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Studying the variation of the CO2 system in seawater of Bania's coast- Syria

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ABSTRACT

We studied the effect of CO2 system parameters in the coastal seawater of Banias City during the year 2022, their effects on salinity and temperature, and the resulting changes in pH values of marine water from several sites distributed along the coast. The results show decreasing temperature and salinity of the water in winter (17.11-17.72°C, 36.51-36.98‰) respectively, increasing the absorption of CO2 of water leading to increasing the concentrations of total inorganic carbon (2250.3-2280.3μmol/kg), alkalinity (2389.3-2395.9μmol/kg) and decreasing pH values of seawater (7.721-7.782). There was a change in temperature and salinity of the seawater in spring (21.94-22.42°C, 37.51-37.88‰ respectively), and in autumn (19.88-19.92°C, 37.35-37.45‰ respectively), in addition to the decrease in the concentrations of total inorganic carbon (2088.4-2154.2μmol/kg, 2219.9-2237.9μmol/kg), alkalinity (2445.2-2449.6μmol/kg, 2456.3-2470.8μmol/kg) and pH values of seawater (7.632-7.684) (7.562-7.673). The study revealed increasing temperature and salinity of the seawater in summer (26.61-27.36°C, 38.41-38.67‰ respectively), and decreasing the biological activity. This was accompanied by increasing the concentrations of both total inorganic carbon (2306.6 – 2381.5μmol/kg), alkalinity (2526.1–2550.7μmol/kg), and pH values of seawater (8.068–8.070).

Keywords: CO2 System Parameters, (AT), (CT), Banias.

1. INTRODUCTION

The increase in the amount of fossil fuel consumption from the Industrial Revolution to the present has increased levels of carbon dioxide in the atmosphere (Solomon et al., 2007). As a percentage of various human activities (cutting and burning of forests and waste, the large spread of machines that operate on fossil fuels to produce energy, cement factories, fuels used in heating and means of transportation, the decrease in agricultural land areas), the rate of its dissolution in marine waters has increased (Sabine et al., 2004; IPCC, 2007; Le Quéré et al., 2018; Gruber et al., 2019). As a result, the oceans play a vital role in mitigating carbon dioxide from the atmosphere (Mikaloff-Fletcher et al., 2006; Sabine et al., 2011).

Accordingly, many international scientific studies have been conducted to understand the cycle of this gas in marine waters and the changes occurring in the carbonate system (Takahashi et al., 1993; Houghton et al., 2001; Thomas et al., 2005; Goyet et al., 2016).

The massive increase in carbon dioxide emitted into the atmosphere (about 79 million tons per day) has been accompanied by an increase in ocean acidity IPCC, (2013), the pH value of surface marine waters decreased by 0.1 units compared to the pre-industrial revolution period (Gattuso and Hansson, 2011; Orr, 2011). Many studies and scientific research programs have shown the possibility of a decrease in the value of the acidity of marine water by 0.14-0.43 units by the year 2100 (Dixson et al., 2010; IPCC, 2014). The protective capacity of marine waters decreased as a result of the increase in the rate of dissolution of carbon dioxide (Meredith et al., 2012; Wijffels et al., 2016). The high acidity of marine waters affects the productivity and production of organic matter in the oceans as a result of controlling environmental and biogeochemical processes (Riebesell et al., 2000; Yoshimura et al., 2013; Yoshimura et al., 2014; Cai et al., 2011).

The carbonate system in marine waters is affected by increasing concentrations of dissolved carbon dioxide, as carbonate ions interact with the increase in concentrations of dissolved carbon dioxide to modify, which leads to a decrease in the saturation state of calcium carbonate in surface seawater, with negative consequences for organisms with limescale shields and biodiversity in the marine environment (Dore et al., 2009; Kroeker et al., 2013; Bates, 2015; Joshua, 2022). Increasing carbon dioxide concentrations in the atmosphere leads to an increase in the rate of its exchange at the air-sea interface until a balance is reached between the two media, which leads to accompanying changes in the pH values of marine waters over time and to a decrease in the ability of the oceans to remove carbon dioxide gas, anthropogenic carbon from the atmosphere (Riebesell et al., 2009; Landschützer et al., 2015).

Furthermore, a decrease in pH will change the balance between different forms of dissolved inorganic carbon (CT) in the oceans, leading to an increase in the proportion of carbon dioxide and bicarbonate (HCO3-) at the expense of carbonate ions (CO32-). Although some photosynthetic organisms will benefit from elevated concentrations of carbon dioxide (Yoshimura et al., 2014). While most other calcareous species show high sensitivity to decreasing carbon dioxide availability (Hutchins et al., 2007). Coastal marine waters play a critical role in the global carbon cycle by connecting oceanic, terrestrial, and atmospheric reservoirs (Regnier et al., 2013).

In addition, the oceans contribute to the regulation of the carbon cycle because they act as receptors for carbon loads carried by coastal rivers (Cai et al., 2011). And as carbon reservoirs via the “carbon pump” mechanism (Sabine and Tanhua, 2010). This study was conducted in the coastal region of Banias (Syria) with the general aim of understanding the spatial and temporal variation of carbon dioxide parameters in marine surface waters, and studying its negative effects on the marine environment with the increase in carbon dioxide concentrations in the atmosphere and the accompanying change in water pH values, the impact of this on living organisms as a result of changes in the carbonate system in marine waters in light of the climate changes prevailing in the region.

2. MATERIAL AND METHODS

This research aims to study the spatial and temporal variation of CO2 parameters in the coastal area of Banias (Figure 1), where surface marine water samples were collected every season from 2022 at a depth of 5 meters and a distance of 1 km from the coast using a 5liter Niskin bottle. Temperature (T), salinity (S), and pH were measured immediately, and to stop all biological processes, 100μL of a saturated solution of HgCl2 was added. AT was analyzed using the method described by Dickson and Goyet, (1994), and CO2 chemical parameters were calculated using CO2SYS (Lewis and Wallace, 1998). Use Ocean Data View (ODV) to present the results.

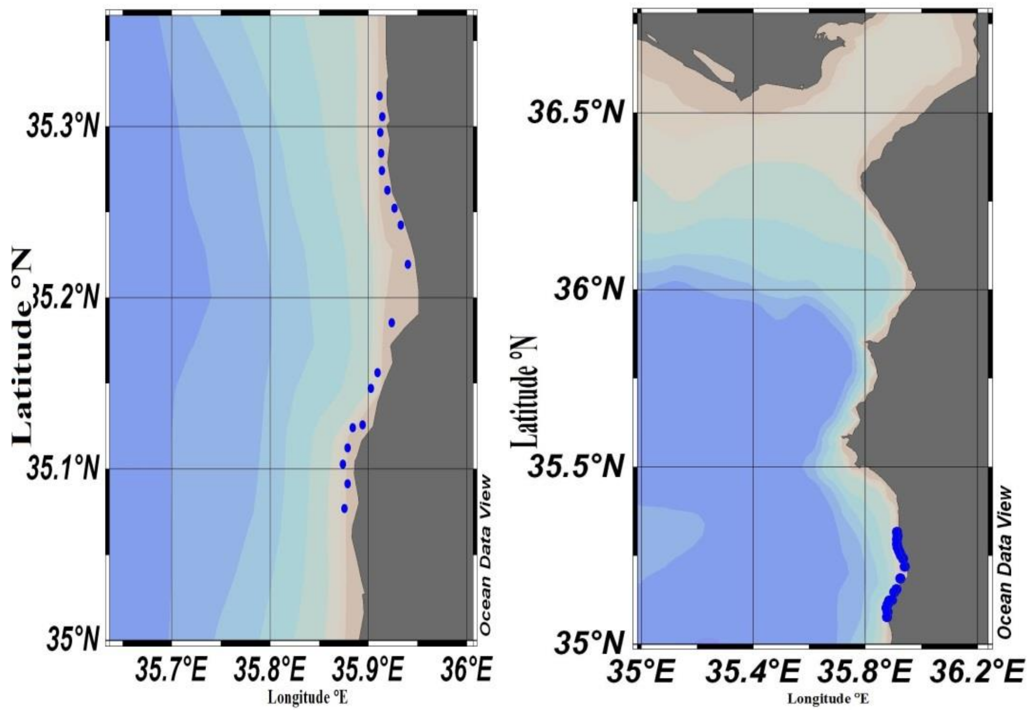

Figure 1 Sampling station along the Coast of Banias

3. RESULTS

Thermohaline characteristics

Temperature of surface seawater (T)

The results showed spatial differences in the temperature of Banias coastal waters (T), due to differences in the movement of water masses and mixing rates. This is in addition to the difference in the depth of the seawater column (Figure 2). In general, temperatures were observed to rise from the south to the north of the Banias coast, ranging from 17.01 °C in the winter to 27.61 °C in the summer, as a result of seasonal changes in the climate cycle, differences in rainfall rates, direction and speed of water masses, and differences in wind speed and direction according to the seasons. This has been confirmed by many studies in different regions (Lee et al., 2006; Touratier and Goyet, 2011). The quality of various human activities: wastewater discharge (sewage and industrial water), in addition to the seasonal variation in the rate of river flow between the north and south of the study area also affected the differences in water temperatures.

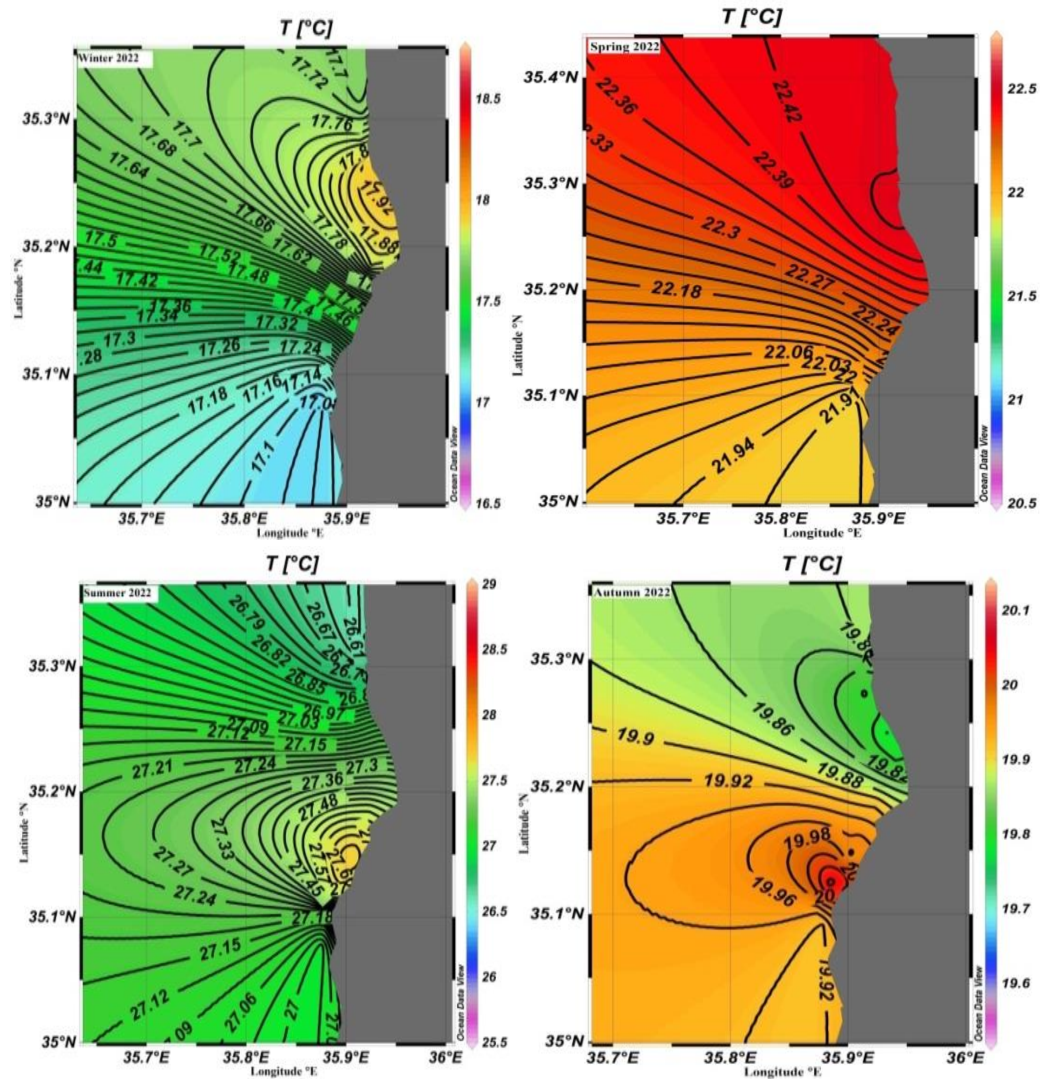

Figure 2 Seasonal changes in temperature of surface seawater between winter and autumn 2022 along the coast of Banias

Salinity of sea surface water (S)

It was observed that there were temporal and spatial differences in salinity values, as the highest value was recorded in the summer (38.65‰) accompanied by an increase in sea surface temperature, while the lowest value (36.51‰) was recorded in the winter (Figure 3). The temporal and spatial variation in salinity values is due to differences in weather factors such as differences in rainfall rates. This is in addition to differences in the direction and strength of winds that affect the levels of mixing of water masses, seasonal changes of evaporation, changes in solar radiation, and changes in the level of human activities (Turatier and Goyet, 2011; Rohling et al., 2009; Zweng et al., 2013; Cossarini et al., 2015; Heng et al., 2021). In general, changes in marine surface water salinity have been associated with changes in sea surface temperature and this has been confirmed by many studies (Gemayel et al., 2015).

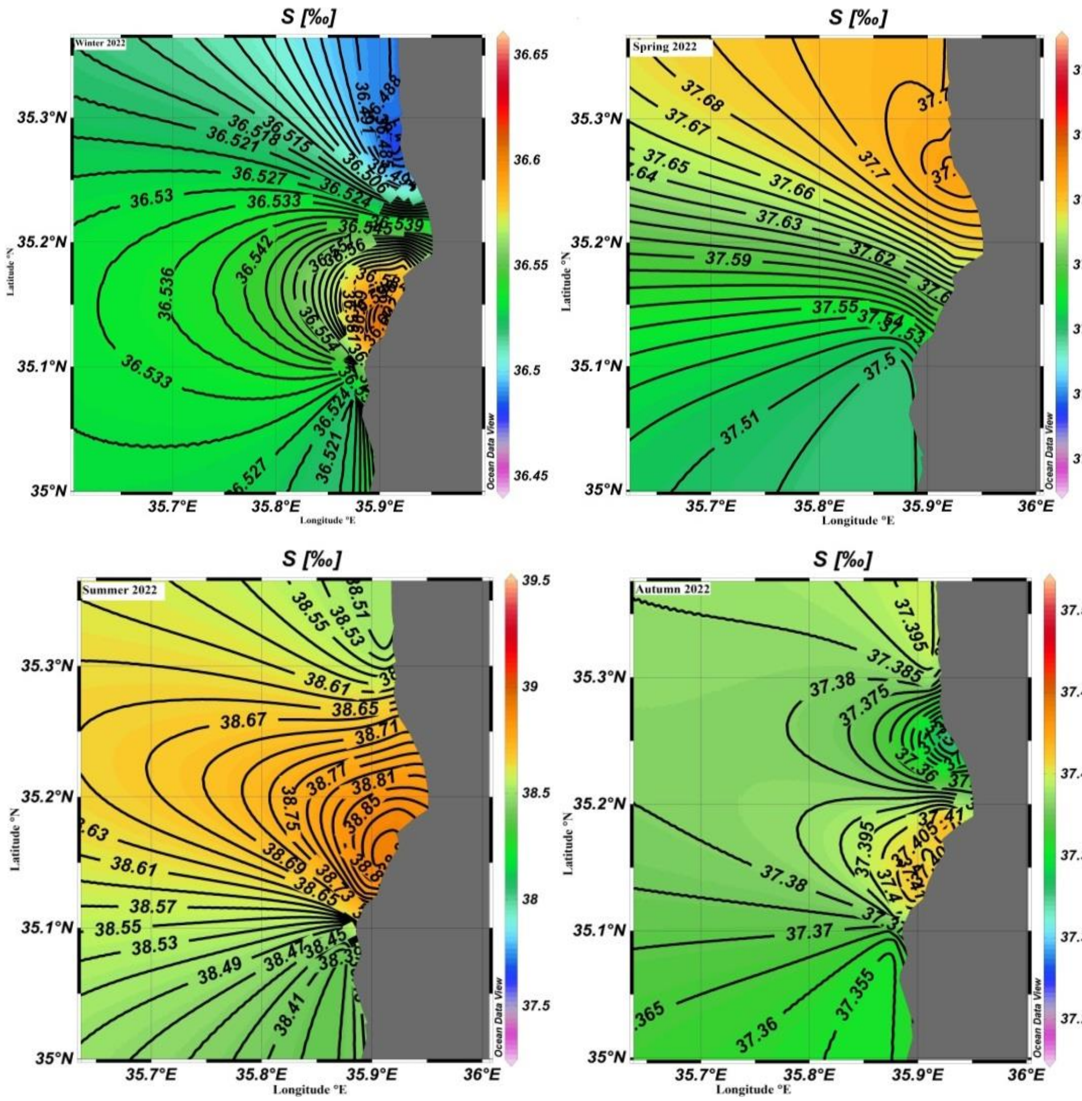

Figure 3 Seasonal changes in the salinity of surface seawater between winter and Autumn 2022 along the coast of Banias

Total alkalinity (AT)

Total alkalinity values in marine surface waters are positively affected by many processes such as photosynthesis, calcium carbonate dissociation, and high-water temperature, compared to the negative effect of other processes such as respiration and calcium carbonate formation (Zeebe and wolf-gladrow, 2001; Bates and Mathis, 2009; Heng et al., 2021). The alkalinity of the surface seawater of the Banias coast showed spatial and temporal changes between the winter and fall of 2022, and the results showed high concentrations in the summer (2520 - 2549 μmol/kg) and lower concentrations in the winter (2389 - 2394 μmol/kg), as shown in (Figure 4). Seasonal changes in the total alkalinity of surface seawater are accompanied by changes in temperature and salinity Poisson and Chen, (1987), Takahashi et al., (1993), and this has been confirmed by many studies in Mediterranean waters (Copin-Montégut, 1993; Copin-Montégut and Bégovic, 2002; Jiang et al., 2014).

Salinity contributes more than 80% to seasonal changes in temperature at different alkalinity values, as a result of differences in river flow rates, rainfall rates, and the effect of evaporation rates between summer and winter (Millero et al., 1998; Lee et al., 2006; Gemayel et al., 2015). It has been observed that there are spatial changes in salinity values between the southern and northern coasts of Banias, as well as in the total alkalinity values of marine surface waters, which shows a linear relationship between them, and this has been confirmed by many studies (Schneider et al., 2010; Laika et al., 2009; Rivaro et al., 2010; Hassoun et al., 2015a). The rise in temperature in summer is accompanied by an increase in the rate of evaporation processes, which contributes to a clear increase in alkalinity concentrations compared to total inorganic carbon (Cossarini et al., 2015).

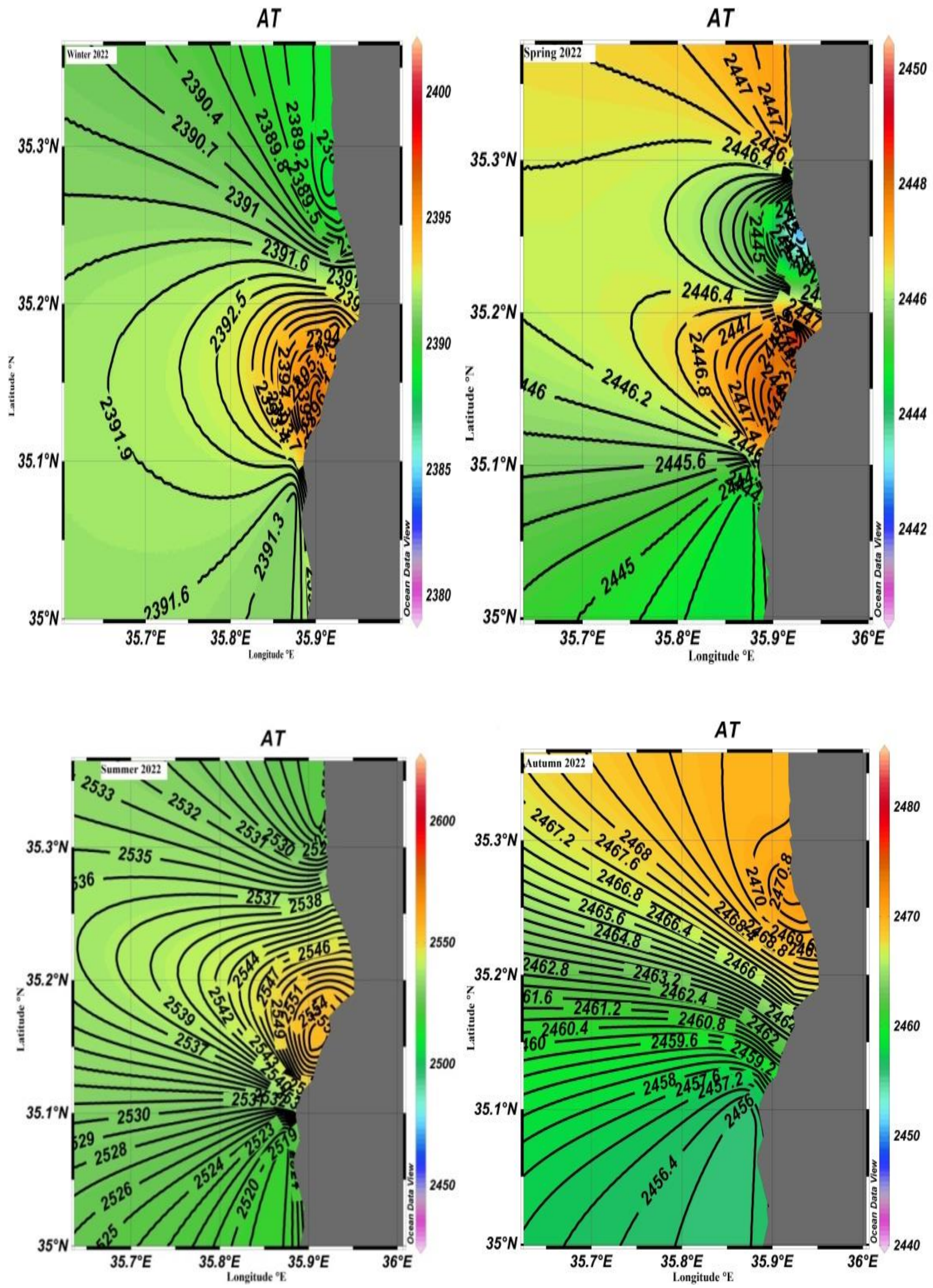

Figure 4 Seasonal changes of AT between winter- autumn 2022 along the coast of Banias

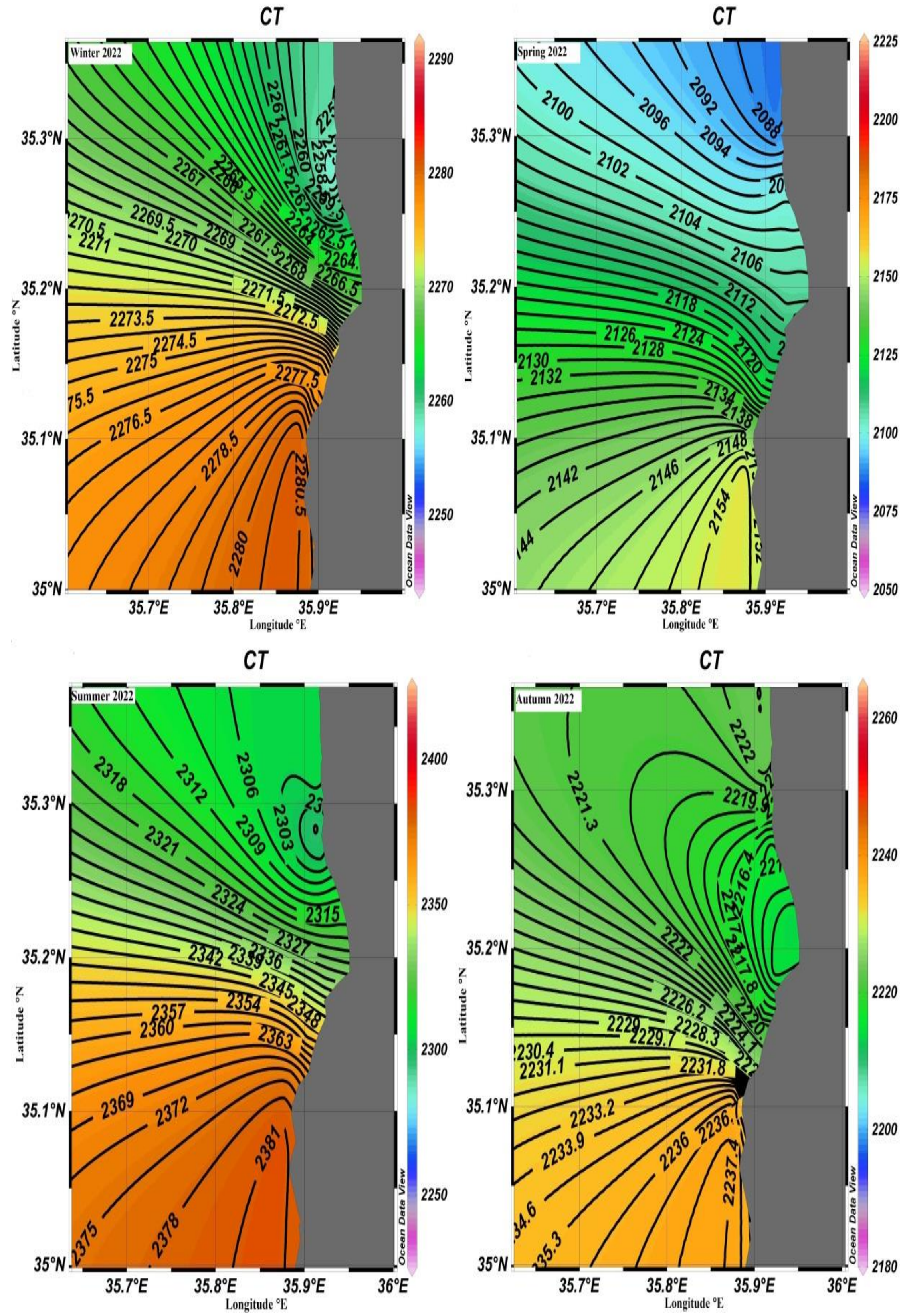

Figure 5 Seasonal changes of CT between winter- autumn 2022 along the Coast of Banias

Total Inorganic Carbon (CT)

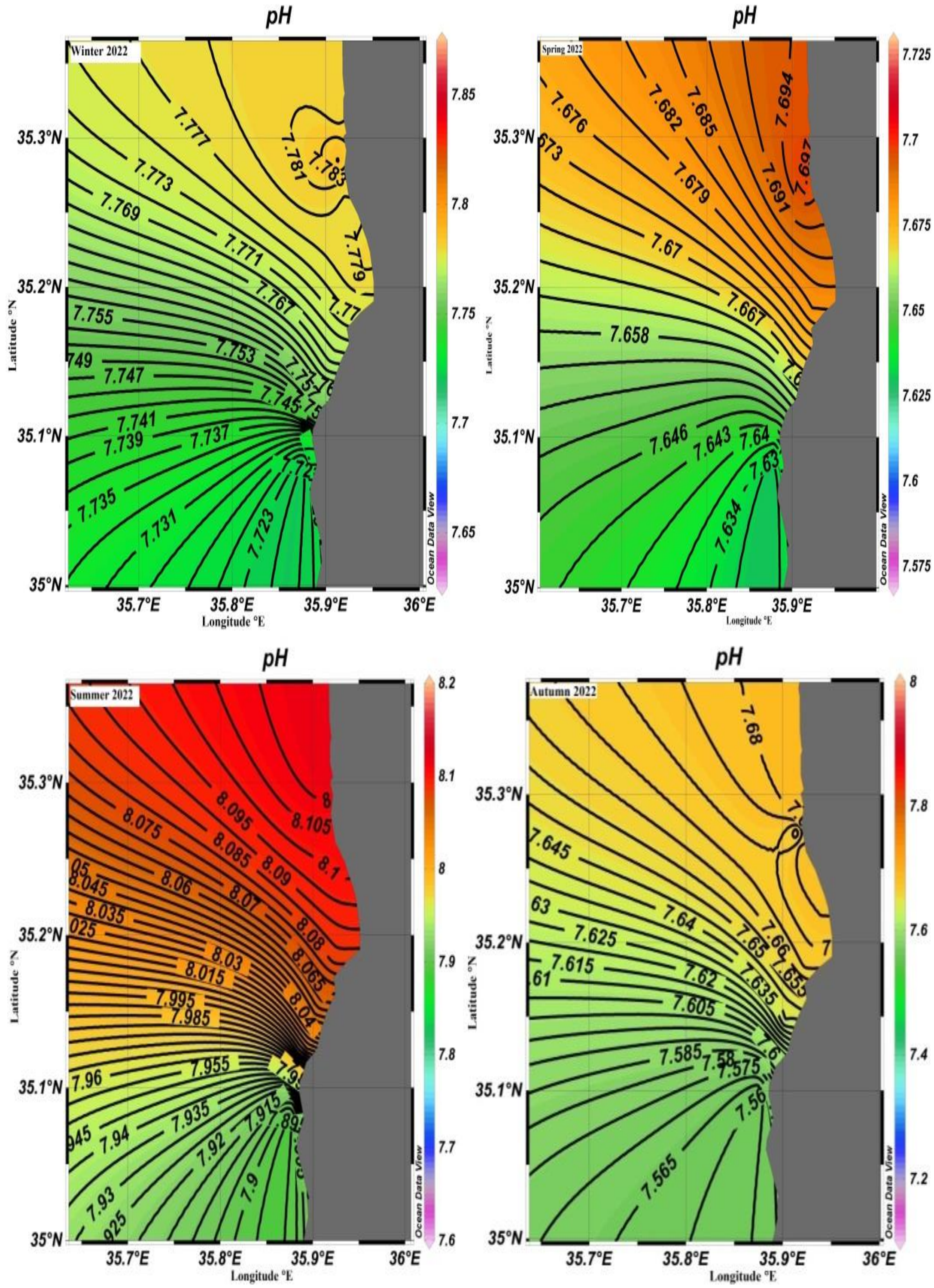

Figure 6 Seasonal changes of pH value in sea surface water between winter and Autumn 2022 along the Coast of Banias

Clear temporal changes were observed in total inorganic carbon in marine surface waters along the coast of Banias from winter (2250.9 - 2280.3 µmol/kg) until autumn (2219.9 - 2237.9 µmol/kg) as shown in (Figure 5), as a result of changes Seasonality of human activities on the beach, vertical mixing of water, and differences in the rate of oxidation processes in the water (Bakker et al., 1999; Sabin et al., 2004; Gemayel et al., 2015). Seasonal changes in temperature and salinity play 80% of the variation in exchange processes at the separation surface between air and sea and in the process of dissolution of carbon dioxide in marine waters, in addition to the difference in the quality of human activities (Schneider et al., 2010).

The southeastern basin is characterized by high concentrations of inorganic carbon in the winter compared to the eastern basin, which is characterized by high concentrations in the summer. The dynamic movement of Mediterranean waters activates the uptake of carbon dioxide from the atmosphere into surface waters and in the process of its transport towards other water basins Hassoun et al., (2015a), which leads to higher CT and AT in the Aegean sub-basins. (Strait of Gibraltar) as confirmed by the study of (Cossarini et al., 2015).

Values of pH surface seawater

The pH values of surface marine waters are affected by the seasonal variation of T and S, which directly affect the carbon dioxide dissolution process (Weiss, 1974). The decrease in freshwater inputs (river water, change in rainfall), the increase in the amount of polluted water (sewage), and the variation in human activities are all factors that contribute to the spatial variation in pH values from one region to another in the study area. This has been confirmed by many scientific studies (Touratier et al., 2012; Hassoun et al., 2015b). In general, an increase in pH values was observed in surface marine waters from the southern coast of Banias towards the north. In addition, acidity increased from summer to winter, accompanied by changes in both the temperature and salinity of marine waters. The pH value ranged between 7.63 in the spring of 2022 and 8.08 in the summer, as shown in (Figure 6), where increasing concentrations of dissolved inorganic carbon in surface marine waters are accompanied by a decrease in pH, and this has been confirmed by many studies, including (Bates and Mathis, 2009).

Since the pre-industrial era, H+ has increased by 26% in marine waters, which has contributed to a decline in average pH values from 8.2 to 8.1 (Raven et al., 2005; Orr et al., 2005; Doney et al., 2009; Gattuso and Hanson, 2011). The greatest and most direct effect of the decrease in pH value on living organisms appears as a result of the decrease in carbonate ion concentration in marine waters. Which leads to negative effects on many marine calcareous organisms. Any change in pH values significantly alters ocean chemistry and ecosystem functioning by altering the carbonate system, and this places many calcifying organisms (such as corals, crustaceans, echinoderms, foraminifera, and mollusks) that depend on various calcite or aragonite forms of Calcium carbonate, building their cell coverings or skeletons are in danger of death and extinction (Gattuso et al., 1998; Kleypas et al., 1999).

4. CONCLUSIONS

As a result, the increase in the proportion of carbon dioxide in the atmosphere was accompanied by clear climatic changes from an increase in the temperature of the atmosphere and the temperature of marine waters, where a clear effect was observed for both the temperature and salinity of the surface waters of the marine area between the southern coast (due to river inputs and fresh water in the sea), compared to the north of Banias Beach in 2022, which led to changes in the carbonate system and pH values of marine water, which will have negative impacts on the marine environment of the studied area on the one hand and biodiversity on the other hand.

Ethical approval

Not applicable.

Informed consent

Not applicable.

Conflicts of interests

The authors declare that there are no conflicts of interests.

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The study has not received any external funding.

Data and materials availability

All data associated with this study are present in the paper.

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