

# SUB-REGIONAL MEDITERRANEAN MARINE HEAT WAVES

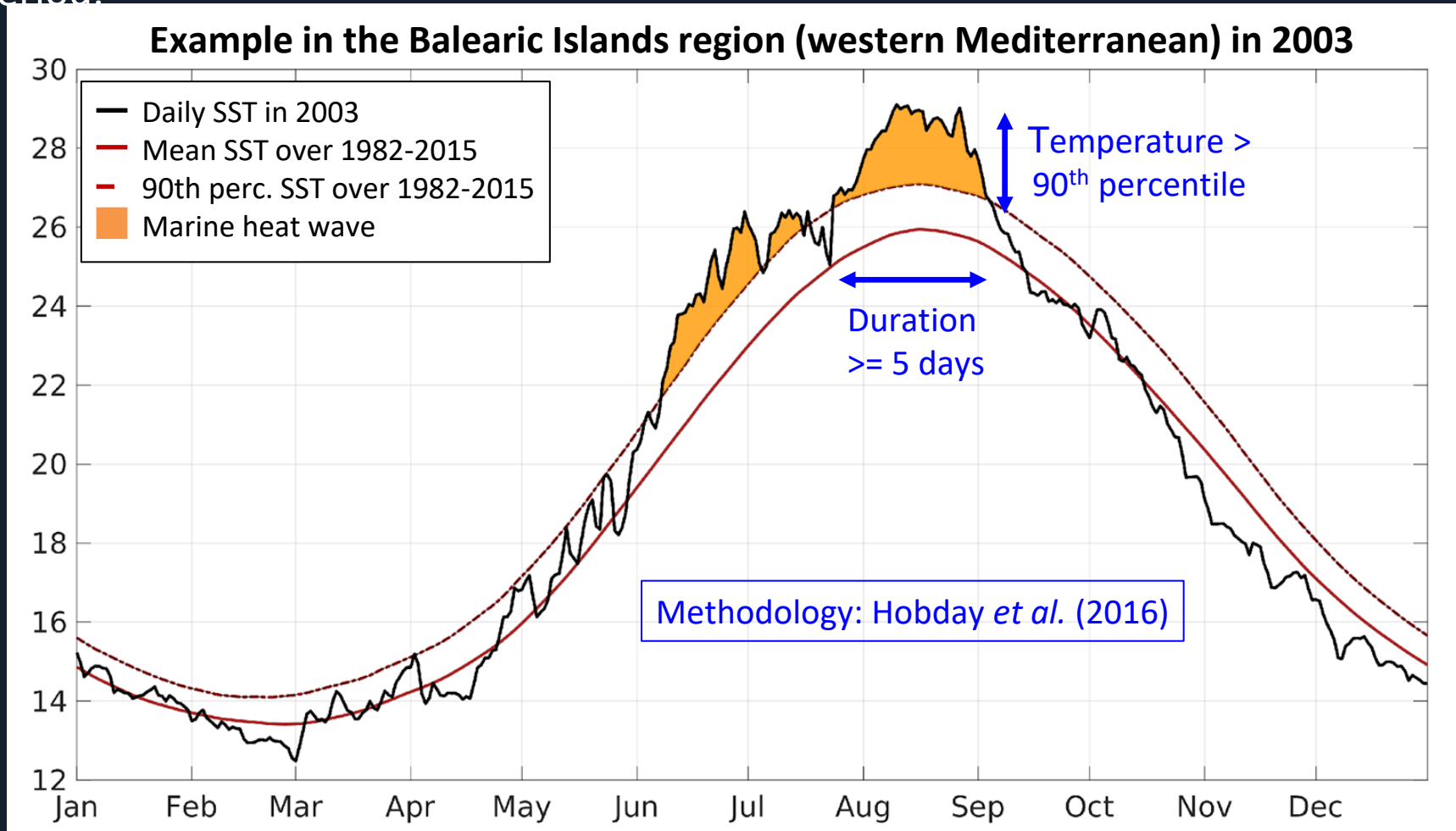
## *Lessons learnt & web application*

Mélanie Juza - Joaquín Tintoré - Àngels Fernández-Mora

OceanPredict-EuroSea joint meeting  
30-June-2022

# MARINE HEAT WAVES: INTRODUCTION

- Marine heat waves are **extreme warm ocean temperatures** during prolonged period.



SST = sea surface temperature

- Marine heat waves are **extreme warm ocean temperatures** during prolonged period.

## Causes

- **Anomalous atmospheric conditions** (*anthropogenic warming, climate modes, favourable synoptic systems, local processes ...*)
- **Ocean drivers** (*local processes, remote ocean teleconnections ...*)



Marine  
heat  
wave



## Consequences

- **Vertical ocean processes** (*impacts on nutrient supply, heat and carbon absorption ...*)
- **Impacts on marine ecosystems** (*surface, subsurface*)
- **Blue economy sectors** (*fishery, tourism...*)
- **Ocean & human health** (*infection diseases, HAB, jellyfish ...*)



Coral bleaching



Seagrass meadow declines



Harmful alga blooms



Mass mortality

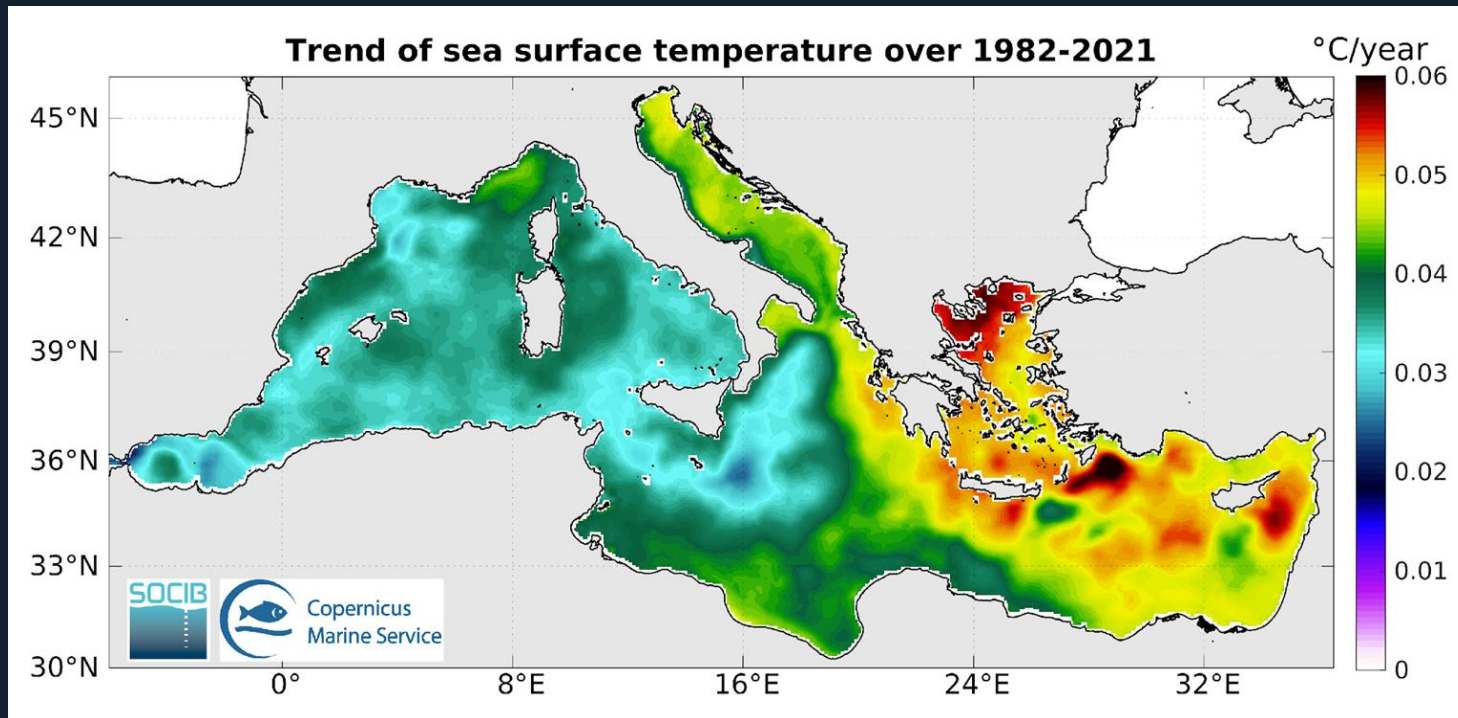


Redistribution

# MARINE HEAT WAVES IN THE MEDITERRANEAN

## Mediterranean Sea:

- Rapid response to global warming
- Strong spatial variations



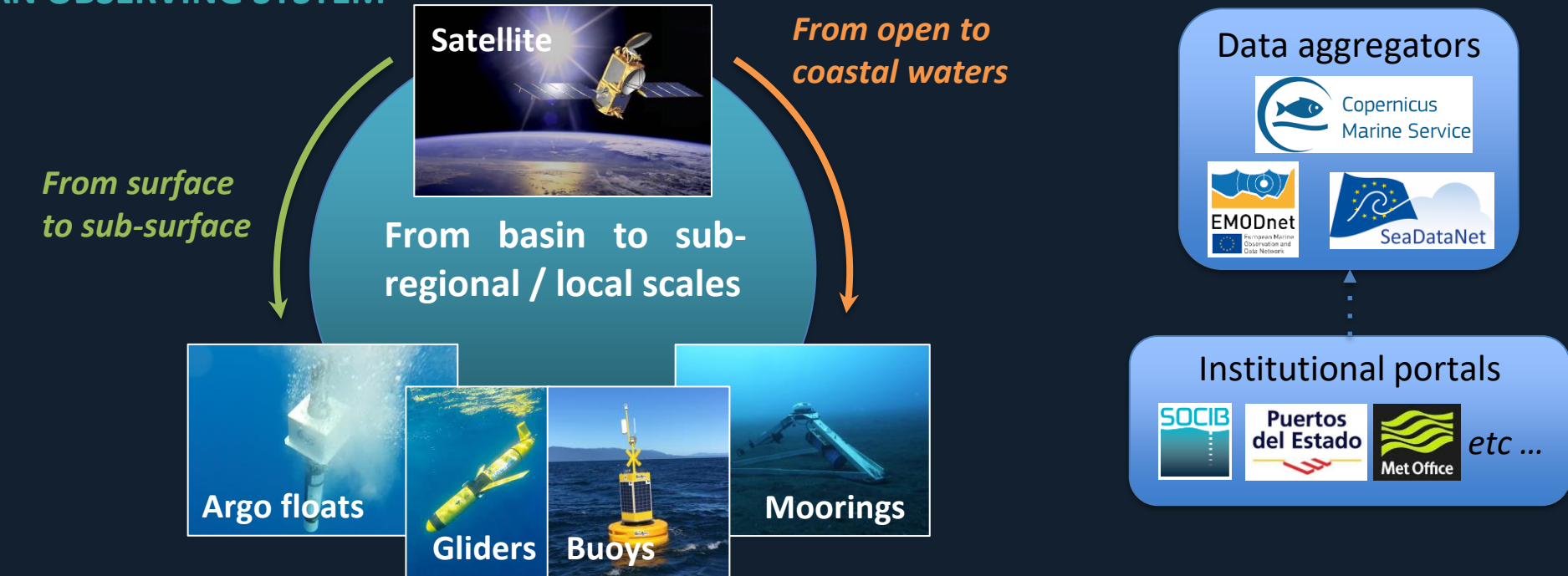
(From <https://apps.socib.es/subregmed-indicators>)



Local/sub-regional scale approach

# MARINE HEAT WAVES IN THE MEDITERRANEAN

## OCEAN OBSERVING SYSTEM



### Multi-platform observations:

✓ Comprehensive characterization of MHWs in the Mediterranean

*“Sub-regional marine heat waves in the Mediterranean Sea from observations: long-term surface changes, sub-surface and coastal responses” (Juza et al., 2022)*

# MARINE HEAT WAVES: LONG-TERM SURFACE CHANGES

## Satellite observations:

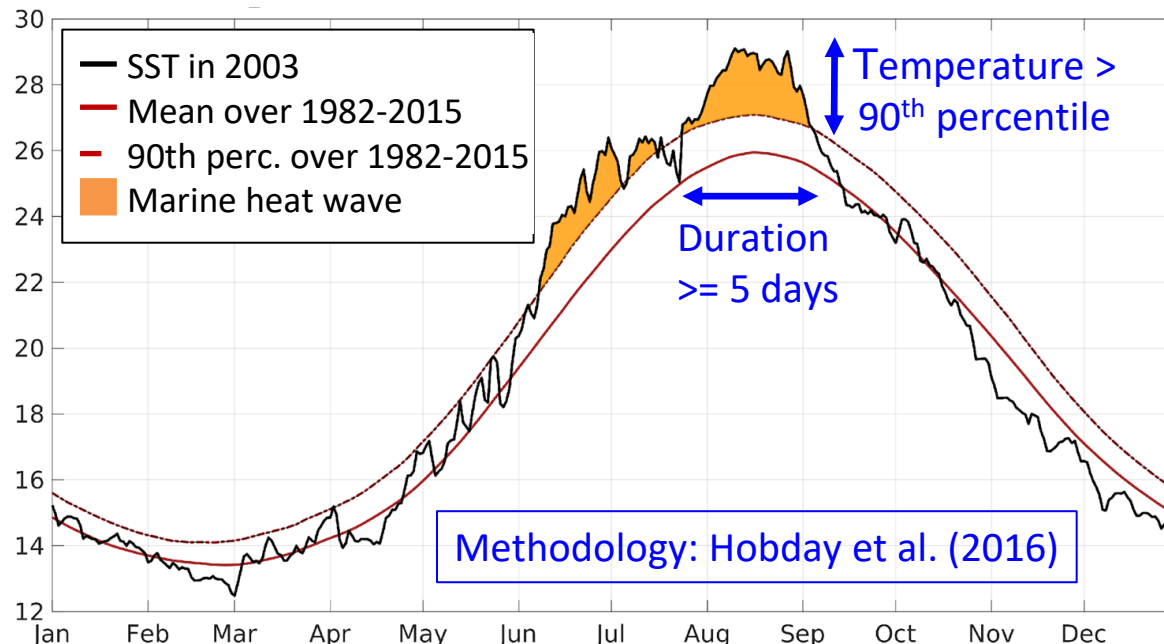


- ✓ Continuous monitoring
- ✓ Daily sea surface temperature
- ✓ 5-6 km spatial resolution
- ✓ 1982-present

## Methodology:

- ✓ Hobday *et al.* (2016)
- ✓ Reference: 1982-2015
- ✓ Local / sub-regional scales

## Example in the Balearic Sea (western Med) in 2003



## MHW event characterization

- Intensity (mean, max)
- Duration

## Annual MHW indicators

- Intensity (mean, max)
  - Mean duration
  - Frequency
- } Total days

# MARINE HEAT WAVES: LONG-TERM SURFACE CHANGES

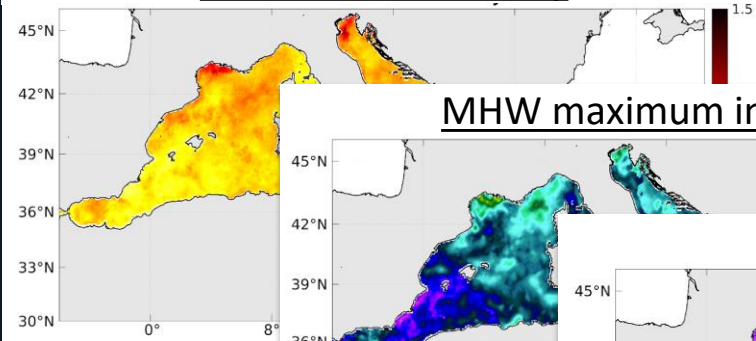
Satellite observations: ✓ Continuous monitoring

✓ Daily SST ✓ 1982-present

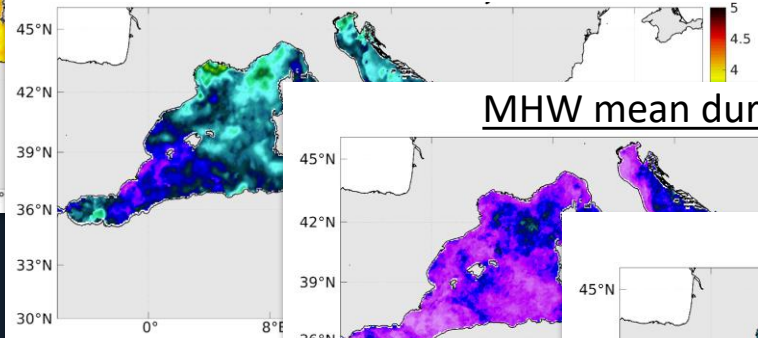
Annual mean (2021)

✓ Annual state of MHW intensity, duration and frequency

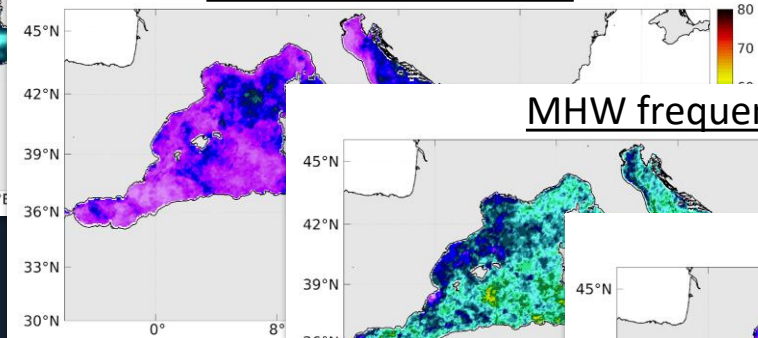
MHW mean intensity



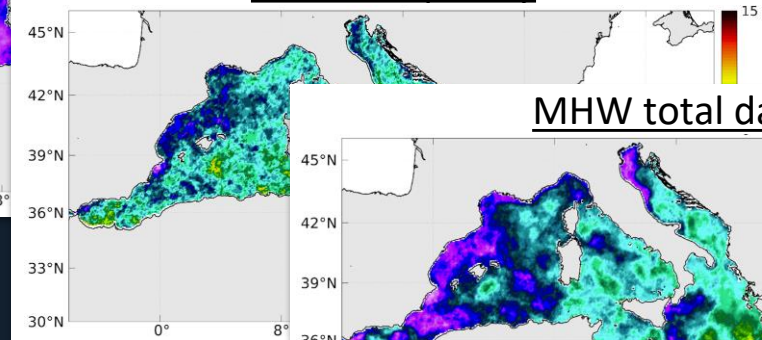
MHW maximum intensity



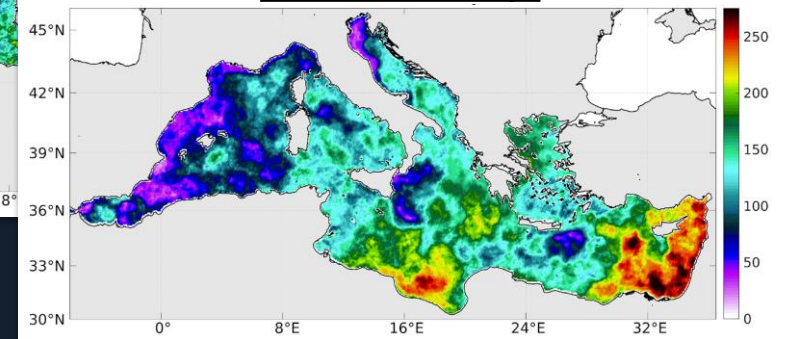
MHW mean duration



MHW frequency



MHW total days



- ✓ Strong values in 2021
- ✓ All sub-regions, spatial variations

(From <https://apps.socib.es/subregmed-marine-heatwaves>)

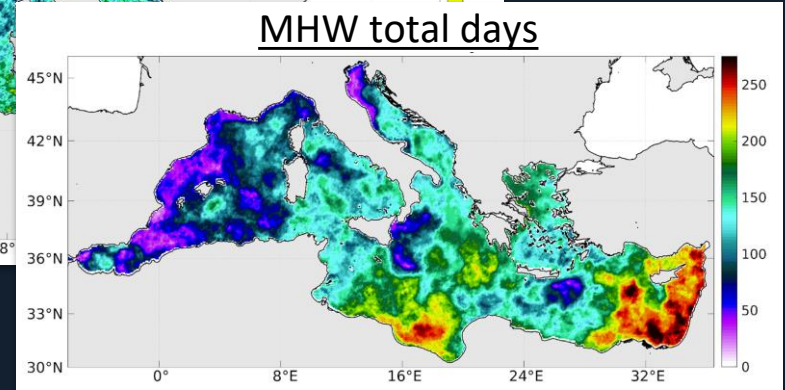
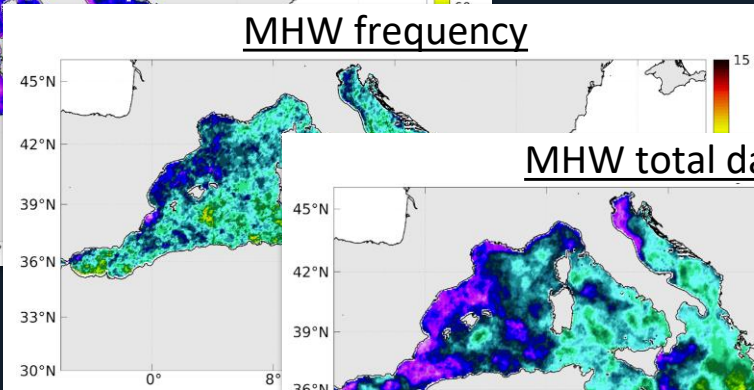
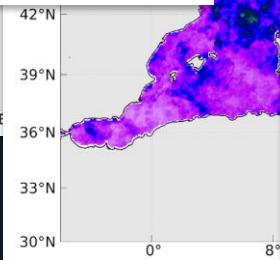
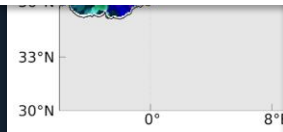
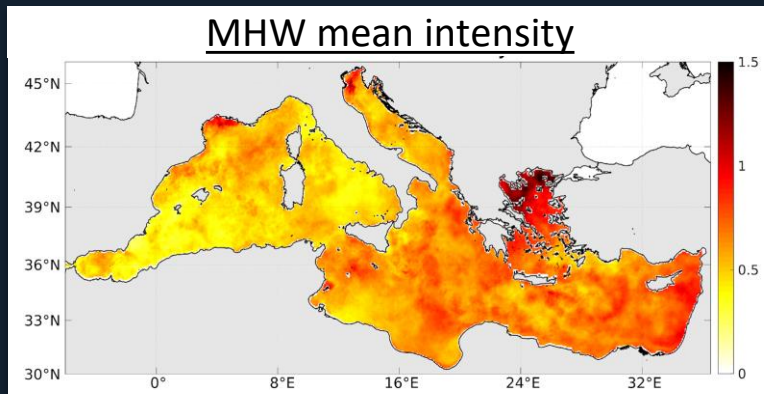
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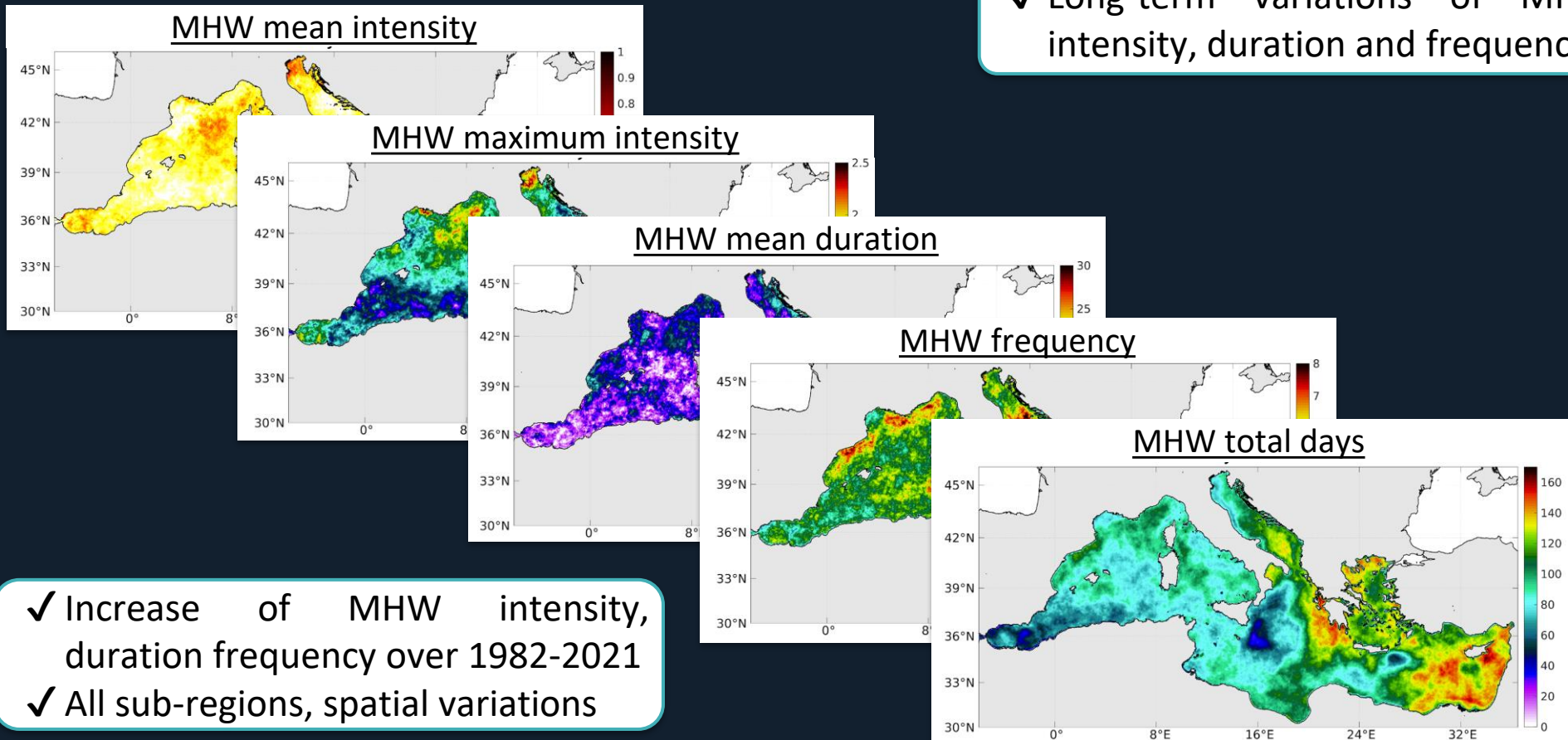
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Satellite observations: ✓ Continuous monitoring

✓ Daily SST ✓ 1982-present

Linear trends over 1982-2021

✓ Long-term variations of MHW intensity, duration and frequency



- ✓ Increase of MHW intensity, duration frequency over 1982-2021
- ✓ All sub-regions, spatial variations

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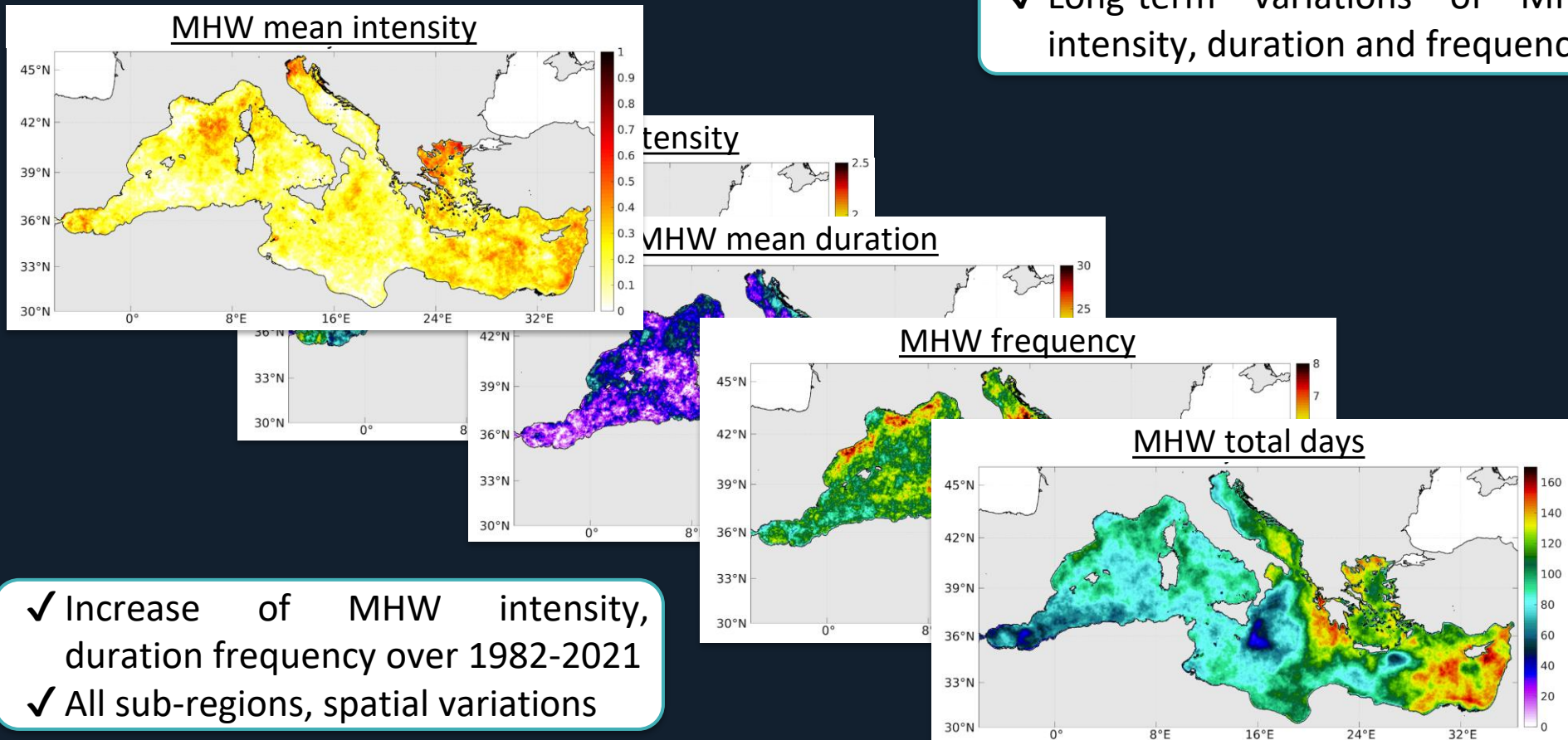
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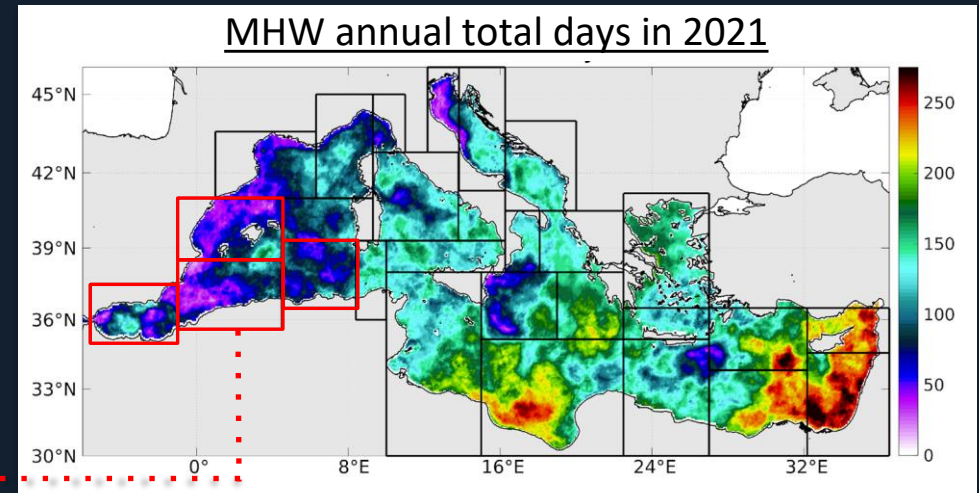
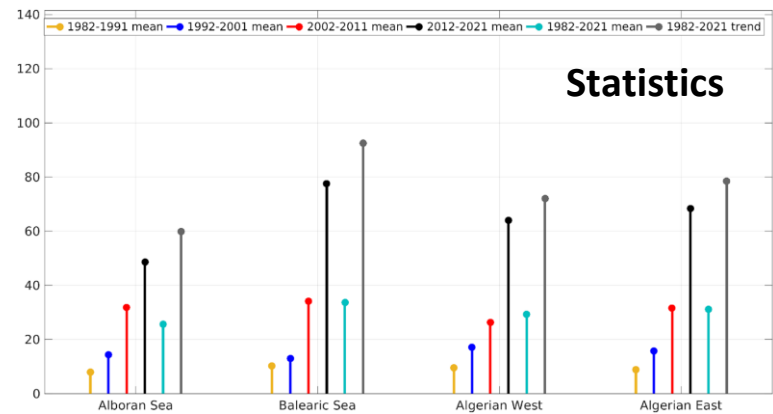
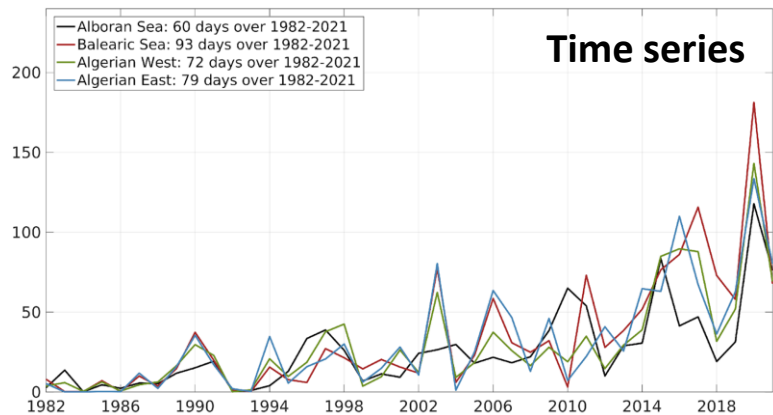
# MARINE HEAT WAVES: LONG-TERM SURFACE CHANGES

Satellite observations: ✓ Continuous monitoring

✓ Daily SST ✓ 1982-present

## Sub-regional time series

### MHW annual total days from 1982 to 2021



(Sub-regions as defined by Manca et al., 2004)

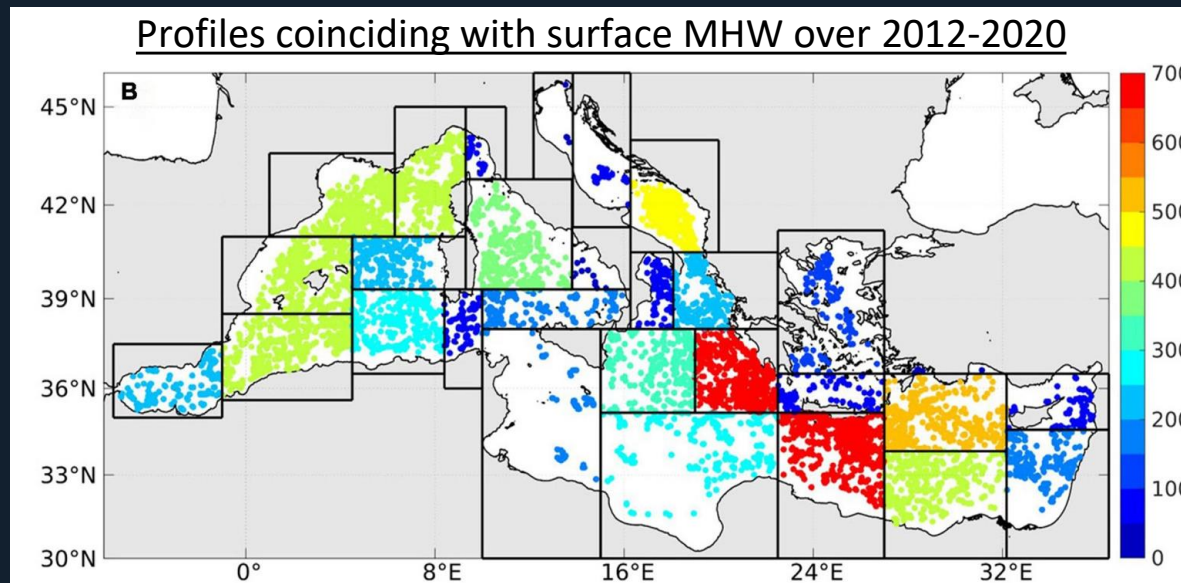
✓ Increase of MHW indicators with acceleration in the last decade in all sub-regions

Satellites ☐ event detection at surface and long-term variations of MHW characteristics at local and sub-regional scales

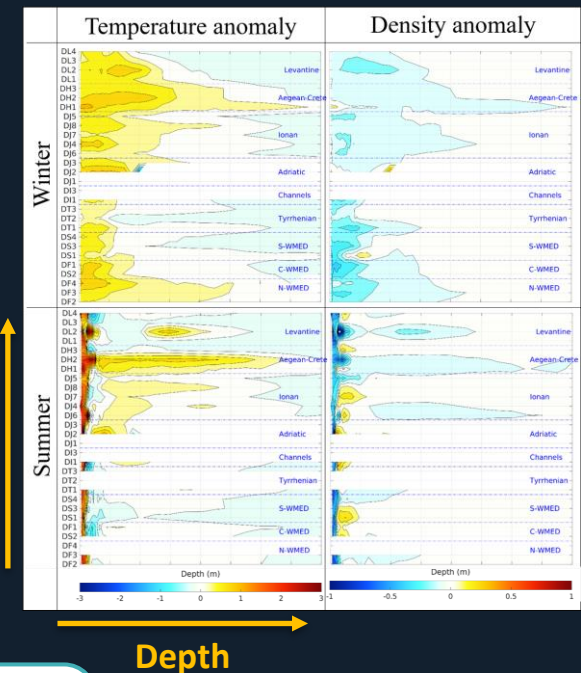
(From <https://apps.socib.es/subregmed-marine-heatwaves>)

# MARINE HEAT WAVES: PROPAGATION IN DEPTH

Profiling floats: ✓ Vertical dim ✓ T/S profiles ✓ 2012-2020  
+ satellite observations + SeaDataNet climatology



(From Juza et al., 2022)

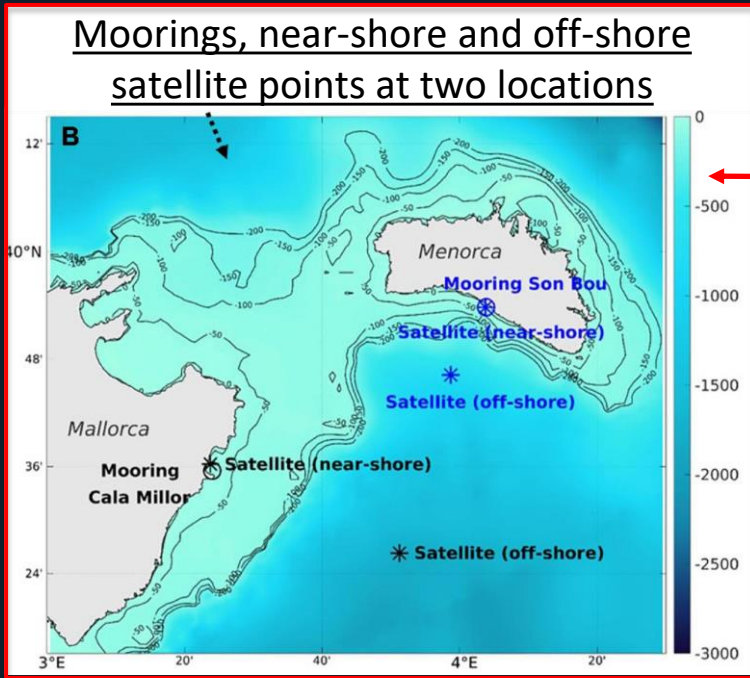


- ✓ Propagation of surface MHWs in sub-surface
- ✓ Sub-regional / seasonal response in sub-surface
- ✓ Resulting enhanced upper-ocean stratification

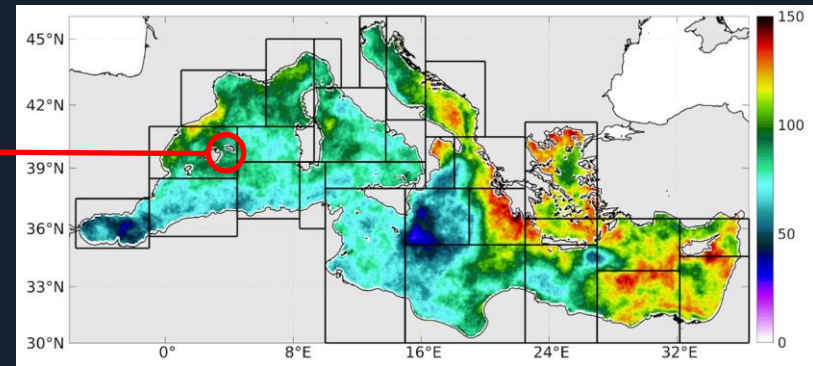
Argo network propagation of surface MHWs in the ocean interior

# MARINE HEAT WAVES: COASTAL RESPONSES

Coastal mooring: ✓ Near-shore ✓ Hourly T ✓ 2012-2020  
+ satellite observations



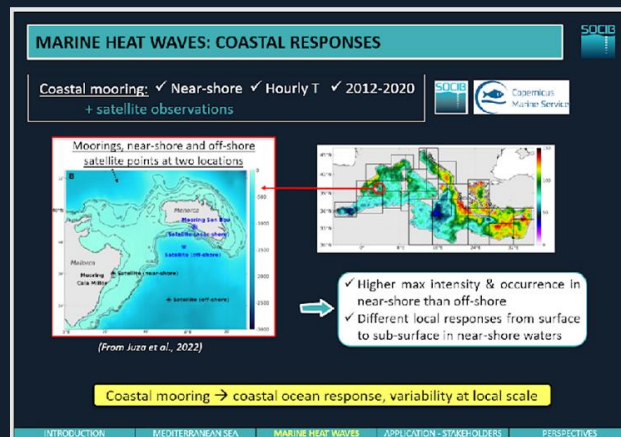
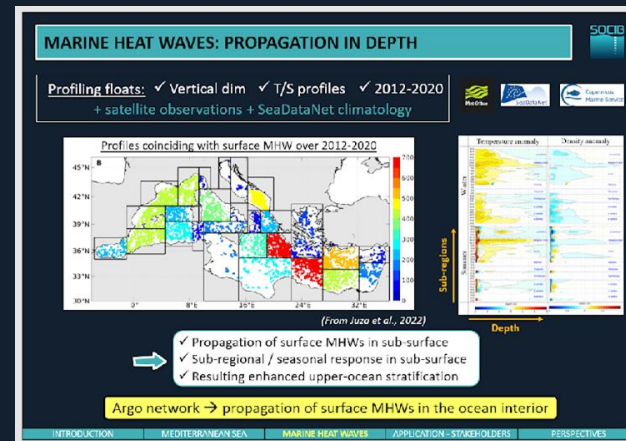
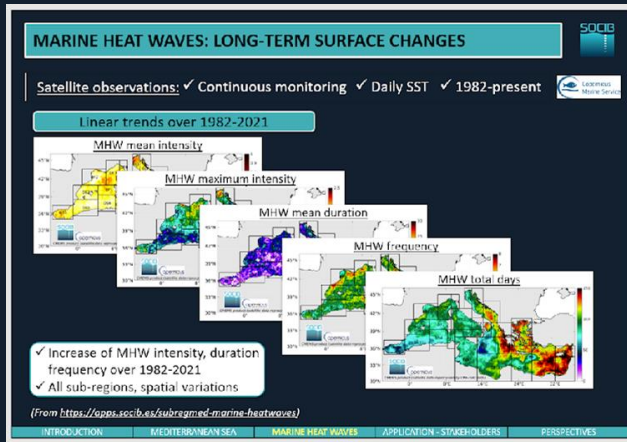
(From Juza et al., 2022)



- ✓ Higher max intensity & occurrence in near-shore than off-shore
- ✓ Different local responses from surface to sub-surface in near-shore waters

Coastal mooring ☐ coastal ocean response, variability at local scale

## Lessons learnt ...

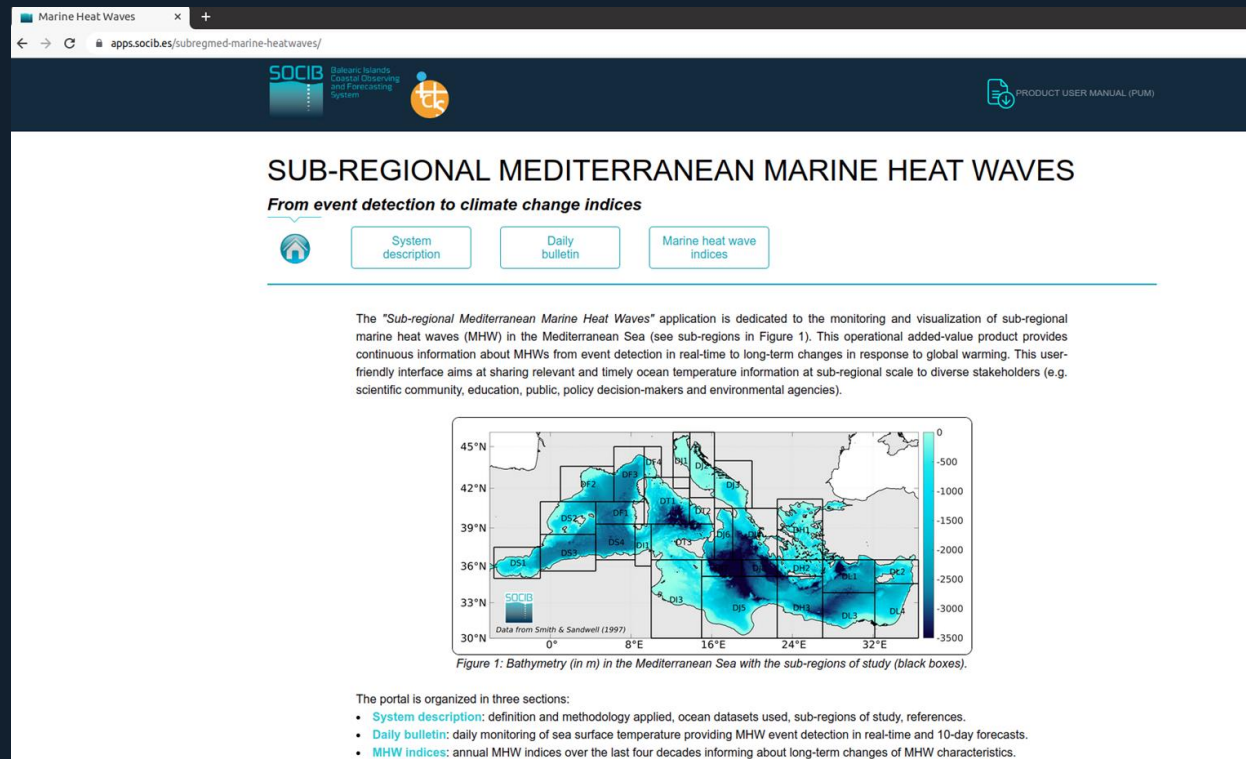


## At sub-regional and local scales

- ✓ Strong variability in surface-subsurface-coastal oceans
- ✓ Diversity and complexity of impacts
- ✓ Relevant information to stakeholder

“Sub-regional Mediterranean marine heat waves”: application to monitor and visualize MHWs at sub-regional scale in the Mediterranean Sea.

open access  
user-friendly  
science-based



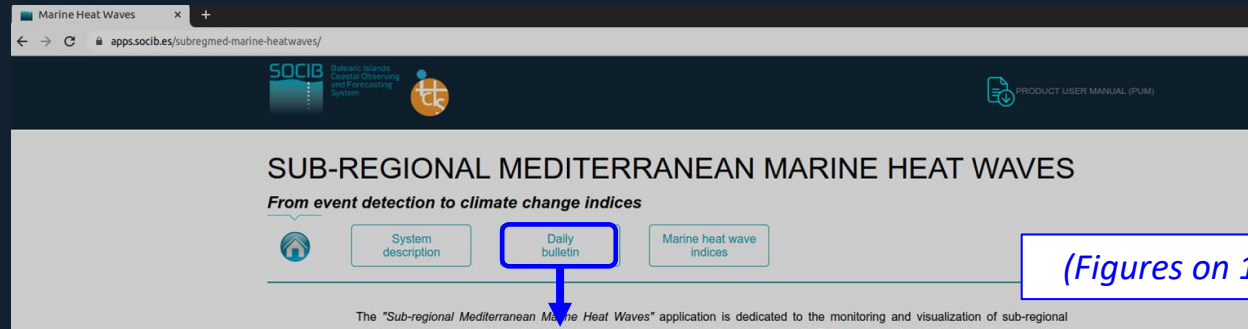
The "Sub-regional Mediterranean Marine Heat Waves" application is dedicated to the monitoring and visualization of sub-regional marine heat waves (MHW) in the Mediterranean Sea (see sub-regions in Figure 1). This operational added-value product provides continuous information about MHWs from event detection in real-time to long-term changes in response to global warming. This user-friendly interface aims at sharing relevant and timely ocean temperature information at sub-regional scale to diverse stakeholders (e.g. scientific community, education, public, policy decision-makers and environmental agencies).

The portal is organized in three sections:

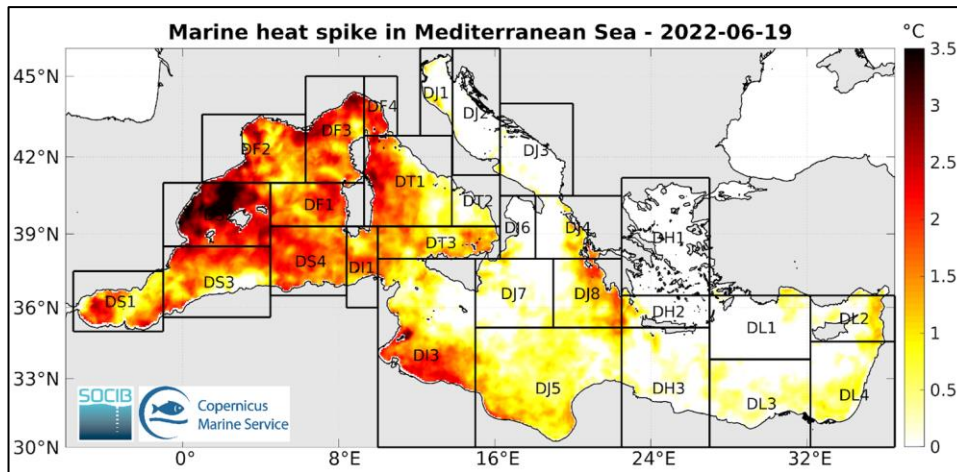
- **System description:** definition and methodology applied, ocean datasets used, sub-regions of study, references.
- **Daily bulletin:** daily monitoring of sea surface temperature providing MHW event detection in real-time and 10-day forecasts.
- **MHW indices:** annual MHW indices over the last four decades informing about long-term changes of MHW characteristics.

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## MHW detection in real-time (satellite observations) & 10-day predictability (model forecasts)



Marine heat spike

Sea surface

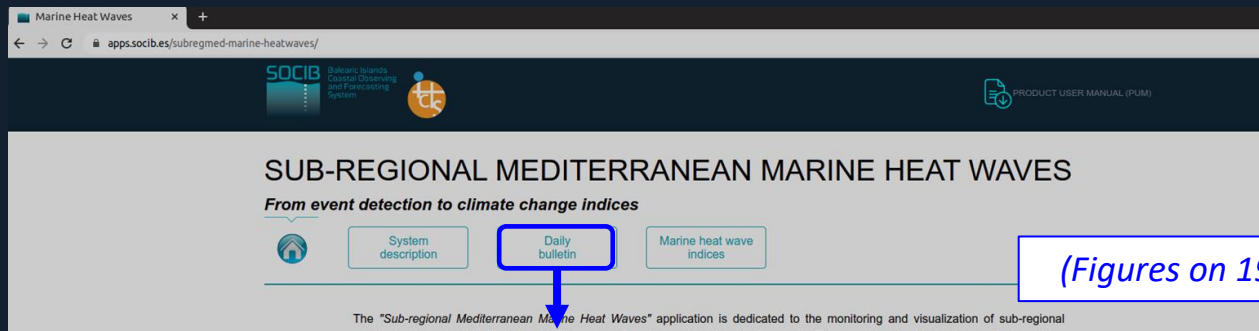
temperature

Sea surface temperature anomaly



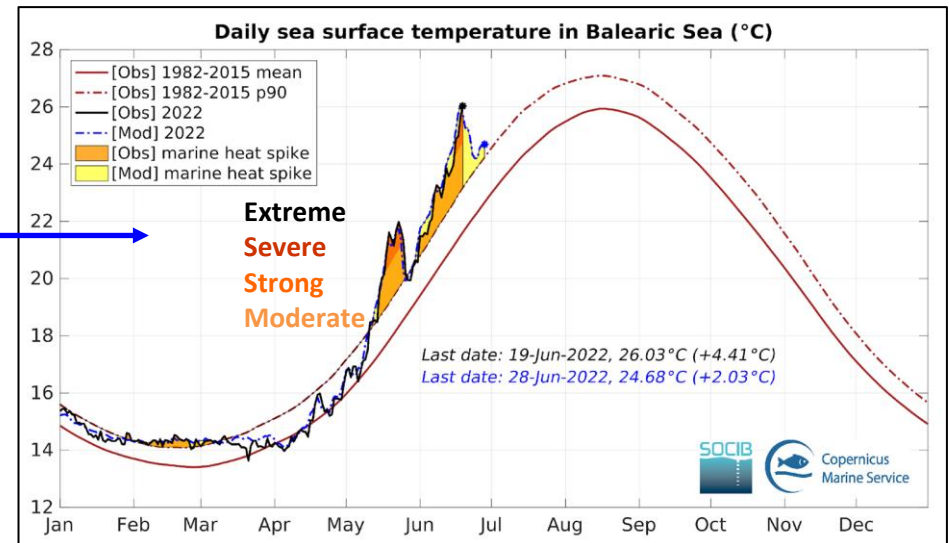
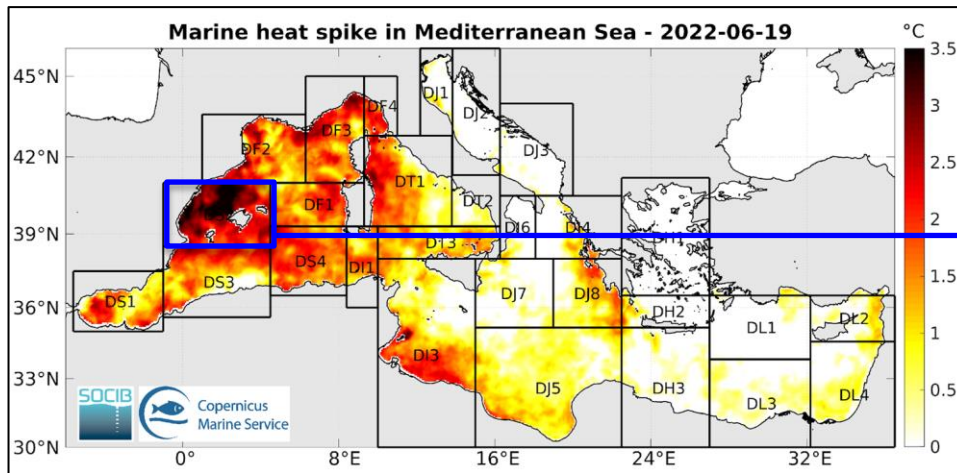
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(Figures on 19-Jun-2022)

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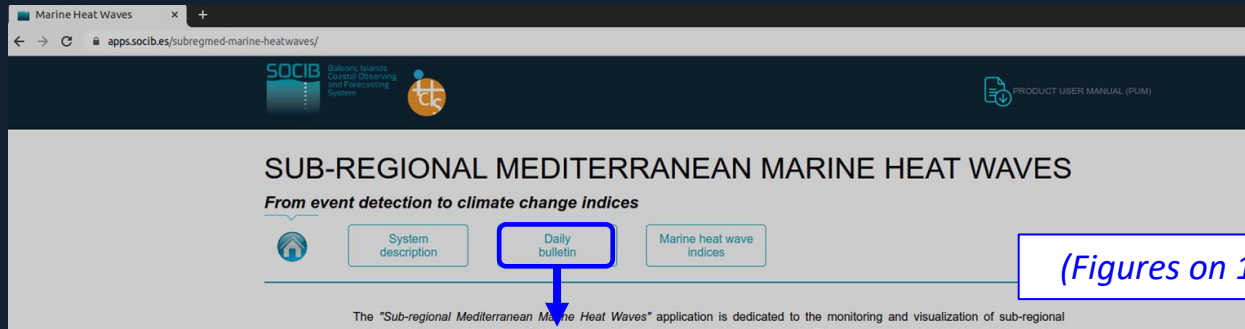
temperature

Sea surface temperature anomaly

In 28 sub-regions of the Mediterranean

“Sub-regional Mediterranean marine heat waves”: application to monitor and visualize MHWs at sub-regional scale in the Mediterranean Sea.

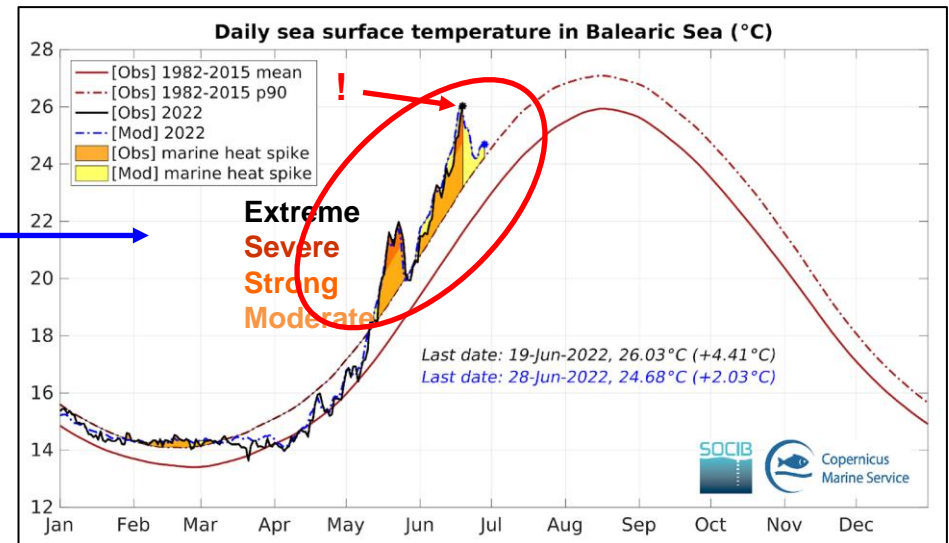
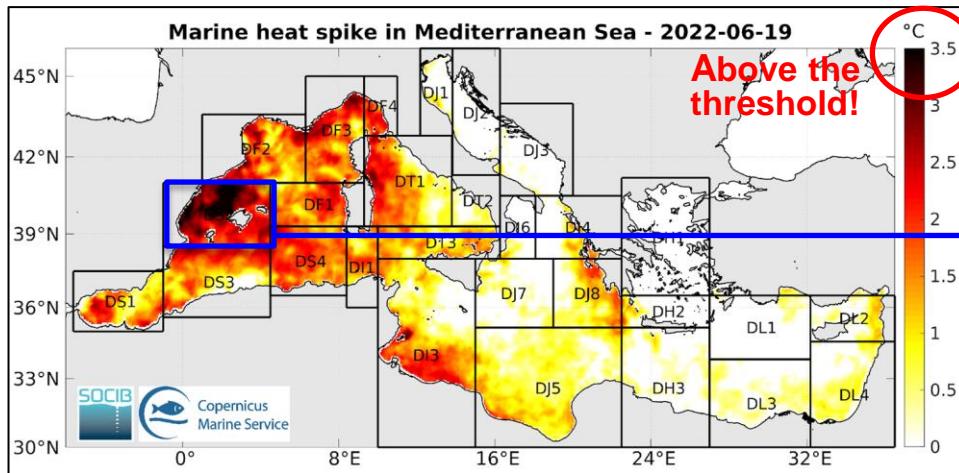
open access  
user-friendly  
science-based



(Figures on 19-Jun-2022)



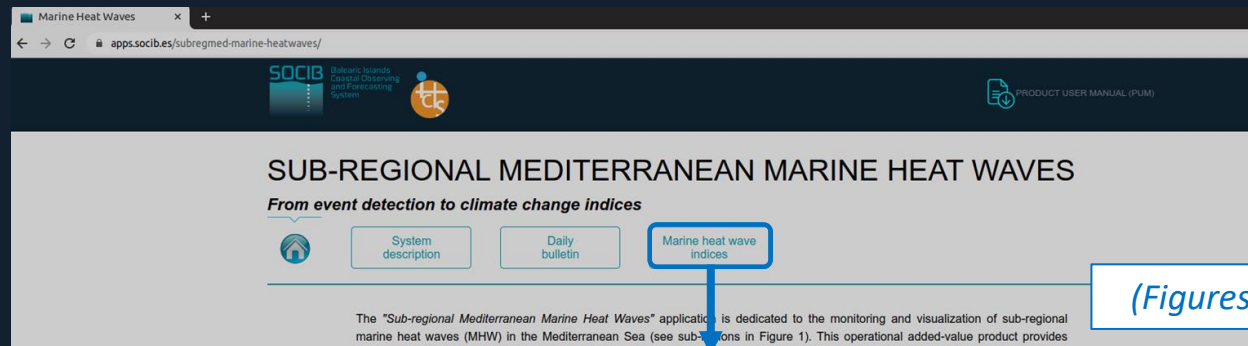
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In 28 sub-regions of the Mediterranean

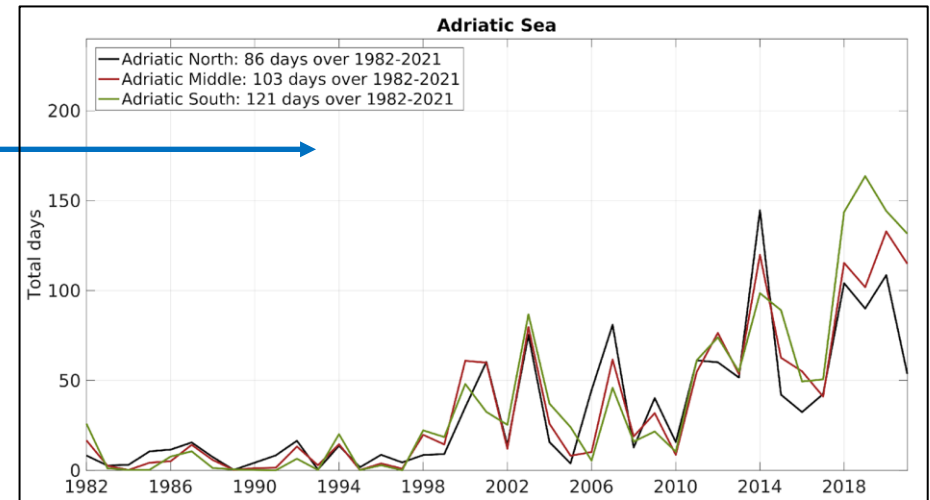
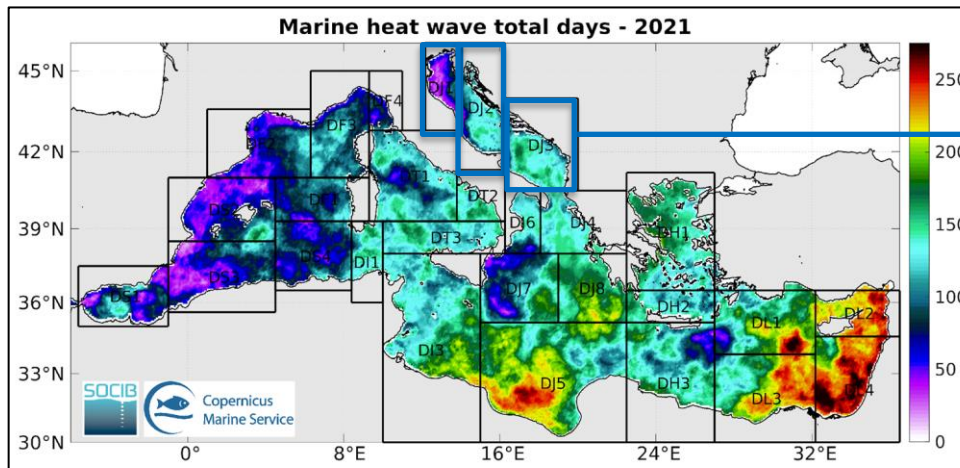
*“Sub-regional Mediterranean marine heat waves”*: application to monitor and visualize MHWs at sub-regional scale in the Mediterranean Sea.

open access  
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(Figures over 1982-2021)

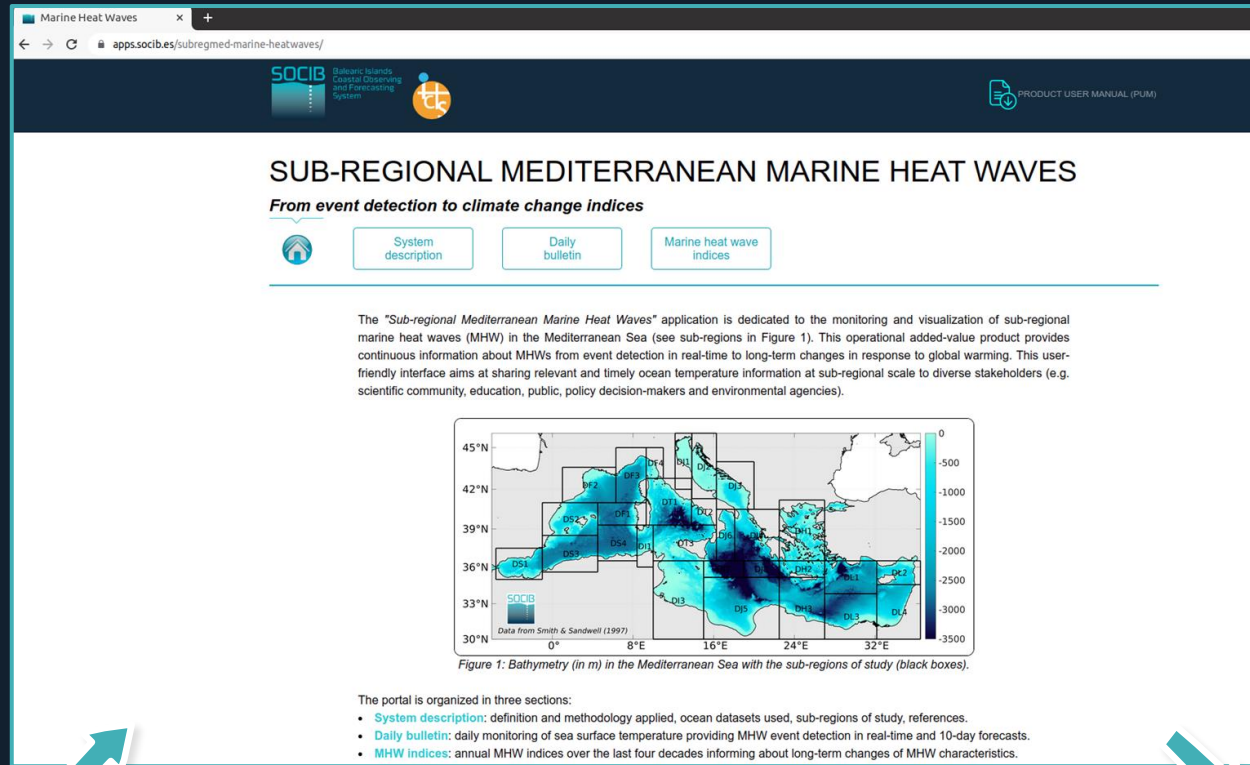
## MHW annual state (last year) and long-term variations (from 1982 until now)



- ? Intensity (mean & max), mean duration, frequency, total days
- ? 2D maps (annual and period means, trends), sub-regional time series and statistics

“Sub-regional Mediterranean marine heat waves”: application to monitor and visualize MHWs at sub-regional scale in the Mediterranean Sea.

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The screenshot shows a web browser window with the URL [apps.socib.es/subregmed-marine-heatwaves/](https://apps.socib.es/subregmed-marine-heatwaves/). The page title is "SUB-REGIONAL MEDITERRANEAN MARINE HEAT WAVES" with the subtitle "From event detection to climate change indices". There are three navigation buttons: "System description", "Daily bulletin", and "Marine heat wave indices". Below the buttons is a paragraph describing the application's purpose: monitoring and visualization of sub-regional marine heat waves (MHW) in the Mediterranean Sea. A map of the Mediterranean Sea is shown with bathymetry contours and sub-regions marked with black boxes and labels (e.g., D1, D2, D3, D4, D5, D6, D7, D8, D9, D10, D11, D12, D13, D14, D15, D16, D17, D18, D19, D20, D21, D22, D23, D24, D25, D26, D27, D28, D29, D30, D31, D32, D33, D34, D35, D36, D37, D38, D39, D40, D41, D42, D43, D44, D45, D46, D47, D48, D49, D50, D51, D52, D53, D54, D55, D56, D57, D58, D59, D60, D61, D62, D63, D64, D65, D66, D67, D68, D69, D70, D71, D72, D73, D74, D75, D76, D77, D78, D79, D80, D81, D82, D83, D84, D85, D86, D87, D88, D89, D90, D91, D92, D93, D94, D95, D96, D97, D98, D99, D100). A color scale on the right indicates bathymetry in meters from 0 to -3500. Below the map is a caption: "Figure 1: Bathymetry (in m) in the Mediterranean Sea with the sub-regions of study (black boxes)." At the bottom, there is a list of three sections: "System description", "Daily bulletin", and "MHW indices".

Copernicus Marine Service  
ocean data

Transfer of knowledge  
to diverse stakeholders

Open access, quality-controlled, historical & near real-time

Science, education, environmental agencies, decision-making ...

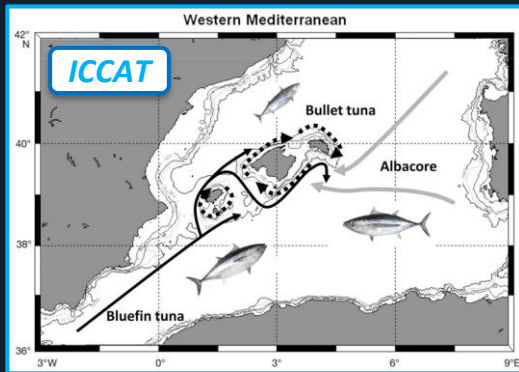
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Transfer of knowledge

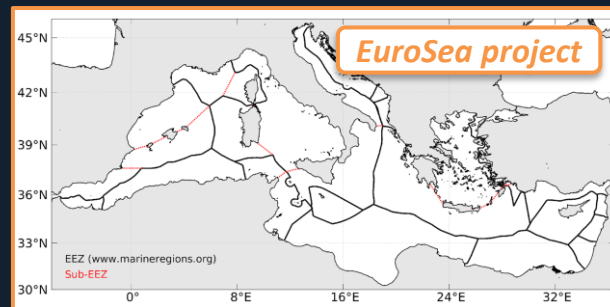
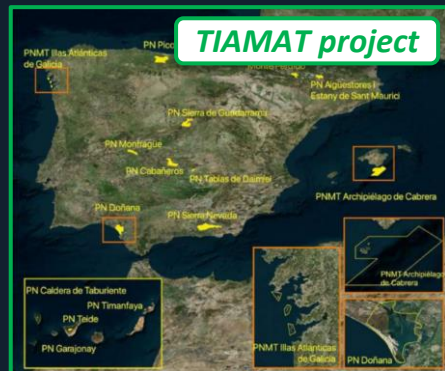
## Regional-national-local stakeholders

- Science community (*EuroSea project, marine biologists*)
- Academic community, education in marine science
- Environmental organizations (*Marilles foundation\**)
- Policy decision-making (*EEZs\*, MPAs, National Parks\**)
- Fishery (*Bluefin Tuna\*, red shrimps*)
- Industry (*aquaculture*)
- Health (*HAB, jellyfish*)
- General public (*journalists*)

Blue economy



(from Reglero et al., 2012)



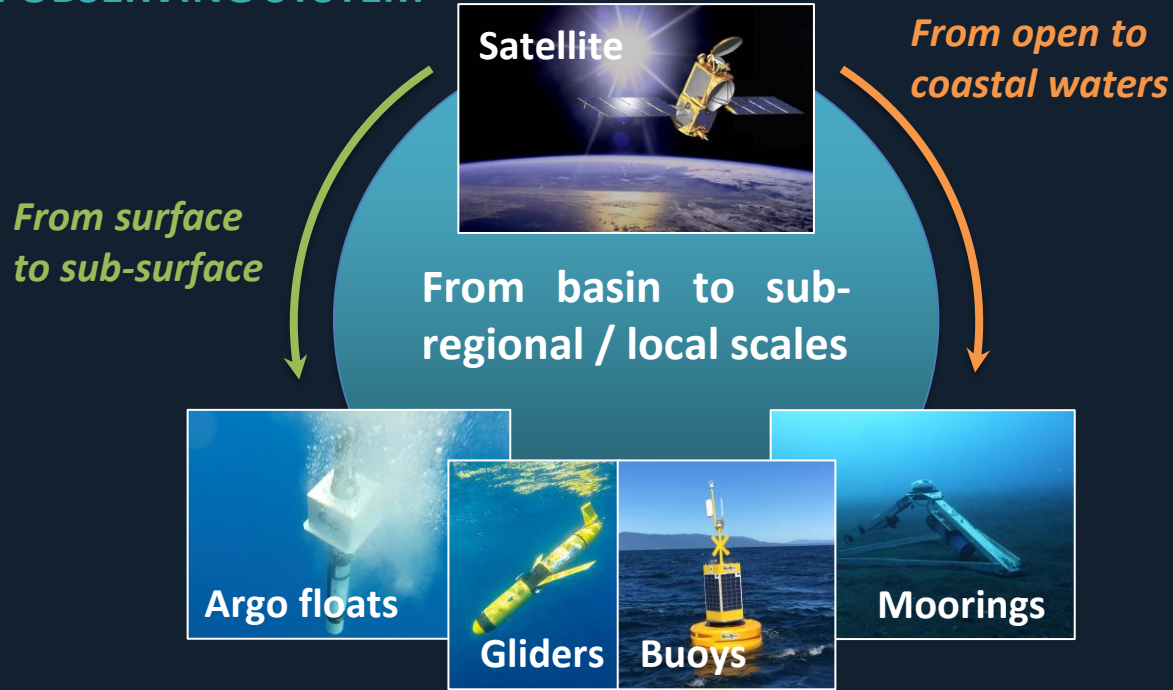
(from Dayan et al., in prog.)



(Balearic Sea annual report)

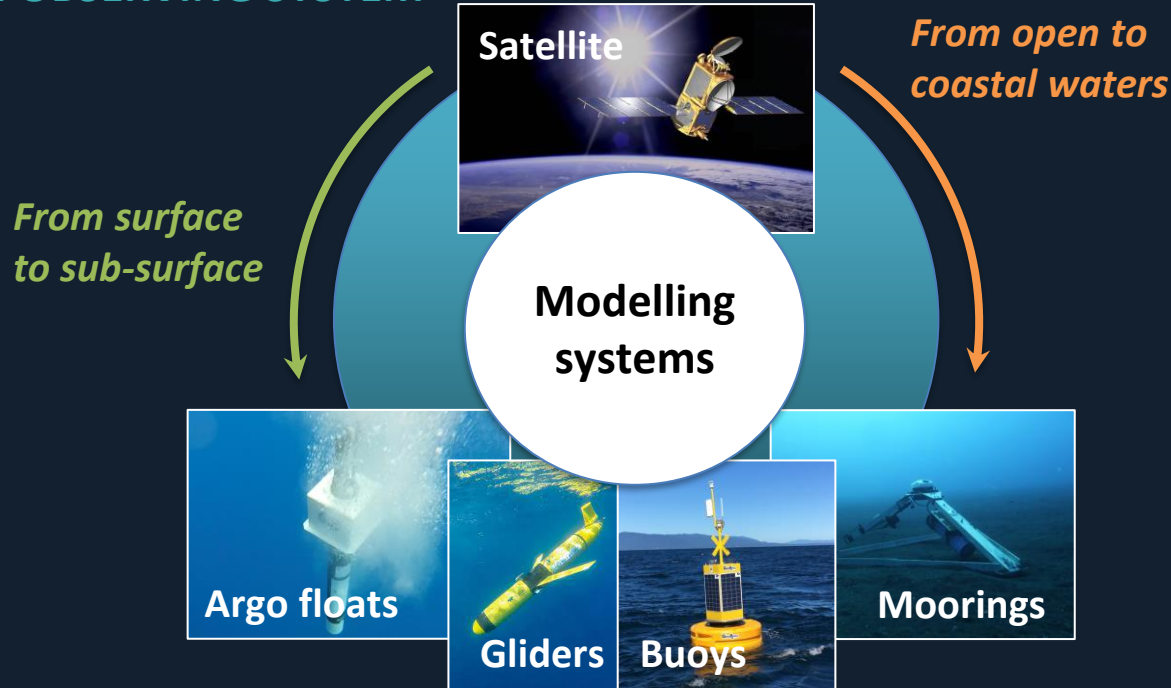
# WEB APPLICATION: COMPLETING INFORMATION

## OCEAN OBSERVING SYSTEM



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## OCEAN OBSERVING SYSTEM



### Modelling systems



- ✓ Complementary in under-sampled regions
- ✓ Key variables for MHWs (sub-surface T, OHC, ML)
- ✓ From weekly to seasonal forecasting capability

# MARINE HEAT WAVES: CONCLUSIONS

**Substantial increase** of surface MHWs in the Mediterranean (intensity, duration, frequency)

**Strong variability** in surface MHWs, sub-surface and coastal responses

**Web application:** continuous - timely information on MHWs in the Mediterranean since 1982

## Stakeholders

- Science community
- Academy/education
- Environmental agencies
- Policy decision-making
- Blue economy sectors
- ...

*At regional, national, local levels*



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- Foster the **continuous ocean monitoring**
- Improve the modelling and **prediction**
- Facilitate the **access to information**
- Design **user-oriented** interface



Implementation of **adaptation strategies** for the sustainable management of the oceans

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**MANY THANKS FOR YOUR ATTENTION**