AdriaClim

Climate change information, monitoring and management tools for adaptation strategies in Adriatic coastal areas

Project ID: 10252001

D3.1.3 The plan coastal ocean observing campaigns as described and needed for activities task

and

D.3.1.4 Report of coastal ocean observing campaigns as described and needed for activities task

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1. Aims and content of the document

These deliverables (D.3.1.3 and D.3.1.4) contribute to the objectives of AdriaClim Activity 3.1. ‘Design and implementation of the observing systems’ under WP 3 ‘Climate Change Monitoring (Observing and Modelling) Systems’ of the AdriaClim project:

● design of coastal ocean campaigns for monitoring biogeochemical and microbial components in selected Pilot areas;

● design and implementation of an integrated regional monitoring network in the selected Pilot areas;

● increase spatial and temporal resolution of biogeochemical monitoring with in situ measurements of biogeochemical components (C, N, P) at the sediment-water interface and microbial pollution

● improve accessibility and dissemination of observing data and products;

Deliverables 3.1.3 and 3.1.4 are merged together to provide an integrated dimension of oceanographic campaigns specifically designed and planned under the AdriaClim project and the in situ measured data collected according to the peculiar environmental and climatic conditions of the target Pilot areas.

Specifically, D.3.1.3 and D.3.1.4 contribute to design of coastal ocean monitoring campaigns and to collect and measure in-situ data on biogeochemical and microbial components according to the pilot areas sensitivity in (Figure 1):

● n 3 : Emilia-Romagna coastal area (ARPAE, UNIBO, ISPRA)

● n 2 : Venice lagoon, City of Venice and Veneto coastal area (ARPAV)

● n 1 : Grado and Marano Lagoon, Gulf of Trieste (ARPA FVG)

● n 8 : Neretva River Estuary and Kastela Bay (IOF)

● n 7 : Northern Adriatic (IRB).

2. Grado and Marano Lagoon, Gulf of Trieste

2.1 Description of the pilot area

The pilot area is characterized by an open sea area, namely the Gulf of Trieste, and a lagoon, the Marano and Grado lagoon, which exchanges mass with the gulf through six mouths. The eastern coast of the pilot area is rocky and the input of fresh water from rivers is very low with respect the contribution of the two main rivers, the Isonzo and Tagliamento that are located in the central and the western section of the area, where the sandy beaches are the constant feature of the coast line.

ARPA FVG carries on an active monitoring in the pilot area, with the aim to define the quality of transitional, coastal and marine waters of the Friuli Venezia Giulia region. Taking into consideration the coastal waters, the current network consists of 16 sampling stations located in the Italian side of the Gulf of Trieste. In these stations, chemical and physical parameters (i.e., temperature, salinity, dissolved oxygen, turbidity and chlorophyll-a) are measured monthly in situ on the whole water column by means of a CTD. In parallel, water samples for nutrient determination (dissolved nitrogen forms, dissolved phosphorus, silicate, total nitrogen and phosphorus) are also collected together with benthos features with a lower frequency. (figure 2.1.1).

1. Regarding the transitional waters, 16 water bodies of the Marano and Grado Lagoon are monitored seasonally and the related dataset is characterized by the parameters aforementioned for coastal waters (figure 2.1.2).
2. According to this intensive and regular monitoring, which is going to continue during the whole project duration and beyond, no additional campaigns are required to increase the detail of measurements required to support the achievement of the AdriaClim objectives. Whereas, for atmospheric and tidal measurements, the installation of new atmospheric and marine sensors is needed.

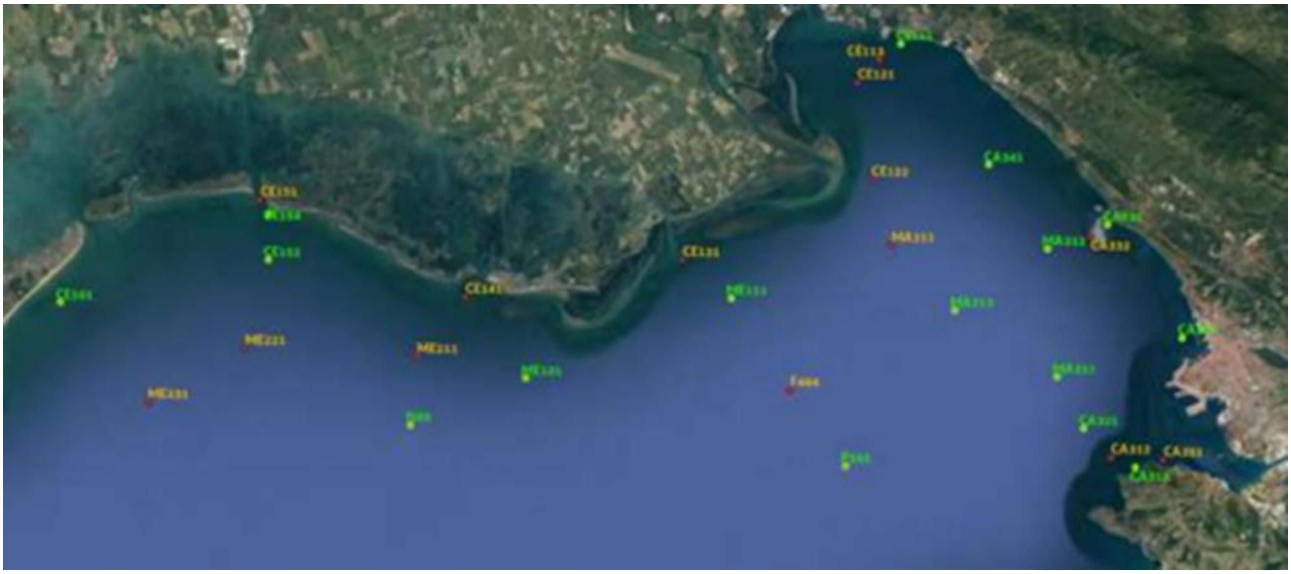

Figure 2.1.2: Monitoring network for the quality of transitional waters in Grado and Marano Lagoon

2.2 Planning of observing campaigns

In the Gulf of Trieste, the monitoring has been conducted thanks the collaboration of two project partners, namely ARPA FVG and CNR-ISMAR. In detail, the following facilities are included:

● the Meteorological-marine station at Molo F. Bandiera (since 1986). Observed variables: 10 m air temperature and wind, sea temperature at 0.4, 2 and 6 m depths.
● the tide-gauge station al Molo Sartorio (since 1859). Observed variables: sea-level height, atmospheric pressure at 2.5 m.
● PALOMA mast (45°37.097’N, 13°33.913’E), 12 km offshore, bottom depth 25 m. Data: sea temperatures (0.4, 2, 15, 25 m below s.l.), wind speed and direction, air temperature, relative humidity, precipitation, solar radiation, air pressure. Data acquisition and elaboration every 5 minutes. Data transmission in real time (every 3 hours)

Along the shore of the Gulf of Trieste data collected refer to:

● atmospheric measurements of the main air variable, namely: precipitation, wind speed and direction, temperature, relative humidity and global solar radiation. Data are available from four coastal meteorological stations: Trieste, Fossalon di Grado, Grado and Lignano Sabbiadoro, with hourly resolution, for the last twenty years.
● In the Gulf of Trieste and the Grado and Marano lagoon, ARPA FVG, since 2001, has developed an active monitoring network with the aim to define the quality of transitional, coastal and marine waters of the Friuli Venezia Giulia region.

Taking into consideration the coastal waters, the data have been collected from:

16 sampling stations located in the Italian side of the Gulf of Trieste. In these stations, chemical and physical parameters (i.e., temperature, salinity, dissolved oxygen, turbidity and chlorophyll-a) are measured monthly in situ on the whole water column by means of a CTD. In parallel, water samples for nutrient determination (dissolved nitrogen forms, dissolved phosphorus, silicate, total nitrogen and phosphorus) are also collected (figure 2.1.1).

With specific reference to the transitional waters data are from:

16 water bodies of the Marano and Grado Lagoon are monitored seasonally and the related dataset is characterized by the parameters aforementioned for coastal waters (figure 2.1.2).

2.3 Report on observing campaigns

Temperature and salinity, the two parameters considered here in the climatic context of the Gulf of Trieste, the 2014-2022 dataset shows an average (±SD) of 16.6°C (±5.3) (Figure 2.3.1) and 36.9 PSU (±1.9) (Figure 2.3.2), respectively. As can be seen, the measurements cover all months (January to December) for each of the years considered within the dataset. Regarding depth, data were collected in the range 0-26 m, i.e., from the surface to the maximum depth recorded, relative to the monitored stations. Altogether, the number of measurements taken is 169782.

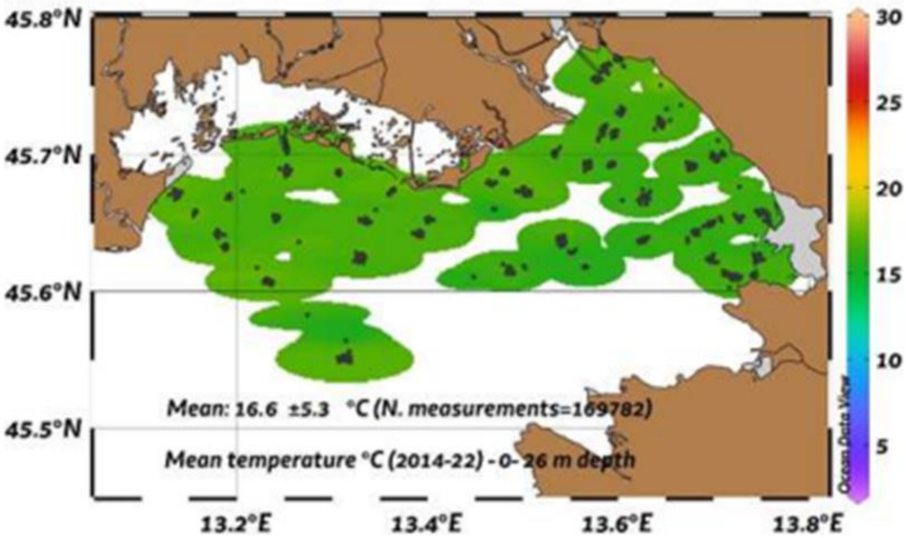

Figure 2.3.1. Mean temperature (±SD) in the Gulf of Trieste in the time period 2014-2022 (January-December) considering all the observations made by ARPA FVG (N=169782) in the water column (0-26 m). Black dots correspond to the georeferenced points where measurements were taken. Map created with Ocean Data View software.

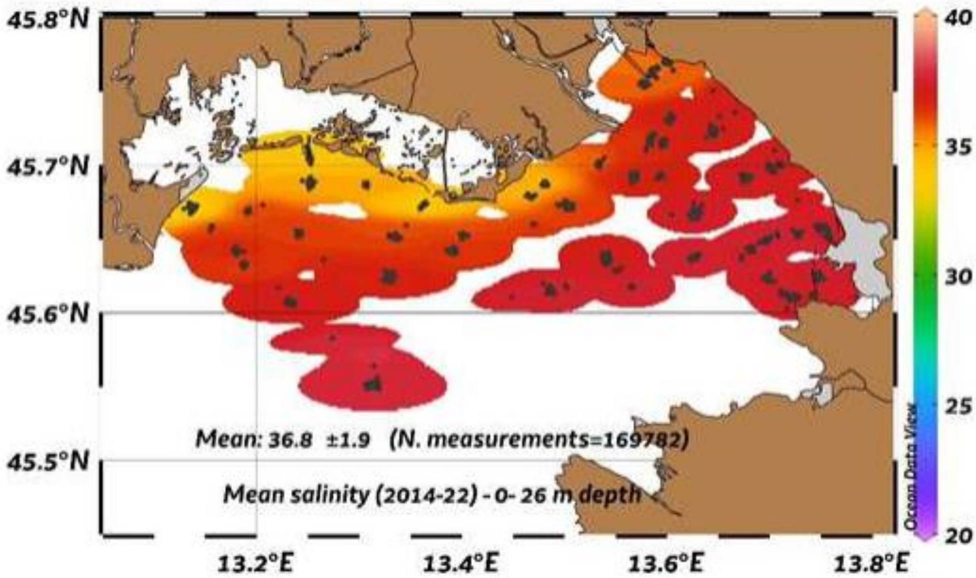

Figure 2.3.2. Mean salinity (±SD) in the Gulf of Trieste in the time period 2014-2022 (January-December) considering all the observations made by ARPA FVG (N=169782) in the water column (0-26 m). Black dots correspond to the georeferenced points where measurements were taken. Map created with Ocean Data View software.

As shown in Table 2.3.1 and Table 2.3.2, we also divided measurements according to the different layers of the water column (surface, intermediate and bottom). For each layer, we provided different depths in order to consider layers with different thickness. The total number of measurements is different for each layer of the water column because of the depth range considered and the shore-offshore gradient, which implies more pronounced bathymetry as one moves away from the coast (Figure 2.3.3).

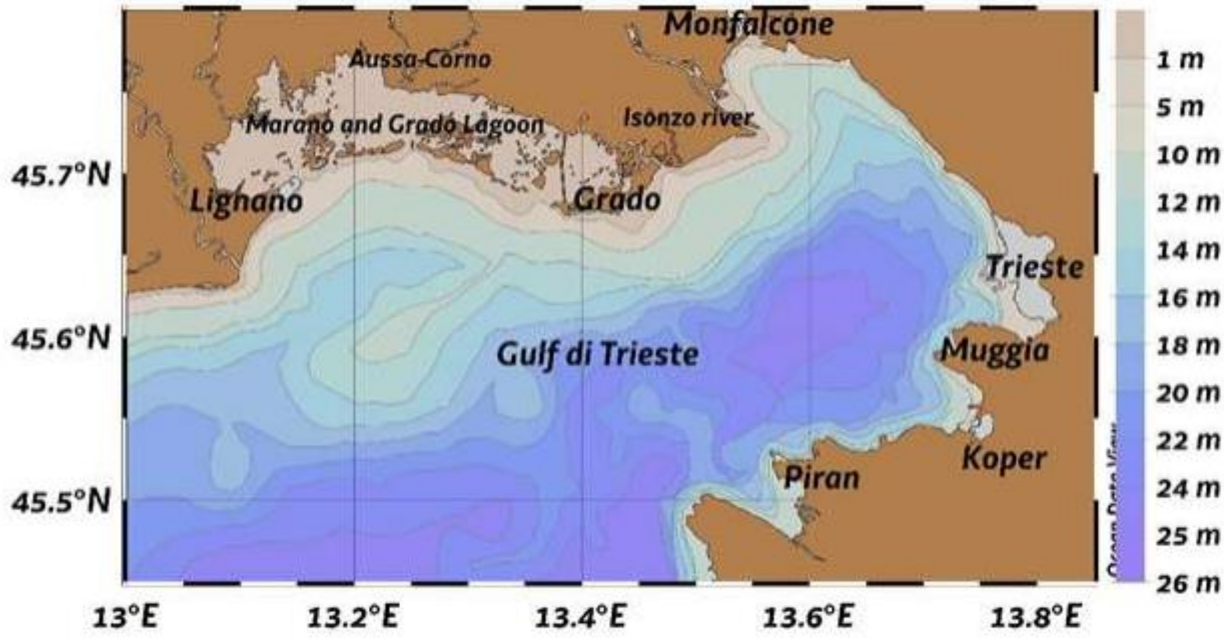

Figure 2.3.3. Bathymetry representation in the Gulf of Trieste

LAYER	DEPTH (m)	MEAN (°C)	±SD (°C)	N of observations
Surface	0 – 5	17.2	5.9	56699
	0 - 8	17.1	5.8	87314
Intermediate	5 - 15	16.6	5.3	87446
	8 - 18	16.2	5.0	70541
Bottom	15 - 26	15.4	4.3	29781
	18 - 26	15.3	4.1	15345
Bottom*	20 - 26	15.1	4.0	8211
ALL DATA	0 – 26	16.6	5.3	169782

Table 2.3.1. Temperature mean (±SD) in the Gulf of Trieste in the time period 2014-2022 (January-December) according to different depths in the water column. The last values correspond to the total mean considering all the observations. Observations are made by ARPA FVG.

LAYER	DEPTH (m)	MEAN (PSU)	±SD (PSU)	N of observations
Surface	0 - 5	35.8	2.8	56699
	0 - 8	36.2	2.4	87314
Intermediate	5 - 15	37.2	0.9	87446
	8 - 18	37.5	0.7	70541
Bottom	15 - 26	37.8	0.5	29781
	18 - 26	37.8	0.5	15345
Bottom*	20 - 26	37.8	0.5	8211
ALL DATA	0 – 26	36.9	1.9	169782

Table 2.3.2. Salinity mean (±SD) in the Gulf of Trieste in the time period 2014-2022 (January-December) according to different depths in the water column. The last values correspond to the total mean considering all the observations. Observations are made by ARPA FVG.

Moreover, temperature and salinity data has been divided in 3 sub-dataset covering a 3-year period each, starting from 2014 (**Table 11**). In each sub-dataset, data has been clustered according to the season in which they have been collected.

As for temperature, the seasonal average value over 3 years does not show substantial changes over the entire considered period, and each season maintains stable temperatures from one three-year period to the next. With regard to salinity, on the contrary, there is a steady increase in the mean seasonal value over the three-year periods considered in spring, summer, autumn and winter. In fact, in the three-year period 2014-2016, the average inter-seasonal variation in salinity ranged from 36.0 to 36.9, while in 2020-2022 it ranged from 36.6 to 37.8, with peaks up to 38.8. This situation is strongly associated with the general decrease in river discharges at the mouth that has occurred in recent years, which causes fresh water not to dilute seawater and lead to higher salinity values. Moreover, in 2021 and 2022, the water masses of southern origin entering the GoTS probably had a higher salinity in itself.

TEMPERATURE (°C)	2014-2016				2017-2019				2020-2022			
SEASON	MEAN	±SD	MIN ÷ MAX	N	MEAN	±SD	MIN ÷ MAX	N	MEAN	±SD	MIN ÷ MAX	N
WINTER (JAN-FEB-MAR)	10.5	1.2	7.0 ÷ 14.3	13813	9.2	1.2	3.7 ÷ 12.1	14492	9.9	1.1	6.5 ÷ 12.6	13232
SPRING (APR-MAY-JUN)	16.4	3.6	10.9 ÷ 27.3	15809	15.9	3.3	9.1 ÷ 24.7	9512	16.7	3.4	10.7 ÷ 25.3	12212
SUMMER (JUL-AUG-SEP)	23.0	1.9	16.6 ÷ 29.7	17580	22.5	2.4	15.1 ÷ 28.5	15532	22.9	2.7	14.7 ÷ 28.2	14955
AUTUMN (OCT-NOV-DEC)	16.1	2.7	8.9 ÷ 21.6	17673	16.4	2.7	7.9 ÷ 20.4	11334	16.3	2.8	8.6 ÷ 21.3	13638

SALINITY (PSU)	2014-2016				2017-2019				2020-2022			
SEASON	MEAN	±SD	MIN ÷ MAX	N	MEAN	±SD	MIN ÷ MAX	N	MEAN	±SD	MIN ÷ MAX	N
WINTER (JAN-FEB-MAR)	36.9	1.7	10.0 ÷ 38.2	13813	37.5	1.5	< 5.0 ÷ 38.5	14492	37.8	1.0	21.0 ÷ 38.8	13232
SPRING (APR-MAY-JUN)	36.0	2.0	10.5 ÷ 38.4	15809	36.3	2.4	9.6 ÷ 38.2	9512	36.7	2.2	10.0 ÷ 38.9	12212
SUMMER (JUL-AUG-SEP)	36.4	1.8	13.9 ÷ 38.3	17580	36.8	1.5	6.8 ÷ 38.3	15532	37.2	1.4	17.6 ÷ 38.6	14955
AUTUMN (OCT-NOV-DEC)	36.4	2.6	< 5.0 ÷ 37.7	17673	36.8	2.2	7.5 ÷ 38.4	11334	37.4	1.3	13.3 ÷ 38.8	13638

Table 2.3.3. Temperature and salinity seasonal mean for each considered triennium (from 2014 to 2022).

Regarding temperature, Figure 2.3.4 shows how the values are distributed across seasons (a-d) in each of the years of the period under consideration (2014-2022), but without the division into three-

year periods seen above. Graphs confirm what was written above, that there is no evidence of significant seasonal variation in temperature over the period 2014-2022.

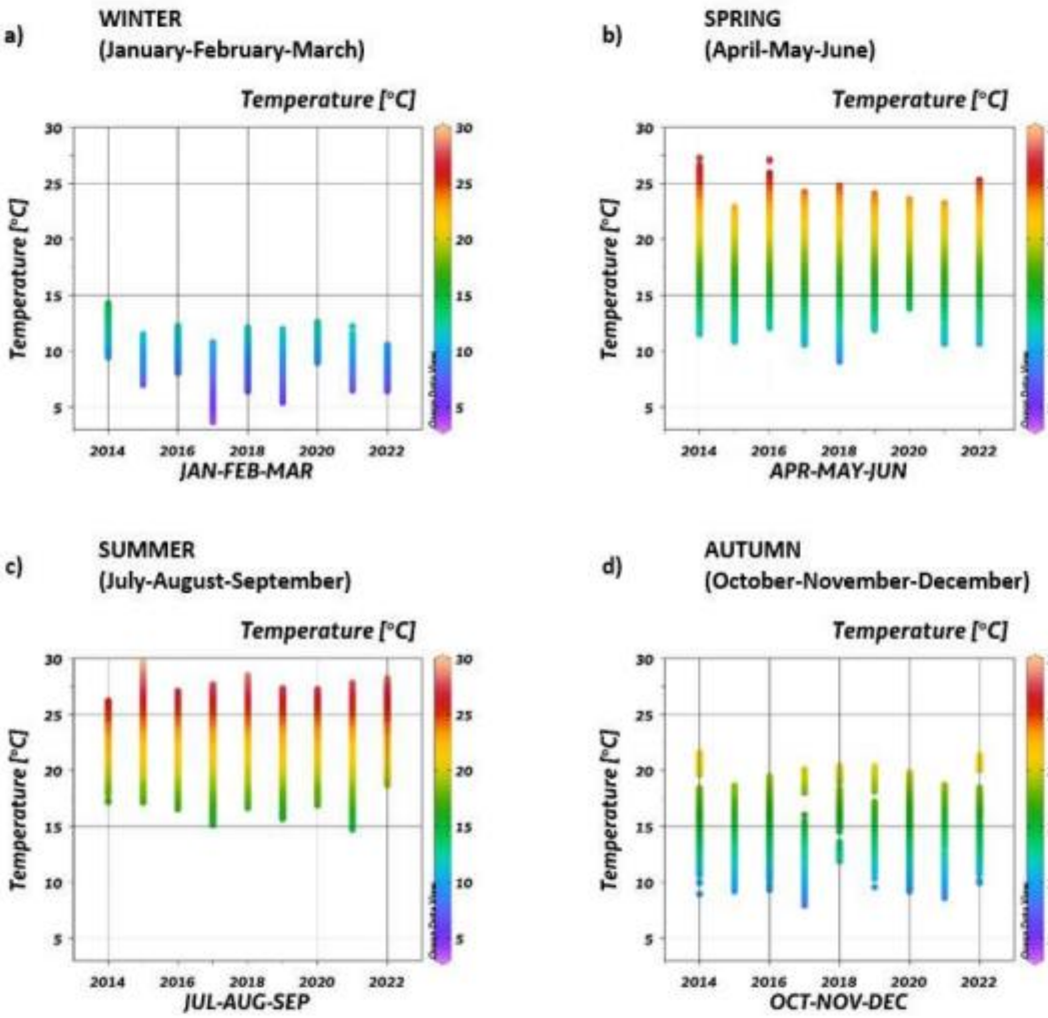

Figure 2.3.4. Seasonal temperature values (a-d) during 2014-2022 in the Gulf of Trieste. Measurements taken at all depths were considered. Graphs created with Ocean Data View software.

It is important to note that there are different sources available that show different information and measurements, as can be seen in the following paragraphs (see 4.4 – Sea climate change: evidence).

These sources do not always agree in showing significant trends and variations, especially depending on the dataset considered. In fact, a trend may or may not be visible depending on the time period considered and the type of data collected. Regarding the monitoring of marine and coastal waters, remember that ARPA FVG collects data monthly or bi-monthly. These are the data reported in this section.

Moreover, the years 2014 to 2022 cover a time period of only 8 years and may not be sufficient to show how physical quantities change, given the brevity of the considered period. In contrast, an 8- year period could provide a more or less clear picture of what is happening at the moment in the short-term.

2.4 Data sharing and open access

CNR-ISMAR data acquired in the Gulf of Trieste are collected in the private ISMAR Meteomarine unified network (http://rmm.dati.ismar.cnr.it/). Real time sea level data is available without authentication through the data portal of the I-STORMS project (https://iws.seastorms.eu/). ARPA FVG meteorological data are available on demand sending a request to the PP11 Project Partner or directly on line at https://www.osmer.fvg.it/archivio.php?ln=&p=dati, while CTD profiles are stored on the private ARPA network and available at the web portal, which has been specifically implemented, see figure 2.5. Chemical data can be found on the regional Open Data portal at the web page https://www.dati.friuliveneziagiulia.it/en/Ambiente/Acqua-Acque-di-classificazione Superficiali-marino/qcsf-bwk5 . Measurements on benthos are available on web portal (figure 2.4.1)

3. Venice Lagoon, City of Venice and Veneto coastal area

ARPAV: Fabio Zecchini, Francesco Rech, Sara Ancona

3.1 Description of the pilot area

The coastal marine environment of the Veneto is extremely sensitive and subject to sudden changes in its chemical, physical and biological characteristics due to the shallowness of the seabed, exchanges with the waters of the lagoon, the inputs from the numerous rivers (among the most important we find Po, Adige, Brenta, Piave and Tagliamento) discharging agricultural, civil and industrial effluents into the sea, meteorological and hydrodynamic variability and the pressures arising from maritime traffic, fishing and tourism. Added to this are the phenomenon of erosion and the works implemented to remedy it, the works to vivify the lagoons and the works to protect Venice from the phenomenon of high water (MOSE system).

3.2 Planning of observing campaigns

The monitoring of the sea and lagoons carried out by ARPA Veneto aims to prevent and reduce possible pollution, protect and improve aquatic environments and their animal and plant populations by defining the environmental status of waters. ARPA Veneto operationally manages the networks, carries out monitoring, processes the data collected and produces dedicated reports.

The marine water monitoring network (fig. 3.2a) consists of 9 transects, perpendicular to the coastline, each consisting of several analysis and sampling stations, important for their strategic location near the main sources of pressure; they are distributed in the four coastal water bodies. In addition to these are stations in the two offshore water bodies.

Figure 3.2a: Coastal marine water bodies and location of water monitoring stations.

The water matrix monitoring activity includes analyses, weather surveys and measurements with a multi-parameter profiling probe to:

● acquire meteomarine parameters (current direction and speed, average wave direction and height, air temperature, wind direction and speed, atmospheric pressure, relative humidity, cloud cover, solar radiation, sea state, colouration and transparency) acquire continuously measured parameters along the water column using probe profiles (water temperature, pH, salinity, dissolved oxygen in %, dissolved oxygen in ppm, chlorophyll 'a')

● determine the concentration of nutrients (phosphorus and nitrogen in particular) in water and pollutants (e.g. metals, PFAS, PAHs, pesticides) in water, biota (fish and molluscs) and sediment

● quantify species and number of individuals of phytoplankton, macrozoobenthos, macrophytes and macroalgae populations sensitive to any environmental alteration ● determine the number and abundance of phytoplanktonic microalgae, including potentially toxic ones

● monitor the possible development of the microalgae Ostreopsiscf. ovata and cyanobacteria, microalgae capable of producing toxins harmful to humans.

Transect, Municipality, Locality	Station code	Distance (m)	Depth (m)	Matrix
8, Caorle, Brussa beach				
	10080	500	3	water
	10082	3704	13	sediment chemistry
	10083	370	2	sediment biology
	20080	926	6	water
	30080	3704	13	water
	30083	3704	13	sediment biology
24, Jesolo, Jesolo lido				
	10240	500	4	water
	10241	0	1	biota
	10242	3519	14	sediment chemistry
	10243	278	3	sediment biology
	10245	0	1	benthic microalgae
	20240	926	7	water
	30240	3704	15	water
	30243	3519	14	sediment biology
40, Cavallino-Treporti, Cavallino beach				
	10400	500	3	water
	10401	0	1	biota
	10403	259	5	sediment biology
	10405	0	1	benthic microalgae
	20400	926	7	water
	30400	3704	13	water
	30402	3704	13	sediment chemistry
	30403	3704	13	sediment biology

Transect, Municipality, Locality	Station code	Distance (m)	Depth (m)	Matrix
53, Venezia - Pellestrina, San Pietro in Volta beach				
	10530	500	7	water
	30532	3704	14	sediment chemistry
	10533	370	5	sediment biology
	20530	926	7	water
	30530	3704	14	water
	40533	3704	14	sediment biology
	40530	8334	18	water
	10532	8334	18	sediment chemistry
	30533	8334	18	sediment biology
	80531	14974	16	biota
56, Venezia, Ca' Roman Pellestrina beach				
	10560	500	4	water
	10561	0	1	biota
	10562	3334	16	sediment chemistry
	10563	407	2	sediment biology
	20560	926	5	water
	30560	3704	16	water
	30563	3334	16	sediment biology
64, Chioggia, Isola Verde				
	10640	500	6	water
	10641	0	1	biota
	30642	3704	19	sediment chemistry
	10643	370	3	sediment biology
	10645	0	1	benthic microalgae
	20640	926	10	water
	30640	3704	19	water
	40643	3704	19	sediment biology

Transect, Municipality, Locality	Station code	Distance (m)	Depth (m)	Matrix
72, Rosolina, Porto Caleri				
	10720	500	3	water
	10721	0	1	biota
	30722	3704	14	sediment chemistry
	10723	1111	3	sediment biology
	10725	0	1	benthic microalgae
	20720	926	6	water
	30720	3704	14	water
	40723	3704	14	sediment biology
	40720	7233	21	water
	10722	7233	21	sediment chemistry
	30723	7233	21	sediment biology
	70721	19900	19	biota
601, Porto Tolle, Po di Pila mouth				
	16010	500	6	water
	16012	741	13	sediment chemistry
	16013	370	5	sediment biology
	26010	926	16	water
	36010	3704	27	water
	36013	741	13	sediment biology
82, Porto Tolle, Po di Tolle mouth				
	10820	500	5	water
	10822	3704	15	sediment chemistry
	10823	500	5	sediment biology
	20820	926	7	water
	30820	3703	15	water
	30823	3704	15	sediment biology

Each campaign lasts an average of three to four days, barring adverse weather and sea conditions, and tends to be carried out in the first few days of the month. Campaigns to detect the presence of benthic microalgae are planned in the period from July to October, with sampling on solid substrates and water near the coastline. The sampling of biota-molluscs for the assessment of chemical status is planned for around June, while the period for the recovery of biota-fish samples depends on the availability of the required species.

In addition, for Bathing Waters, there is a network of 95 sampling points within 500 m of the coast. On a monthly basis, from May to September, water and air temperature data are acquired.

In addition to the monitoring network for marine-coastal waters, the Veneto Region has a monitoring network for lagoon waters consisting of 271 sampling points located in the Caorle and Baseleghe lagoons, in the Venice lagoon and, in the Po Delta area, in the Caleri, Vallona, Marinetta, Barbamarco, Canarin and Scardovari lagoons and in the Po branches (Maistra, Pila, Tolle, Gnocca and Goro). The network also includes 39 control points where only field surveys are carried out (chemical-physical water parameters by multi-parameter probe and meteo-marine parameters). In the lagoons of the Po Delta, Arpav also manages a network of 9 multi-parameter probes that continuously measure the water's chemical and physical data (temperature, conductivity, salinity and dissolved oxygen). The probes are located in the Caleri, Marinetta, Vallona, Barbamarco, Basson, Canarin and Scardovari lagoons.

3.3 Report on observing campaigns

All analytical activities are carried out at ARPAV by the highly specialised technical staff of the Regional Laboratories Department and the O.U. Sea and Lagoon Quality Unit, with the sole exception of the parameter saxitoxin in mussels, the research for which is entrusted to the Experimental Zooprophylactic Institute of the Venezie.

The analytical results, after validation, are entered into the Veneto Regional Environmental Information System (SIRAV) through the computer programme called "LIMS". In the LIMS application, managed by the Regional Laboratories Department, all the information relating to each individual sample is entered, from the master data to the analytical results; the data entered, processed and validated by the Operating Unit Manager, are transferred to the central SIRAV database.

Data relating to surveys carried out directly in the field (multi-parameter probe, Secchi disk, meteorological surveys) are managed locally and entered into a special database called Veneto Sea Data System (SDMV).

The data (field surveys, analytical results, etc.) are fed into the Veneto Sea Data System (SDMV), which has the purpose of collecting and organising all sea-related information.

3.4 Data sharing and open access

ARPA Veneto hosts a section dedicated to the monitoring of marine and lagoon waters on its institutional website:

https://www.arpa.veneto.it/temi-ambientali/mare-e-lagune

Bulletins and reports are issued periodically and can be consulted at the following links:

- for marine-coastal waters

https://www.arpa.veneto.it/temi-ambientali/mare-e-lagune/informare

- for the waters of the Venice lagoon

https://www.arpa.veneto.it/temi-ambientali/mare-e-lagune/rapporti-acque-lagunari

- for the waters of the lagoons of the Po river delta

https://www.arpa.veneto.it/territorio/rovigo/lagune-delta-del-po

The location of the sampling points is available on the page:

https://www.arpa.veneto.it/dati-ambientali/dati-storici/acque/mare-e-lagune

Data are provided in open mode and are available in the section:

https://www.arpa.veneto.it/temi-ambientali/mare-e-lagune/open-data

In particular, at the following link, it is possible to find the data detected by the probe profiles:

https://www.arpa.veneto.it/dati-ambientali/open-data/idrosfera/acque-marino-costiere-e-acque di-transizione/acque-marino-costiere-e-transizione-profili-sonda

while the weather-marine parameters are available at the link:

https://www.arpa.veneto.it/dati-ambientali/open-data/idrosfera/acque-marino-costiere-e-acquedi-transizione/acque-marino-costiere-e-transizione-parametri-meteo- marine

4. Emilia-Romagna coastal area

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ARPAE: Andrea Valentini, Cristina Mazziotti, Silvia Unguendoli

ISPRA: Tommaso Petochi, Alì Porzanbar, Antonello Bruschi, Matteo Ciani, Giovanna Marino

4.1 Description of the pilot area

The Emilia-Romagna pilot area is defined by 120 km of coastline from Po River Delta to Cattolica. Considering the different hydrological and trophic conditions, this pilot area is divided into three subareas (A, B and C). Mainly, subarea A is located nearby Po River Delta and delimited by Lido di Volano and Casalborsetti transects. Also, it is influenced by the riverine discharge and the nutrient loadings. Subarea B is a transitional area between Ravenna port and Cesenatico while subarea C, from Bellaria to Cattolica, is the southern area characterized by hydrological conditions mainly guided by the large-scale basin circulation.

4.2 Planning of observing campaigns

In the Emilia-Romagna pilot area, University of Bologna supported by Daphne Oceanographic Structure (Emilia-Romagna Regional Environmental Protection and Energy Agency, ARPAE

Cesenatico) designed a monitoring network considering the existing one for the coastal and marine waters of ARPAE. The main goal was to monitor the biogeochemical condition of marine sediment and of waters considering the potential effect of river discharges (Po River and Apennine Rivers) from Autumn 2021 to Spring 2022. To that, Unibo teams selected 18 out of 35 existing stations along the Emilia-Romagna region grouped into four transects (Figure 4.1 and Table 4.1).

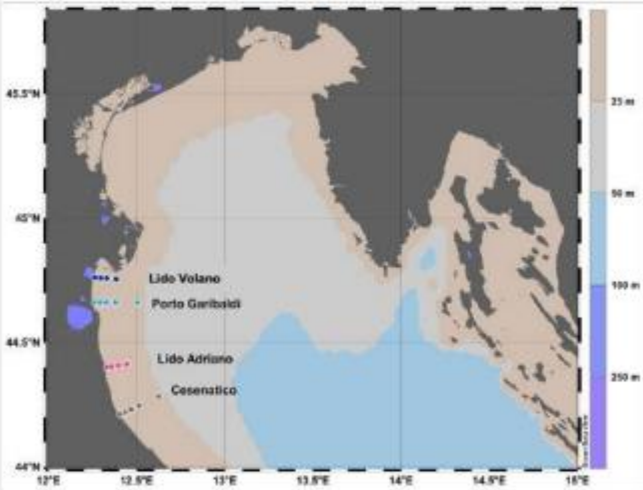

Figure 4.1: Map of sampling points in the Emilia-Romagna pilot area

The four transects were located from the northern site of Lido di Volano, nearby the Po River Delta, to the southern one of Cesenatico and were perpendicular to the coast from 0.5 and 20 km distance from the coastline. Four sampling campaign were carried out with the support of the RV “Daphne II” (ARPAE) along the EMR pilot area:

- AdriaClim 1: 17 and 21/12/2020
- AdriaClim 2: 18 and 21/05/2021
- AdriaClim 3:29 and 30/11/2021
- AdriaClim 4: 11 and 12/04/2022

Transect	Station ID	Lat (N)	Long (E)	Distance from the coast
Lido di Volano	2	44.76276	12.25855	0.5 km
Lido di Volano	302	44.76146	12.29015	3 km
Lido di Volano	602	44.759562	12.32815	6 km
Lido di Volano	1002	44.757262	12.37915	10 km
Porto Garibaldi	4	44.661455	12.25705	0.5 km
Porto Garibaldi	304	44.661557	12.28815	3 km
Porto Garibaldi	604	44.661757	12.32495	6 km
Porto Garibaldi	1004	44.661958	12.37615	10 km
Porto Garibaldi	2004	44.662162	12.50215	20 km
Lido Adriano	9	44.401248	12.32565	0.5 km
Lido Adriano	309	44.405148	12.35644	3 km
Lido Adriano	609	44.40915	12.39264	6 km
Lido Adriano	1009	44.415052	12.44324	10 km
Cesenatico	14	44.212043	12.40254	0.5 km
Cesenatico	314	44.221043	12.43074	3 km
Cesenatico	614	44.232345	12.46434	6 km
Cesenatico	1014	44.247647	12.50994	10 km

Cesenatico	2014	44.28515	12.62314	20 km

Table 4.1 Details of monitoring stations of Emilia Romagna

At each station, water column conditions were monitoring using the CTD (Idronaut mod. Ocean Seven 316 Plus, Figure 4.2)) and a fluorimeter (Turner Design 10AU, Table 4.2) to acquire the following chemical-physical parameters: salinity, temperature, pressure, dissolved oxygen, pH, chlorophyll-a and turbidity. CTD is calibrated by the manufacturer once per year, and ARPAE scientific team always checks the quality of the data collected during monitoring to avoid any issue.

Figure 4.2: Sampling activities in the Erm pilot area

Water samples were collected with a 5-L Niskin bottle at each station, and immediately transferred to the ARPAE Cesenatico Laboratory for nutrient analysis. Phosphate (ion), nitrogen (ions) and silicate (ion) concentrations were determined according to Standard methodologies of Grasshoff (1983) and of Bran+Luebbe N° G-177-96-Rev.1 (Multitest MT19).

Furthermore, to collect marine sediments (0-5 top cm) at each station, samples were retrieved with a Van Veen grab sampler (1000 cm²) and kept on ice avoiding air exposure or other contaminations. Samples were immediately transferred to the laboratory, processed, and stored for nutrient (C, N, P) and granulometry analysis according to standard procedures (ICRAM, 2001).

Type of sensor	Range	Accuracy	Sensitivity	K time
Pressure	0 -200 dbar	0.2 %	0.03 %	50 ms
Temperature	-3 - +50 °C -	0.003 °C	0.0005 °C	50 ms
Conductivity	0 – 64 mS/cm	0.003 mS/cm	0.01 mS/cm	50 ms
Dissolved oxygen	0 – 50 ppm	0.1 ppm	0.01 ppm	3 s
	0 – 500% sat.	1% sat.	0.1 % sat	3 s
pH	0 – 14 pH	0.01 pH	0.001 pH	3 s
Turbidimeter	0 – 30 ftu	1% f.s.	ftu	1 s
Fluorimeter	0 – 30 µg/l	1% f.s	0.1 µg/l	1 s

Table 4.2 Details of CTD and fluorimeter sensors

Moreover, within the Emilia-Romagna Pilot area, in collaboration with UNIFE (University of Ferrara), Arpae designed a precise geometric leveling network (part of an integrated regional monitoring network) along the Emilia-Romagna coasts. Leveling is the operation of measuring vertical distances to determine differences in elevation. The elevation or height of a point of the earth is its vertical distance above (or below) a reference surface (vertical datum). Figure 4.3 displays the activities carried out by the operators during the leveling measures.

Figure 4.3 benchmarks of the RGC (Rete GeodeticaCostiera, Coastal Geodetic Network) along the Emilia-Romagna coasts

The main goal was to define precise elevation of 51 benchmarks of the coastal geodetic network called RGC (Rete Geodetica Costiera, see Figure 4.4 and Figure 4.5). The RGC was used to connect all the parameters monitored in a single geodetic system, especially for the elevation coordinate. For example, the RGC was used to connect the new tide gauge stations with permanent GNSS co-located of Cervia and Cattolica (Figure 4.6), in the south of Emilia Romagna region, with the pre-existing tide gauge stations of Porto Garibaldi and Marina di Ravenna, in the north of the Emilia-Romagna region.

Figure 4.4: benchmarks of the RGC (Rete GeodeticaCostiera, Coastal Geodetic Network) along the Emilia-Romagna coasts

Figure 4.5: benchmarks of the RGC,north section on the top, south section in the lower panel.

Figure 4.6: new tide gauge with co-located GNSS permanent station of Cattolica (left) and Cervia (right)

During the AdriaClim project, guidelines have been drafted about precise geometric leveling, tide gauges and GNSS co-located. GNSS co-located with tide gauges allows the monitoring of the subsidence of the territory eliminating this data from the sea level. The leveling campaign was carried out (by an external company) between 31 January and 26 April 2023.

During and after the campaigns were applied the international standards for high-precision geometric leveling. In particular, we established a maximum allowed discrepancy of $\pm 2.5\sqrt{\ell}$ mm in double-run leveling where ℓ is the length of the leveling segment in km, and a maximum value for ring closure of $\pm 2.5\sqrt{L}$ mm, where L is the length of the ring in km.The leveling network was measured with digital levels with INVAR staffs(standard deviations 0.4 mm km-1 in double-run leveling). In summary approximately 210 km of precise leveling between main and secondary lines were carried out.

The benchmark PGFV0100 (Porto Garibaldi) was chosen as a reference benchmark for the entire network with elevation deriving from the ellipsoidal height of the GARI00ITA GNSS station (Figure

4.7) belonging to the EUREF Permanent GNSS network (http://www.epncb.oma.be/). EUREF is a IAG (International Association of Geodesy) Reference Frame sub-commission for Europe.

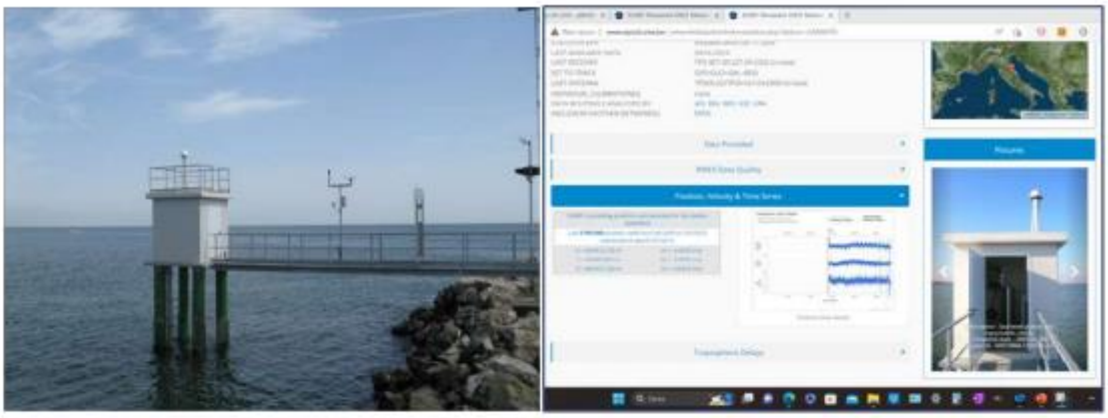

Figure 4.7: the Porto Garibaldi tide gauge with co-located GARI00ITA GNSS (left); in the right, the time series of the GNSS coordinates calculated by EUREF and adopted as reference

The transformation between ellipsoidal to geoid height was carried out using national ITALGEO2005 undulation model provided by IGMI (Istituto Geografico Militare Italiano – Italian Military Geographic Institute).

Planning observing campaigns for aquaculture: There is a rising interest to investigate the potential impact of climate change on aquaculture in ERM. Shellfish aquaculture is an historical human activity in transitional and marine coastal area of ERM and a strategic sector for the ble economy in the Region which hosts over 20% of national shellfish production areas. Taking into account the vulnerabilityof aquaculture to CC and the evidence of climate change in ERM (e.g. temperature rise, extreme events), in AdriaCLIM project, historical dataset of microbial parameter of interest for human health (*Escherichia coli* ; Salmonella spp.) measured in harvested shellfish and growing waters of ERM, were analyzed for cross correlations with environmental parameters and for implementation of a microbial diffusion model under climate change scenarios carried out include the analysis of historical dataset.

These activities were carried out in collaboration with Istituto Zooprofilattico Sperimentale della Lombardia ed Emilia-Romagna (IZSLER) under AdriaCLIM

Analysis of prob measurements collected between 2005 and 2021 from 24 nearshore stations. The probe measurements are water salinity (Sal), dissolved oxygen (O2), pH and surface temperature (Tw). Environmental data were collected in situ at the same shellfish sampling time

4.3 Report on observing campaigns

Water content, porosity and dry bulk density of sampled sediments were determined according to ICRAM (2001). After the removal of organic matter by hydrogen peroxide, grain size analysis was performed with wet sieving obtaining three major dimensional fractions: <63 µm (silt-clay), 63-250 µm (fine sands) and > 250 µm (medium sands).

Dry sediment samples (at 60 °C for 48h) were analyzed for total carbon (TC), total nitrogen (TN), organic carbon (OC) and carbon and nitrogen stable isotope ratios ($\delta^{13}C$ and $\delta^{15}N$), and using a Thermo Flash elemental analyzer (Thermo EA-1112) coupled to a Thermo Fisher Delta IRMS Plus XP isotope ratio mass spectrometer and methods from Fry et al. (1992). Only for OC and $\delta^{13}C$ analyses, the samples were pretreated and acidified with HCl 1.5 M and drying at 60 °C. Isotope ratios were expressed as: (‰)

where X is $\delta^{13}C$ or $\delta^{15}N$, and R the corresponding ratio $^{13}C/^{12}C$ or $^{15}N/^{14}N$, and the standard reference materials were Vienna Pee Dee Belemnite for carbon and atmospheric N_2 for nitrogen. Analytical uncertainty was estimated on replicate measurements of internal standard (Acetanilide for C and N, International Atomic Energy Agency IAEA- CH-6 for $\delta^{13}C$ and IAEA-NO-3 for $\delta^{15}N$) and was 0.02%, 0.05%, 0.1‰ and 0.2‰ for C, N, $\delta^{13}C$ and $\delta^{15}N$, respectively.

Total and inorganic phosphorus content were determined in dry sediment samples using a modification of the combustion method and HCl extraction procedure according to the procedures of Solórzano and Sharp (1980) and Aspila *et al*.,1976. The orthophosphate concentrations in extracts are measured using the standard ascorbic acid molybdate blue spectrophotometric method (Strickland & Parsons, 1972). Spectrophotometer was set at 850 nm and calibrated using different standard solutions. Additionally, for quality control of the analytical methods, TP and IP were measured in Certified Reference Materials (*Sco-I Cody Shale, United States Geological Survey)*.

Final results on sedimentary total phosphorous show higher values in Lido Volano transect among all the sampling campaigns and compared to thar of the others marked by similar values (Figure 4.8). Both total nitrogen and organic carbon (Figure 4.8) are marked by similar contents and trends among the transects and the seasons except for Lido Volano. In this case, TN and TOC show higher variability from the first two sampling campaigns, Autumn 2020 and Spring 2021, compared to the last two, Autumn 2021 and Spring 2022.

To detect potential origin of the sedimentary organic matter collected during the fours sampling campaigns, three potential sources have been selected, and carbon and nitrogen isotopes were measured: the Po River, the Apennine Rivers including the Reno, Lamone, Fiumi Uniti, Bevano and Savio Rivers, and marine phytoplankton (Figure 4.8). The Po river is the main contributors to both carbon and nitrogen in benthic sediments collected during the first two sampling campaigns

(Autumn 2020 and Spring 2021), while in the last two sampling campaigns (Autumns 2021 and Spring 2022) carbon and nitrogen isotopic signatures are more indicative of Apennine Rivers contribution. This shift in source contribution from the Po River to the Appennine Rivers occurred in concomitance with the critically low Po River discharge and the ongoing drought recorded in the whole basin since October 2021 ([https://webbook.arpae.it/indicatore/Portata-dei-fiumi 00001/?id=46803a8c-c127-11e2-9a51-11c9866a0f33](https://webbook.arpae.it/indicatore/Portata-dei-fiumi00001/?id=46803a8c-c127-11e2-9a51-11c9866a0f33)).

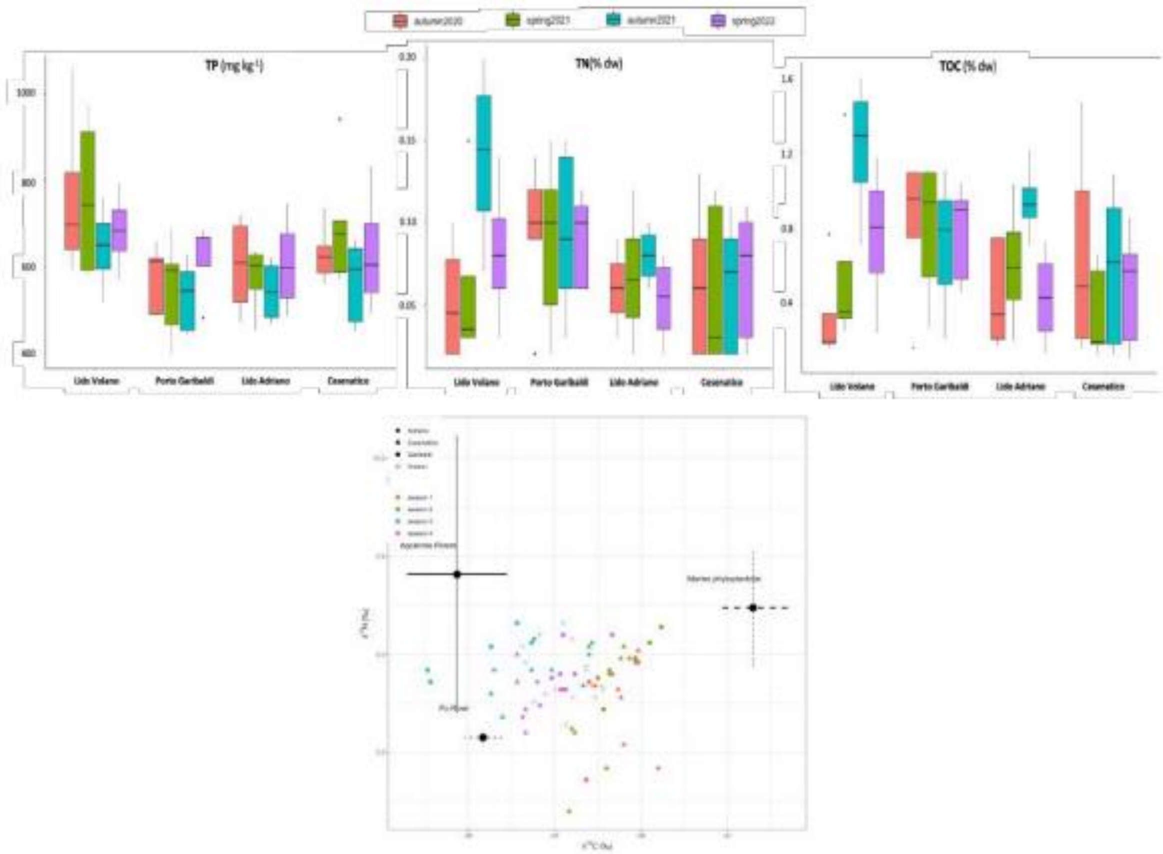

Fig 4.8 ***Top****: Sedimentary TP, TN and TOC measured in the sediments, and* ***bottom****: Dual stable isotope plot of potential organic matter and sediments of ERM pilot area during the four sampling campaigns*

Benthic sediments within the land-to-sea aquatic continuum represent a sink and recycling compartment for nutrients, i.e. organic carbon, nitrogen and phosphorus in the pilot area of Emilia Romagna coast. The in-situ measured data on benthic TOC, TN and TP represent a substantial contribution to overcome the data gaps, and will improve the understanding of related benthic processes and seasonal variations, and the impacts of climate change and variability on the nutrients cycles, and their representation in ocean and climate models in the pilot coastal region of Emilia Romagna.

Regarding the geometric leveling network performed by Arpae. Table 4.3 shows the geoid elevations obtained at the end of the measurements.

Locality	**benchmark**	**H - elevation (m)**
Gabicce	GABI0100	4.9961
Cattolica	CARI0010	2.4911
Cattolica	**Tide Gauge benchmark**	1.8033
	CARI0100_New	2.7315
	CARI0200	1.9998
	CARI0210	1.9726
	CARI0300	3.2543
Riccione	CARI0401	3.2712
	CARI0500	3.1043
	CARI0600	3.0605

Rimini	CARI0700	1.9319
	RICE0100	2.9055
	RICE0200	2.879
	RICE0310	2.9219
Bellaria-Igea Marina	RICE0500	2.0666
	RICE0550	1.5882
	RICE0600	2.4174
	RICE0700	2.6371
Cesenatico	CESA0100	1.6934
	CESA0200	2.1897
Cervia	CESA0300	2.0312
Cervia	**Tide Gauge benchmark**	1.2145
	CESA0400	1.6856
Lido di Classe	SAPC0100	3.9629

	SAPC0150	1.5639
	SAPC0200	1.5051
Lido di Dante	SAPC0301	2.1624
Lido Adriano	SAPC0400	1.2829
	SAPC0500	1.4281
Punta Marina	SAPC0600	4.2072
	SAPC0650	0.7922
Marina di Ravenna	SAPC0700	2.0623
	PCPG0020	2.6037
	PCPG0010	1.5978
	PCPG0100	1.6583
Casalborsetti	PCPG0200	2.1346
	PCPG0300	0.6926
	PCPG0400	1.7074

	PCPG0450	1.7476
	PCPG0500	1.6111
Lido di Spina	PCPG0600	1.8209
Porto Garibaldi	**PGFV0100 reference benchmark**	1.865
	PGFV0200	3.7967
	PGFV0300	2.5907
Lido delle Nazioni	PGFV0400	2.1123
	PGFV0500	0.2724
Lido di Volano	PGFV0600	2.6615
Goro	FVFG0100	0.5986
	FVFG0200	-1.8621
	FVFG0300	1.3015
Gorino	FVFG0400	2.0408
Faro di Goro	FVFG0500	nd

Table 4.3: geoid elevation H of RGC benchmark and new tide gauges benchmark in Cattolica and Cervia

4.4 Data sharing and open access

All Individual data sets on bulk sediments and water column are available at Zenodo® repository and digital object identifiers are also given.

- data will be available at https://zenodo.org/communities/oceanography difa/?page=1&size=20

Data sets are available under a Creative Commons Attribution 4.0 International Public License (CC BY). When using data from this dataset please cite these data sets, along with the original sources. Data from the sanitary monitoring network of shellfish areas along the Emilia-Romagna coast will be entered in a geodatabase under development by ISPRA and IZSLER.

5. Neretva River Estuary

IOF: Gordana Beg Paklar, Natalija Dunić, Hrvoje Mihanović, Stipe Muslim

5.1 Description of the pilot area

The Neretva is the largest river in the eastern part of the Adriatic Sea with a total length of 218 km, of which only about 20 km are in Croatia. The Neretva River valley is densely populated and is one of the most important agricultural areas in Croatia. The valley is surrounded by hilly karst rich in groundwater that supplies numerous springs, streams and lakes. The Neretva River delta is also a valuable ecosystem, home to numerous endemic species and is included in the Ramsar List as a wetland of international importance.

Saltwater intrusions into the Neretva estuary have many negative impacts: on agricultural production, drinking water sources, biodiversity and the balance of this fragile ecosystem. Unfortunately, the salinization problem is expected to become even more severe in the future under projected climate change and due to potential rise of sea level and reduction of freshwater inflow during summer.

5.2 Planning of observing campaigns

Within the AdriaClim project an automatic meteo-oceanographic station is installed in Metković harbor (Table 5.1). The station is equipped with sensors for continuous measurements of wind speed and direction, air temperature, relative humidity, air pressure, water temperature, conductivity, hydrostatic pressure and with radar tide gauge. The meteorological parameters are measured with the Lufft WS500, the oceanographic ones with the SeaBird HydroCAT SMP, while the water level data are collected with OTT RLS tide gauge. The measurement interval for the meteorological parameters and water level is one minute and for water temperature, conductivity and hydrostatic pressure 10 minutes. Data transfer interval is 10 minutes. A visual presentation of the collected data is available online at IOF web site: http://faust.izor.hr/autodatapub/postaje?jezik=eng.

Six CTD sensors (CTD-diver, Royal Eijkelkamp) and three sensors for dissolved oxygen content (mini DOT Logger, PME) were installed at four selected locations in the Neretva River estuary: Metković, Opuzen, Komin and Rogotin (Table x). In addition, two field campaigns were conducted, the first at the end of March 2023, and the second in mid-May 2023. CTD measurements were carried out at 16 stations along the Neretva River during the first campaign, from the river mouth to Metković (Figure 5.1) and at 19 stations in the second campaign. The third campaign will be conducted at the end of June 2023. Sediment samples were collected at mooring locations.

automatic meteo oceanographic station (Metković - harbor)	AMOS	43°03'19''N	17°39'06''E	CTD	1 m	-
Rogotin	P01	43°02'15''N	17°28'53''E	CTD	5 m	CTD, TO2
Komin	P02	43°02'41''N	17°30'53''E	CTD	5 m	CTD, TO2
Opuzen	P03	43°01'04''N	17°34'05''E	-	-	CTD
Metković	P04	43°03'18''N	17°39'01''E	-	-	CTD, TO2

Table 5.1. Locations of automatic meteo-oceanographic station and moorings with CTD and O_2 sensors

Figure 5.1 Locations of the CTD measurements along the Neretva River course during the first campaign (31 March 2023).

6. Split-Dalmatia coastal area

IOF: Gordana Beg Paklar, Danijela Bogner, Branka Grbec, Živana Ninčević, Stefanija Šestanović, David Udovičić

6.1 Description of the pilot area

Split-Dalmatia County is located in the central part of the Adriatic coast and is divided into three geographical subunits: hinterland, coastal area and islands. The coastal area forms a narrow strip along the coast between the mountain ranges and the sea and is highly urbanized. The IOF monitoring program in the Split-Dalmatia County is focused on the Kaštela Bay, a semi-enclosed coastal bay, covering an area of 57 km^2 and having an average depth of 23 m. Due to its natural characteristics (closed bay) and intensive industrialization in the past, as well as increased urbanization, Kaštela Bay is one of the areas where the ecological balance has been disturbed. Consequently, increased eutrophication has been recorded. The area suffers from a number of issues related to climate change, such as sea level and air temperature rise, increased frequency of various extreme events like heat waves, storms, flooding events and the more frequent appearance of prolonged dry periods.

6.2 Planning of observing campaigns

CTD measurements and samplings for analysis of microbiological and phytoplankton parameters were conducted on the monthly basis during the period from January 2020 to December 2022. Due to the technical problems and COVID-19 pandemic circumstances, CTD data and samples were collected within 25 field cruises. Samples were collected vertically at 5-8 standard oceanographic depths with Niskin bottles. Two stations with different trophic status are chosen: one is located in the center of the Kaštela Bay (central part of Kaštela Bay, 43°51′N; 16°38′E, depth 38m) and the other near the island of Vis (central Adriatic Sea, 43°N; 16°33′E, depth 103m (Table 6.1).

Thermohaline properties were measured with a calibrated Sea-Bird Electronics SBE-25 CTD probe, with fine vertical resolution (10 cm) and data were averaged for every 1 m. The first analysis and quality control of the data were performed on board immediately after the probe had been uploaded, while more detailed quality control was performed after the cruises using methods described in D3.3.1.

Microbiological investigations aimed to study the structural and functional features of microbial food web by observing the following parameters: abundance and production of heterotrophic bacteria (with different DNA content, i.e. High- DNA bacteria and Low- DNA bacteria), abundances of two cyanobacteria groups, i.e. Prochlorococcus and Synechococcus), abundances of pico

eukaryotic algae and abundances of protistan grazers (heterotrophic nanoflagellates).

For cell counting, samples were analyzed using a Beckman Coulter CytoFLEX cytometer with a fast flow rate of 60 mL min−1. Fresh samples for autotrophic cell analysis (2 mL) were preserved in 0.5% glutaraldehyde, flash- frozen and stored at –80◦C until analysis (within 1 week). Samples for analysis of bacteria were preserved in 2% formaldehyde kept at 4◦C until analysis. Autotrophic cells were divided into three groups: two cyanobacteria (SYN and PROC) and PE, distinguished according to light scattering, cellular chlorophyll content, and phycoerythrin-rich cell signals, respectively. According to the cellular nucleic acid content, the bacterial populations were divided into two sub groups, HNA and LNA bacteria.

Bacterial cell production was estimated by measuring the incorporation of 3H-thymidine in bacterial DNA. Methyl-3H-thymidine was added to 10 mL samples at a final concentration of 10 nmol (specific activity: 86 Ci mmol−1). Triplicate samples and a formaldehyde-killed adsorption control (final concentration: 0.5%) were incubated for 1 h. The incubations were stopped with formaldehyde (final concentration: 0.5%). The thymidine samples were extracted with ice-cold trichloroacetic acid (TCA). The TCA-insoluble fraction was collected by filtering the samples through 0.2 mm pore size polycarbonate filters.

The microbiological investigations are improved within the AdriaClim project by upgrading laboratory equipment. A new CCD camera mounted on an epifluorescent microscope improved research capacities by enabling a better view of fluorescence microscopy images, higher resolution and finer sensitivity. The laboratory flow cytometer is upgraded with an automatic plate loader that helps to optimize sample processing by time reduction. The cytometer red laser is activated.

In order to detect changes in the phytoplankton community under the influence of climate change, seawater was sampled at the same two stations as for microbiological parameters: coastal station in Kaštela Bay and in open waters at the Stončica station (Table x). Namely, at these stations there are long-term data series on the composition of the phytoplankton community dating back to 1956 and chlorophyll a concentrations dating back to 1977. Samples were taken at standard oceanographic depths for chlorophyll a concentration and community composition. A new molecular method based on DNA microarray technology with the aim to improve detection and determination of harmful algae is introduced as the existing monitoring program based on light microscopy did not allow the identification of all harmful species down to the species level. Method is based on the labeling of the target nucleic acids, which then are hybridized to the probes on the microarray. The laser in a microarray scanner scans the slides and recognizes the hybridization pattern according to fluorescent excitation and identifies present species.

Kaštela Bay	ST 101	43°51'N	16°38'	38 m
Stončica	CJ009	43°N	16°33'E	103 m

Table 6.1. Oceanographic stations in the Split-Dalmatia pilot site

6.3 Report on observing campaigns

The responses of the microbial food web to environmental conditions were investigated at several levels:

1.Quantitative-through changes of certain parameters (e.g., increase or decrease of the number, biomass and/or production of certain microbial groups of organisms);

2.Qualitative/structural- through changes in the composition and size structure of the microbial food web;

3.Functional-through changes in trophic relationships within the microbial food web

All microbiological parameters exhibited the usual values with a constantly higher value at the coastal site which is expected. Obtained concentrations confirm the oligotrophic character of both sites (Figures 6.1 and 6.2). Understanding how microbial communities are affected by different drivers of climate change is important for making accurate predictions about ecosystem response to changing climate scenarios. The predicted temperature increases of 3 °C in the near future, as a result of global warming, could cause a significant increase in bacterial growth at temperatures below 16 °C. It could also increase the proportion of bacterial production transferred to the metazoan food web. Therefore, global warming is expected to increase the role of the microbial food web in the carbon cycle in the Adriatic Sea.

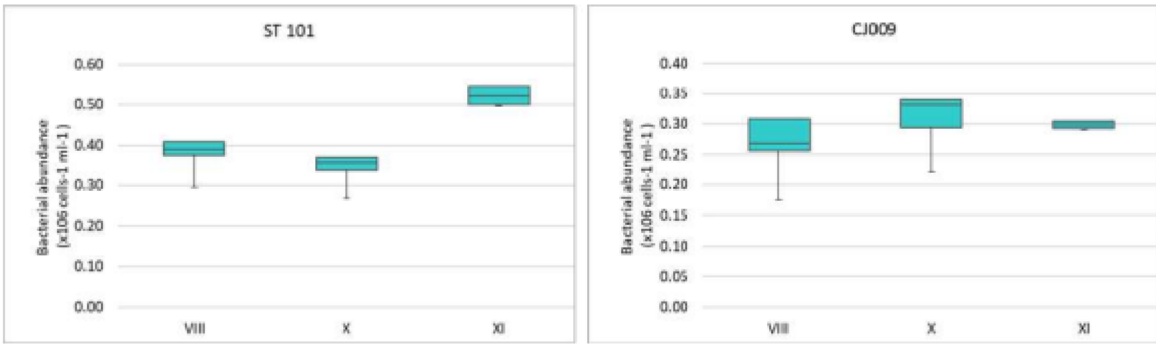

Figure 6.1. Boxplot of heterotrophic bacterial abundances at investigated sites in the period July – November 2022. Central line indicates median value, boxes indicate the lower and upper quartiles, and vertical lines indicate minimum and maximum.

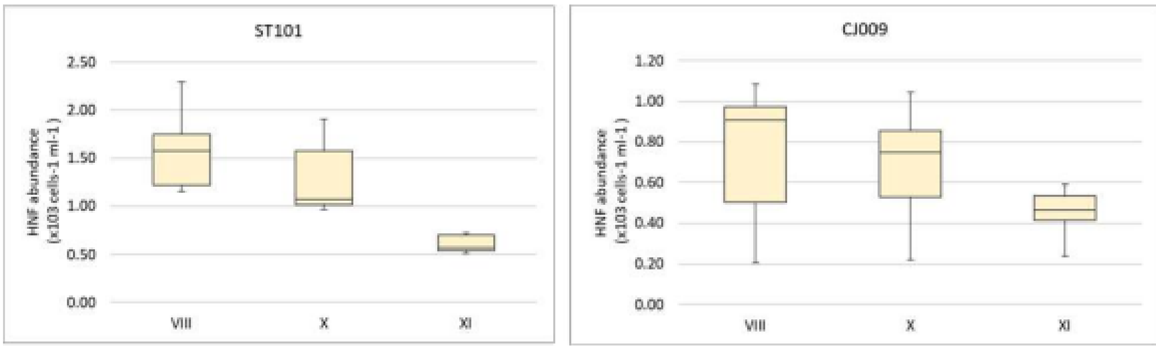

Figure 6.2. Boxplot of heterotrophic nanoflagellates abundances (HNF) at investigated sites in the period July – November 2022. Central line indicates median value, boxes indicate the lower and upper quartiles, and vertical lines indicate minimum and maximum.

The highest chlorophyll a concentration in Kaštela Bay were measured in the surface layer in winter and in the bottom layer in spring (Figure 6.3). This distribution of phytoplankton biomass is consistent with the natural distribution of nutrients, which are evenly distributed in the water column in winter, and the phytoplankton component develops better in the surface layer due to the available light. In contrast, in the warmer season, due to stratification, the nutrient supply is limited to the surface layer and light intensity is strong enough to stimulate phytoplankton growth in the nutrient-rich bottom layer. The vertical distribution of chlorophyll concentration in open waters clearly indicates periods of mixing and stratification of the water column, when higher biomass is in the lower layer (Figure 6.4). Such a vertical distribution is common for open waters. Obtained phytoplankton biomass and community structure, as well as seasonal *distributions, were common for the coastal and open waters of the Adriatic Sea.*

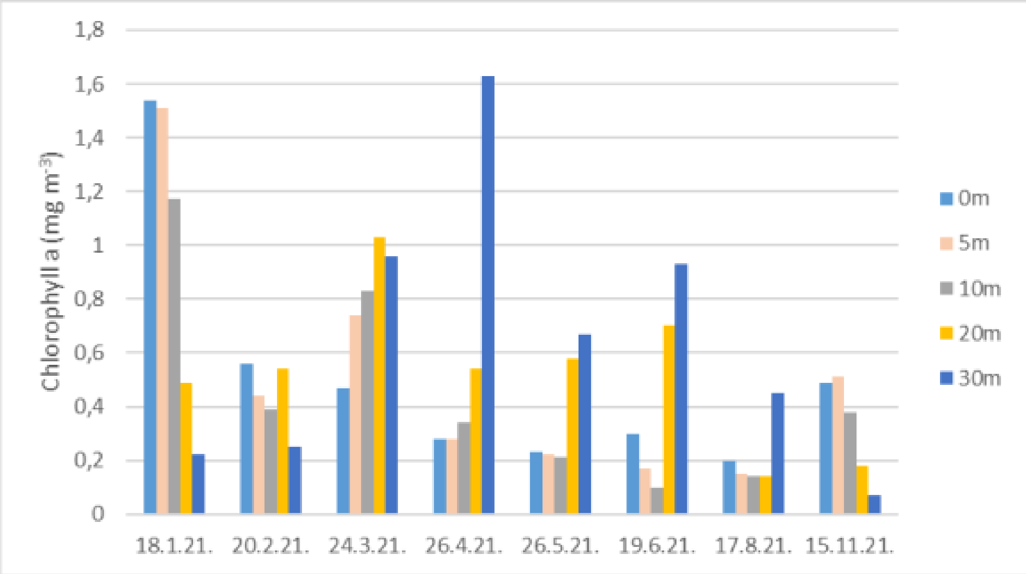

Figure 6.3. Seasonal and vertical distribution of chlorophyll a concentration in Kaštela Bay in January – November 2021.

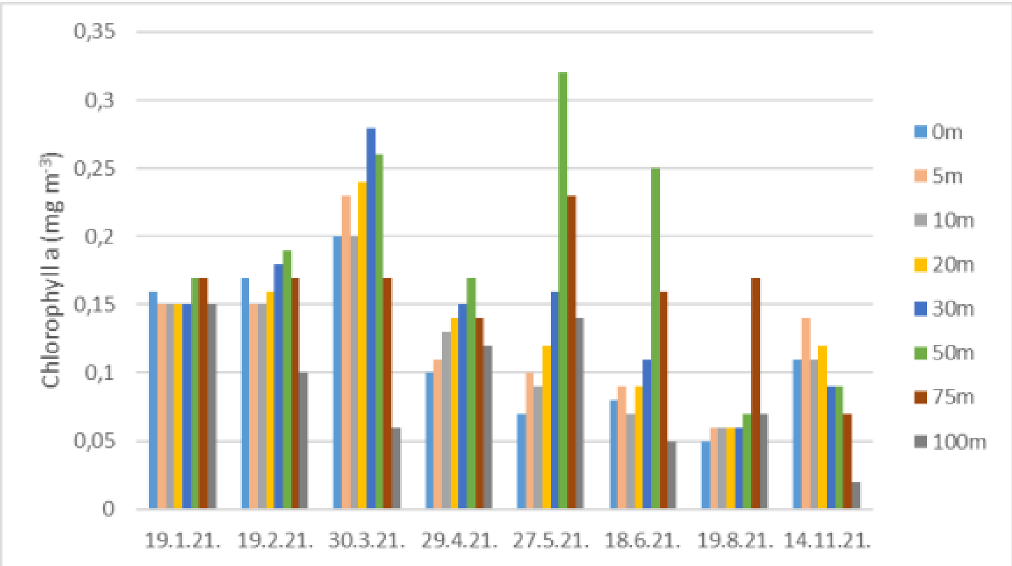

Figure 6.4 Seasonal and vertical distribution of chlorophyll a concentration in offshore waters in January –November 2021.

6.4 Data sharing and open access

The data obtained within the AdriaClim project by the IOF team will be available on the AdriaClim Geoportal.

7. North-Eastern Adriatic Sea

IRB : Ana Baricevic, Martin Pfannkuchen

7.1 Description of the pilot area

The North – Eastern Adriatic Sea is a shallow (up to 40 m depth), semi-enclosed coastal area with steep ecological gradients, which are mainly noticeable through changes in nutrient composition, salinity, temperature and oxygen saturation. The area is under significant influence of freshwater inputs (Po River as the largest freshwater input into the Adriatic) and the established Adriatic Sea circulation. In addition to river dilution and nutrient enrichment, the area is characterized with periodic inflows of high salinity waters transferred by the Eastern Adriatic Current (EAC) from the southern to the northern part of the Adriatic Sea. Given the ecological characteristics, the North – Eastern Adriatic Sea is a highly productive and dynamic marine ecosystem. It is an ideal basin to study the influence of freshwater inflows and fast oceanographic changes on marine ecosystem.

7.2 Planning of observing campaigns

Observing campaigns in the Northern – Eastern Adriatic Sea were organized in the framework of the national oceanographic monitoring network of the Reference Centre for the Sea (Ministry of Economy and Sustainable Development of the Republic of Croatia). Two stations (Figure 7.1, Table 7.1) were included and monthly sampling conducted in the period from January 2020 to January 2023. Variables that were measured include: temperature, conductivity (salinity), dissolved oxygen, Chlorophyll A and nutrients (N, P, Si). Samplings were conducted with the CMR – RBI research vessel Burin using CTD probe (temperature, conductivity and dissolved oxygen) from the surface to the bottom and collecting sea water with Niskin bottles (Chlorophyll A and nutrients) on depths of 5, 10 and 20 m (Figure 7.2). All the samples were immediately laboratory processed and analysed in the CMR – RBI. Observing system of the Northern – Eastern Adriatic Sea was supported with the real time data collecting of the AdriaClim project installed observing oceanographic buoy (Figure 7.2) on the Rovinj – Po transect, position 5 nm from the coast of Croatia (Lat: 45.075492, Lon: 13.598978) during a period from January 2023 – June 2023. Oceanographic buoy enabled measuring of diverse set of meteorological (wind direction and speed, air temperature, relative humidity, atmospheric pressure, solar irradiation, precipitation and air visibility) and oceanographic variables (surface current, wave height, PCO2, temperature, conductivity (salinity), dissolved oxygen, light transmission, pH, phytoplankton pigments; phycocyanin, phycoerythrin and chlorophyll-a).

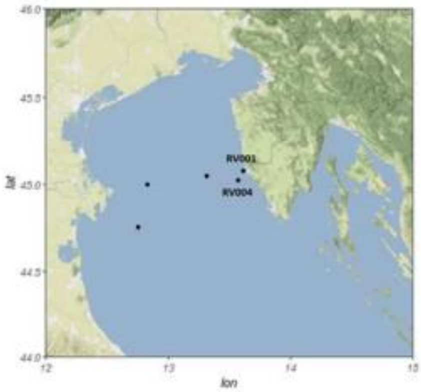

Figure 7.1 Map of the Rovinj – Po transect and sampling stations in the Northern – Eastern Adriatic Sea pilot area

Transect	Station ID	Lat (N)	Long (E)	Distance from the coast
Rovinj - Po	RV001	45.080000	13.610000	1 nm
Rovinj - Po	RV004	45.076450	13.568094	4 nm

Table 7.1. Description of the sampling stations included in the observing campaigns

Figure 7.2 Research vessel (A), sampling procedure (B), and oceanographic buoy (C) in the Northern – Eastern Adriatic Sea pilot area

7.3 Report on observing campaigns

An overall number of 36 observing campaigns (January 2020 - January 2023) were conducted in the Northern – Eastern Adriatic Sea. CTD probe (Sea Bird, USA) measurements of bottom – surface water column oceanographic parameters (temperature, conductivity and dissolved oxygen) were collected for each campaign on two sampling stations (RV001 and RV004). In each campaign, Niskin bottles water column collections were conducted and 6 samples (2 stations x 3 depths) of 500 mL per parameter (chlorophyll-a and nutrients) were prepared for laboratory measurements. After prefiltration (200 µm mesh size), chlorophyll-a Niskin samples were filtered on Whatman GF/C filters and immediately frozen at -20°C until analysis (within a week). Total chlorophyll - concentrations were determined on a Turner TD-700 fluorometer after three hours extraction in 90% acetone (in the dark, with grinding). Nutrients analyses were performed using methods described in Strickland and Parsons (1972). All measuring instruments are calibrated by the manufacturer once per year, and CMR scientific team always checks the quality of the data collected during monitoring to avoid any issue. First results obtained following the observing campaigns (Figure 7.3) indicate all year presence of the water column (20 m – surface) vertical mixing for all oceanographic parameters. Only salinity shows occasional (early and late summer) differences of the measured values between surface and deeper layers (20 m depth). The highest sea temperatures were in the observed period (January 2020 – January 2023) usually recorded in August while the lowest were recorded in February or March. Chlorophyll – a concentrations follow the annual succession of higher peeks detected in autumn and spring but a missing spring peek is detected for the year 2022. In general, higher values of measured nutrients were recorded for winter months with orthophosphate concentrations of all year limiting values for the studied area (Figure 7.4).

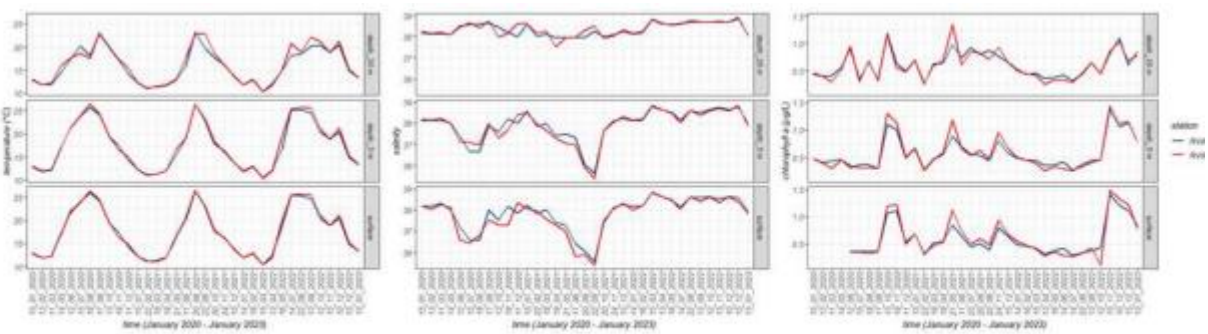

Figure 7.3 Measured oceanographic parameters (temperature, salinity and chlorophyll - a) in the Northern – Eastern Adriatic Sea pilot area for the studied period (January 2020 - January 2023). The two sampling stations indicated in blue (RV001) and red (RV004)

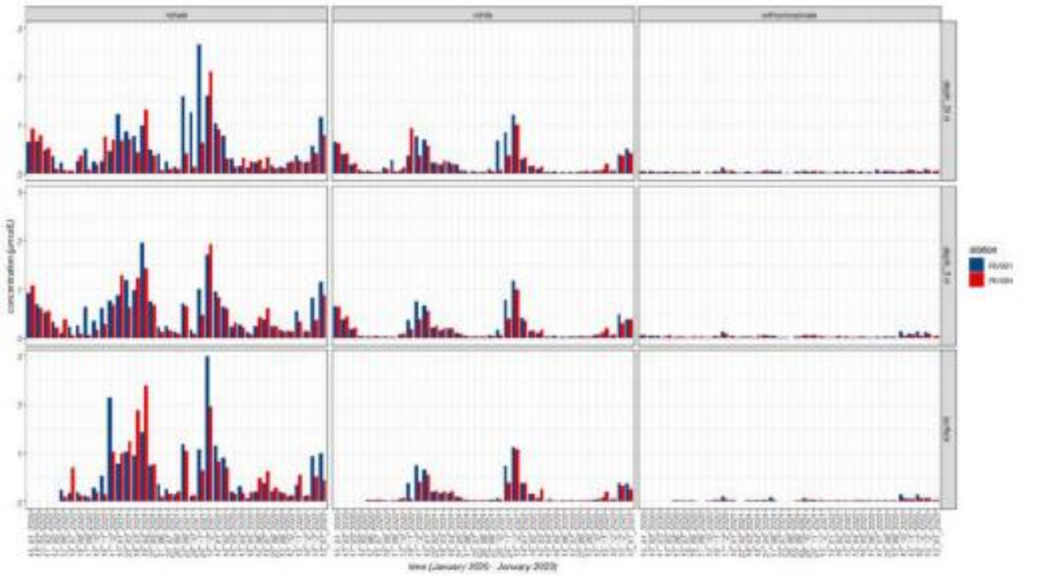

Figure 7.4 Measured nutrients (nitrate (NO_3), nitrite (NO_2), and orthophosphate (PO_4)) in the Northern – Eastern Adriatic Sea pilot area for the studied period (January 2020 - January 2023). The two sampling stations indicated in blue (RV001) and red (RV004)

7.4 Data sharing and open access

All the observing campaigns data was deposited in the big data repository of the CMR – RBI, created as ERDDAP to provide free and open source data in unified format for all users

Annexes

List of Figures:

The two sampling stations indicated in blue (RV001) and red (RV004

List of Tables.

Bibliography

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