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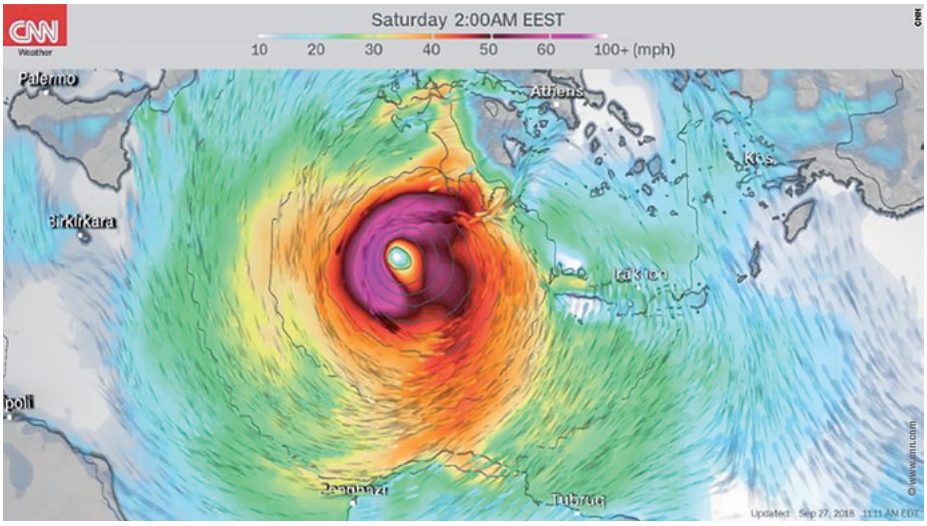
CLIMATE CHANGE IN THE MEDITERRANEAN SNAPSHOT:

Impact of storm surges on MPAs

This factsheet presents knowledge on storm surge events, to show what is happening and is likely to happen, and how it can affect Mediterranean MPAs and its ecosystems. It belongs to a series of climate change factsheets specifically developed to keep Mediterranean MPA managers informed.

WHAT ARE THE CAUSES OF EXTREME CLIMATE EVENTS?

Extreme climate events can be either attributed to natural climate phenomena or to human-induced climate changes. Indeed, climate change can cause different types of impacts, such as modifying the cyclonic activity or alter cyclonic paths in certain areas, increasing mean sea level and extreme water levels or causing changes in wave climate (mean or extreme) and winds that can consequently affect storm frequency and intensity [ref.01].



A medicane, a rare storm in the South Ionian Sea. Updated Sept 27, 2018

In this sense, **coastal storms** have been defined as a *meteorologically-induced disturbance to the local maritime conditions (i.e. waves and/or water levels) that has the potential to significantly alter the underlying morphology and expose the backshore to waves, currents and/or inundation.*[1] They are usually associated with the passage of cyclonic systems such as tropical and extra-tropical cyclones or with strong winds and/or precipitations which, combined with the anomalous maritime conditions, can contribute to the severity of storms.

Among the different types of cyclones affecting the Mediterranean region, extreme cyclones play a particularly important role: these severe weather events can cause wind-storms, storm surges, landslides and flooding. **Storm surges** are sudden increases in water levels caused by low pressure and associated winds. The degree of storm surge resulting from coastal storms is nonetheless complex and it can vary significantly across the various Mediterranean regions, due to the topography of each area, the prevailing winds and storm characteristics.

Sudden and rare storms, such as **Mediterranean hurricanes** or **medicanes** [ref.02], resemble tropical cyclones, although they are weaker and smaller in size. They can result in higher than usual mean sea level, wind gusts that exceed 119 kilometers per hour and extreme precipitation that could cause localized flooding and changes in sedimentation patterns.

Indicators of coastal storm severity

Coastal storm severity is accomplished by studying parameters such as the significant wave height, the wave period, the energy, the storm duration and the inter-arrival time between storm events. In most cases, upper wave height and storm duration are the most important parameters to describe events with high impacts on coastal areas. Specific coastal characteristics at site level and sensitivity as well as the type of storm will help to describe their severity and define thresholds to be applied at different coastal areas. For example, strong and persistent winds prevailing in some areas, such as the northerly mistral in southeast France and bora in the Balkans, resulting from the unique topography of these regions, often cause sudden storms supported by atmospheric circulation features, such as Mediterranean cyclones [ref.04].

Storm severity is usually identified by establishing a certain threshold in terms of wave height, which must persist over minimum period which is relevant to the storm duration. These thresholds are site-specific and the most common one applies to waves reaching a significant height and ranging from 1 to ≤4 m and a minimum storm duration of 6 to 30 hrs[2].

1. Harley, M. 2017. Coastal Storm Definition
2. Wave-height threshold from wave-storms differs from the wave regimes in regular conditions

WHAT ARE THE CURRENT OBSERVATIONS AND PROJECTIONS FOR THE MEDITERRANEAN?

Current research indicates that the **strongest large-scale precipitation** extremes are found in the northwestern Mediterranean coast. In contrast, intensity decreases towards the east (in the northern Mediterranean) and towards the south. The majority of these intense precipitation events in the northwestern Mediterranean occur in autumn, while eastern Mediterranean cases occur predominantly in winter except in northwestern Africa, where precipitation is intense in spring. Increased frequency of strong surface winds has also been observed in northern and central parts of Italy since the mid-1970s correlated with an increase in temperature [ref.03].

Few studies have been dedicated to assess the storm trends across the Mediterranean coasts. Information collected with a dataset of wave climate time series gathered from 30 buoys over the Mediterranean and covering coastal areas from Greece, Italy, France and Spain for the years 1985-2019, indicated 35 storm events per year occurring in coastal areas, most of which developed during October-March. The most extreme storm events usually have significant wave height (over 4 m) and a mean duration of 27 hours roughly [ref.05]. In contrast, the current frequency of Mediterranean hurricanes is of 20 storms per decade with an average of 1-2 per year.

Current **projections** cannot provide high confidence cyclonic activity trends on a long-term basis and they are likely to vary by region. However, General Circulation Models for simulating the response of the global climate system suggest some consensus on a decrease in cyclone numbers and frequency of storm surge extremes (coverage and duration) in the whole Mediterranean region over winter. [ref.06, 07, 08, 13]. Moreover, some authors have suggested that storm surges will shift towards spring and will also become more likely in summer, especially in the Eastern Mediterranean and the Adriatic (2015) with certain local frequency increases over some specific areas such as the North Adriatic [ref.08, 09].

Despite the significant uncertainty of model projections, intense windstorms and heavy precipitation intensity are expected to increase, especially in the northern Mediterranean [ref.08] and longer surge events are likely to continue to appear in certain parts of the basin. Projected higher storm surges are also expected in the eastern Mediterranean and the Adriatic, Balearic and Tyrrhenian Seas in the first part of the 21st century (until 2050).

While they will be fewer ordinary to moderate storm events, it is likely the increase of frequency of **violent cases with winds** over 60-90^{kt} (1kt = 0,51m s^{-1}) -Mediterranean hurricanes or medicanes- over the whole Mediterranean Sea as the century progress. This risk is largest over the western Mediterranean basin with a maximum probability that they occur around in October [ref.10].

Impacs of a sea storm in Camogli, Italy (2018)

HOW ARE STORM EVENTS INFLUENCING MPA COASTAL HABITATS AND SPECIES?

Coastal zones are highly vulnerable to storm events. During destructive storm conditions, the elevated energy and/or water levels may well be beyond the capacity of the coastal zone to dissipate them, potentially exposing the upper shore and coastal land to unusually strong forces and hazardous conditions. These events can have **catastrophic consequences** particularly for low-lying coastlines and cause coastal flooding. Regarding flood occurrence, the Mediterranean is in fact highly heterogeneous, including large affected areas in autumn in the north western Mediterranean, as well as isolated winter flashfloods in the eastern part [ref.11]. High **impact floods,** caused by a large accumulation of precipitation in a river catchment, may occur locally with high intensity over a short duration, or gradually over a number of days, often affecting large areas. Sea-cliff erosion can also be induced by the strong storms.

MPAs will be affected by storm duration, intensity and direction. Extreme storms may induce significant direct (e.g. flooding, **coastal erosion,** damage to properties) and indirect (e.g. salt intrusion, land subsidence, vegetation destruction) impacts to the coastal zone but also in the marine realm. Shallow sublittoral communities will be affected by abrasion and damage can affect deeper habitats and community diversity. Severe storms have been shown to affect also coralligenous outcrops [ref.12], posing threats to their resilience.

Cabo de Palos, Spain

VALUE OF MPAs:

How do they contribute to adapt and mitigate risks caused by storm events?

MPA's ecosystems play a **critical role** in protecting and maintaining coastlines. Coastal ecosystems can dampen waves, reduce water flow and flooding, attenuate stormwater runoff, and build up coasts by contributing to the processes that generate, trap, and distribute sediment across shorelines.

By managing effectively and maintaining the functionality and services of these ecosystem services, MPAs are contributing to increasing the **ecological, social, and economic resilience** of coastal and marine communities to storm events.

On sedimentary shores, beach features, such as the **Posidonia banquettes** and berms, help to reduce the shoreline retreat and dune vulnerability. Likewise, wetland habitats with vegetation and deltas recreate natural floodplains and attenuate wave energy, stabilize shorelines, and accrete sediment more effectively than degraded or fragmented habitats.

Monitoring the impacts of storm events in coastal and marine communities in MPAs will help us quantify these changes and understand the species sensitivity to these impacts. These will ultimately allow us to develop our capacity to predict long-term changes and the resilience and **adaptive capacity** of marine and coastal communities.

Additional sources of information

In Europe there are several regional operational storm-surge fore-casting systems:

Copernicus Marine Environment Monitoring Service (CMEMS) combines information from different regional domains into one unified plat-form (http://marine.copernicus.eu).

The EMODnet (www.emodnet.eu) databases and National Database Centers can also offer important information regarding wave intensity and storms close to MPAs.

European Severe Weather Database (https://www.eswd.eu/), which collects and provides detailed and quality-controlled information on severe convective storm events throughout Europe.

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