CLIMATE CHANGE IN THE MEDITERRANEAN SNAPSHOT:

Impact of warming air and sea temperature on MPAs.

Project co-financed by the European Regional Development Fund

The following factsheet presents key data for understanding the impact of sea surface and air temperature changes on **Mediterranean Marine Protected Areas** (MPAs). The Mediterranean is in fact one of the world's most vulnerable regions to climate change. Due to its particular geographic location, lying at the crossroads of arid North-African and temperate Central-European climates, all changes in Mediterranean seawater and air circulation are likely to affect its ecosystems and climate. The current temperatures registered in air and seawater show clear evidence of both local and regional climate changes, which strongly affect MPAs and their biodiversity, as well as local communities and visitors.

WARMING SEA SURFACE TEMPERATURE

What has happened up until now:

Today we know that the surface waters of the Mediterranean sea have seen an increase of their temperature of more than 1.27 °C over last 30 years. This Mediterranean image (Figure 1) shows evidence from satellite observations on the consistent warming trend that has been found for sea surface temperature in the 1982–2016 period, particularly in summer period. Differences (from lighter to darker orange colour) are particularly evident at the south-eastern Mediterranean region and at some localities.

Observations in the first meters of depths at some sites (e.g. MPAs), also show an increased frequency of exceptionally warm conditions and the number of days with extreme temperatures. The warming of the surface water also is deepening depth of the thermocline, thus is the transition zone between the warm surface and cold deep waters.

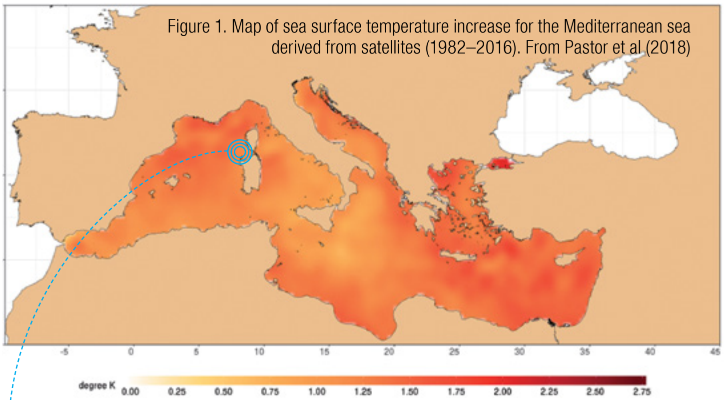
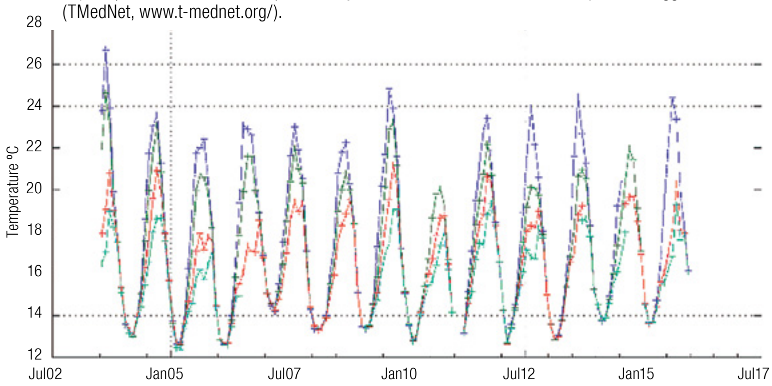
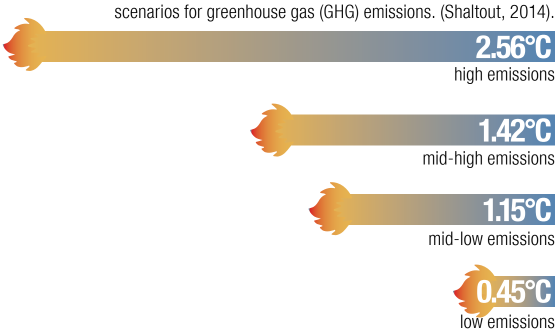


Figure 1. Map of sea surface temperature increase for the Mediterranean sea derived from satellites (1982–2016). From Pastor et al (2018)

Bonifacio Nature Reserve (Corsica): Mean monthly temperatures at different depths (**11m**, **25m**, **35m**, **42m**) between years 2003-2015 derived from temperature loggers in situ (TMedNet, www.t-mednet.org/).



Increase surface seawater temperature predicted by 2100 under different scenarios in each IPPC assessments is used different climate models and scenarios for greenhouse gas (GHG) emissions. (Shaltout, 2014).



What will happen by 2100 (compared to 1982-2012):

Climate change predictions are based on different possible scenarios depending on the level of greenhouse gas emissions in the 21st century. They range from low to high emission scenarios. Today predictions indicate a worrying continue warming trend of the sea that could increase as much as 2.5 °C by 2100, particularly in the Levantine region, Balearic Islands, northwest Ionian and the Aegean Sea.

Strong marine heat waves have occurred in the Mediterranean in 1994, 2003 and 2009 – from 1925 to 2016 the global frequency and duration of marine heatwaves has increased by 34% in average and is expected to continue increasing. In the Eastern Mediterranean, their prevalence might grow from once every two years to multiple occurrences per year.

CUMULATIVE EFFECTS OF CLIMATE CHANGE

Warming doesn't occur in isolation but together with other stressors from human activities. All changes are expected to take place in coastal areas that are already under strong pressures from urbanization, pollution, overpopulation vulnerable to further pressures. Furthermore, any additional issue caused by climate change can aggravate the existing problems and create new risks.

SURFACE AIR TEMPERATURE INCREASE

What has happened up until now:

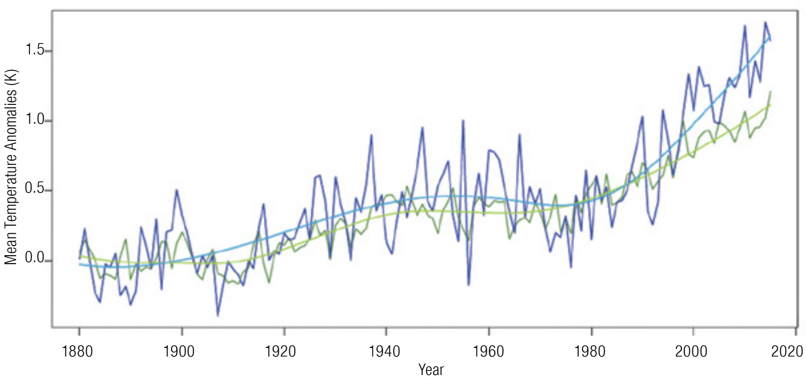
Mediterranean mean air annual temperatures are now 1.4 °C higher than those in the late-19th century, with the steepest rise (1.4 °C) being registered over the last two decades. For example, in countries like Spain or France the average annual air temperatures have been exceeding the normal levels over the last 5 years, reaching as much as 1.1-1.2°C increase.

What will happen by 2100 (compared to 1970-2000)

Mediterranean average surface air temperature is expected to be 2.2 °C higher in 2040, possibly exceeding 3.8 °C in some regions in 2100.

According to a low emission (or lower warming), scenario B1 of the IPCC with different global models, warming will be between 1.5 °C and 4 °C where for high emission scenario (A2), the temperature in summer might rise up to 6.5 °C in countries such as Turkey, Morocco, Algeria, southeast Europe and the Iberian Peninsula.

Annual mean air temperature anomalies are shown with respect to the period 1880–2018, **for the Mediterranean Basin** (blue) **and the globe** (green)
Data from http://berkeleyearth.org/



WHAT ARE THE RISKS FOR MARINE BIODIVERSITY AND THE BENEFITS OF MPAs TO RESIST AND ADAPT TO TEMPERATURE CHANGE?

RISKS

Increased mortality and extinction of native marine species

Recent mass mortality episodes in the Mediterranean have been associated with unusually high temperatures and heat waves, which turn marine species more vulnerable to pathogens and diseases. MPAs projected to have increasing fluctuations in water and climate conditions are at higher risk and may experience an increase of these episodic mass mortality events. Today, hard underwater bottom communities of coralligenous and rocky habitats are already severely affected in different MPAs.

Marine invasive alien species

Changes in the climate conditions are causing an increased arrival and further spreading of new species, to terrestrial and marine ecosystems. This can also increase the arrival of species from warmer environments (from further south or eastern regions) and the spreading of exotic (non-native) species into new areas, posing a new challenge for the native protected communities in the MPAs.

Shifts in marine species distribution

The changes in sea temperature, along with salinity variations, are already causing shifts in the distribution of Mediterranean marine native species. Highly specialist communities such as those settled in submarine caves are particularly at risk as they are dispersed in the marine environment and are more sensitive to any possible perturbations.

Marine population blooms

Unlike other marine species, the jellyfish seem to be benefiting from the increase of seawater temperature in the Mediterranean. Jellyfish outbreaks (or blooms) are proliferating along the Mediterranean coast, including MPAs, with negative impacts on fisheries and tourism activities. For example, there are regular press reports about the nuisance that the blooms are causing to beachgoers in the region, resulting in cancelled reservations or shorter stays, and thus a reduction of revenues from tourism.

Shifts in seasonal visitors' patterns

Following the current climate predictions, MPAs will experience an increase in visitor numbers over longer periods, with peaks during spring and autumn rather than the summer, as the visiting period expands.

Increased risk of wild fires

Warmer summer temperatures, associated with drier climate conditions, involving less rain and humidity or changes in wind conditions, increase the risk of wild fires. This will affect coastal landscapes of MPAs where forests and shrublands of pines, holm oak trees and other communities develop. MPAs at highest risk are those in the regions of Spain and Turkey, followed by Greece, certain parts of central and southern Italy, Mediterranean France, and the coastal region of the Balkans.

OPPORTUNITIES FOR ADAPTATION

Promoting consumption of invasive alien species

Some marine invasive exotic species are adequate for human consumption, such as the lion fish (to be captured with caution!) and the bluespotted cornetfish. This provides an alternative source for fisheries, which could relieve overfished native stocks and contribute to invasive species mitigation control efforts in MPAs.

New habitats for native marine species

Some marine native species from the south of the Mediterranean, such as the dusky grouper, are able to increase their distribution range by inhabiting new areas in the north-west, where they can establish new populations.

Better distribution of visits throughout the year

Shifting seasonal visitation patterns in MPAs can also be perceived as an opportunity to distribute visits more evenly throughout the year. This could alleviate the impact of intense touristic activity during July and August, as well as diversifying the leisure and educational activities in the area through different periods of the year. As the visiting periods are likely to become longer than they are now, this it could also benefit the local economy.

BENEFITS OF MPAs

Cooling Effect

Well preserved forests and other green areas in the coastal parts of Mediterranean MPAs can have cooling effects due to natural shade and reduce the overall heat sensation. This is beneficial both for the local population and visitors, especially during the summer months, when increased temperatures are already starting to take a toll on human health.

Refugia areas for species

MPAs, especially when part of a network with similar communities, can offer safe areas to spread species that are changing their distribution ranges due to temperature increase (so-called climate migrants). Because cold-water species, such as the slender goby and the European sprat, will have limited areas for spreading because of seawater temperature increase, well-preserved habitats in north-western MPAs will be crucial for their survival.

Sentinel Sites

MPAs are areas where conservation and research efforts are intense, whereas stressing factors are minimized. This allows for early detection of signs and impacts of climate change, as well as a timely implementation of adaptive actions. These areas are inhabited by key representatives of larger ecosystems and biodiversity, which turns them very valuable for understanding the coastal and marine ecosystems and for providing warnings of changes.

Better resilience to wild fires

Young, re-grown forests are more easily affected by fires than pristine, old-growth forests – since generally re-grown forests (including plantations) are less abundant inside protected areas than elsewhere. Pristine forest trees in coastal areas of Mediterranean Pas, such as the holm oak, help maintain natural fire resistance and, in case of fire, ensure a slower flame propagation. Additionally, increased surveillance efforts inside MPAs during summer months result in shorter response times in case of fire, which is especially useful in more remote areas.

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Elaborated and designed by:
IUCN Centre for Mediterranean Cooperation, 2019.
IUCN-Med received cofunding for this project from the MAVA Foundation

MPA-ADAPT PROJECT PARTNERS: