of AdriBioPro 2024



#### PROGRAMME

| TIME                    | October 1st 2024  |  |  |
|-------------------------|---|--|--|
| 17:00-18:00             | Registration  |  |  |
| 18:00-19:00             | Opening Exhibition "Man and the Sea"  |  |  |
| <b>October 2nd 2024</b> |   |  |  |
| 08:30-09:30             | Registration  |  |  |
| 09:30-10:40             | Opening ceremony  |  |  |
| 10:40-11:30             | Skills high-level panel session: Blue economy in south Adriatic region  |  |  |
| 11:30-12:00             | Coffe break   |  |  |
| 12:00-13:00             | FAO AdriaMed dialogue on the past and present Adriatic fisheries and aquaculture: next 25 years (Identifying Gaps and Opportunities for Future Development; The role of young generation) | Climate change and impact to ecosystems  | <p>MedSeaRise Workshop</p>   |
| 13:00-14:00             | Lunch   | Sea level rise: how to exploit climate change scenarios for effective adaptations?                                     |  |
| 14:00-15:00             | Elasmobranch biodiversity, conservation and management  | Poster session   |  |
| 15:00-15:30             | Networking  |  |  |
| 15:30-16:30             | <b>October 3rd 2024</b>   |  |  |
| 9:30-11:00              | MedSeaRise project meeting (on invitation only)   | Marine and freshwater biodiversity, systematics, taxonomy and data management  | SeaComp Workshop<br>CRADLES Event  |
| 11:00-11:30             | Coffe break   | Aquatic alien and invasive species   | Coffe break  |
| 11:30-13:30             | MedSeaRise project meeting (on invitation only)   | Fisheries resources and fishing technology<br>Marine protected areas, conservation of aquatic resources and ecosystems | BLUECONNECT Kick-Off Meeting with Stakeholders<br>BLUECONNECT Project Management Team meeting (on invitation only) |
| 13:30-14:30             | Light lunch   | Networking   |  |
| 14:30-15:00             |   |  |  |
| 15:00-17:00             | SKILLS Project Executive Committee Meeting (on invitation only)   | Aquaculture and blue growth  | Round table -Fishing tourism in Montenegro   |
| 19:30-22:00             | Marine litter, ecotoxicology, and water pollution<br>Closing event and Seafood evening  |  |  |
| <b>October 4th 2024</b> |   |  |  |
| 09:00-15:00             | Project Meetings - Institute of Marine Biology  |  |  |

#### Conference spaces

|                    |                             |                 |
|--------------------|-----------------------------|-----------------|
| KC Nikola Đurković | Institute of Marine Biology | Hotel Vardar    |
| Theater Hal        | Meeting Room                | Conference Room |
| Multimedial Hall   |                             |                 |
| Gallery            |                             |                 |
| Foyer 1            |                             |                 |
| Foyer 2            |                             |                 |

#### KC "Nikola Đurković", Multimedial Hall

##### 12:40-14:00 Panel session MedSeaRise

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**Jasmina Obhodaš:** New insights from climate change studies based on the evaluation of temporal trends of marine environmental indicators including impacts on rising sea levels