Ocean Heatwaves and Sea Level Rise

(Climate) Extremes: Heatwaves, Changes in Ice, Drought, Floods

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Waves

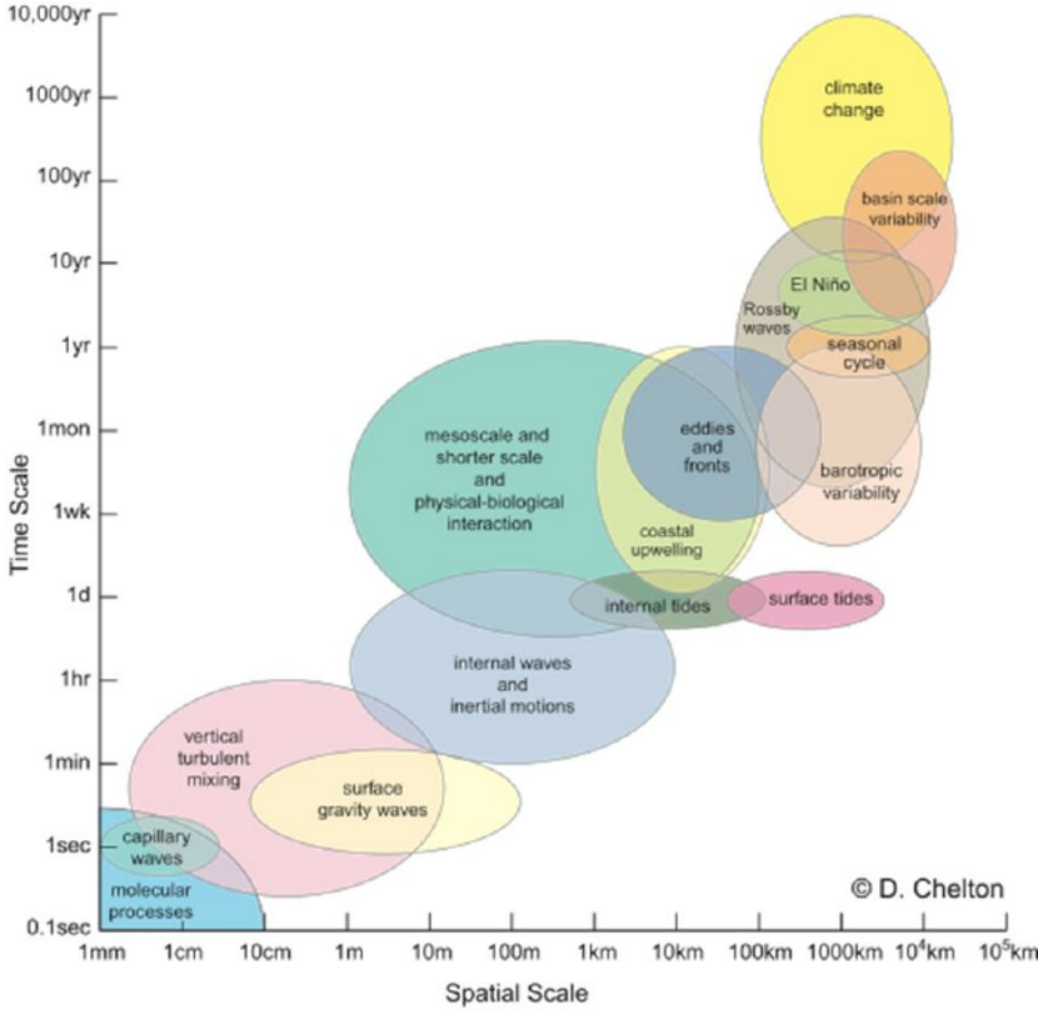
Heat

Sea Level

Blooms

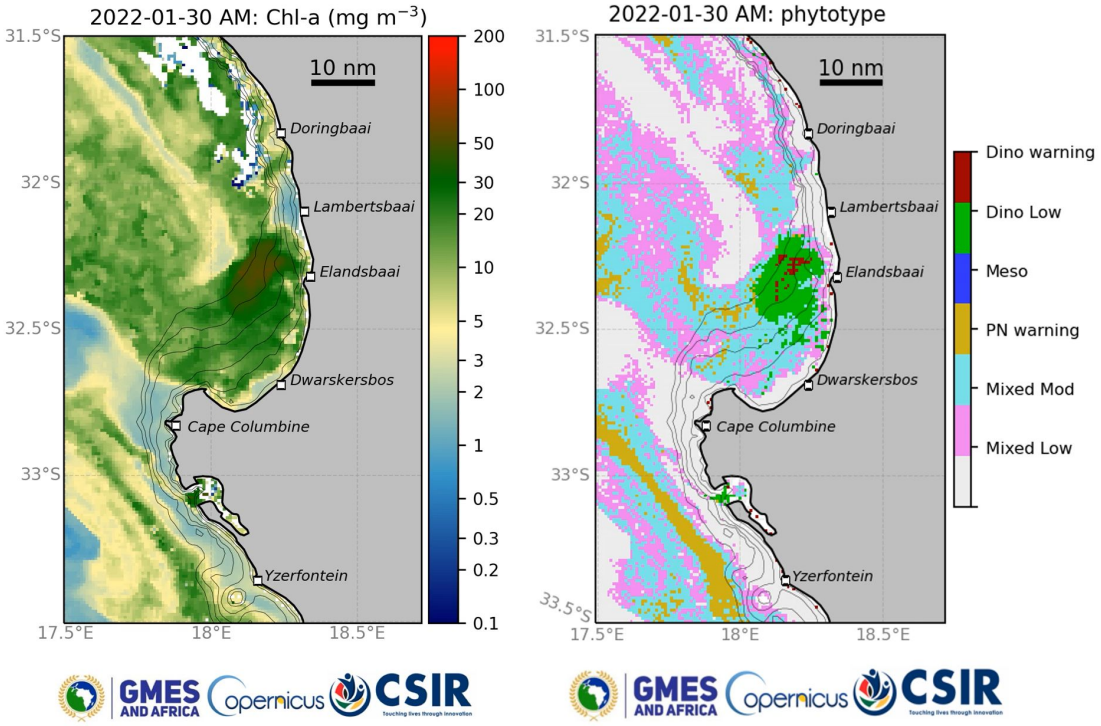
What do we need to know and do to appropriately visualise climate extremes in the ocean?

- The ocean is an extreme place!
- Single events are hard to link to climate
- Changing climate shifts the baselines.
- Understand the timescales of factors that influence ocean extremes (varies a lot!)
- Use data that appropriately resolves these scales:
  - Real time events (what is happening now?)
  - Climate context (How extreme is this compared to 'normal'?)
- **Visualise in this context!** Consider;
  - baseline
  - likelihood / attribution
  - ....be prepared for questions linking to climate.



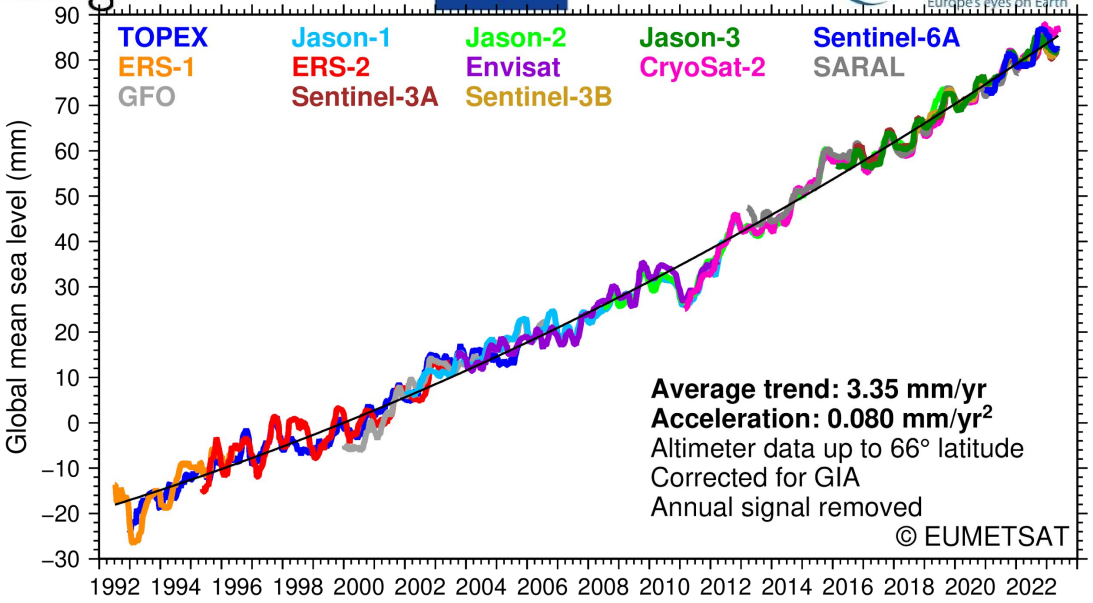
An example: Harmful Algal Blooms

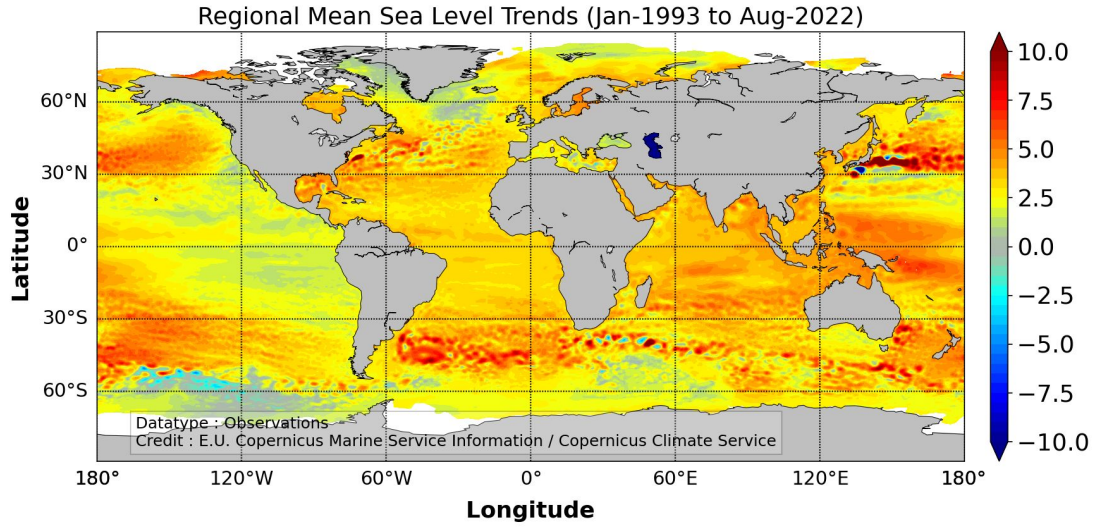
- In some places –**'normal'** – occur regularly associated with natural phenomena
- In other contexts – a result of anthropogenic effects (e.g. pollution)
- Drivers and impacts could be exacerbated by climate scale changes (e.g. winds, warming, acidification, deoxygenation)
- Might not matter if natural or not – still impactful!
- Example on right is extreme, but we **can't** immediately link it to climate.
- Individual events are still extremely heterogeneous
- May need 30+ years of ocean colour data to start to disentangle climate effects from decadal variability (Henson et al., 2010)



Example: Sea level (and storm surges and waves)

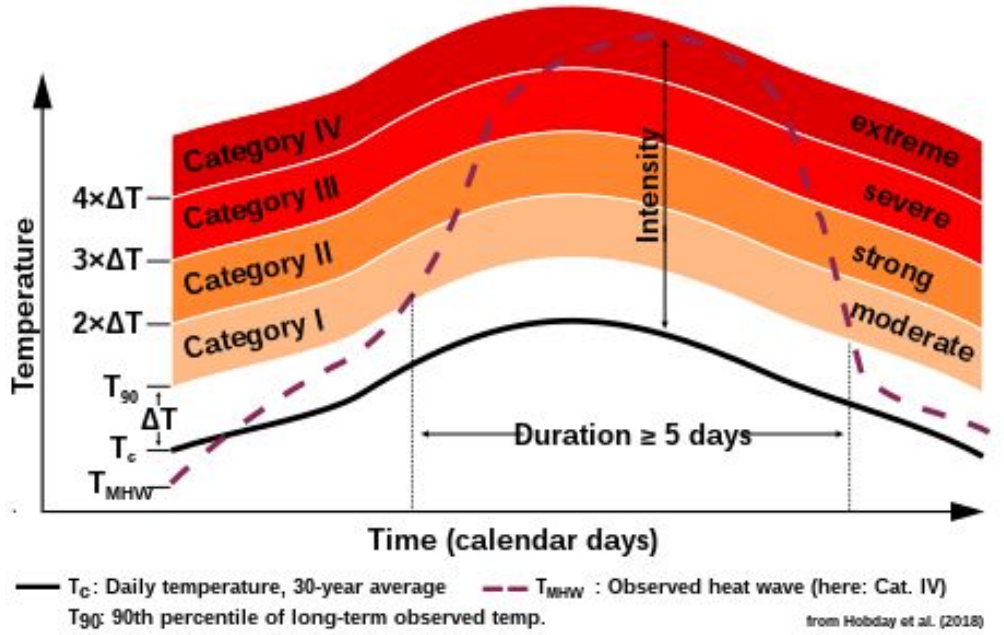
- Mean sea level – important as a baseline (changing with climate change).
- SSHA – **anomalies** to mean sea level
  - Relative change over a given time
  - Shows short term variability i.e. around currents, eddies and storms.
- Waves
  - Significant wave height
    - Extreme waves can damage ships and infrastructure
  - Wave generation related (in part) to wind field
- Higher mean sea level (climate) + higher SSHA + higher waves >> greater coastal flood risk!
- Visualisation options:
  - [CMEMS ocean indicators]

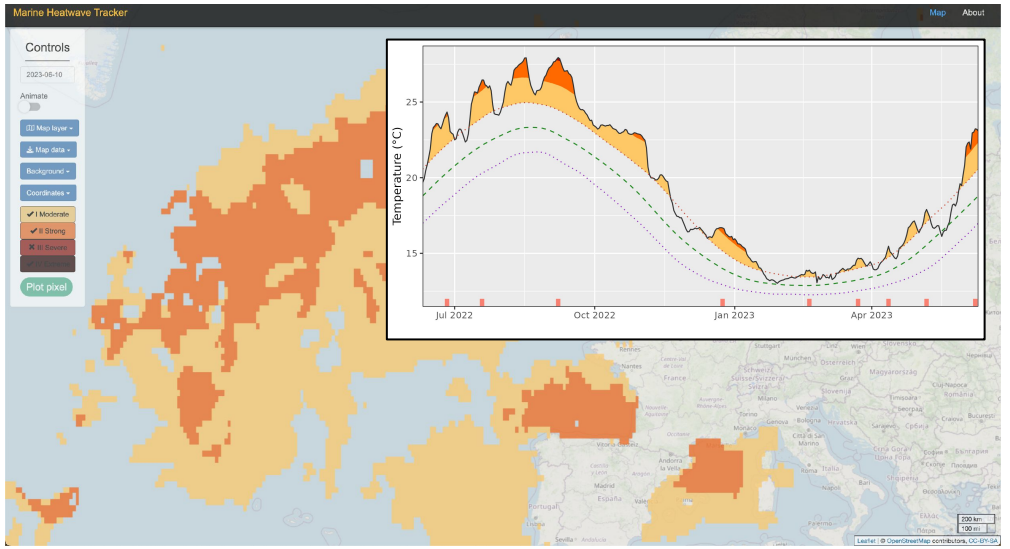




Example: Marine heatwaves…what are they?

- Can be classified using thresholds vs long term average (see toolkit later and Hobday et al., 2018 □ Essential reading!)
  - Also vary for more extreme events or impacts on specific organisms.
- Caused by:
  - Changes in ocean heat transport (e.g. Boundary currents, thermocline variability)
  - Persistent, large-scale, atmospheric systems.
  - Atmosphere-ocean teleconnection
    - Kelvin waves, climate oscillations
  - See Holbrook et al., 2019 and Sen Gupta et al., 2020
- Affected by anthropogenic climate change
- Visualisation options:
  - http://www.marineheatwaves.org/tracker.html
  - http://whalemap.ocean.dal.ca/MHW/
  - https://t-mednet.org/visualize-data/marine-heatwaves

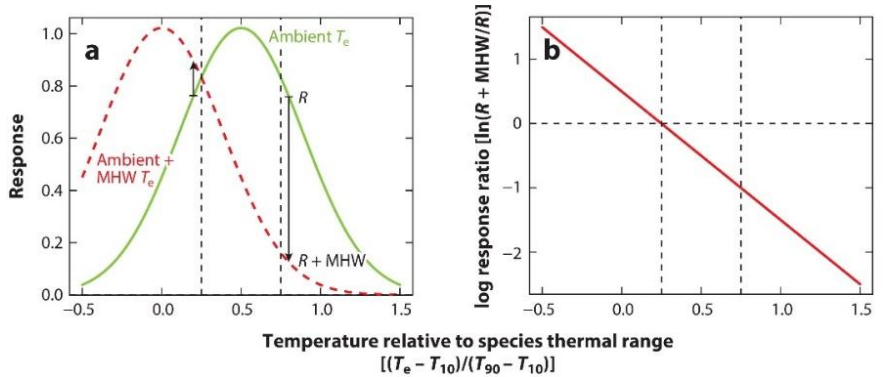


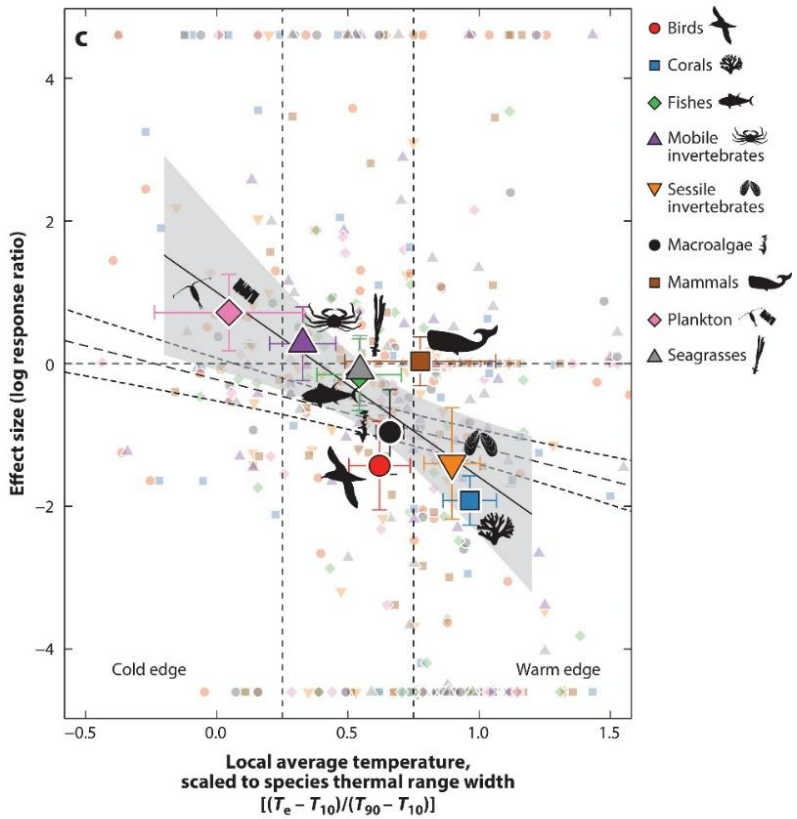


What are the impacts of marine heatwaves?

- Impact on air-sea flux of CO_2
- Tropical cyclone formation
- Coral bleaching
- Mammal and sea bird mortality
- Harmful Algal Blooms
- Spatiotemporal shifts in habitats (affecting fisheries).

Note – also some benefits for some creatures – depends on interplay between heatwave and thermal limits per species (Smith et al., 2023 □ Great review!)

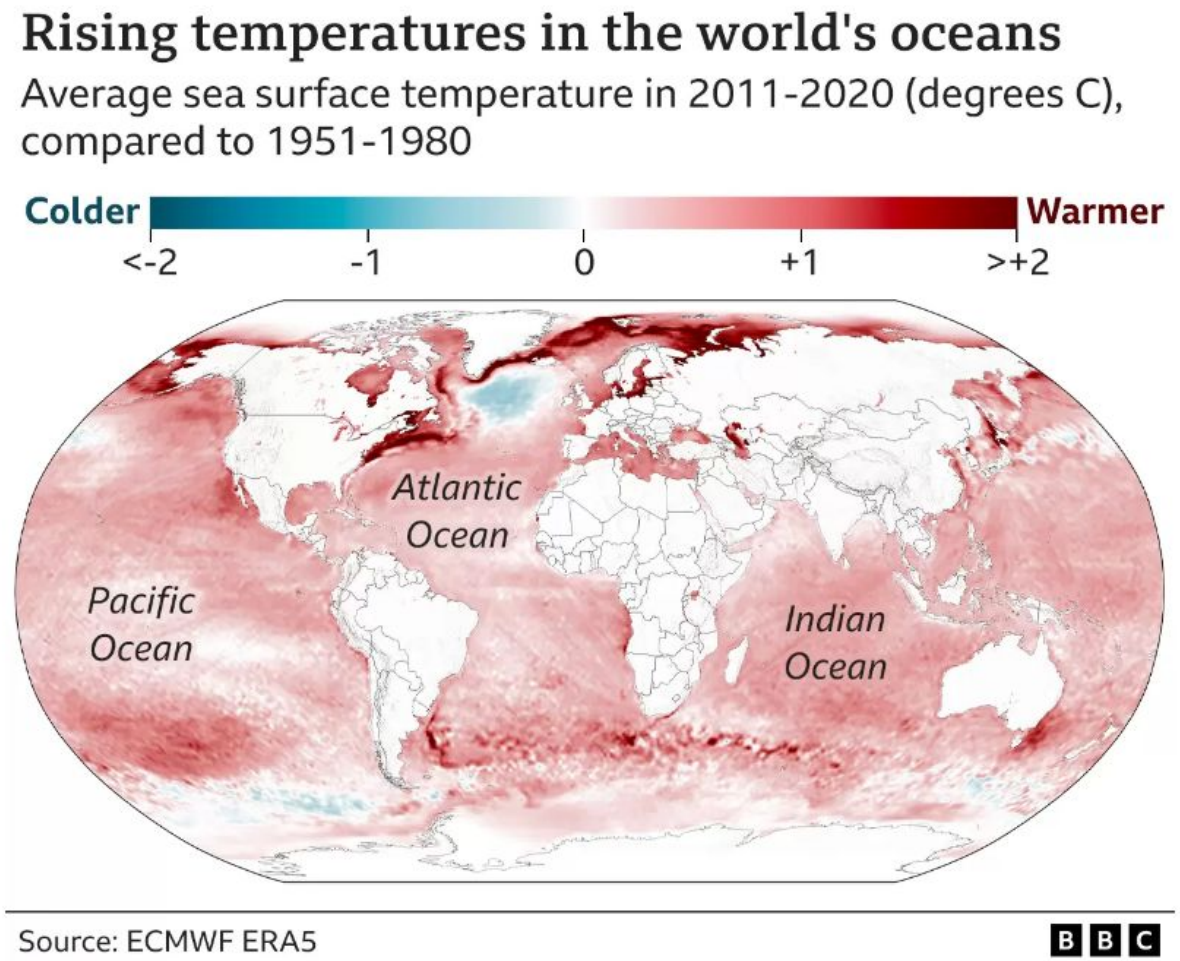


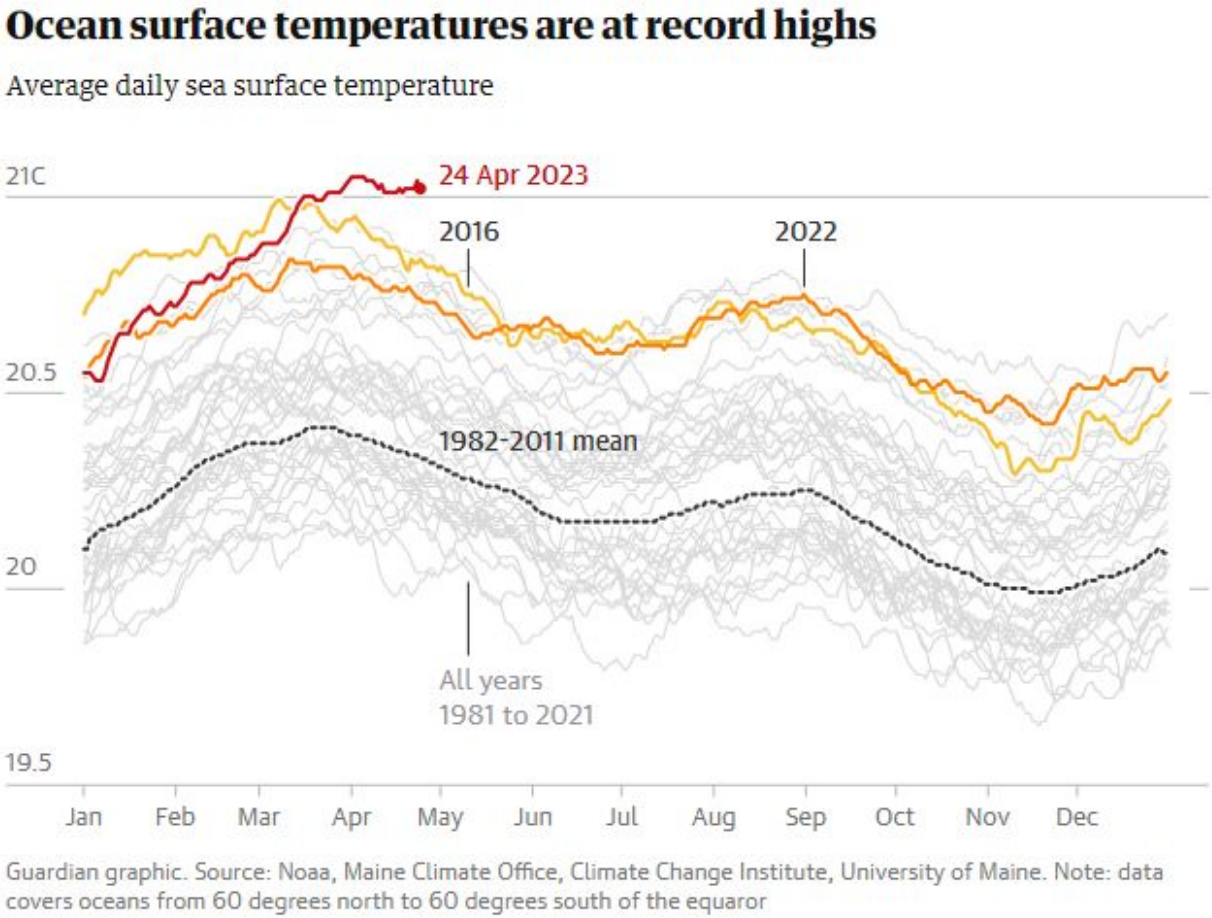


Smith KE, et al. 2023
Annu. Rev. Mar. Sci. 15:119–45

Marine heat in the media...

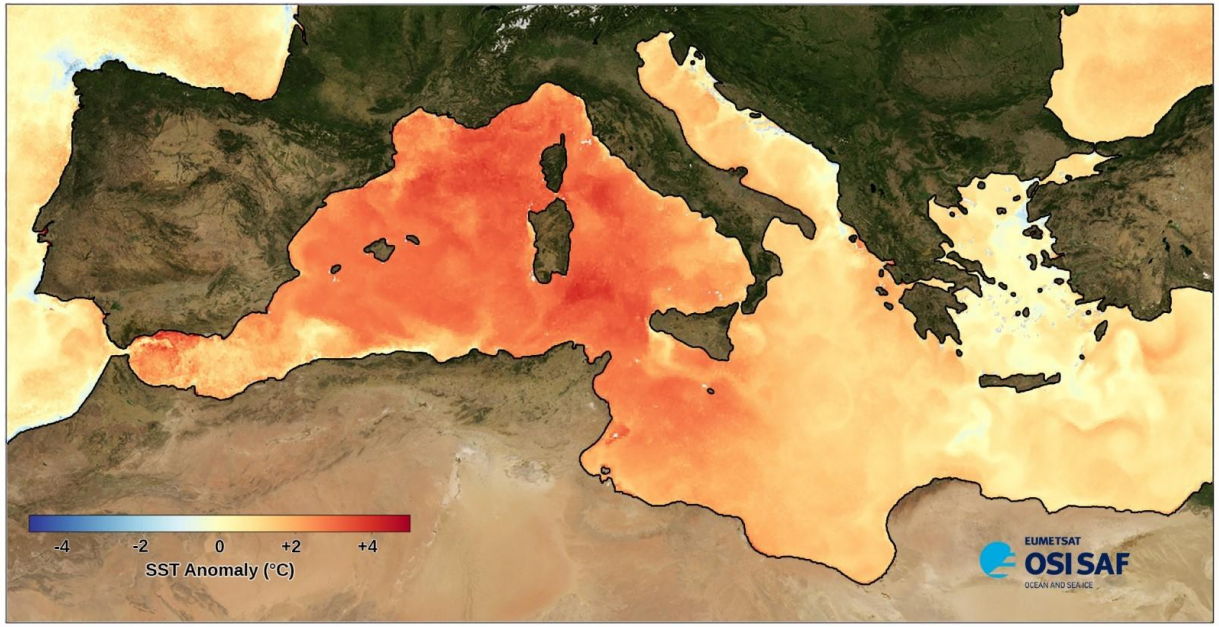
ENSO recently declared....





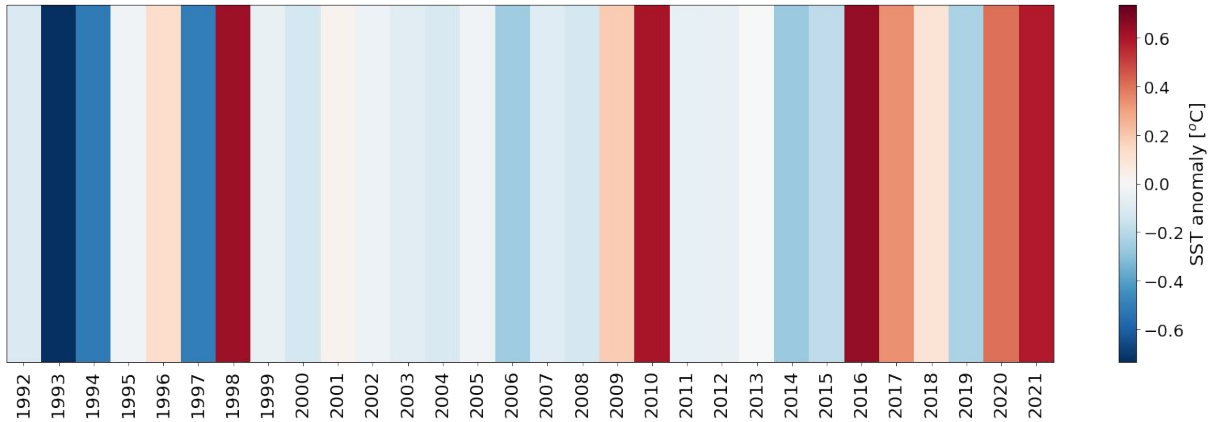
Mediterranean 2022

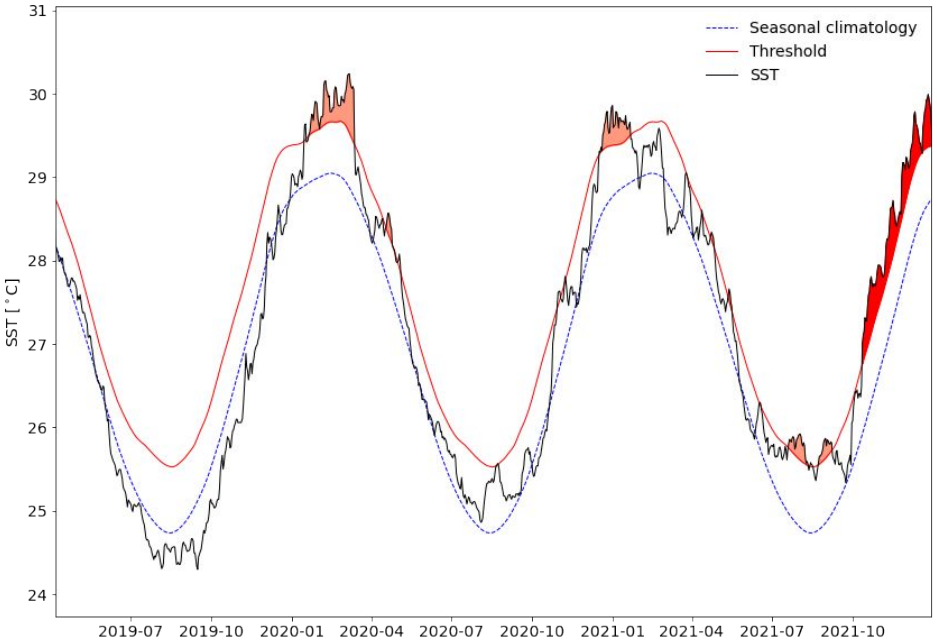
- Major marine heatwave – 5°C warmer than average.
- Contributing to established trend connecting regional MHWs with mass mortality events.
- Concern about long-term impacts on fisheries and aquaculture
- Summary article from CMEMS
- Recent paper: Guinaldo et al., 2023



Great Barrier Reef

- 91% of coral affected in 2021
- Happened during La Nina (typically cooler).





A practical look at the last example....

- Case study: https://www.eumetsat.int/marine-heatwave-intensification-threatens-coral-reef-health

- Code: https://gitlab.eumetsat.int/eumetlab/oceans/ocean-training/applications/ocean-case-studies/-/blob/main/Case_studies/UN_Ocean_Decade/Challenge02_ecosystems_and_biodiversity/Marine_heatwaves_intensification_threatens_coral_reef_health.ipynb

- Code can be run directly on the WEkEO Jupyterlab or after suitable set up (see README)

Thanks for listening! Please ask me questions on slido

Want to know more?

- EUMETSAT Helpdesk:
  - ops@eumetsat.int
- Upcoming training events on EUMETSAT Copernicus marine EO data:
  - https://training.eumetsat.int/
- Code resources for working with EUMETSAT Copernicus marine EO data:
  - https://gitlab.eumetsat.int/eumetlab/oceans
  - https://github.com/wekeo/wekeo4oceans
- Examples of data in use:
  - https://www.eumetsat.int/case-studies

- My Twitter:
  - @brloveday

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