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Original paper

Intensity of Coastal Upwellings of the Southern Coast of Crimea and their Impact on the Oxygen Regime of the Water Area

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Abstract

The paper analyses long-term data of the MHI Oceanological Data Bank for spring-summer seasons (May–September) of 1986–2000 and 2007–2023 and assesses the conditions of upwelling occurrence, their duration, influence on the change of temperature and oxygen regimes and content of nutrients in the water area of Goluboy and Yalta Bays. Fourteen upwellings were detected during the mentioned periods. The volume of analysed data was 3288 values of depth, temperature, sigma-t, oxygen content and nutrients. Upwellings recorded in the first period (1986–2000) were observed only in the Yalta Bay water area. They are characterised by large temperature variations, significant changes in sigma-t and for May upwellings by very high values of oxygen content. An analysis of the current MHI database from 2007 to 2023 allowed us to identify upwellings in the waters of Goluboy Bay, including the area of the stationary oceanographic platform, in July 2007, May 2010, 2012 and 2013, June and September 2013 and June 2021. We compared the temperature, coastal sigma-t and oxygen content for May and June 2012, 2013 and June 2021 and concluded that the intensity of upwellings had significantly decreased, the reasons for which are still unclear and may require further research. The paper considers differences in the content of biogenic nitrogen and phosphorus in the coastal water areas of the Southern Coast of Crimea during upwellings. These differences were manifested in the increase in the content of mineral forms of phosphorus and insignificant change in the content of mineral complexes of nitrogen. The analysis of the used database for these periods showed the insufficiency of target measurements and the need to adjust the monitoring system, especially in the spring–summer period, when the probability of upwelling is maximum.

Keywords: coastal upwelling, Southern Coast of Crimea, temperature regime, oxygen regime, nutrients

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Интенсивность прибрежных апеллингов Южного берега Крыма и их влияние на кислородный режим акватории

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Аннотация

Проанализированы многолетние данные Банка океанологических данных МГИ за весенне-летние сезоны (май – сентябрь) 1986–2000 и 2007–2023 гг., оценены условия возникновения апеллингов, их продолжительность, влияние на изменение температурного и кислородного режимов и содержание биогенных элементов в акватории Голубого и Ялтинского заливов. В указанные периоды обнаружено 14 апеллингов. Объем проанализированных данных составил 3288 значений глубины, температуры, плотности, содержания кислорода и биогенных элементов. Апеллинги, зафиксированные в первый период (1986–2000 гг.), отмечены только в акватории Ялтинского залива, для них характерны большие перепады температуры, существенные изменения плотности воды, а для майских апеллингов – очень высокие значения содержания кислорода. Анализ современной базы данных МГИ с 2007 по 2023 г. позволил выявить апеллинги в акватории Голубого залива, включая район расположения стационарной океанографической платформы, в июле 2007 г., мае 2010, 2012 и 2013 гг., июне и сентябре 2013 г. и июне 2021 г. В результате сравнения температуры, плотности прибрежных вод и содержания в них кислорода за май, июнь 2012, 2013 гг. и июнь 2021 г. сделан вывод о существенном снижении интенсивности апеллингов, причины которого пока неясны и могут стать предметом дальнейших исследований. Рассматриваются различия в содержании биогенных азота и фосфора в прибрежных акваториях Южного берега Крыма в периоды прохождения апеллингов. Эти различия проявились в увеличении содержания минеральных форм фосфора и незначительном изменении содержания минеральных комплексов азота. Анализ используемой базы данных за указанные периоды показал недостаточность целевых измерений и необходимость корректировки системы мониторинга, особенно в весенне-летний период, когда максимальна вероятность возникновения апеллингов.

Ключевые слова: прибрежный апеллинг, Южный берег Крыма, температурный режим, кислородный режим, биогенные элементы

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Introduction

The coastal zone of the Southern Coast of Crimea (SCC) is characterized by significant dynamic activity, as evidenced by numerous cases of upwelling on the sea surface. Upwelling occurs when, due to the Coriolis force and viscosity, the longshore wind direction deflects surface water away from the shore and deep water moves up instead. Generally accepted criterion for determining temperature upwelling corresponds to cases with a sharp (more than 5 °C) decrease in surface water temperature [1, 2]. The structure and dynamics of coastal upwelling near the SCC were described in [3], where the authors consider two types of coastal upwelling near the SCC – Ekman wind-driven and reverse storm surge ones. Characteristics of their occurrence conditions for 1980–1985 were given and it was shown that the most intensive and long-lasting Ekman upwellings were formed near the urban-type settlement of Katsiveli (Goluboy Bay). The paper also considers the influence of upwellings on the uplift of the cold intermediate layer core closer to the surface up to 30 m horizon.

In [4], the authors consider that circulation of the coastal anticyclonic eddy is one of the internal causes creating conditions for the development of upwelling near the coast of Crimea even with the absence of wind stress longshore component or when it is weak. According to the authors of [4], the main hydrodynamic processes contributing to the occurrence of upwelling in the SCC water area are as follows:

– intense western and south-western flows of the Rim Current along the southern shores of Crimea;

– interaction of the Rim Current northern periphery with the shelf relief heterogeneities (capes, bays) of the Crimean Peninsula;

– longshore eastern and north-eastern flows of the northern peripheries of anticyclonic dynamic formations, realising the Ekman effect at longshore wind intensification;

– reverse storm surge winds from the western and northern sectors, normal to the shore.

The interaction of these factors determines complex structure and dynamics of coastal waters and influences the process of upwelling formation.

The results of determining the regularities of coastal upwelling development in the Black Sea using satellite data are presented in [5]. The Black Sea water area was zoned according to the frequency of coastal upwellings. It was shown that upwellings were more frequently observed in the north-western part of the sea and much less frequently in the area of Yalta, Feodosiya, Novorossiysk and especially near the coast of Turkey. These areas are characterised by the absence of upwellings in certain years. Their occurrence frequency is 1–8 days per month.

Identification of areas with the highest frequency of coastal upwellings during the warm period for the Black Sea was carried out in [2]. A number of satellite images of the entire Black Sea area obtained from AVHRR sensors of NOAA satellites in 1997–2011 were analysed. The observation time interval was extended to 2015 for the SCC. Significant interannual variability of the total duration of upwellings was noted over the period under consideration. For the SCC, estimates of the interaction of the upwelling with the surrounding multiscale dynamic structures, such as the area of active anticyclonic eddies formation, under the influence of the Rim Current southwest of the SCC were presented. As a result, the width of the developed upwelling can reach 30 km near the SCC. According to the authors of [2], upwellings are a kind of windows in which the thermocline and subthermocline waters interact with the atmosphere during the warm period of the year.

An analysis of intra- and inter-annual variability of the frequency, speed and duration of westerly winds contributing to the occurrence of upwellings near the SCC is presented in [6]. Six-hourly data on wind speed components at 10 m height obtained from atmospheric reanalysis ERA5 for 1979–2021 and temperature monitoring data at the Black Sea hydrophysical subsatellite polygon of Marine Hydrophysical Institute (MHI) were used.

Upwelling is detected as temperature decreases due to the rise of colder deep waters, most often from April to October, when the surface temperature is higher than the subsurface water temperature [7]. This is most contrasting in the summer months, with the highest vertical temperature gradient in the thermocline. Such upwelling is determined by the sea surface temperature obtained from contact measurements [1], including thermistor chains installed in shelf zones [8–10], as well as from satellite data [2, 11, 12].

Using modern methods of mathematical modeling (multi-scale coupled ocean–atmosphere modeling platform NOW (NEMO-OASIS-WRF) with a resolution of 2 km), one of the cases of wind-driven coastal upwelling in the Black Sea near the SCC on 24–25 September 2013 was studied in [13], where the authors applied this model successfully in order to reproduce a sharp decrease in sea surface temperature by 10 °C within two days. The increased spatial resolution of the simulation made it possible to identify upwelling features associated with the relief and shape of the coastline.

The above studies did not assess the impact of upwelling on the water area oxygen regime, nor did they analyse the associated change in the content of hydrochemical parameters, in particular, such ecosystem components as elements of the main biogenic cycle, with their content affecting the productivity of marine coastal zone ecosystems significantly [11, 14]. Rise of deep waters saturated with nutrients provides growth of phytoplankton biomass and other components of the biosphere [15].

In [16], it was shown that the area of Goluboy Bay was a convenient polygon for synchronous remote and subsatellite studies of natural oceanological processes and impact of coastal anthropogenic sources of pollution on the state of the marine coastal environment. An undoubted advantage of this polygon is the location of a stationary oceanographic platform (SOP) in its south-western part at a distance of 430 m from the coast near Katsiveli with a sea depth of 27 m at the sampling point, which makes it possible to monitor promptly the development of upwelling in the SCC area based on changes in surface water temperature. In [11], the upwelling that occurred in May 2010 was studied using not only contact methods but also satellite data. In [16], the authors discuss the results of expedition research conducted on the SOP by the MHI Marine Biogeochemistry Department in 2009–2014 and analyse the impact of upwelling mainly on the content of individual components of the carbonate system, dissolved oxygen and elements of the main biogenic cycle. It was shown that not affecting the content of inorganic forms of nitrogen, the powerful upwelling observed in May 2014 in the SOP area led to an increase in phosphate concentration by 3–4 times compared to background values.

In the present study, the conditions of upwelling occurrence in the water area of Goluboy (including the SOP near Katsiveli) and Yalta Bays, their duration and influence on the changes in temperature and oxygen regimes and the content of nutrients were studied. We analysed data for May–September of these periods as the season of the most frequently occurring upwellings, easily registered due to the large temperature difference between surface and deep water layers.

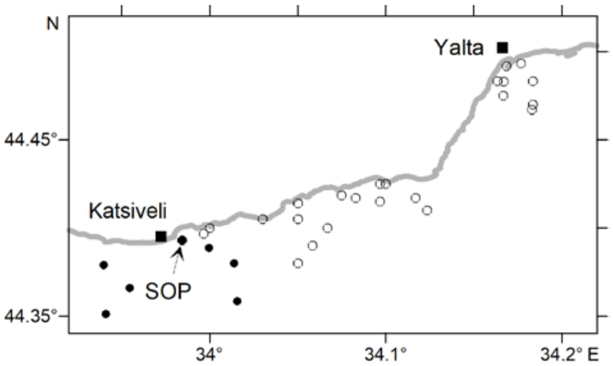
Given the importance of upwelling for assessing the ecological state of coastal waters, further study of this phenomenon, especially its seasonal dynamics with detailed information on oxygen and nutrient content, is particularly relevant.

The aim of the paper is to assess the intensity and duration of coastal upwellings formed in spring and summer in the water areas of Goluboy and Yalta Bays by analysing changes in sigma-t, their temperature and oxygen regimes and the content of nutrients.

Materials and methods of study

The paper analysed long-term data of the MHI Oceanological Data Bank (ODB) for 1986–2000 and 2007–2023 in order to assess the conditions of upwelling occurrence in the water area of Goluboy (including the SOP near Katsiveli) and Yalta Bays. We assessed the intensity and duration of upwelling, as well as its influence on changes in temperature and oxygen regimes, sigma-t and content of nutrients (inorganic and total phosphorus and inorganic nitrogen) for May–August. The data analysed for the selected upwellings for the 1986–2000 period (July 1986, May 1987 and 1989, July 1997) comprised 2108 values of all water parameters including oxygen and nutrients. The distribution of values by year was found to be uneven, namely, 580 – in 1986, 575 – in 1987, 666 – in 1989 and 287 – in 1997.

In 2007–2023, upwellings were recorded in July 2007, May 2010, 2012 and 2013, June and September 2013, June 2021. The analysed data comprised 1180 values of the above parameters. The distribution of values by year was found to be uneven, namely, 384 values of all analysed parameters in 2007, 224 – in 2010, 137 – in 2012, 323 – in 2013 and 112 – in 2021. Only one upwelling was identified in the provided database on 7 September 2013 with a maximum temperature difference of up to 14 °C. In the analysed MHI ODB, upwellings were not recorded for 2014 (data for July and August only), 2015 (September), 2016 (May and July), 2017 (June and September), 2018 (July), 2019 (July), 2020 (September). In the 2022 and 2023 spring–summer period (data for May–September), no upwellings were recorded in the water area of Yalta and Goluboy Bays, which was confirmed by the conclusion of the authors of [5] that the SCC coastal waters belong to the part of the Black Sea where upwellings are not registered every year.



F i g . 1 . Study area. The circles are stations performed in 1986–2000 and the dots are those performed in 2007–2023

Fig. 1 shows the location scheme of sampling stations.

It should be noted that three of the analysed upwellings were observed in Yalta Bay (1986–1989) and 11 ones in Goluboy Bay (1997, 2007–2021).

Results and discussion

In the SCC coastal zone (summer 1986–2000), the characteristics of coastal waters during the period of upwellings in the water area of Goluboy (including the SOP near Katsiveli) and Yalta Bays were considered. The duration of upwellings during this period varied from 6 to 28 h with a temperature decrease by 8–9 °C.

The 6 h upwelling observed on 14 July 1986 was accompanied by a decrease in temperature in the surface water layer by 8.33 °C and an increase in oxygen content to 7.76 mL/L, while before the upwelling, this value in the surface water layer was 5.39 mL/L. During the upwelling period, a vertical increase in sigma-t from 13.3 kg/m^3 near the surface to 14.1 kg/m^3 at a depth of 20 m was observed as well as an increase in oxygen content from 7.76 to 8.12 mL/L, an increase with depth in phosphates and total phosphorus content about three times, with unchanged inorganic forms of nitrogen (nitrites and nitrates).

The upwelling duration in the Yalta Bay water area on 25 May 1987 was more than a day (beginning – 25 May at 7:56 a.m., termination – 26 May at 11:00 a.m.), with a temperature difference of 8 °C (15.60–7.60 °C). The upwelling was accompanied by an increase in surface water oxygen content to 8.65 mL/L (7.04 mL/L before upwelling). Sigma-t also increased from 12.30 to 14.30 kg/m^3. An increase in phosphorus and nitrite nitrogen content was recorded on the second day of upwelling at a depth of 5 m. It should be noted that upwelling in May was also characterised by a decrease in ammonium content as compared to the previous period.

The upwelling duration in the Yalta Bay water area on 11 May 1989 was 6 h with a temperature difference of more than 9 °C. Sigma-t also increased from 13.24 to 14.10 kg/m^3 during the upwelling and decreased up to 11.78 kg/m^3 looking past it. Of note is the higher oxygen content (8.70–9.01 mL/L) in the bay waters during the upwelling period, which persisted (8.63 mL/L) even after the upwelling termination on 15 May 1989. During the upwelling period, an increased content of total phosphorus was noted at the surface horizon, while the content of nitrates, phosphates and nitrites did not change at depth.

In the Goluboy Bay water area, the upwelling was recorded on 22 July 1997. Its duration was 7 h, with a temperature decrease of more than 9 °C. Sigma-t before its beginning was 10.47 kg/m^3 and during the upwelling period – 13.02–14.19 kg/m^3. Dissolved oxygen concentration in the surface layer was 5.86 mL/L on 18 July 1997 and 7.27–6.11 mL/L during the upwelling period. The content of biogenic compounds (phosphates, total phosphorus and nitrites) did not change vertically, with nitrates content only increased in the surface water layer.

Thus, in the first period under study, upwellings, regardless of their duration and temperature difference, were always accompanied by an increase in oxygen content and sigma-t. No such unambiguous conclusion can be made with regard to nutrients. An increase in the content of only total phosphorus and phosphates was recorded during three upwellings in July 1986, May 1987 and 1989 in the Yalta Bay water area and on 20 July 2007 in the Goluboy Bay water area, where the phosphates content increased almost three times and that of total phosphorus – one and a half times. The content of inorganic nitrogen did not change with depth during the upwelling period. A similar situation is described in [15], when under the influence of a powerful upwelling lasting one day in May 2014 in the SOP area, the content of inorganic nitrogen did not change, while the phosphates concentration increased 3–4 times compared to the background values. The reason can include differences in the cycles of these nutrients: for nitrogen, it is the water–atmosphere system and for phosphorus, it is the water–bottom system. Unlike inorganic nitrogen, phosphorus has no gaseous forms in water and its ability to accumulate near the bottom and return to the water column as a result of oxygen decrease under reducing conditions is well known. These differences are particularly evident in other water areas. Such conditions were recorded in Sevastopol Bay and described in [17]. Since upwelling is the rise of deep water, an increase in phosphorus is understandable.

In 2007–2023, the upwelling was revealed in the Goluboy Bay water area in July 2007, May 2010, 2012 and 2013, June and September 2013, June 2021. On the SOP, samples were collected at surface, 0.5 and 5.0 m horizons.

The upwelling duration on 20 July 2007 was one day, with a temperature decrease of about 10°C, sigma-t increase from 9.96 kg/m^3 (before the upwelling) to 13.86 kg/m^3 (during the upwelling) and dissolved oxygen concentration increase from 5.5 to 7.96 mL/L at 1 m depth. The upwelling was accompanied by an increase in phosphates concentration almost three times (from 1.6 to 4.3 μg/L) and in total phosphorus – one and a half times (from 4.3 to 7.4 μg/L), with almost no effect on the content of nitrites and nitrates.

The 24 h upwelling recorded in May 2010 was accompanied by a decrease in temperature by 7.5 °C, an increase in sigma-t by about two units and a slight (up to 7.14 mL/L) increase in dissolved oxygen content.

In May 2012, several upwellings were observed: on 24 and 25 May with duration from 6 to 48 h with temperature decrease by 9.4–10.4 °C, and on 30–31 May with duration of a day with temperature decrease by more than 9 °C. All three upwellings of May 2012 were accompanied by an increase of oxygen content in the surface water layer up to 7.36 mL/L, with its content before the upwelling at 5.86 mL/L. During all three upwellings, sigma-t increased from 11.91 to 14.07 kg/m^3 (Table). The content of nutrients during the upwelling period in May 2012 was not measured.

Parameters of coastal upwellings in Yalta and Goluboy Bays found in 1986–2021

Upwelling date	Upwelling duration, h	Range of		
		sigma-t, kg/m^3	temperature, °C	oxygen content, mL/L
14.07.1986	6	11.40–13.40	13.20–21.03	5.39–7.72
25.05.1987	28	12.30–14.30	7.60–15.60	7.04–8.65
11.05.1989	6	11.80–14.10	8.30–17.30	8.63–9.01
22.07.1997	7	10.50–13.23	11.70–22.20	5.89–7.27
20.07.2007	24	10.01–13.96	14.90–25.00	5.50–7.96
27.05.2010	24	11.83–13.47	11.46–18.95	6.68–7.14
24.05.2012	6	11.91–14.03	8.15–18.61	5.86–7.36
25.05.2012	48	12.50–14.03	8.60–17.80	6.74–7.22
30.05.2012	24	12.50–14.07	8.62–18.00	6.74–7.25
25.05.2013	30	12.10–13.89	10.00–18.58	6.54–6.90
28.05.2013	5	12.01–13.78	10.20–18.76	6.25–6.83
01.06.2013	2	11.50–13.46	12.00–20.00	5.95–7.15
07.09.2013	24	11.30–13.79	10.12–21.50	5.60–7.11
02.06.2021	13	12.62–13.60	11.19–17.54	6.30–6.72

Note: The ranges of sigma-t, temperature and oxygen content are given for the surface horizon.

The overview table of all coastal upwellings detected in the MHI ODB for two periods 1986–2000 and 2007–2023 makes it possible to compare their influence on the change of water mass parameters such as sigma-t, temperature and dissolved oxygen saturation of the SCC coastal water areas on the example of Yalta and Goluboy Bays. Table does not present data on changes in the concentration of nutrients during the upwelling period because in the MHI ODB, these elements were determined only during the upwelling period in May 1987 and 1989, in July 1986, 1997 and 2007 and in September 2013. Nutrients were not determined during other upwelling periods.

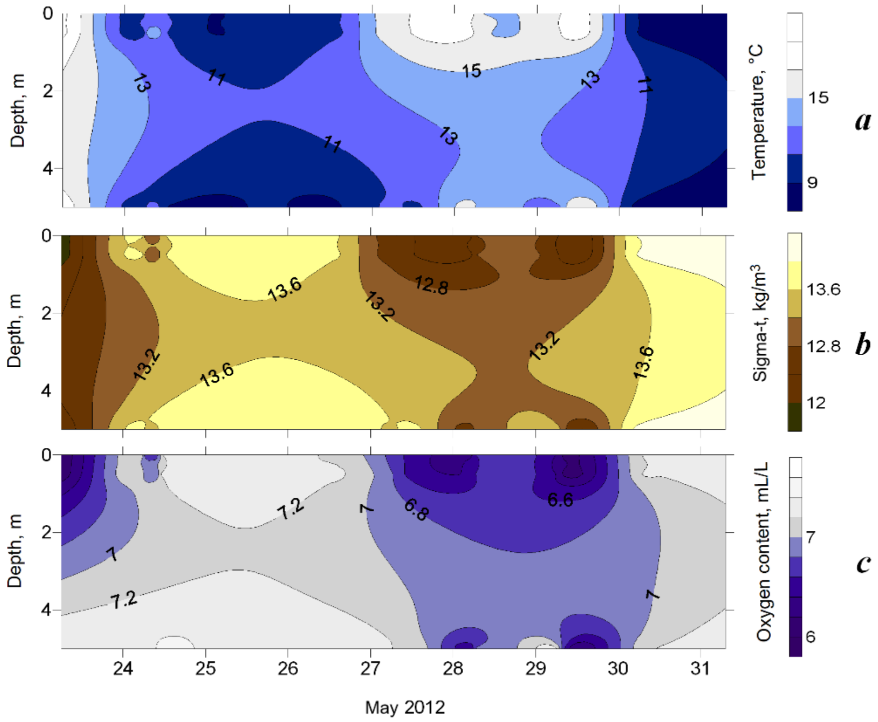
The data in Table show that regardless of the upwelling duration, the change in oxygen content depends mainly on the change in sigma-t and temperature difference during the upwelling period. During the identified upwellings, temperature decreases ranged from 8 to 10.5 °C in May and July, 6.5 to 8 °C in June, with a maximum of 11.4 °C in September 2013. The increase in sigma-t resulted from the upwelling was maximum (by 2.0–2.73 kg/m^3) in July 1997 and 2007 and minimum (by 1.33 kg/m^3) in 2021. The maximum increase in dissolved oxygen content was observed in July 1986 (2.33 mL/L) and 2007 (2.46 mL/L). In May 1987 and 2012, it was 1.20–1.61 mL/L and the remaining upwellings were characterised by an increase in aeration by no more than 0.58 mL/L.

Figs. 2–5 show changes in coastal water parameters (temperature, sigma-t, oxygen content) under the influence of coastal upwellings in the Goluboy Bay water area around the SOP location in the modern period (2012–2021).

When comparing the information presented in Figs. 2, *a* and 2, *c*, a clear dependence of oxygen content on water temperature can be seen: at the upwelling, lower temperatures are accompanied by higher oxygen content. Sigma-t (Fig. 2, *b*) increases slightly at the upwelling but in contrast to temperature and oxygen content, separate decreased sigma-t lenses are observed at the surface and 5 m horizon up to a value of 12.60 kg/m^3. Later, at the upwelling over the whole area until 31 May, the sigma-t field is almost homogeneous with a value of 13.40 kg/m^3. Fig. 2, *b* also demonstrates that decreased sigma-t lenses location corresponds to the area of low oxygen concentrations.

The upwelling of 30 h duration recorded on 25 and 26 May 2013 differed from the upwelling in May 2012 by a decrease in temperature by about 8 °C and a lower difference in sigma-t from 12.10 to 13.80 kg/m^3, which was also reflected in a slight (6.54–6.86 mL/L) change in the surface water layer oxygen content (Fig. 3).

The upwelling recorded on 28 May 2013 was characterised by a duration of 5 h, temperature decrease by 8.5 °C and comparable changes in sigma-t and dissolved oxygen content (see Table). A very short (2 h) upwelling took place on 1 June 2013 (Fig. 3), with a temperature decrease of about 8 °C. It was accompanied by a decrease in oxygen content from 7.15 mL/L during the upwelling period to 5.95 mL/L



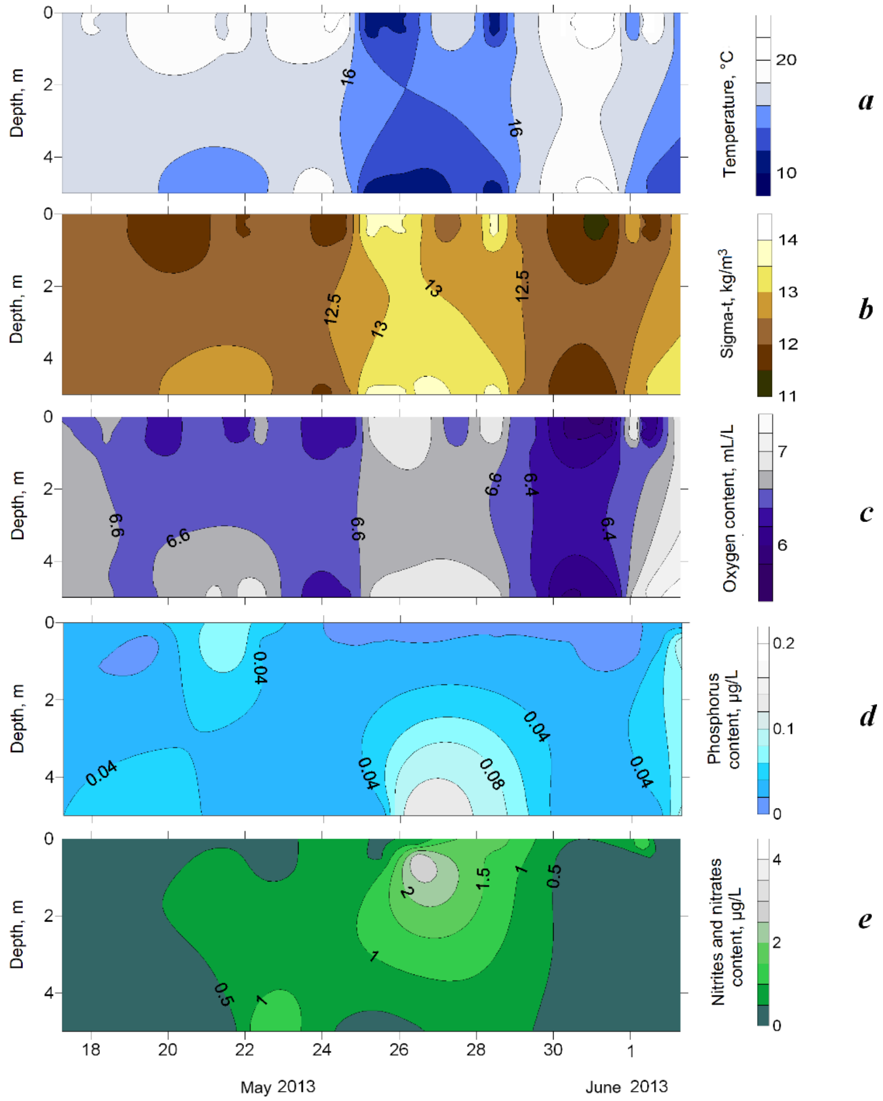
F i g . 2 . Parameters of coastal waters: temperature (*a*), sigma-t (*b*) and oxygen content (*c*) during upwellings from 24 to 30 May 2012 in the Goluboy Bay water area (stationary oceanographic platform – SOP)

after its termination. Sigma-t at the surface horizon increased to 13.46 kg/m^3 during the upwelling period and decreased to 11.50 kg/m^3 after its termination.

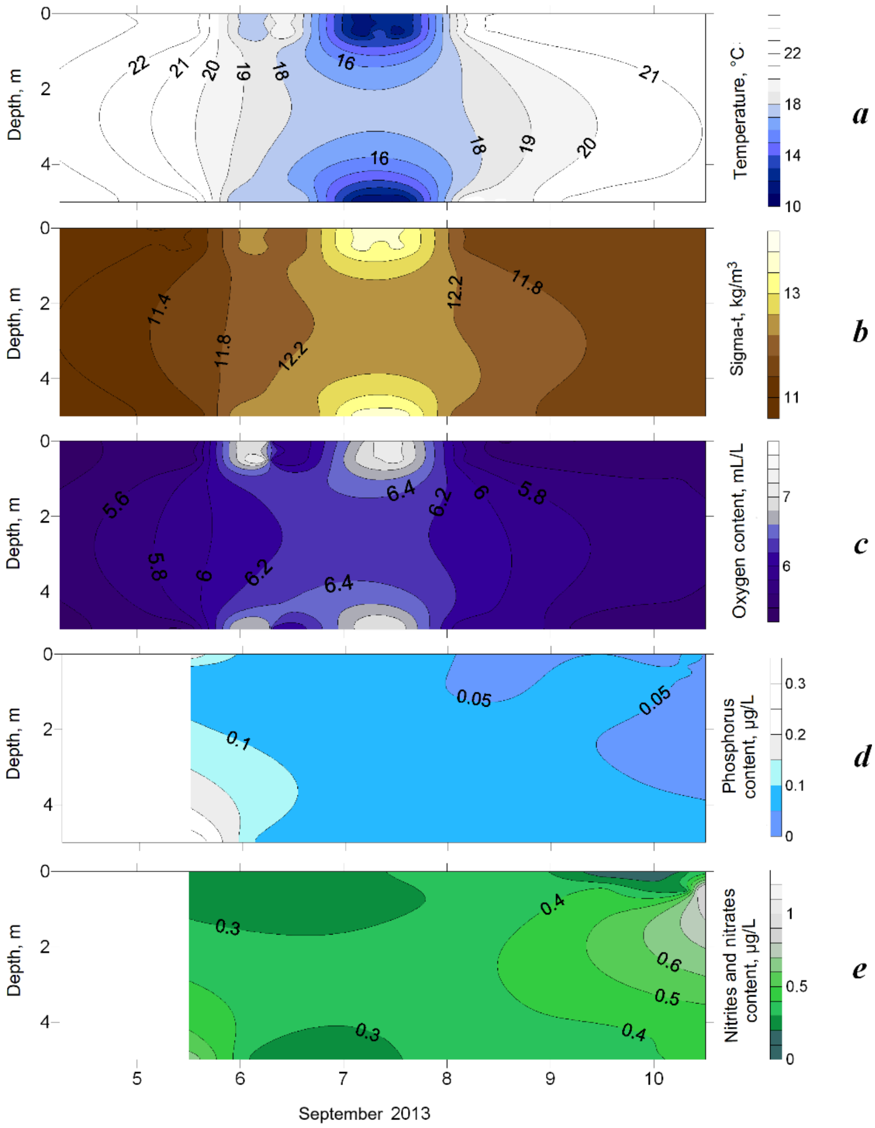
When comparing the data presented in Figs. 2 and 3, it can be noted that in May 2013 the observed upwellings were characterised by a smaller temperature difference, sigma-t and oxygen content changes than in May 2012.

On 7 September 2013, the upwelling of 24 h duration was recorded in the Goluboy Bay water area, with a temperature difference of more than 10 °C (from 21.5 to 10.12 °C), sigma-t increase from 11.34 to 13.79 kg/m^3 and subsequent decrease after the upwelling to 5.6 mL/L with an increase in dissolved oxygen content to 7.11 mL/L (Fig. 4). In addition, the phosphates content doubled as at the upwelling in July 2007. This is also noted in the findings of [15], where the upwelling of May 2014 was described.

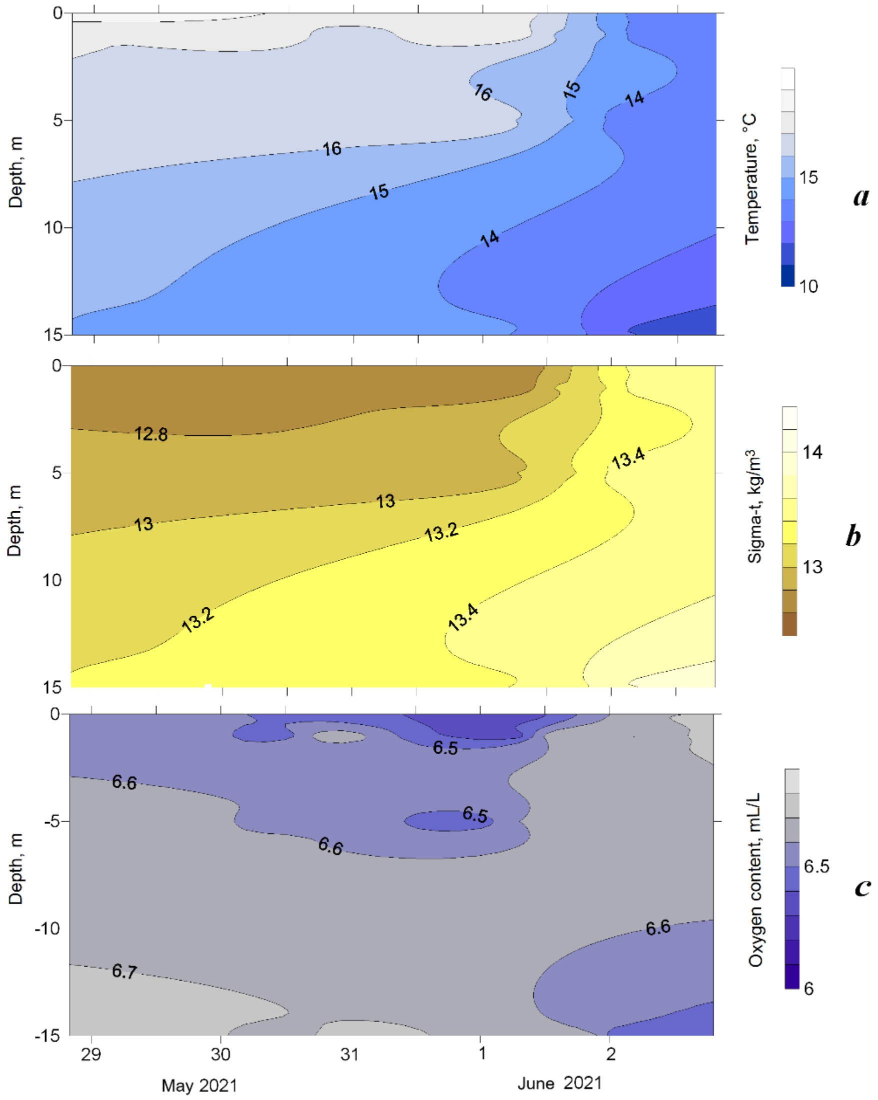
Higher upwelling intensity of on 7 September 2013 compared to May and June of the same year can be related to the effect of such a climatic factor as wind. In [6], in which the duration of winds favourable for the upwelling occurrence was



F i g . 3 . Parameters of coastal waters: temperature (*a*), sigma-t (*b*), oxygen content (*c*), biogenic phosphorus (*d*) and sum of nitrites and nitrates (*e*) during upwellings from 26 to 30 May 2013 and 1 June 2013 in the Goluboy Bay water area (SOP)



F i g . 4 . Parameters of coastal waters: temperature (*a*), sigma-t (*b*), oxygen content (*c*), biogenic phosphorus (*d*) and sum of nitrites and nitrates (*e*) during an upwelling on 7 September 2013 in the Goluboy Bay water area (SOP)



F i g . 5 . Parameters of coastal waters: temperature (*a*), sigma-t (*b*) and oxygen content (*c*) during an upwelling on 2 June 2021

studied, it was shown that the longest duration (from 6 h to several days) of westerly winds had been recorded from 29 August to 8 September 2013.

The duration of the upwelling on 2 June 2021 was about 13 h (Fig. 5).

Fig. 5 shows that the upwelling of June 2021 can be characterised by minimal values of temperature difference (by about 6.5 °C), minimal change in sigma-t (by 1.33 kg/m^3) and the slightest change in oxygen content (by 0.16–0.42 mL/L).

Analysis of the information presented in Figs. 2–5 makes it possible to conclude that during the upwelling on 2 June 2021, the temperature decrease was the lowest one since 2012. This is probably why the distribution of oxygen content across all horizons (6.56–6.72 mL/L) was fairly uniform and sigma-t variation was negligible (from 12.62 to 13.52 kg/m^3).

According to the MHI ODB data, analysis of seasonal dynamics of upwelling occurrence in the SCC coastal water areas showed that eight upwellings were recorded in May, three – in July, two – in June and only one – in September.

The reasons for our finding of a slight decrease in upwelling intensity in the spring–summer period from 2012 to 2021 remain unclear, as more intense upwelling was observed in September 2013. In consideration of the intricacy of the processes that occur in the SCC coastal water areas, which are subject to factors of diverse natures, it is evident that further observations and the enhancement of the monitoring system are imperative to address the raised queries.

Conclusion

Based on the analysis of the MHI ODB *in situ* data for two periods 1986–2000 and 2007–2023, assessments of the influence of coastal upwellings on changes in temperature and oxygen regimes and content of nutrients in the Goluboy Bay water area, including the SOP in Katsiveli, and in the Yalta Bay water area were obtained. The maximum frequency of upwelling occurrence in the spring–summer season was confirmed.

It is shown that as a factor of change in water aeration, the upwelling contributes to the increase in dissolved oxygen content at any duration of its effect as a result of the accompanying temperature difference and change in sigma-t.

The upwellings recorded during the first period were noted in the Yalta Bay (three upwellings) and Goluboy Bay (one upwelling) water areas. They were characterised by large temperature differences, significant changes in sigma-t, and for the May upwellings – by very high oxygen content both before and after the upwelling. The reasons for such variability of parameters of the identified upwellings have still been unclear.

The analysis of the data for the second period (2007–2023) showed that the formed upwellings were detected in the Goluboy Bay waters, including the SOP area. Comparative analysis of information on the upwelling intensity for May and June 2012, 2013 and June 2021 made it possible to identify a significant decrease in the upwelling intensity based on changes in coastal water parameters (temperature, sigma-t and oxygen content), the reasons for which remain unclear and can be further studied.

It was concluded that the rise of deep water resulted from the upwelling contributed to the increase in the content of mineral forms of phosphorus and affected insignificantly the concentration of mineral complexes of nitrogen. The assumption that the difference in changes in the content of these biogenic complexes under the effect of the coastal upwelling is associated with differences in the systems of their circulation and requires further research.

The analysis of the used database for these periods showed the insufficiency of target measurements and the need to adjust the monitoring system, especially in the spring–summer period, when the probability of upwelling is maximum.

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