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TAKING THE PULSE OF OUR PLANET FROM SPACE

CAREHeat

EUMETSAT ECMWF EUSPA

CAREheat: deteCtion and threAts of maRinE Heat waves

Rosalia Santoleri & the CareHeat team

24/05/2022

CAREHeat

deteCtion and threAts of maRinE Heat waves

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CAREHeat: Marine Heat Waves (MHW)

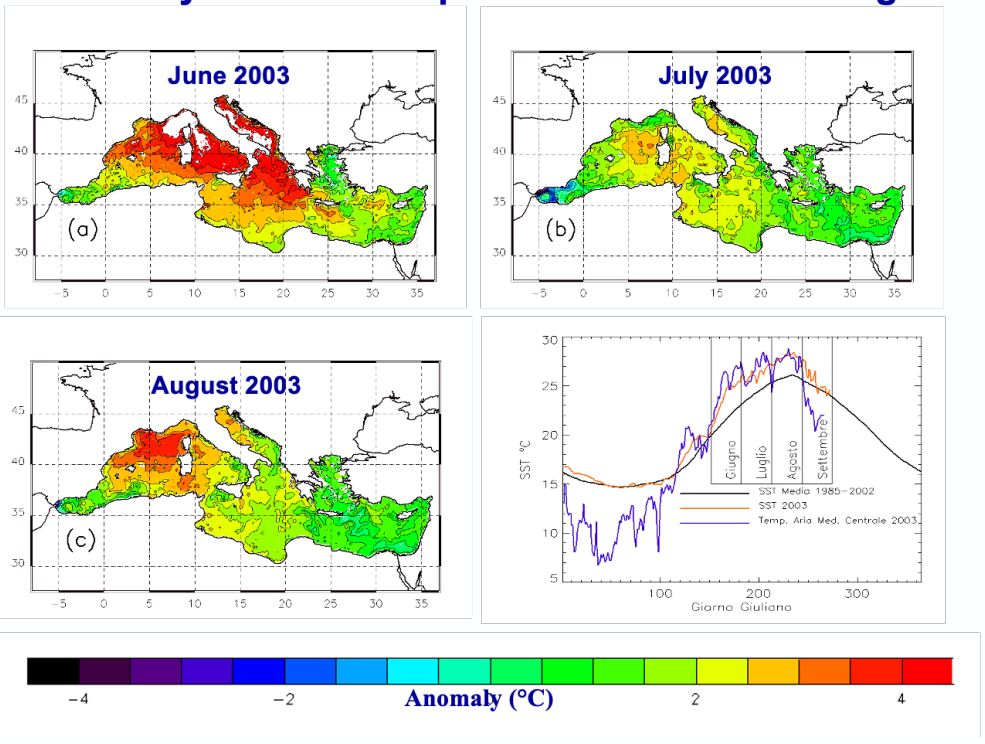
Marine HMarine Heath Waves (MHW) –
abnormal warm seawater temperature events –
THREATH living organisms and marine ecosystems and planetary health

More Frequent lately …. but **Many Unknowns**

Are MHW well identified? How frequent are MHW?
What are the Drivers and the Triggers of these extreme events ?
What are the Effects on Ecosystems and their Services?
Do they Co-Occur with other Hazardous events?

First NRT evindence of MHW summer 2003

The warm summer of 2003 observed in NRT: SST anomaly 2003 with respect to 1985 – 2002 average

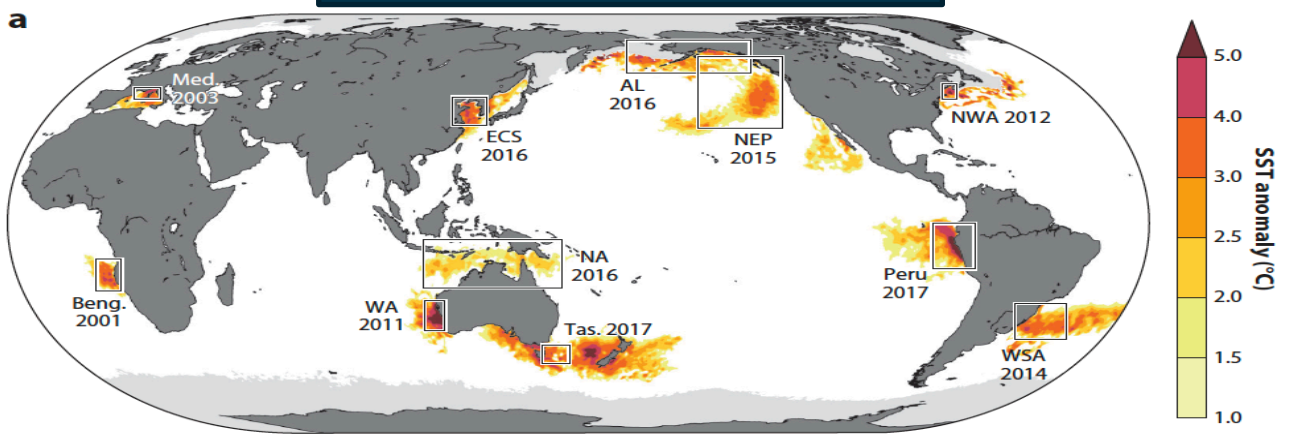


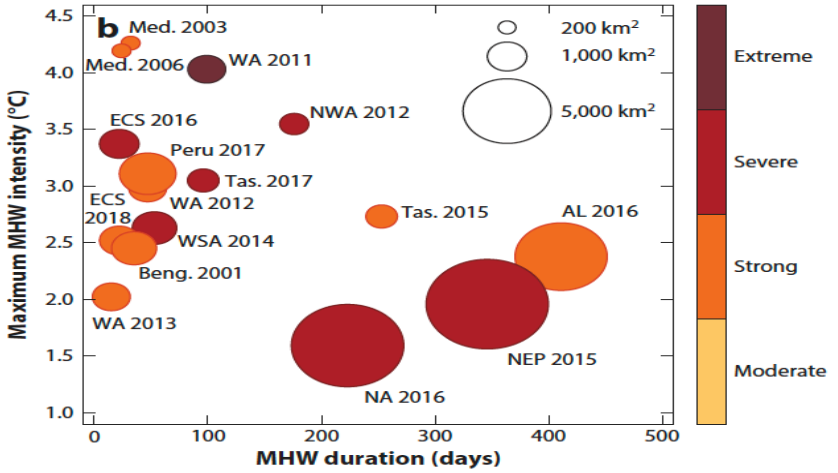
SST 4-5 °C > climatology
2003 MHW lasting 2-3 month

From Marullo & Guarracino 2003

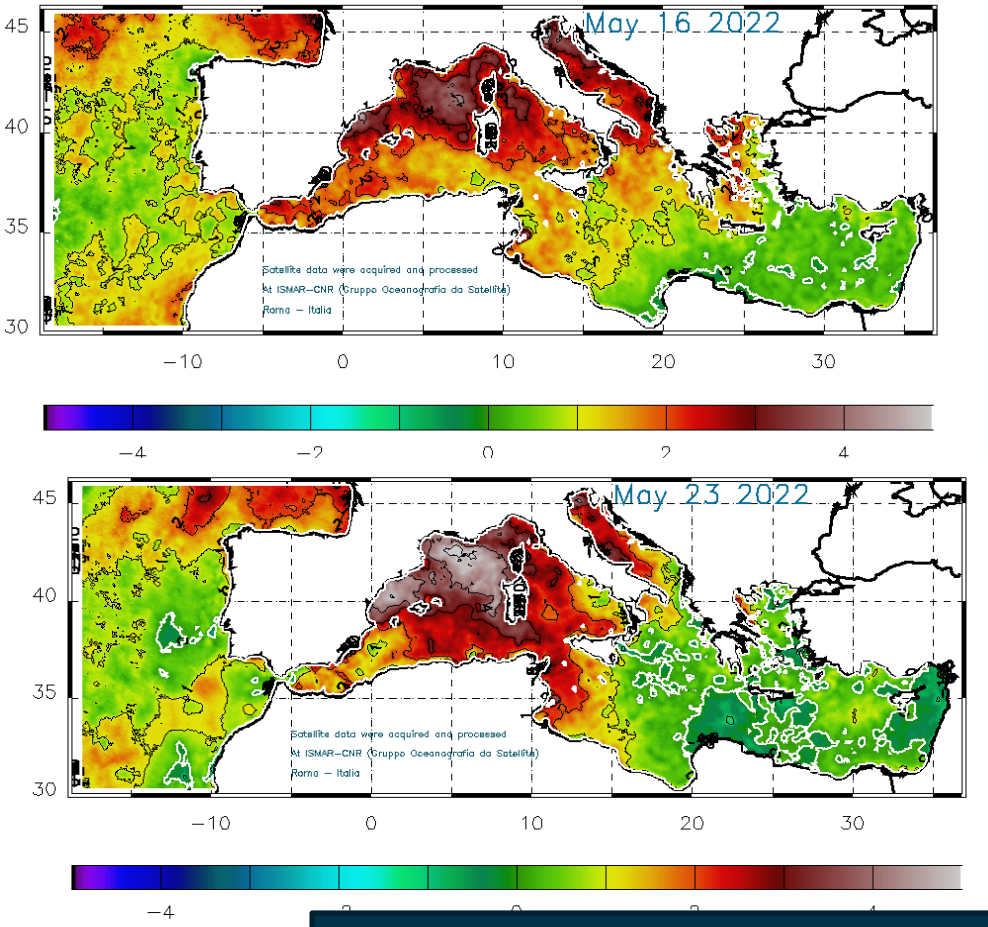
MHW frequently observed in any region of the ocean

Oliver et al. Annu. Rev. Mar. Sci. 2021.





A strong MHW is now occuring over the MED

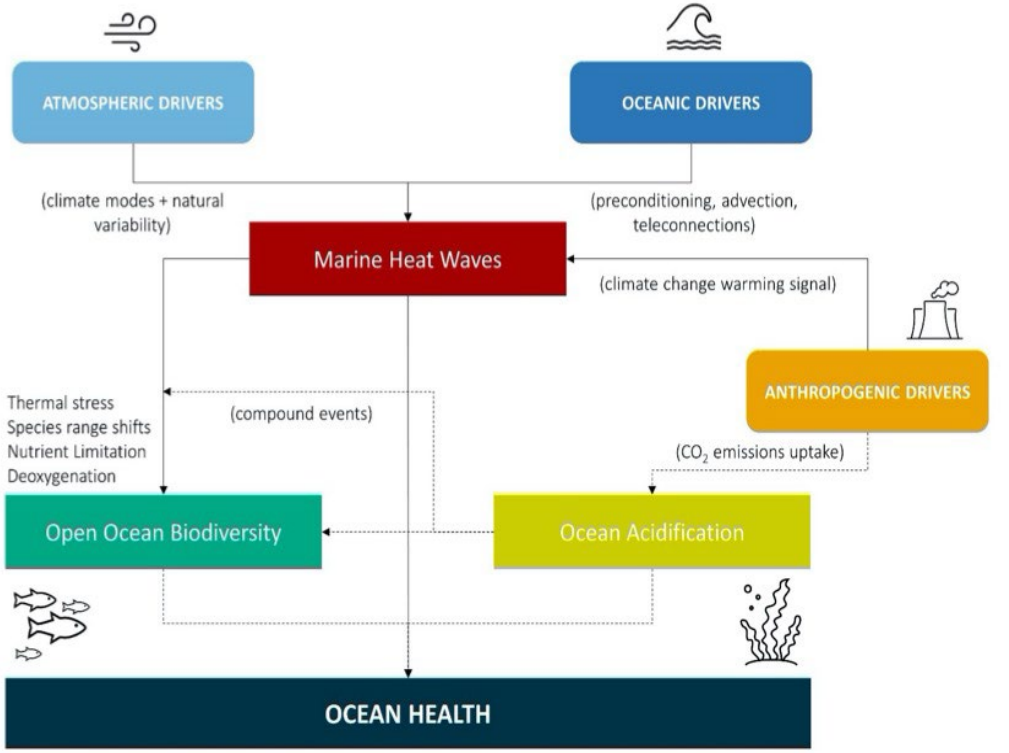


Prominent MHWs have been reported to have a devastating impact on marine ecosystems

MWH started on11/05/2022. ….

CAREHeat AIMS

- IMPROVE current MHW **Detection** and **Characterization** methodology
- ADVANCE the understanding of the physical processes involved in **MHW Development**
- ASSESS MHW impact on marine **Ecosystems and Biogeochemistry**
- ASSESS the impact of MHW on **Ecosystem Services**

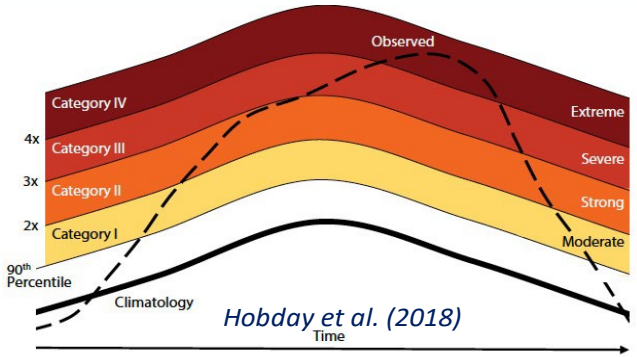


CAREHeat Project started March 2022

Improving the MHW detection method

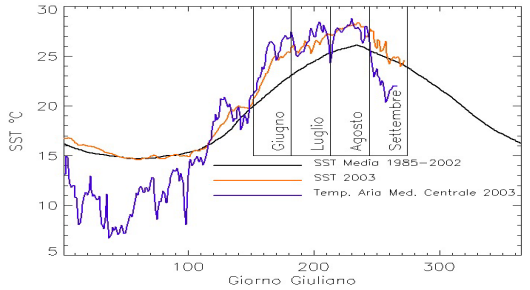
MHW detection

Widely used MHW detection method is Hobday et al. (2016). This method is based on local temperature anomalies exceeding a given climatology percentile threshold.



Hobday et al. (2018)

FIGURE 2. Categorization schematic for marine heatwaves (MHWs) showing the observed temperature time series (dashed line), the long-term regional climatology (bold line), and the 90th percentile climatology (thin line). Multiples of the 90th percentile difference (2x twice, 3x three times, etc.) from the mean climatology value define each of the categories I–IV, with corresponding descriptors from moderate to extreme. This example peaked as a Category IV (extreme) MHW.

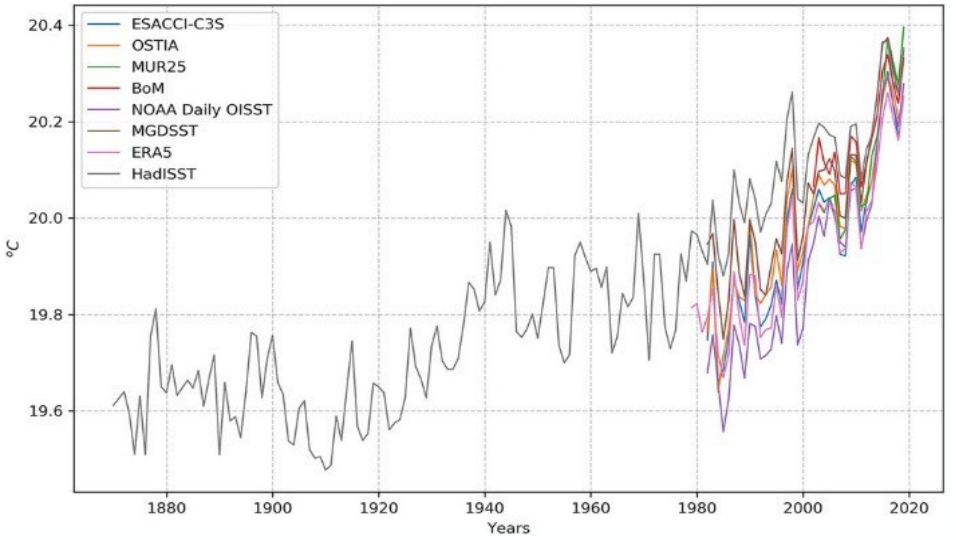


Marullo & Guarracino (2003)

Aims

What is the contribution of natural mode of variability?

What is the effect of SST trend on MHW detection?



Yang et al 2021: Global monthly mean SST time series for all the ensemble members for the whole covered period originally obtained in each SST product.

Method Improvements

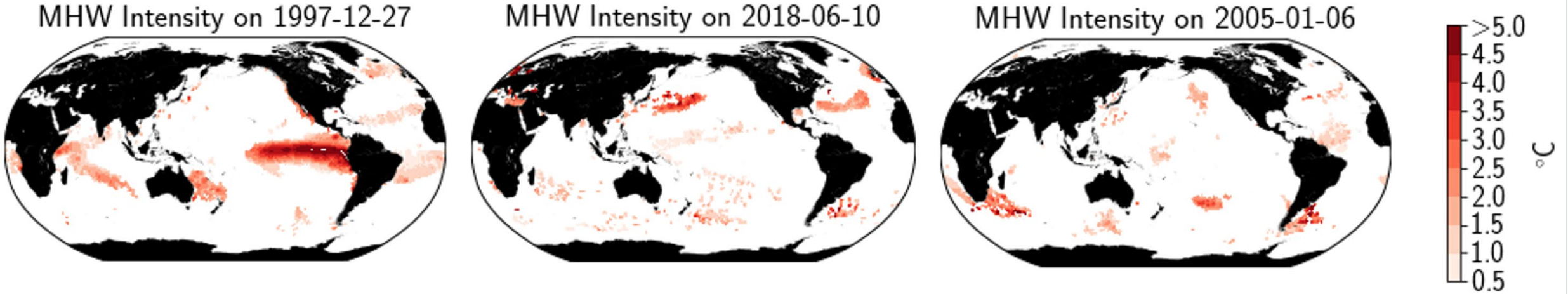
- SST TRENDS and impact of CLIMATE MODES on the statistical thresholds at regional and global scale
- Sensitivity of MHW detection with respect to the baseline climatology definition (e.g., moving versus fixed climatology)
- Effects of DIURNAL WARMING
- Disentangling the main drivers of MHW development

CAREHeat will extensiive use of all available satellite datasets to improve detection

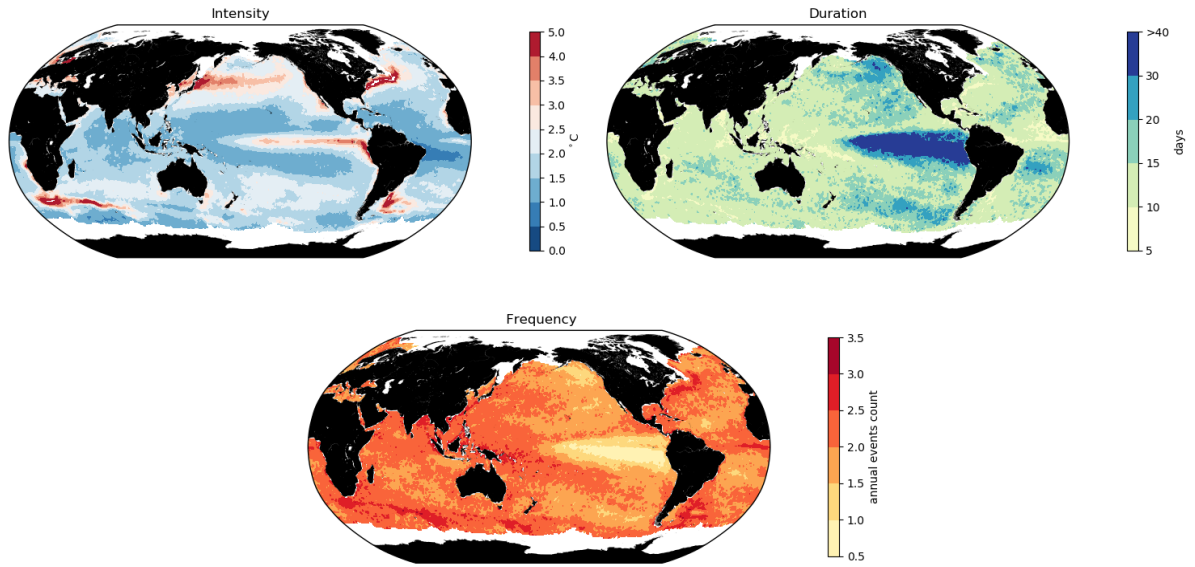
Validation

Novel MHW products will be compared with well-known MHW events

The effect of climate modes, main current systems on MHW detection



Pisano et al. (2020)
C3S_511 SPQB – MHW catalogue produced by C3S_511
Detection with current methodology applied to ESA CCI SST Level-4 dataset (v2.0)

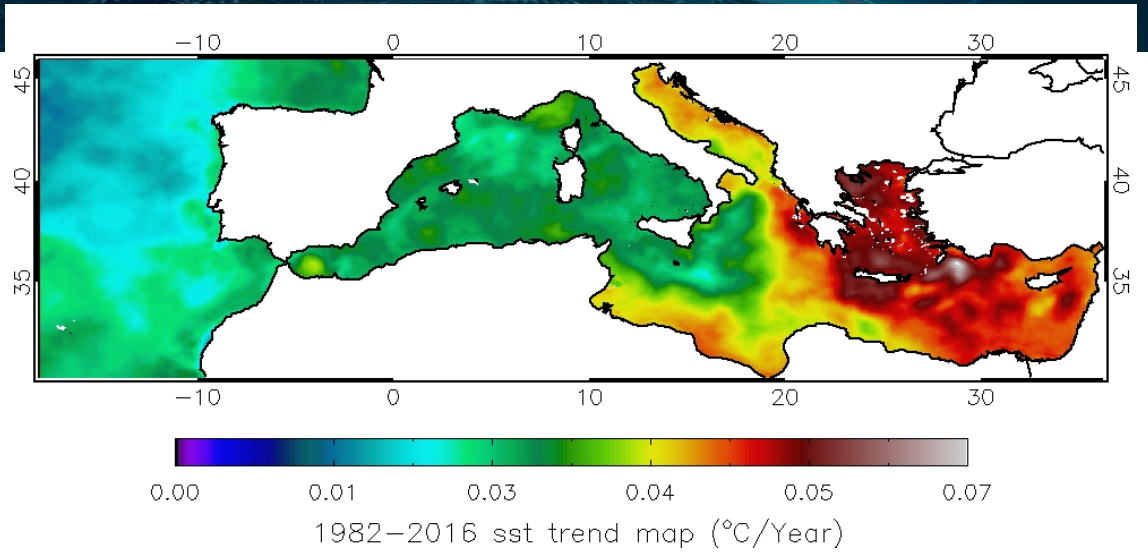


Spatial distribution of average properties of MHWs

Can the MHW detection be improved by the use of additional satellite dataset (eg currents, winds, etc) and surface forcing?

Shall we revise the definition of the MHW?

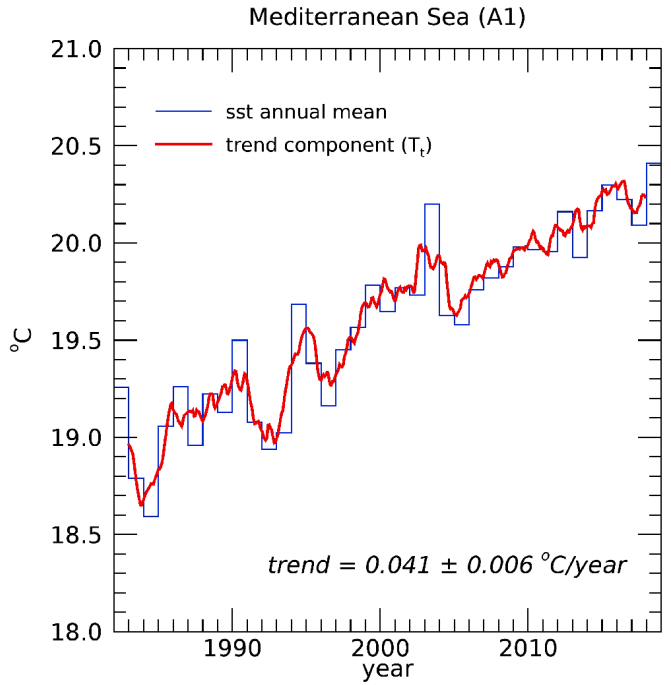
Impact of SST trend on MHW detection: MED case

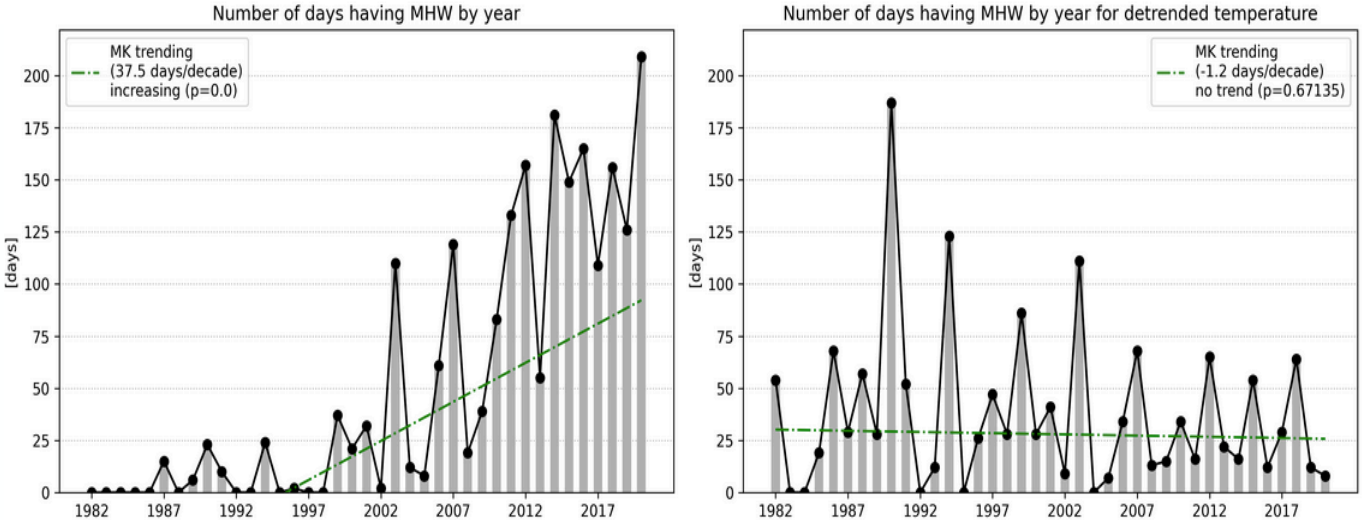


The Mediterranean SST is warming up with a trend of 0.04 °C per year

In presence of SST trend how can we define a reference climatology ?
What is the impact of the trend in MHW identification?

Pisano et al 2020





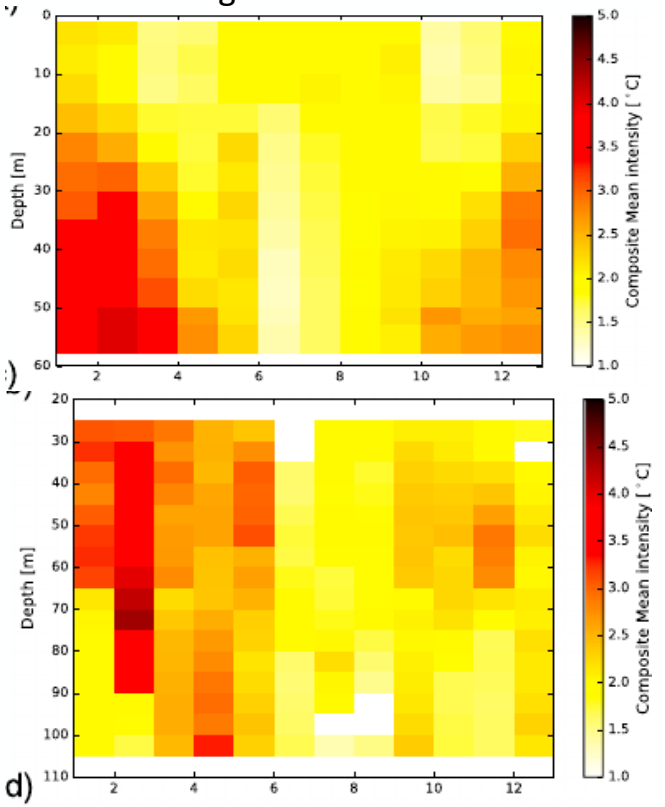
With the courtesy of Justino Martínez (Institute of Marine Sciences, ICM-CSIC, Barcelona, justino@icm.csic.es)

4D MHW reconstruction

Reconstructing the information related to MHW events in the subsurface of the ocean is crucial for our understanding of MHW and their impact on ecosystems.

- Different studies demonstrated an intensification of MHW at depth as well as a deeper penetration of the signal (e.g. Schaeffer and Roughan, 2017).
- The characteristics of subsurface events can differ from the ones at the surface: Darmaraki & al (2019) shown that in the MED Sea, subsurface events are seasonally shifted and appear, on average, longer and more intense but less frequent and less extended in space than surface MHW
- The propagation of surface events to depth can strongly impact benthic organisms and ecosystems => In response to the unusual thermal stress, marine communities have to either acclimatize or track more suitable habitat farther poleward or deeper.. Habitat-forming species are dying and are not able to recover after the MHW has subsided (Wernberg et al.,2016)

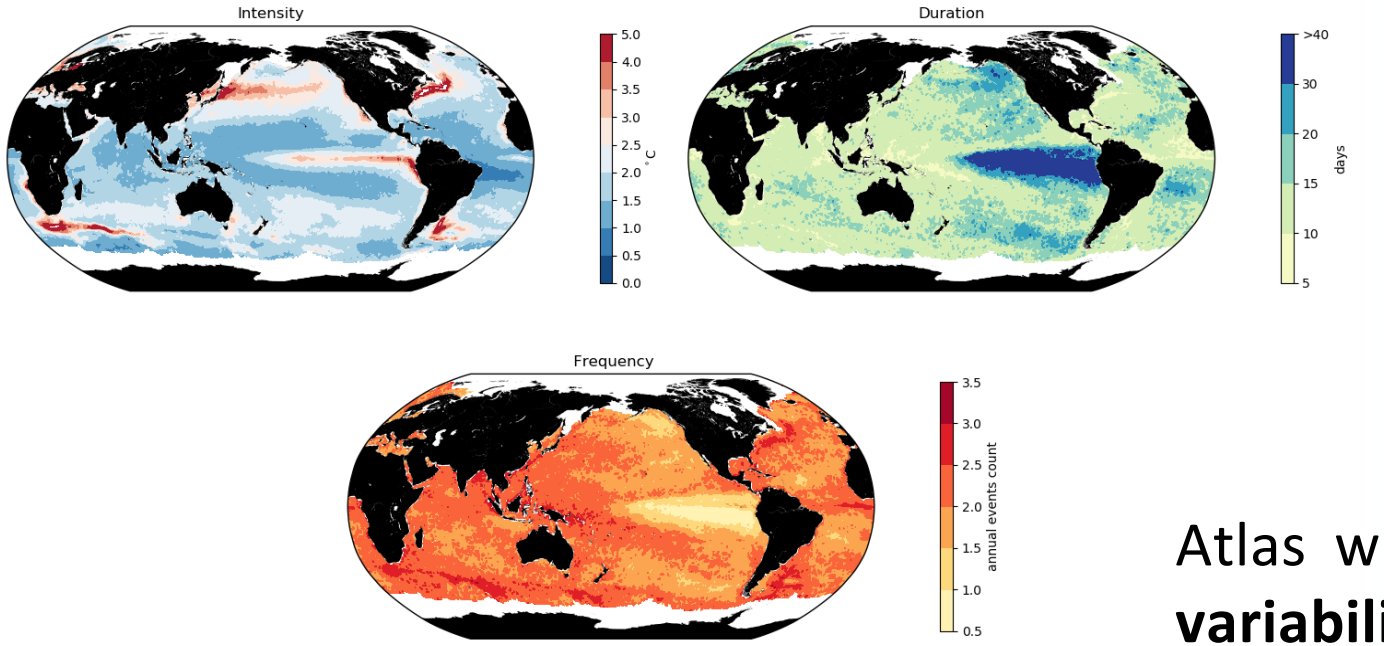
MHW intensity as a function of depth
2 sites along the Australian coast



CAREHeat aims to better characterize the subsurface MHW events through the reconstruction of a dedicated 4D MHW dataset. Optimize the AI approach will be used to reconstruct MHW in the subsurface for past events over a recent 10-year period

MHW Surface Global Atlas

MHW improved detection methodology will be developped by CAREHeat and use to produce a new MHW Atlas covering the satellite era (> 10-20 years)



The Atlas will be accompanied by a list of ancillary information:
METEOROLOGICAL
OCEANIC GEOPHYSICAL
BIOLOGICAL

Atlas will be uses to **CHARACTERIZE MHW variability**, **drivers and precursors** that are responsible for MHW occurrence and evolution

MHW impact on biodiversity and biogeochemistry

Assess the IMPACT of MHW on marine **biodiversity** and **biogeochemistry** along the water column

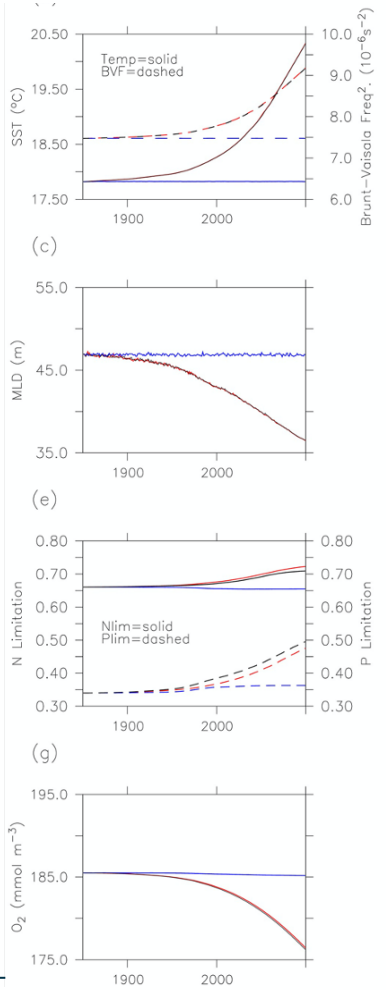
Strategy

- Use MHW4D products
- Assess EFFECTS of MHW during and after the event
- Exploit synergies between Ocean Colour observations, BGC-Argo floats and biogeochemical models
- Capitalize on open carbon products (e.g., C_{phyto} and POC) within the ESA Ocean Science Cluster

Key questions to address

1. How MHW impact on Chl concentration?
2. Do biomass or physiology affect Chl changes?
3. Impact on phytoplankton community structure?
4. Impact on ocean biogeochemistry - nutrients and oxygen?
5. Impact on higher trophic levels?
6. Impact and sensitivity on pH and air-sea CO_2 fluxes during MHW events?

IDENTIFY **compound events** and ASSESS impacts and links with oceanic biological productivity



Strategy

- Use MHW4D products
- -Identify the co-occurrence of MHW with extreme anomalies in CMEMS-biogeochemical model output

Key questions to address

1. Identification and Frequency of compound events
2. Identify cumulative impact on ocean productivity
3. identify positive feedbacks driving cocompound events

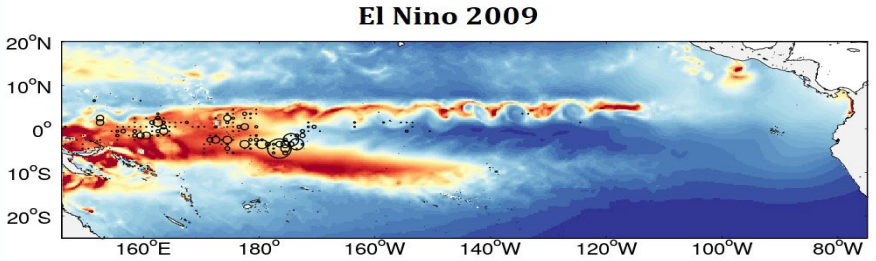
MHW impact

Fisheries

Two species of tropical Tunas

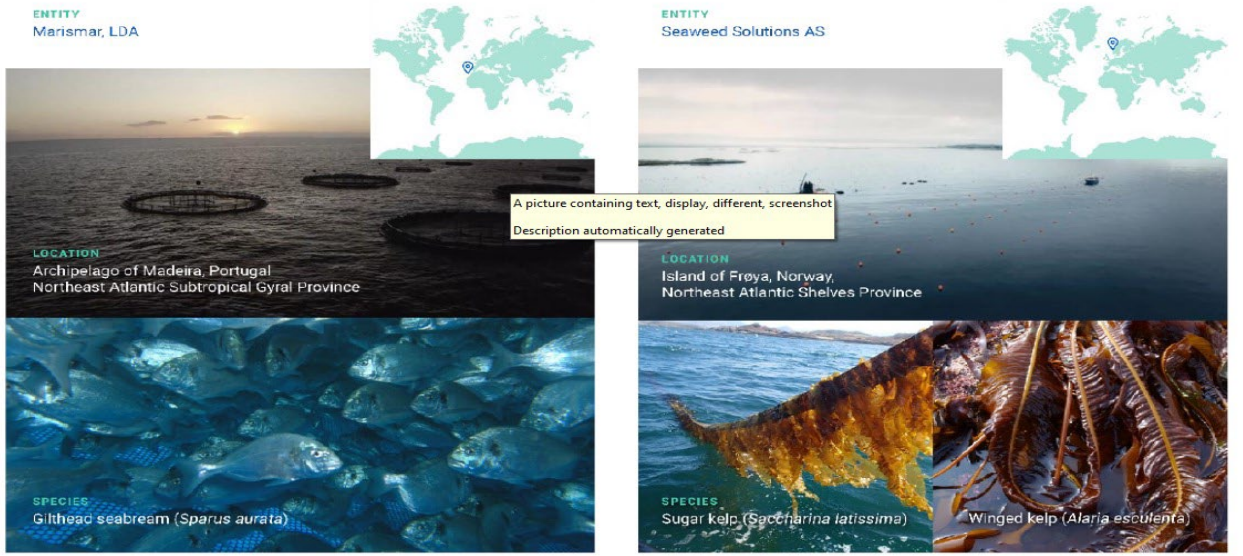
Evaluate short-term impacts of MHW on larvae, juveniles, immature and mature tunas

Evaluate long-term impacts of MHW on tuna recruitment



Density distribution of biomass for tunas as predicted by the model SEAPODYM

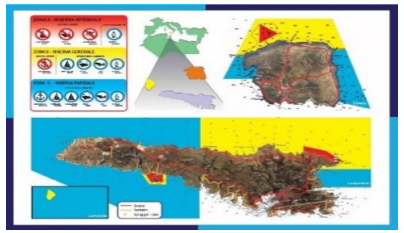
Aquaculture



Assess how two economically important marine species (Sea Breams and Sugar Kelp), from different trophic levels respond to acute thermal stress during events of MHW, in Portugal and Norway. Analysis of impacts on life cycle and mortality, distribution and productivity

Marine Protected Areas

MPA Isole Pelagie (Lampedusa)



Corals

Sea urchins

Marine birds

Assess MHW impact on fertility and reproduction, nesting, mortality, and behaviour


CAREHeat
deteCtion and threAts of maRinE Heat waves
Thanks for your attention
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