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Global warming impacts in the Mediterranean Sea and Balearic Islands region

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Global warming continues in 2025 impacting the Mediterranean Sea

- Climate change brought new records in 2025 for the ocean temperatures in the Mediterranean Sea, which were associated with records on marine heatwaves, ocean salinity and sea level rise.
- Web-based applications implemented by the Balearic Islands Coastal Observing and Forecasting System (SOCIB) allow monitoring of the ocean state, variability and changes in near real-time and over the last four decades.

After the record-breaking temperatures for the global ocean in 2023 and 2024 (Cheng et al., 2023, 2024; Copernicus Global Climate Highlights 2023, 2024), global warming continues impacting ocean state and variability. 2025 ranked as the third warmest year on record for the global average surface air temperatures going back to 1850 as well as for the extra-polar global-average sea surface temperature (SST) (Copernicus Global Climate Highlights, 2025). The average global temperature for 2023-2025 is the first three-year average above 1.5°C. SSTs remained high throughout 2025, despite the absence of El Niño conditions which contributed to the warm SSTs in 2024 and 2025. The unprecedented SSTs were associated with marine heatwaves (MHWs) around the globe, in particular in the Mediterranean Sea. In this semi-enclosed sea, climate change brought new records in 2025 for the ocean temperatures, salinity and sea level affecting marine life, coastal communities and industries.

Record ocean temperatures: How does the temperature of the Mediterranean Sea vary?

- The ocean warming rate over the period 1982-2025 averaged in the Mediterranean Sea is around 0.4 °C/decade varying locally from 0.14 to 0.65 °C/decade.
- In 2025, SST was the second warmest on record after 2024 with a basin-averaged annual mean of 21.09 °C corresponding to a mean anomaly of 1.36 °C w.r.t. the period 1982-2015.
- In 2025, the Mediterranean suffered 190 MHW days with a maximum intensity of 4.27 °C as a basin-average with regional variations.
- Ocean warming is also affecting the intermediate and deep layers with new records registered.

Sea surface temperatures

Spatially-averaged annual mean SST as observed by satellites in the Mediterranean Sea were the warmest over the last eight years ever registered since 1982 (https://apps.socib.es/subregmed-indicators/ocean_temperature.htm) with 2024 being the record-breaking year, following the exceptional 2025, 2023 and 2022. Mediterranean warming continues its acceleration with local trends varying between 0.14 and 0.65 °C/decade in the southeast of Rhodes Island (Figure 1). In 2025, SST was the second warmest on record with an annual mean of 21.09°C corresponding to a mean anomaly of 1.36°C w.r.t. the period 1982-2015 (Figure 2). Satellites observed the highest seasonal SST values ever registered in spring over the last 44 years in the western

Mediterranean Sea. More specifically, June 2025 was the warmest month of June ever registered since1982 in the western sub-basin with a regionally-averaged monthly mean anomaly reaching 3.5 °C. In both western and eastern sub-basins, all seasons of 2025 ranked among the three warmest seasons on record. These records in SST have been associated with records on MHW maximum intensities in 2025 reaching regionally averaged values of 4.27, 5.23 and 3.30 °C in the Mediterranean Sea, western and eastern sub-basins, respectively (Figure 2).

Marine heatwaves

MHW properties show strong spatio-temporal variations at sub-regional scales (Figure 3, https://apps.socib.es/subregmed-marine-heatwaves/). In 2025, the sub-regional MHW mean and maximum intensities (above the mean), mean duration, frequency, and total days ranged over 1.60–2.84°C, 2.76–6.79°C, 11–39 days, 6–9 events, and 75–253 days, respectively. Locally, MHW mean and maximum intensities, mean duration, frequency, and total days reached maximum values of 3.82 and 7.95 °C (in the coastal Gulf of Lion), 117 days (in the coastal south Tunisia), 17 events (in the western Alboran) and 311 days (off Tel Aviv), respectively (Figure 3). It is worth mentioning that the western Mediterranean sub-basin suffered unprecedented warm SSTs in June-July 2025. During this period, all the sub-regions of the western Mediterranean experimented with very intense MHWs reaching Category II during 2-3 weeks and approaching Category III in early-July. On 2nd of July 2025, the SST anomaly w.r.t. the period 1982-2015 reached a spatially-averaged value of 6.5°C in the Liguro-Provençal sub-region and approached 8°C locally in the coastal area of the Gulf of Lion.

Balearic Islands: In 2025, the region experienced its warmest year on record for SST (after 2022, 2023 and 2024) with a regional mean value of 20.7°C. It suffered very intense and long-lasting MHWs, with an exceptional event in June and early-July (Figure 4). On 3rd of July, the regionally-averaged SST reached 28.41°C corresponding to an anomaly of 4.94 °C. Locally, the buoy at Dragonera Island observed warmer ocean temperatures around 31°C on 1st of July and 13th of August 2025.

Coastal and subsurface ocean temperatures

High-resolution observations from fixed moorings and drifters allowed the detection of locally very warm temperatures. In particular, very warm temperatures on hourly time series were registered in summer 2025 in the Balearic Islands at the Dragonera buoy operated by Puertos del Estado with a maxima observed of 31 and 30.9, respectively, on 1rst of July at 12.00 and 13th of August at 15.00, respectively. At the buoy off Mahon, a maximum of 31.2 °C was also registered on 13th of August at 15.00 .

Moreover, as a contribution to the Global Ocean Observing System, SOCIB has deployed ocean gliders and profiling floats which have allowed observing ocean warming not only at surface but also in intermediate and deep waters, until 2000 m depth. In the Balearic Islands region, profiling floats observed the highest values of ocean heat content integrated within the upper 150 and 700m in summer 2025 (https://apps.socib.es/subregmed-indicators/heat_and_salt_contents.htm). Finally, recent studies have demonstrated ocean warming in the subsurface in the Mediterranean Sea in the last decade (Chevilard et al., 2024; Juza et al., 2025).

Record ocean temperatures: What are their impacts?

- In 2025, the ocean salinity reached its third record in the eastern Mediterranean Sea with a subbasin-averaged annual mean value around 38.9 psu.
- Over the period 1993-2025, the sea level trend reached 3.4 cm/decade as a basin-average, with a maximum local value of 5.6 cm/decade reached in the Aegean Sea.
- Increasing and extreme temperatures have multiple impacts such as modifying ocean systems, threatening marine life and human health, and increasing coastal communities' vulnerability.

Consequences on ocean system

The evaporation of warmer water increases the ocean salinity, in regions where there is a marked excess of evaporation over precipitation. In the eastern Mediterranean, the ocean salinity also reached its third record in 2025 with a sub-basin-averaged annual mean value exceeding 38.9 psu corresponding to an anomaly higher than 0.1 psu (https://apps.socib.es/subregmed-indicators/ocean_salinity.htm). Through thermal expansion of the oceanic water column, warm ocean waters also contribute to an increase in the sea level. Average in the Mediterranean Sea, sea level continued rising with linear trends over the period 1993-2025 of 3.4 cm/decade and reaching its highest anomaly on records since 1993, being this rise much higher in some sub-regions. Indeed, locally, the rate of sea level rise reached 5.6 cm/decade in the Aegean Sea along the Greek coast (https://apps.socib.es/subregmed-indicators/sea_level.htm, Figure 1). Changes in the upper ocean temperatures may also increase the stratification that can in turn modify vertical exchanges hindering nutrient supply, reducing heat and carbon absorption into the deep ocean, and depriving the deep ocean of oxygen, among other key processes.

Balearic Islands: In this region, sea level continued to rise with a trend of 3.4 cm/decade over the period 1993-2025. In 2025, the region experienced its record-breaking year for sea level anomaly, following the previous records in 2024 and 2023.

Consequences on marine life

Furthermore, increasing temperatures and extreme warm events in the ocean threaten marine ecosystems. Devastating consequences on marine species and habitats have been observed from surface to deep waters during and after previous events, such as seagrass meadows declining, coral and gorgonians mortality harmful algal blooms, mass mortality of marine organisms, alteration of reproduction cycle and growth of species, change in abundance or distribution of marine species. In the Mediterranean Sea, marine heatwaves strongly affect key species such as the endemic seagrass "Posidonia Oceanica", which provides habitats and protection for marine species, produces oxygen, absorbs an important part of anthropogenic carbon dioxide, and protects the coast from erosion (Guerrero-Meseguer et al., 2017; Marbà et al., 2014). In addition, the introduction of invasive and voracious species from the eastern sub-basin reaching the western basin has been observed to contribute to the deterioration of habitats and distribution shift of marine species.

Increasing temperatures also contribute to the reduction of oxygen since warm waters hinder its solubility in the ocean and make the water column more stable (stratified) preventing oxygen-rich surface waters from mixing with deep waters. Marine biodiversity loss is caused by ocean warming and deoxygenation, as well as ocean acidification through anthropogenic carbon absorption (Le Grix et al., 2025). The decrease of phytoplankton and oceanic plants reduces the oxygen production - since these microorganisms generate oxygen through photosynthesis processes - impacting marine life and global atmosphere. Indeed, half the oxygen we breathe comes from the ocean.

Consequences on communities

The resulting biodiversity loss and marine life deterioration have impacts on essential goods and services offered by the oceans affecting key sectors of the Blue Economy (e.g. marine living resources and tourism) (Smith et al., 2021; Atalah et al., 2024). Bringing more heat and moisture to the atmosphere, warm waters can contribute to the intensification of extreme events such as storms with heavy rainfalls that can cause flooding, beach loss, or infrastructure destruction (Mitchell et al., 2006). The coastline will also be impacted by the sea level rise accelerated in the last decades with global warming. Finally, human health will also be affected by ocean warming and extreme event intensification through infectious disease, harmful algal blooms or lack of food (UNEP/MAP and Plan Bleu, 2020).

How to mitigate the situation?

- To implement effective measures to reduce the greenhouse gas emissions.
- To preserve marine species and habitats.
- To implement sustainable ocean monitoring systems for science-based management.
- To foster the transfer of scientific and technological knowledge towards all sectors involved.

The increase of ocean temperatures and its multiple impacts are a consequence of global warming. Experts of the international community have stated that the only solution to limit the warming (without going back to the past situation) would be to immediately, sustainably and globally reduce the greenhouse gas emissions.

It is also crucial to preserve nature areas (e.g. seagrass meadows) and to protect the ocean which are suffering not only from global warming but also from severe degradation effects induced by human activities (e.g. contamination, overfishing, maritime traffic, natural resource extraction and coastal urbanization).

In order to better better understand and face the effects of climate change, it is essential to monitor the ocean. What is not observed, it cannot be managed. We need to observe, analyse and predict the ocean to be able to anticipate and take action.

Science plays a key role in collecting and analysing data, and improving our understanding of the ocean. Also, scientific knowledge has to be shared facilitating the access to information through open-access monitoring and visualization tools. In this way, science enables us to support evidence-based decision-making for an effective and adaptive management in the context of climate change.

Sources of information

Web-based applications

Open-access web-based applications have been implemented for the Mediterranean Sea to continuously monitor and visualize timely information on the ocean state and variability, from event detection to long-term variation monitoring, in the different sub-regions. See and access the applications below:

- Sub-regional Mediterranean Sea indicators (Juza and Tintoré, 2020)
- Sub-regional Mediterranean Marine heatwaves (Juza and Tintoré, 2021)
- TIAMAT Observatory - Cabrera Archipelago (Juza et al., 2023)

References

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- Juza, M., Fernández-Mora, A., and Tintoré, J. (2022). Sub-regional marine heatwaves in the Mediterranean Sea from observations: long-term surface changes, sub-surface and coastal responses, Frontiers in Marine Science, 785771. doi:10.3389/fmars.2022.785771
- Juza, M., de Alfonso, M., and Fernández-Mora, Á. (2024). Coastal ocean response during the unprecedented marine heatwaves in the western Mediterranean in 2022, in: 8th edition of the Copernicus Ocean State Report (OSR8), edited by: von Schuckmann, K., Moreira, L., Grégoire, M., Marcos, M., Staneva, J., Brasseur, P., Garric, G., Lionello, P., Karstensen, J., and Neukermans, G., Copernicus Publications, State Planet, 4-osr8, 14. doi:10.5194/sp-4-osr8-14-2024
- Juza, M., Heslop, E., Zarokanellos, N. D., and Tintoré, J. (2025). Multi-scale ocean variability in the Ibiza Channel over 14-year repeated glider missions. Frontiers in Marine Science, 12, 1604087. doi:10.3389/fmars.2025.1604087

Annual reports

- https://apps.socib.es/subregmed-indicators/SOCIB_Annual_Report_2025.pdf (Juza, 2026)
- https://apps.socib.es/subregmed-marine-heatwaves/SOCIB_Annual_Report_2025.pdf (Juza, 2026)
- https://apps.socib.es/subregmed-indicators/SOCIB_Annual_Report_2024.pdf (Juza, 2025)
- https://apps.socib.es/subregmed-marine-heatwaves/SOCIB_Annual_Report_2024.pdf (Juza, 2025)

Figures

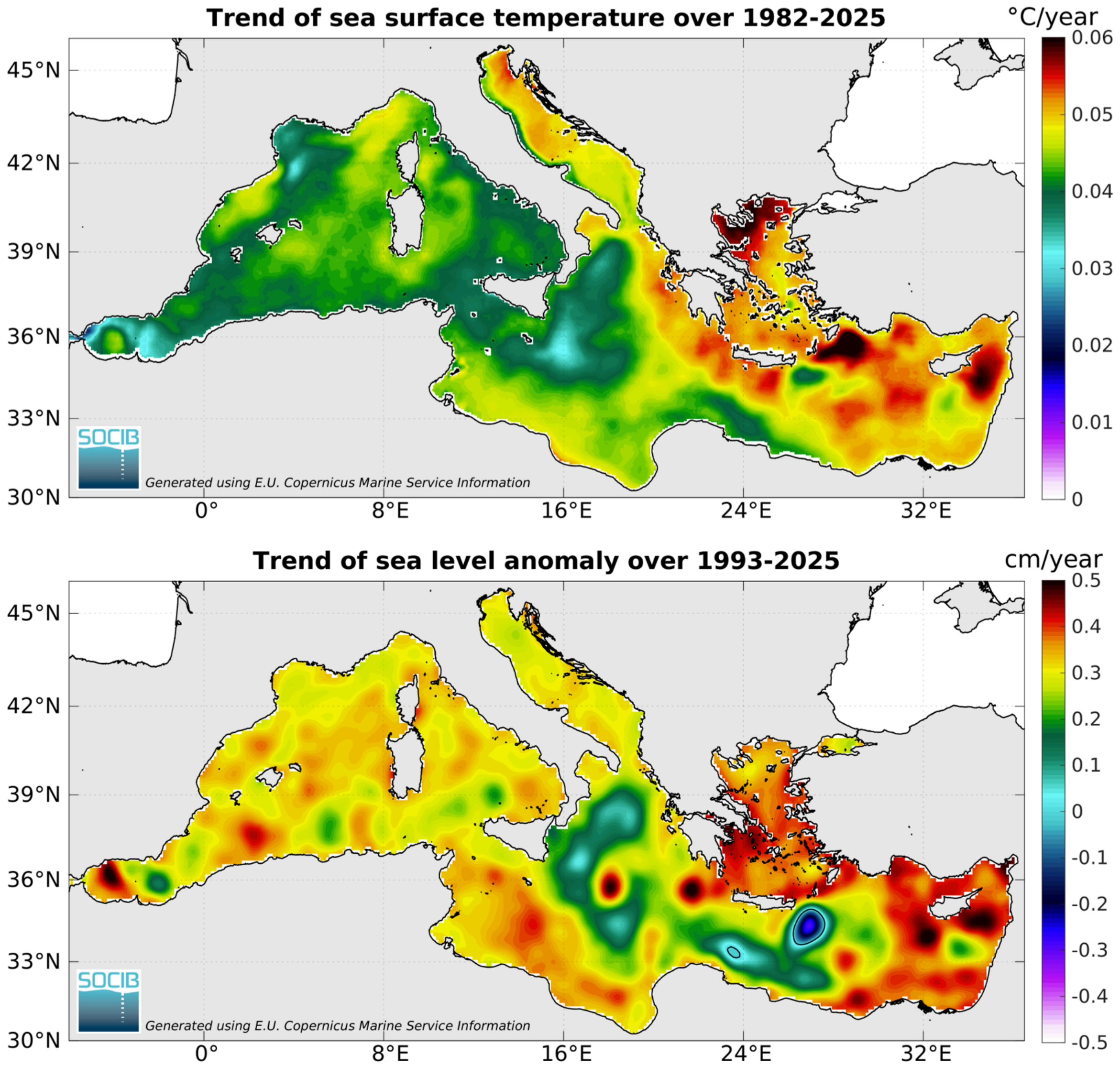

Figure 1. Linear trends of SST (top) and SLA (bottom) over the periods 1982-2025 and 1993-2025, respectively in the Mediterranean Sea. Source: Sub-regional Mediterranean Sea indicators (updated on January 2026; Juza and Tintoré, 2020), SOCIB.

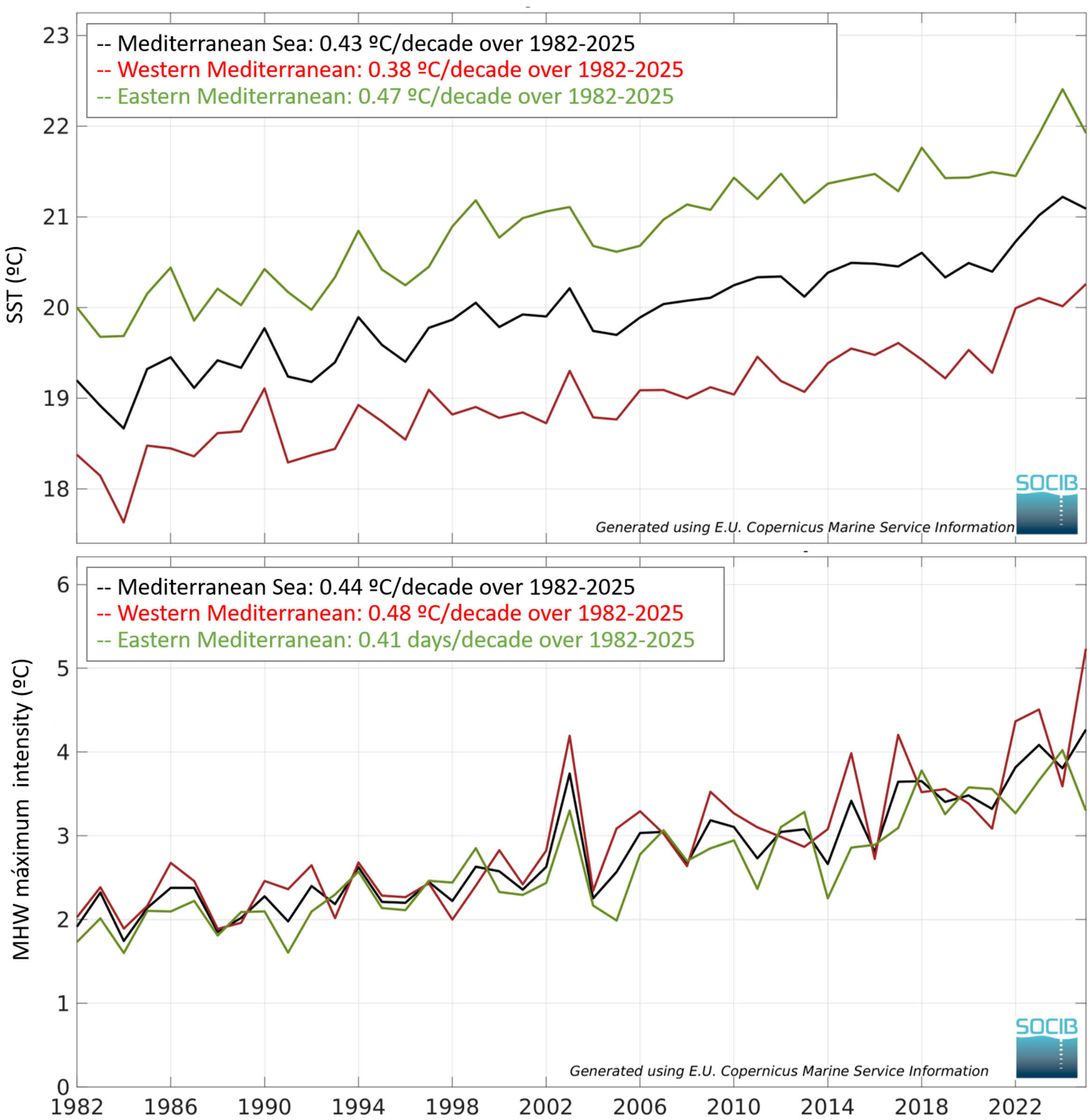

Figure 2. Annual SST (top) and MHW maximum intensity (bottom) averaged in the Mediterranean Sea, western and eastern sub-basins from 1982 to 2025. Sources: Sub-regional Mediterranean Sea indicators and Sub-regional Mediterranean Marine heatwaves (updated in January 2026; Juza and Tintoré, 2020, 2021), SOCIB.

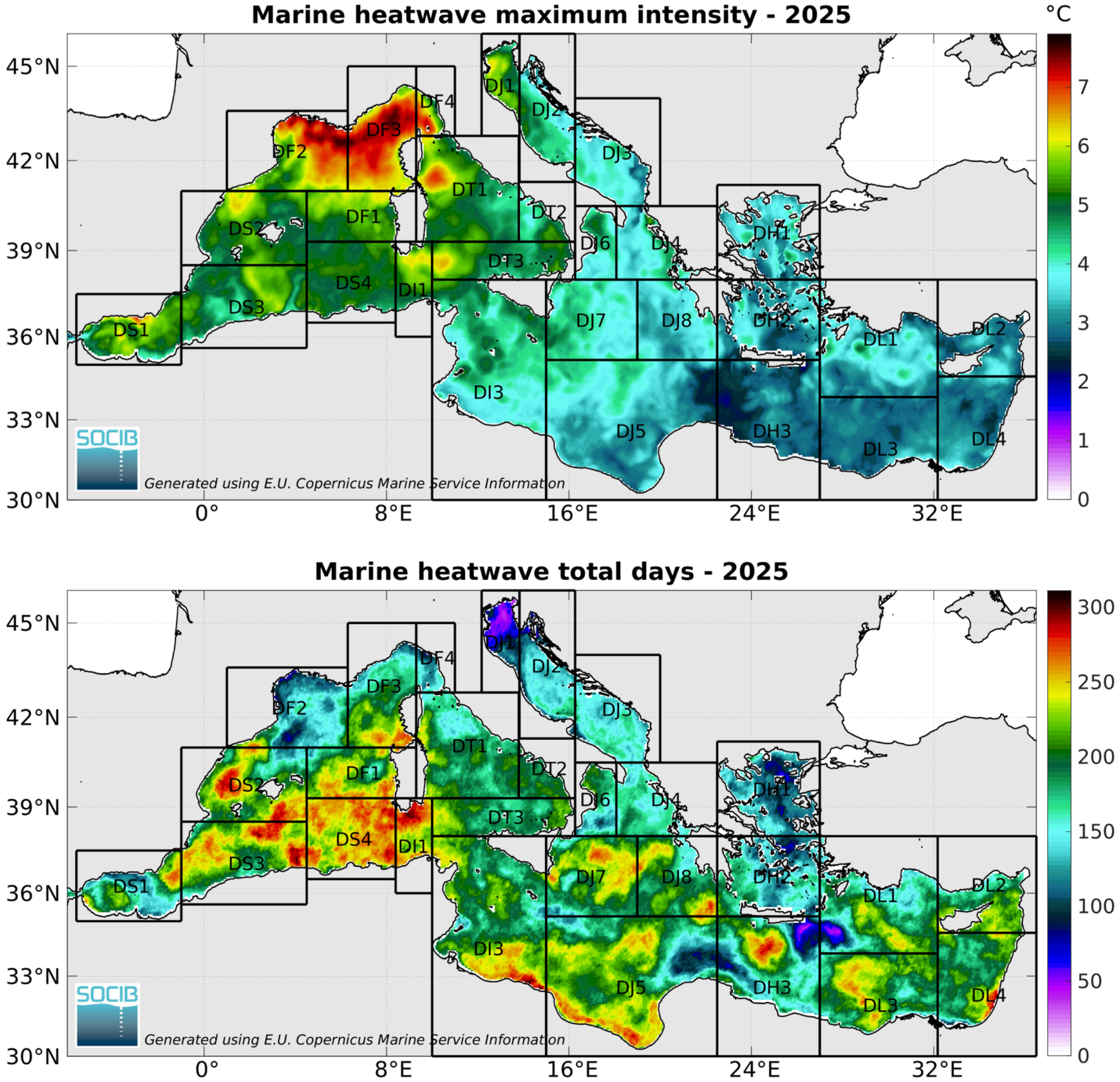

Figure 3. MHW maximum intensity (in °C, top) and total days (bottom) in 2025 in the Mediterranean Sea. Source: Sub-regional Mediterranean Marine heatwaves (updated in January 2026; Juza and Tintoré, 2021), SOCIB.

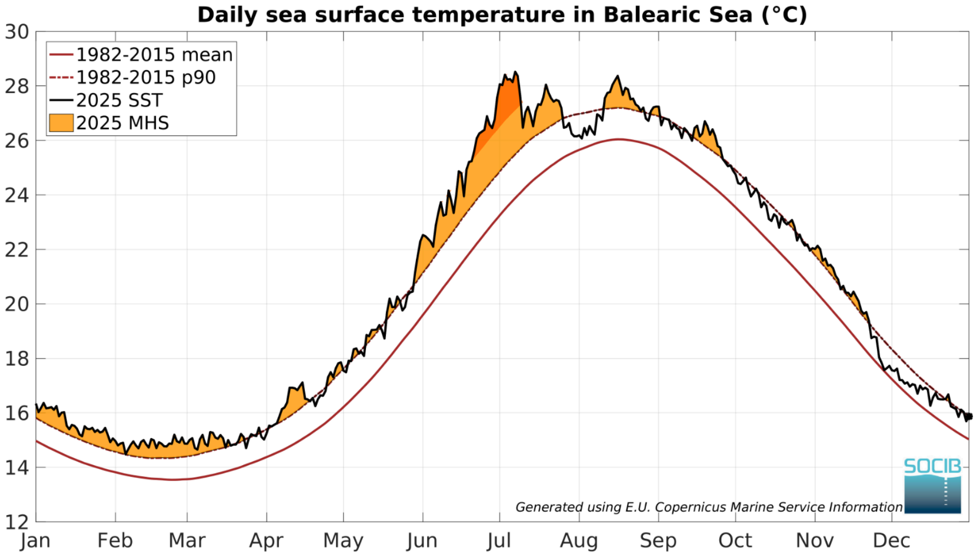

Figure 4. Daily SST averaged in the Balearic Islands region in 2025. MHWs are indicated in orange. Source: Sub-regional Mediterranean Marine heatwaves (updated in January 2026; Juza and Tintoré, 2021), SOCIB.

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