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ASSESSING COVID-19 LOCKDOWN EFFECTS ON THE VULNERABLE AND SENSITIVE AREA OF TARANTO BASIN

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Abstract

The Taranto basin, a complex marine ecosystem with typical lagoon features, has been declared Site of National Interest (SIN) because of serious contamination of marine sediment. Since February 2014, The Coastal Engineering Laboratory (LIC) of DICATECh of the Polytechnic University of Bari (Italy) maintains a place-based research programme in the Mar Grande and Mar Piccolo of Taranto, providing records of hydrodynamic and water-quality measurements.
Taranto, like the rest of Italy, had a lockdown since March 2020 which has reduced the industrial activity which is the main source of human stress on the ecosystem of the Mar Piccolo and Mar Grande. Here, the impact of COVID-19 lockdown on sea surface temperature SST is investigated using the satellite and in situ measurements. Rising sea surface temperatures related to global warming are increasingly affecting marine habitats and people who depend on them.

Keywords

Coastal marine environment, Coastal monitoring, Water quality indicators, COVID-19 lockdown

1. *Introduction*

Coastal sites with typical lagoon features are extremely vulnerable. The coastal environment is a dynamic ecosystem in which natural and anthropogenic processes interact, modifying its geomorphological, physical and biological characteristics (Boero et al., 2016). Taranto coastal area is classified as a "Site of National Interest" (SIN) and it is composed of two parts: the Mar Grande and the Mar Piccolo. Due to its semi-enclosed features, the Taranto coastal area is characterised by a limited sea water circulation and is particularly vulnerable and disproportionately affected by the impacts of anthropic activities.

The semi-closed basin of the Mar Grande of Taranto (De Padova et al., 2017, 2020), located in the internal part of the Ionian Sea, in southern Italy, is separated from that of the Mar Piccolo by a head that closes it in a gulf, oriented towards the artificial island which constitutes the original nucleus of the city, connected to the rest of the territory through the Porta Napoli bridge and the swing bridge. Capo San Vito, the Cheradi Islands of San Pietro and San Paolo and the island of San Nicolicchio form a small archipelago that perfectly closes the ideal arch created by the bay of the Mar Grande, thus separating the latter from the Ionian Sea.

Taranto coastal area represents a rich and fragile resource, subject to modifications caused by both natural variations and anthropic activities (De Serio & Mossa, 2015). It is characterized by continual diffusion of contaminants with a strong ecological risk to the marine ecosystem and human health (De Padova et al., 2020). It undergoes a considerable amount of pollution caused by both heavy industry and the military shipyard (De Padova et al., 2023).

Although this coastal area is exposed to urban and industrial discharges as well as intense naval traffic, the hydrogeological characteristics of the Taranto coastal area have favoured the distribution of transitional habitats and a very high biodiversity (Carlucci et al., 2020).

In the Mar Grande and in the northern part of both bays of Mar Piccolo, there are some underwater springs called “citri”, which bring fresh water mixed with brackish water.
The two most important ones are the citro Galeso in the First Bay near the Galeso river, and the citro Le Kopre, in the northeastern part of the First Bay (Umgiesser et al., 2007). The submarine fresh

water sources have a karst origin and their flux, coming from the sea bottom up to the surface, sometimes creates “rings” with considerable extension. The presence of these freshwater inputs influences the basin salinity gradients giving it the typical characteristics of a transitional environment (De Pascalis et al., 2016).

As reported for various coastal systems many Italian estuarine and coastal waters have changed from balanced and productive ecosystems to ones experiencing sudden trophic changes, biochemical alterations and a deterioration in the quality of natural habitats. The increase in the rate of supply of organic matter, the nutrients loading and the scarce hydrodynamism, determined strong eutrophication events in the area of Mar Grande and Mar Piccolo (Alabiso et al., 1997, 2005; Caroppo & Cardellicchio, 1995; Cardellicchio et., 2016).

Many studies showed that there is a water exchange between Mar Grande and Mar Piccolo (De Pascalis et al, 2015) so for this reason is important to understand water quality conditions of Mar Grande. It is characterized peridodically by periods of homogeneity of water columns occur. Therefore, also in the first Bay, the stratification is sharp as in the second inlet because of water exchange with Mar Grande. Owing to this situation, different mixing speeds for nutrients take place between the second inlet and the Mar Grande-first inlet (Alabiso et al., 1997).

Alabiso et al. (2005) showed a seawater temperature positive trend during the years and chlorophyll, Organic Matter and Dry Weight data pointed out a condition of progressive eutrophication, moving from Mar Grande to Mar Piccolo.

For these reasons is important study the changes of physical-biogeochemical parameters due to anthropogenic activities and climate change in Mar Grande.

The changes of temperature, salinity and primary production (associated at growth of chlorophyll and organic matter) fuels mineralization processes, stimulating both aerobic and anaerobic metabolism, and nutrient recycling back to the water column by enhancing benthic fluxes.

Therefore, it needs to receive constant and rigorous environmental monitoring action (Di Leo et al., 2013; Armenio et al., 2016, 2017, 2019; De Serio et al., 2020).

Moreover, field measurements are often limited in time and space, and for this reason is important to carry out long-term monitoring of hydrodynamics, chemical and physical parameters especially in this case of shallow basins subjected to strong anthropization and urban discharges (Armenio et al., 2018a, b). Consequently, the planning and management of coastal activities play a very important role.

Furthermore, environmental monitoring of the waters in the Gulf of Taranto is of paramount importance, not only to preserve the natural ecosystem but also to safeguard the city's rich cultural heritage. In fact, from a cultural perspective, Taranto is a city steeped in history and heritage. Its history is deeply intertwined with the sea, with a maritime tradition dating back millennia. The sea has played a crucial role in the city's daily life, influencing its culture, cuisine, and economy.

These two seemingly distinct realms – the natural environment and the anthropogenic cultural legacy – are inextricably intertwined, forming a delicate balance that underscores the city's unique identity and historical significance."

Furthermore, the waters of the Gulf of Taranto are also the site of numerous ancient shipwrecks, valuable testimonies to the maritime history of the region. These underwater archaeological sites are an integral part of Taranto's cultural heritage and require rigorous protection from negative impacts on the marine environment.

For these reasons, the conservation and environmental monitoring of the waters of the Gulf of Taranto are essential not only to preserve the marine ecosystem but also to ensure the continuity of the city's cultural heritage.

The COVID-19 lockdown provided an opportunity to examine the effect of reduced anthropogenic activities on the environment.

Research was carried out in order to obtain an understanding of the nature of respiratory clouds (De Padova et al., 2021) and the SARS-CoV-2 spreading from wastewater treatment facilities to natural water bodies (Wang et al., 2020; Yusoff et al., 2021).

Many studies have reported that the effect of COVID-19 lockdowns promoted the reduction of pollution. In Braga et al. (2020) a quantitative analysis of suspended matter patterns, based on satellite-derived turbidity, was performed resulting in the evidence of high-water transparency considered as a transient condition determined by a combination of natural seasonal factors and the effects of COVID-19 restrictions. However, it is yet unclear if its impact will be long- or short-term (Depellegrin et al., 2020; Prakash et al, 2021). Indeed, although a variability of Chl concentration in accordance with a seasonal cycle was observed from winter to fall 2020 in North Adriatic Sea, a second order effect due to the decrease of human activities could not be excluded (Braga et al., 2022).

The study by Elsaid et al. (2021) summarized the observed environmental effects of COVID-19 as reported in the literature for different countries worldwide. Many reports (Patel et al., 2020; Selvam et al., 2020; Yunus et al., 2020; Liu et al., 2021), have indicated improvements in the quality of water resources, with decreased levels of suspended matter and turbidity, as well as reduced biological and chemical oxygen demand. These improvements are attributed to the decreased discharge of wastewater into these bodies of water.

For a thorough review of COVID-19 epidemic time impacts on the environment on a global scale, the reader can refer to (Manoiu et al., 2022).

Taranto, like the rest of Italy, had a lockdown since March 2020 which has reduced the industrial activity which is the main source of human stress on the ecosystem of the Mar Piccolo and Mar Grande. Here, the impact of COVID-19 lockdown on sea surface temperature SST is investigated using satellite and in situ measurements.

Rising sea surface temperatures related to global warming are increasingly affecting marine habitats and people who depend on them (Heron et al., 2016; Chimienti et al., 2020, 2021).

2. *Method and sampling*

2.1 In situ data

In December 2013, as part of the RITMARE flagship project, with funds from the PON R&C 2007-13 project provided by the Italian Ministry of Education, Health and Research, a weather-oceanographic station (station MG) was installed in the Mar Grande basin with geographic coordinates 40°27.6' N and 17°12.9' E (Fig. 1).
The local depth of this station is on average equal to 23.25m. The elastic structure, called MEDA, is 6 meters high and is positioned 7 miles from the coast.

Fig. 1: Target area: location of the industrial discharges and monitoring station

The monitoring station can boast numerous tools, in order to obtain the time trend of different hydrodynamics, chemical and physical parameters. In detail, being also a meteorological station, it provides measurements of wind speed and direction detected by a Windsonic sonic anemometer, but also data on air temperature and humidity, atmospheric pressure and net solar radiation. The atmospheric parameters are measured at an average height of 1.5 m above sea level. Furthermore, it is equipped with oceanographic sensors, distributed along the depth (5.6m below the sea surface), to measure parameters such as water temperature, salinity, dissolved oxygen, and the concentrations of chlorophyll and dissolved organic material. The structure is equipped with solar panels, connected to 24 rechargeable 12 V batteries, and with a special remote-controlled communication system via mobile phone which allows for receiving the measured data in real time. Data is collected continuously every hour using an average of 60 measurements every 10s.

Further details on the MG station can be found in (Mossa et al., 2021).

2.2 *Remote sensing data and processing*

Satellite derived sea surface temperature (SST) was obtained by using data acquired by Landsat 8-9. Specifically, the SST products are generated from the Landsat Collection 2 Level-1 thermal infrared bands, Top of Atmosphere (TOA) reflectance and TOA brightness temperature and other auxiliary data by the United States Geological Survey (USG) and provided at a spatial resolution of 30 m (Cook et al., 2014). Table 1 reports the days of the available cloud-masked images considered.

Tab. 1: Landsat 8-9 dataset used for the analysis.

	2018	2020
March	7	12
April	8	13, 29
May	26	22
June	2, 11	7
July	4, 13, 20, 29	2, 9, 18, 25
August	5, 21, 30	3, 10, 19, 26
September	6, 15	4, 11, 20, 27

All available images for each month were averaged to obtain maps of the monthly average SST over the area of interest. To assess the reliability of the satellite SST products and the suitability of the dataset in representing the monthly average, a comparison with the monthly average SST data acquired by buoy in MG station and the SST in correspondence of the MG station was carried out. Considering the months from March to September of both 2018 and 2020 a Root Mean Squared Error (RMSE) of 1.5 °C, and a Mean Bias (MBE) and Mean Absolute (MAE) Error of -0.9 °C and 1.2 °C, respectively, were obtained. Moreover, scatterplot in Figure 2 reported a high correlation resulting in a R^2 equal to 0.96.

Results obtained suggest the potential of using the satellite SST to investigate spatial distribution of temperature differences from pandemic period (2020) to pre-pandemic period (2018).

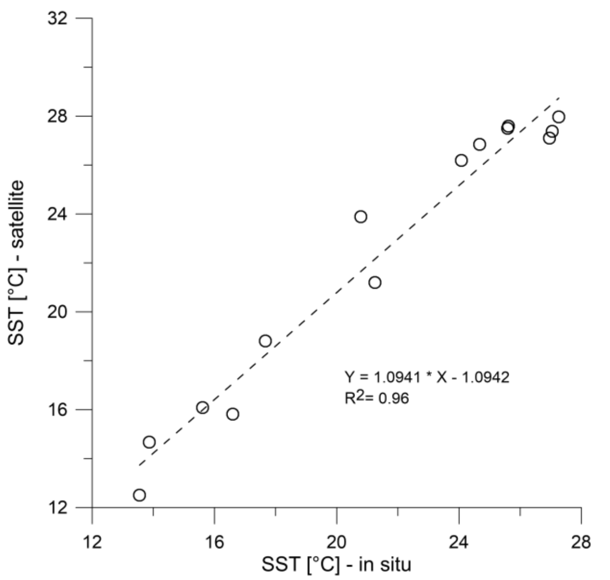


Fig. 2: Scatter plot of satellite SST with in-situ SST

3. Results and discussions

3.1 Meteo-oceanographic conditions during lockdown

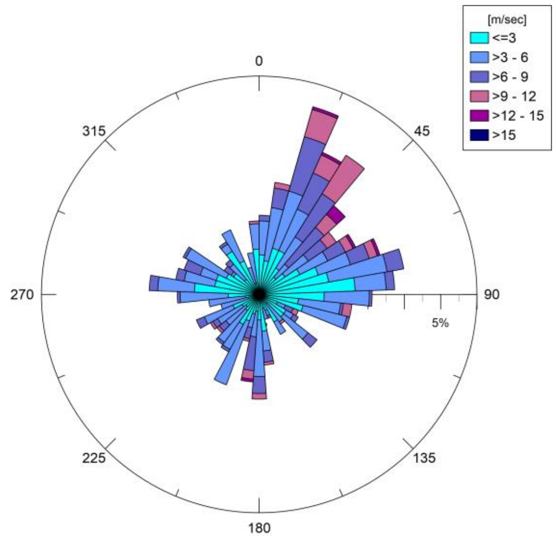
The wind and wave data, referred to the period of lockdown (March 2020–April 2020), have been processed. The directions of propagation are shown in Figs 3.

The months of March–April 2020 are characterized by winds that mainly come from S-SW with peak intensities greater than 10 m/s.

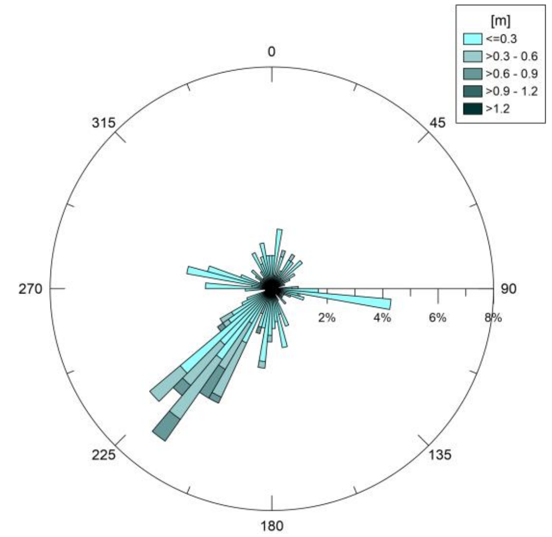
In these months, a well-defined and evident path can be recognized, with high waves that came from N-NE and peak intensities in a high range of 0.9–1.2 m.

Considering the monitoring carried out in 2014 (De Serio & Mossa, 2016), it can be stated that also in this case it was not possible to find a close correspondence between the wind distribution and the significant wave distribution.

As described in the De Serio and Mossa (2016), along the south-western border of the Mar Grande there is a large opening that represents a privileged passage for significant waves. Therefore, the waves are not strictly locally generated and their response is more controlled by the topography of the region and by diffraction rather than by transient wind forcing.



(a)



(b)

Fig. 3: Polar plot of measured (a) wind and (b) waves in March - April 2020.

3.2 Impact of lockdown on sea temperature, salinity and chlorophyll: in situ data

The sea surface temperature (SST), Salinity (S) and chlorophyll (Chl) data from the meteo-oceanographic station (MG), have been processed for both two years (2018 – 2020). Figure 4 shows the sequence of monthly mean for SST, S and Chl.

A general growing trend of SST is evident for the two considered years. However, the trend in water temperatures shows different intensities for the two years, with the highest values during 2018. Moreover, 2018 was warming up faster than 2020.

The sequence of monthly mean highlighted a general growing trend of salinity for 2020. Instead, a general decreasing trend of salinity during summer months of 2018 can be observed. These different trends of SST and S between the two years (2018 and 2020) can be due to a drastic reduction in the leakage of cooling freshwater water from industrial discharges during the two months of the mandated nationwide lockdown.
In fact, the semi-closed basin of the Mar Grande of Taranto slowly transports freshwater heated water away from industrial discharges to the open sea, and therefore is not able to minimize the physical effects of cooling water on the aquatic environment.

The trend in chlorophyll (Chl) shows a faster decrease then the same period of 2018 (about a month after the beginning of the Italian 2020 lockdown). Although such phenomenon might be due to natural environmental conditions, such as moderate winds, it is interesting this striking coincidence between the faster consistent Chl concentration decrease, occurred a month after the beginning of the Italian 2020 lockdown.

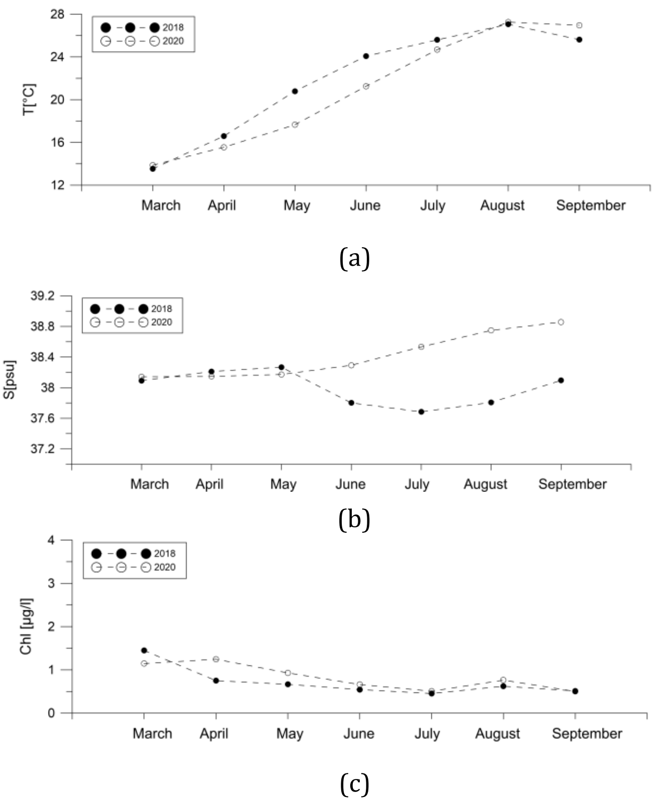


Fig. 4: Trend of SST (a), Chl (b)and Salinity (c) during 2018 and 2020.

3.3 *Impact of lockdown on SST: satellite-derived maps*

The monthly means SST maps obtained from Landsat 8-9 data were used to calculate differences from pandemic period (2020) to pre-pandemic period (2018) for each month (from March to September) (Fig. 5), as following:

$$\mathrm{Delta}_{\mathrm{SST}_i} = \mathrm{SST}_i(2020) - \mathrm{SST}_i(2018) \quad (1)$$

where $i \in \{March, \dots, September\}$.

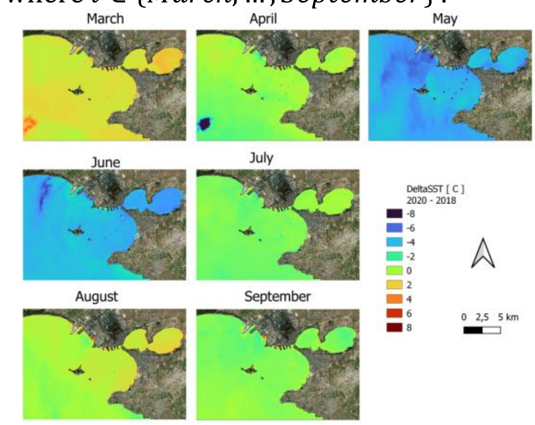


Fig. 5: $\mathrm{Delta}_{\mathrm{SST}}$ maps from March to September covering the Taranto Basin.

While in March, April, July, and September $Delta_{SST}$ shows overall values within the interannual fluctuations due to environmental conditions and uniformly spatially distributed within the study area, significant negative values of $Delta_{SST}$ are evident in May and June. This behavior is also evident from measurements acquired in situ in correspondence of MG location (Fig. 1).

To evaluate the effects of discharges on the measurement of $Delta_{SST}$ in the area interested by industrial activities, 4 transects were considered (Fig. 6): TR1 and TR2 located outside the areas affected by discharges but close to them, TR3 in correspondence with both ILVA1 and ILVA2 (Figure 1) discharges, and TR4 in front of the ENI discharge. Only months from March to July were considered to cover a time range from the shutdown of industrial activities (March) until two months after the restart of activities (July). On the x-axis the number of pixels starting from the closest ones to the coast is represented.

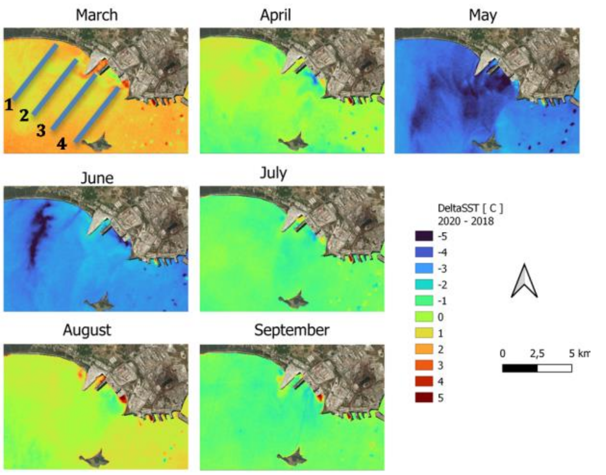
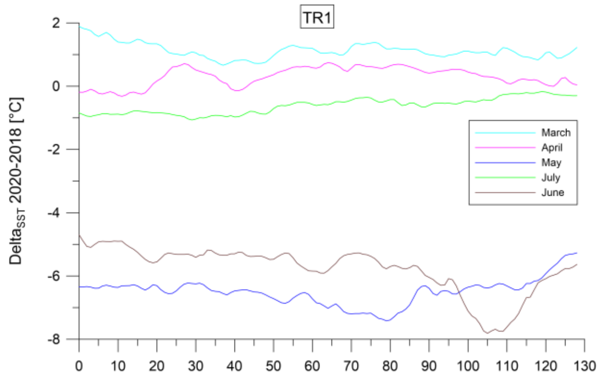


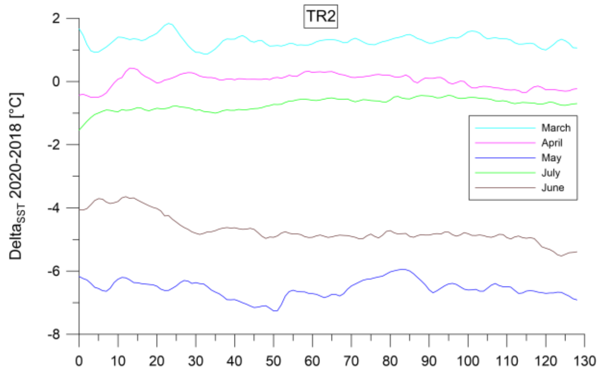
Fig. 6: Close-up of $Delta_{SST}$ maps from March to September of the area interested by industrial discharges. The four transects considered in the analysis are superimposed.

From the analysis it results that (Fig. 7):

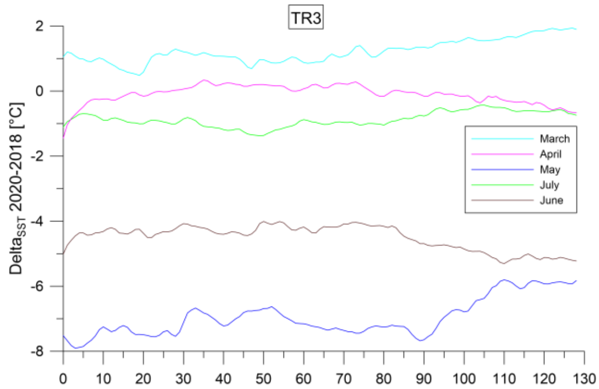
1. all transects are characterized by an initial condition in March denoting a warmer 2020 with respect to 2018;
2. in April $Delta_{SST}$ decreases reaching almost zero, showing in the transects parts near the industrial discharges negative values that tend to reach zero moving away from the coast. Thus, it seems that the lack of contribution of industrial wastewater leads to lower temperature values in 2020 compared to the pre-pandemic period;
3. May and June show strongly negative $Delta_{SST}$ values. It seems that the industrial inactivity produces the most visible effects in May and that $Delta_{SST}$ slowly returns to its initial state in July passing through an intermediate condition in June;
4. Comparing May data for all the transects, it results that TR3 presents the most negative $Delta_{SST}$ values. In addition, a tendency to increase when moving away from the coast is also evident.



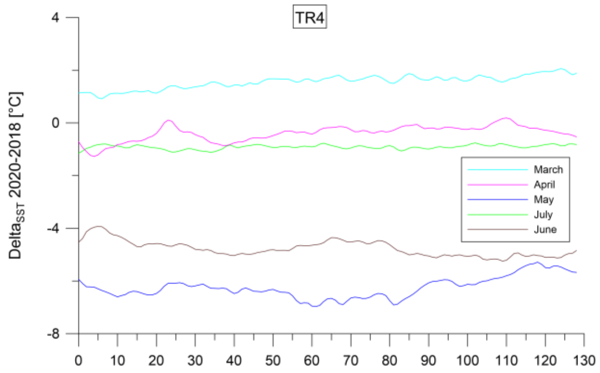
(a)



(b)



(c)



(d)

Fig. 7: Delta$_{SST}$ profiles along the four transect considered.

4. Conclusions

This study was conducted in a particular climatic period, during which we are witnessing climate changes, partly natural and partly due to an anthropogenic impact, which are leading to a progressive warming of the planet. This can lead to a series of consequences on marine biodiversity and good ecosystem functioning. This is why it is necessary to study and monitor this rapid change.

During the COVID-19 lockdown we witnessed the almost total closure of industries, man "paused" all the most polluting activities, for this reason the lockdown provided the opportunity to study the effects of the reduction of transport and other anthropogenic activities on the environment.

The oceans play a crucial role in the global climate system. Life on Earth in terms of productivity is directly influenced by the characteristics of the oceans. The consequences of COVID-19 lockdown have been substantial as pollution levels have dropped significantly. The lockdown due to pandemics has been reported to have improved coastal ocean water and atmospheric air quality.

For example, emissions of greenhouse gases, nitrogen dioxide, carbon black have drastically decreased.

This study, carried out in the semi-closed basin of the Mar Grande of Taranto, showed a clear difference regarding the trend of SST and salinity during the months of the pandemic compared to the pre-pandemic ones (year 2018); In particular, the results highlighted that 2018 was warming up faster than the 2020.

Instead, a general decreasing trend of salinity during summer months of 2018 was observed while a general growing trend of salinity for 2020 was shown. These different trends of *S* between the two years (2018 and 2020), can be due to the lower supply of cooling water, fresh by the ENI and Ilva industries.

The trend in Chl showed a faster decrease then the same period of 2018 (about a month after the beginning of the Italian 2020 lockdown). Moreover, Chl had a slight increase in the months of April and May and then returned to normal conditions.

Most likely the increase in Chl was due to natural events, in fact during the months of April and May there were strong storm surges due to the wind coming mainly from S-SW which could have brought nutrients from the open sea towards the coast. Although such phenomenon might be due to natural environmental conditions, such as moderate winds, it is interesting this striking coincidence between the faster consistent Chl concentration decrease, occurred a month after the beginning of the Italian 2020 lockdown.

The results obtained by using the satellite SST to evaluate the effects of discharges on the measurement of Delta$_{SST}$ in the area interested by industrial activities highlighted that all transects are characterized by an initial condition in March denoting a warmer 2020 with respect to 2018.

For the transects near the industrial discharges, the results showed that the lack of contribution of industrial wastewater leads to lower temperature values in 2020 compared to the pre-pandemic period. The industrial inactivity has produced the most visible effects in May and the Delta$_{SST}$ slowly returned to its initial state in July passing through an intermediate condition in June.

These results highlighted the importance of the environmental monitoring of the vulnerable and sensitive area of Taranto basin and the preservation of the city's cultural heritage.

It has become evident that these two seemingly separate domains are intrinsically linked, with the health of one directly impacting the vitality of the other.

By implementing comprehensive conservation strategies and sustainable environmental practices, we can ensure not only the protection of the Gulf's fragile ecosystems but also the enduring legacy of Taranto's cultural heritage for generations to come.

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References

Alabiso, G., Cannalire, M., Ghionda, D., Milillo, M., Leone, G., & Caciorgna, O. (1997). Particulate matter and chemical-physical 18 conditions of an inner sea: The Mar Piccolo in Taranto. A new statistical approach. *Marine Chemistry, 58* (3), 373-388.

Alabiso, G., Giacomini, M., Milillo, M., & Ricci, P. (2005). The Taranto sea system: 8 years of chemical–physical 20 measurements. *Biol Mar Mediterr.*, *12* (1), 369-373.

Armenio, E., Ben Meftah, M., Bruno, M. F., De Padova, D., De Pascalis, F., De Serio, F., Di Bernardino, A., Mossa, M., Leuzzi, G., & Monti, P. (2016). Semi enclosed basin monitoring and analysis of meteo, wave, tide and current data: Sea monitoring. In *Proceedings of Environmental, Energy, and Structural Monitoring Systems (EESMS)*, IEEE Workshop (pp. 1-6). Bari, Italy.

Armenio, E., De Padova, D., De Serio, F., & Mossa, M. (2017). Monitoring system for the sea: Analysis of meteo, wave and current data. In *Proceedings of IMEKO TC19 Workshop on Metrology for the Sea, MetroSea* (pp. 143-148). Naples, Italy.

Armenio, E., De Padova, D., De Serio, F., & Mossa, M. (2018a). Monitoring system in mar Grande basin (Ionian Sea). (2018). *IEEE International Workshop on Metrology for the Sea; Learning to Measure Sea Health Parameters, MetroSea* (pp. 104–109).

Armenio, E., De Padova, D., De Serio, F., & Mossa, M. (2018b). Environmental technologies to safeguard coastal heritage. SCIRES-IT - *SCIentific RESearch and Information Technology*, *8*(1), 61-78. http://dx.doi.org/10.2423/i22394303v8n1p61

Armenio, E., Ben Meftah, M., De Padova, D., De Serio, F., & Mossa, M. (2019). Monitoring Systems and Numerical Models to Study Coastal Sites. *Sensors*, 19, 1552.

Boero, F., Foglini, F., Fraschetti, S., Goriup, P., Macpherson, E., Planes, S., Soukissian, T., & The CoCoNet Consortium (2016). CoCoNet: towards coast to coast networks of marine protected areas (from the shore to the high and deep sea), coupled with sea-based wind energy potential. *SCIRES-IT - SCIentific RESearch and Information Technology, 6* (Suppl.), 1-95. http://www.sciresit.it/article/download/12592/11435.

Braga, F., Scarpa, G.M., Brando, V.E., Manfè, G., & Zaggia, L. (2020). COVID-19 lockdown measures reveal human impact on water transparency in the Venice Lagoon. *Science of The Total Environment,* 76, 139612.

Braga, F., Ciani, D., Colella, S., Organelli, E. Pitarch, J., Brando, V.E., Bresciani, M. Concha, J.A., Giardino, C., Scarpa, G. M., Volpe, G., Rio, M.H., & Falcini, F. (2022). COVID-19 lockdown effects on a coastal marine environment: Disentangling perception versus reality. *Science of The Total Environment*, 817,153002.

Carlucci, R., Cipriano, G., Cornelia F., Ricci, P., Maglietta, R., Mazzariol, S., De Padova, D., Mossa, M., Bellomo, S., & Fanizza, C. (2020). Exploring data from an individual stranding of a Cuvier's beaked whale in the Gulf of Taranto (Northern Ionian Sea, Central-eastern Mediterranean Sea). *Journal of Experimental Marine Biology and Ecology*, 533, 151473.

Cardellicchio, N., Annicchiarico, C., Di Leo, A., Giandomenico, S., & Spada, L. (2016). The Mar Piccolo of Taranto: An interesting marine ecosystem for the environmental problems studies. *Environmental Science and Pollution Research,* 23, 12495–12501.

Caroppo, C., & Cardellicchio, N. (1995). Preliminary study on phytoplankton communities of Mar Piccolo in Taranto (Jonian 37 Sea). *Oebalia XXI* (pp. 61-76).

Chimienti, G., De Padova, D., Mossa, M., & Mastrototaro, F. (2020). A mesophotic black coral forest in the Adriatic Sea. *Scientific Reports*, *10*(1), 8504.

Chimienti, G., De Padova, D., Adamo, M., Mossa, M., Bottalico, A., Lisco, A., Ungaro, N., & Mastrototaro, F. (2021). Effects of global warming on Mediterranean coral forests. *Scientific Reports*, *11*(1), 20703.

Cook, M., Schott, J. R., Mandel, J., & Raqueno, N. (2014). Development of an operational calibration methodology for the Landsat thermal data archive and initial testing of the atmospheric compensation component of a Land Surface Temperature Product from the archive. *Remote Sensing*, *6*(11), 11244-11266.

De Padova, D., De Serio, F., Mossa, M., & Armenio, E. (2017). Investigation of the current circulation offshore Taranto by using field measurements and numerical model. In *Proceedings of the 2017 IEEE International Instrumentation and Measurement Technology Conference*. Torino, Italy.

De Padova, D., Ben Meftah, M., De Serio, F., & Mossa, M. (2020). Management of Dredging Activities in a Highly Vulnerable Site: Simulation Modelling and Monitoring Activity. *J. Mar. Sci. Eng*., 8, 1020.

De Padova, D., & Mossa, M. (2021). Multi-phase simulation of infected respiratory cloud transmission in air. *AIP Adv*., 11, 035035.

De Padova, D., Di Leo, A., & Mossa, M. (2023). COVID-19 Lockdown Effects on a Highly Contaminated Coastal Site: The Mar Piccolo Basin of Taranto. *Water*, 15, 1220.

De Pascalis, F., Petrizzo, A., Ghezzo, M., Lorenzetti, G., Manfè, G., Alabiso, G., & Zaggia, L. (2015), Estuarine circulation in the Taranto Seas, *Environmental Science and Pollution Research*, *23*(13), 12515-34.

De Serio, F & Mossa, M. (2016). Environmental monitoring in the Mar Grande basin (Ionian Sea, Southern Italy) *Environmental Science and Pollution Researc*h. 23, 12662–1267.

De Serio, F., Armenio, E., Ben Meftah, M., Capasso, G., Corbelli, V., De Padova, D., De Pascalis, F., Di Bernardino, A., Leuzzi, G., Monti, P., Pini, A., Velardo, R., & Mossa, M. (2020). Detecting sensitive areas in confined shallow basins. *Environmental Modelling and Software*, 126, 104659.

Depellegrin, D. Bastianini, M., Fadini, A., & Menegon, S. (2020). The effects of COVID-19 induced lockdown measures on maritime settings of a coastal region. *Science of The Total Environment*, 740, 140123.

Di Leo, A., Annicchiarico, C., Cardellicchio, N., Giandomenico, S., & Spada, L. (2013). Trace metal distributions in Posidonia oceanica and sediments from Taranto Gulf (Ionian Sea, Southern Italy). *Mediterr Mar Sci 14*(1), 204–213.

Elsaid, K., Olabi, V., Sayed, E.T., Wilberforce, T., & Abdelkareem, M.A. (2021). Effects of COVID-19 on the environment: An overview on air, water, wastewater, and solid waste. *J Environ Manage*. 15(292), 112694.

Heron, S. F., Maynard, J. A., van Hooidonk, R., & Eakin, C. M. (2016). Warming trends and bleaching stress of the World's coral reefs 1985–2012. *Scientific Report.* 6, 38402.

Liu, F., Wang, M., & Zheng, M. (2021). Effects of COVID-19 lockdown on global air quality and health. *Sci. Total Environ,* 755(Pt.1), 142533.

Manoiu, V., Katarzyna K.W., Craciun A.I.., Akman. C., & Akman E. (2022). Water Quality and Water Pollution in Time of COVID-19: Positive and Negative Repercussions. *Water*, *14*(7), 1124.

Mossa, M., Armenio, E., Ben Meftah, M., Bruno, M.F., De Padova, D., & De Serio, F. (2021). Meteorological and hydrodynamic data in the Mar Grande and Mar Piccolo, Italy, of the Coastal Engineering Laboratory (LIC) Survey, winter and summer 2015. *Earth System Science Data*, *13* (2), 599-607.

Patel, P.P., Mondal, S., & Ghosh, K.G. (2020). Some respite for India's dirtiest river? Examining the Yamuna's water quality at Delhi during the COVID-19 lockdown period. *Sci. Total Environ*. 2020(744), 140851.

Selvam, S., Jesuraja, K., Venkatramanan, S., Chung, S.Y., Roy, P.D., Muthukumar, P., & Kumar, M. (2020). Imprints of pandemic lockdown on subsurface water quality in the coastal industrial city of Tuticorin, South India: a revival perspective. *Sci. Total Environ*. 2020(738),139848.

Umgiesser, G., Scroccaro, I., & Alabiso, G. (2007). Mass exchange mechanisms in the Taranto Sea. *Transitional Waters Bulletin* I(2), 59–71.

Vijay, P., K., Vimala, G., Preethi Latha, T., Jayaram, C., Nagamani, P.V., & Laxmi, C.N. (2021). Assessment of water quality along the southeast coast of India during COVID-19 lockdown. *Frontiers in Marine Science*, 8, 338.

Wang, J., Shen, J., Ye, D., Yan, X., Zhang, Y., Yang, W., Li, X., Wang, J., Zhang, L., & Pan, L. (2020). Disinfection technology of hospital wastes and wastewater: Suggestions for disinfection strategy during coronavirus Disease 2019 (COVID-19) pandemic in China. *Environmental Science and Pollution Research,* 262, 114665.

Yunus, A.P., Masago, Y., & Hijioka, Y. (2020). COVID-19 and surface water quality: improved lake water quality during the lockdown. Sci. Total Environ. 2020(731), 139012.

Yusoff, F.M., Abdullah, A.F., Aris, A.Z., & Umi, W.A.D. (2021). Impacts of COVID-19 on the Aquatic Environment and Implications on Aquatic Food Production. *Sustainability*, *13*(20), 11281.