Warming trends and extreme events analysis from **high resolution temperature observations** in Mediterranean coastal areas: insights for the assessment of **coastal ecosystems vulnerability to climate change**

Nathaniel Bensoussan, Joaquim Garrabou & T-MEDNet network

Bensoussan N.[1], Garrabou J.[1], Linares C., Cebrian E., Kipson S., Teixido N., Romano J.C., Ramos-Esplà A., Kersting D.K., Riera i Arago V., Payrot J., Blouet S., Bachet F., Charbonnel E., Zuberer F., Pairaud I., Sartoretto S., Bergere H., Houard T., Dominici J.M., Negre-Santucci N., Harmelin J.G., Ruiz J.M., Ledoux J.B., Zabala M., Topcu E., Ozturkb B., Sini M., Bensoussi J., Ghanem R., Ocaña O., Reñones O., Díaz D., Kızılkaya Z. et al.

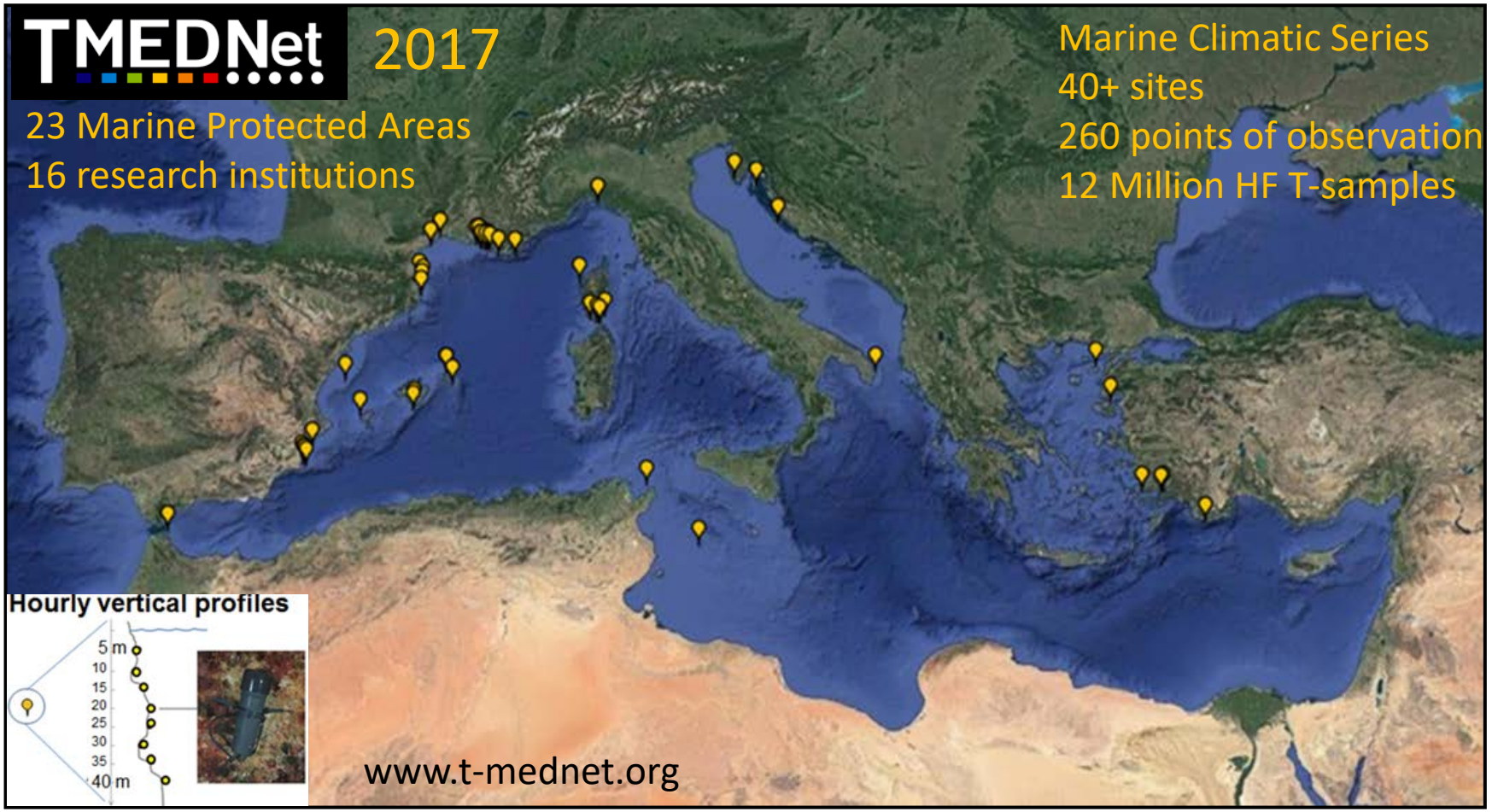
Scientists:

Managers:

International Mistral workshop – Climate Change Impacts in the Mediterranean Region
16-18 October 2017, Montpellier - France

- # T-MEDNet Coastal warming Mediterranean observation network

Build the first line of CC sentinel sites in coastal-littoral zone at Mediterranean scale
the Alboran, W-MED, Adriatic, Tunisian, Aegean Seas



Scientists:

Managers:

- **T-MEDNet protocol for HF T-profiling in coastal waters**

Thermographs set to 1 hour

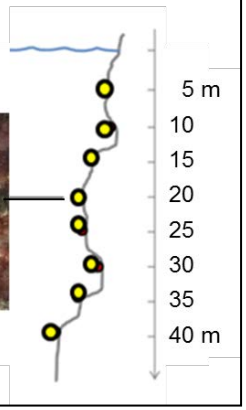
Tidbits v2

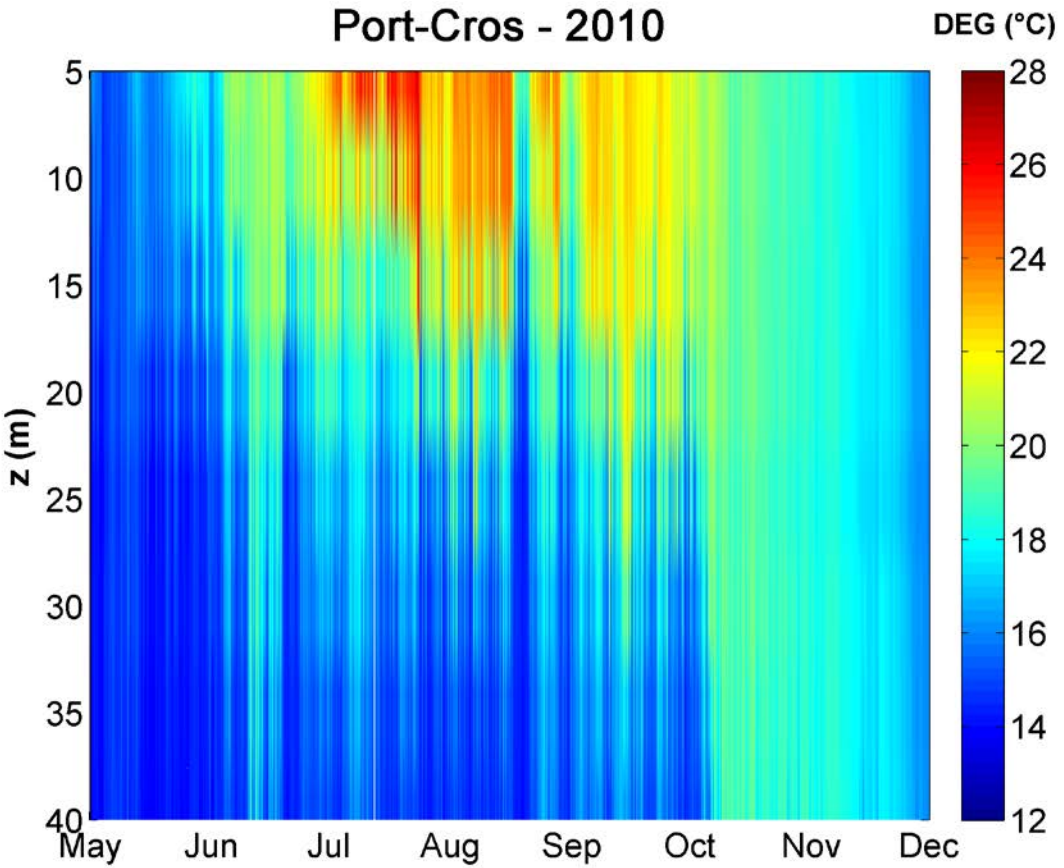
Hobo Water Temp pro v2

Specifications
Controled vs. SBE56

Accuracy : 0.2°C
Resolution : 0.01°C

Installed by divers 5:5:40 m

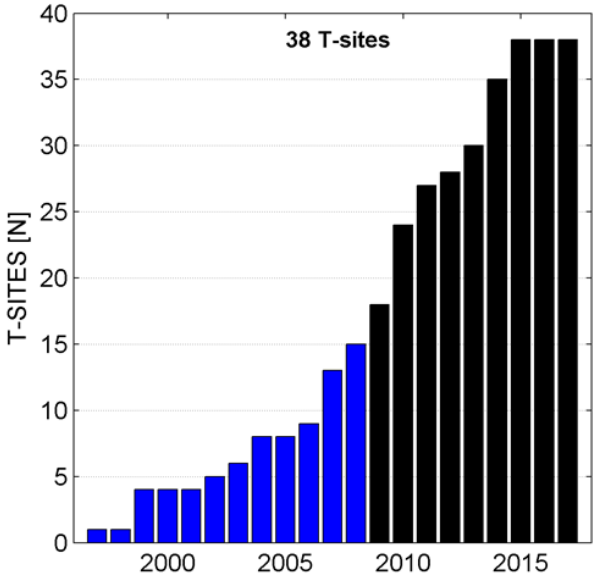


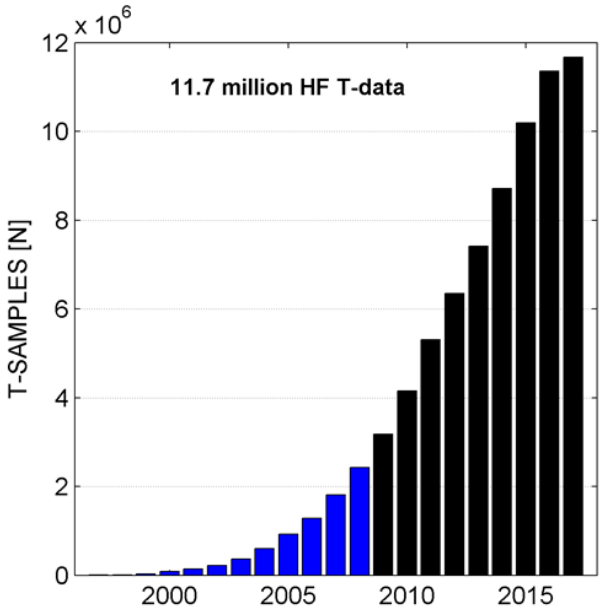


Recovered twice a year by divers

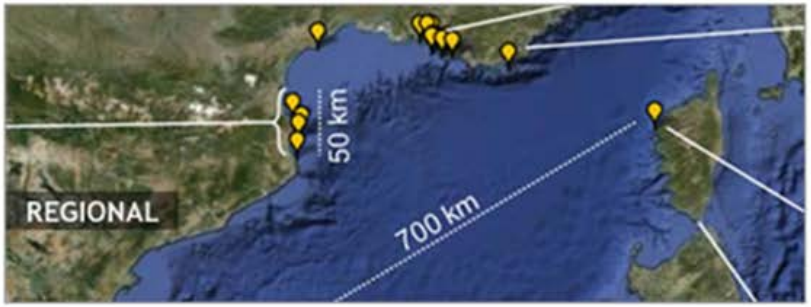
Cost effective – High resolution – Long-term

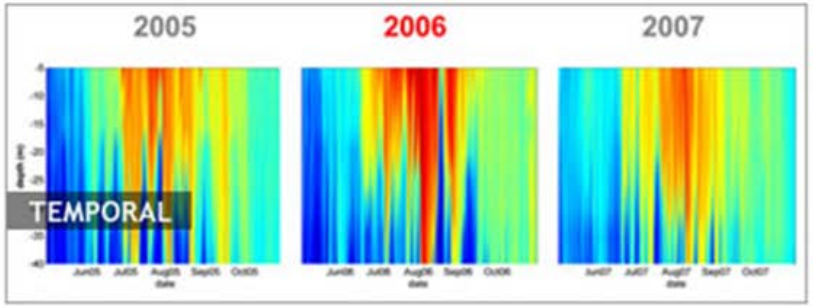
- **Build observation network** **Time sequence of sites equipment and data acquisition**

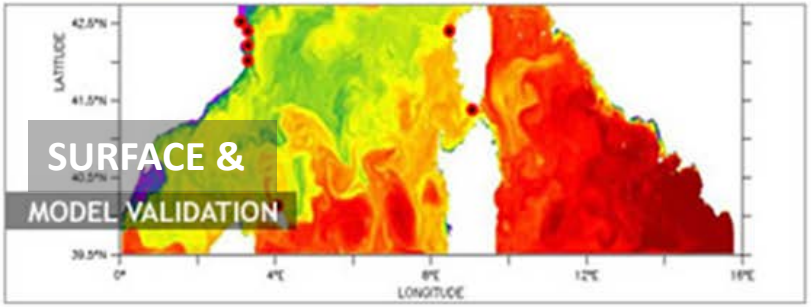




RESULTS


50 km
700 km
REGIONAL

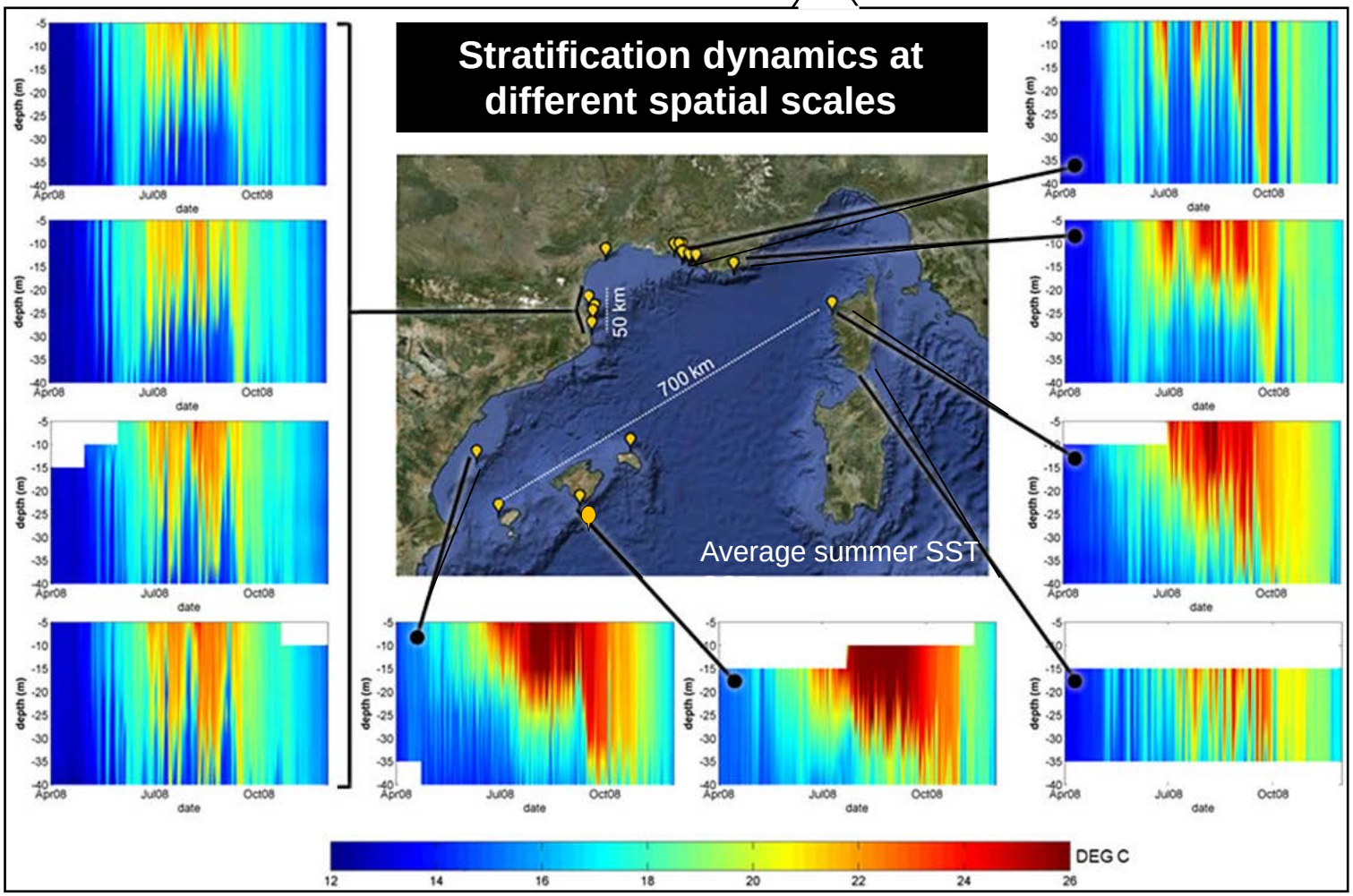

2005
2006
2007
TEMPORAL


LATITUDE
LONGITUDE
SURFACE &
MODEL VALIDATION

MORTALITY EVENTS

- **Stratification dynamics over extensive spatial and temporal scale for the very first time in Mediterranean coastal waters**

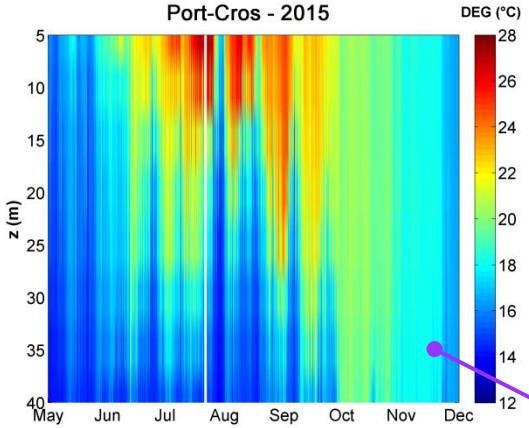
1999 - 2000 - 2001 - 2002 - 2003 - 2004 - 2005 - 2006 - 2007 - **2008 -** 2009 - 2010 - 2011 - 2012 - 2013 – 2014…

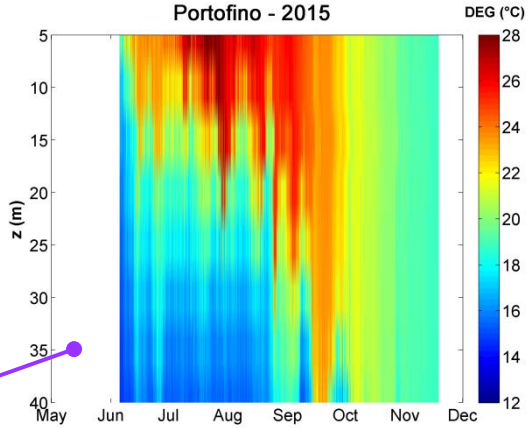


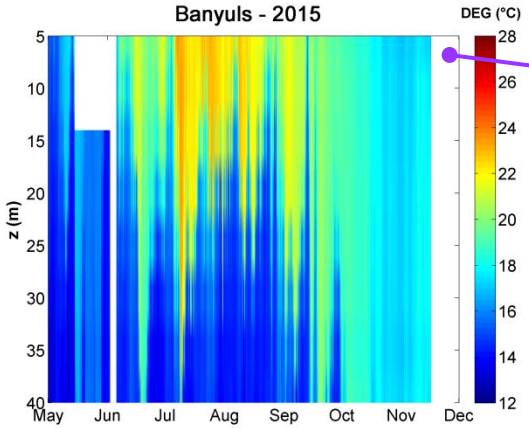
A year acoss the network

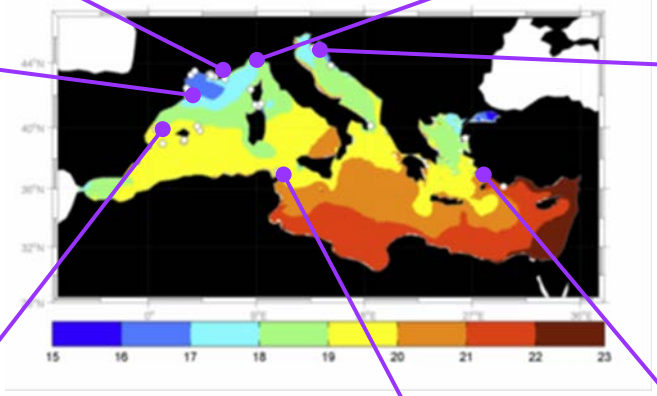
TMEDNet

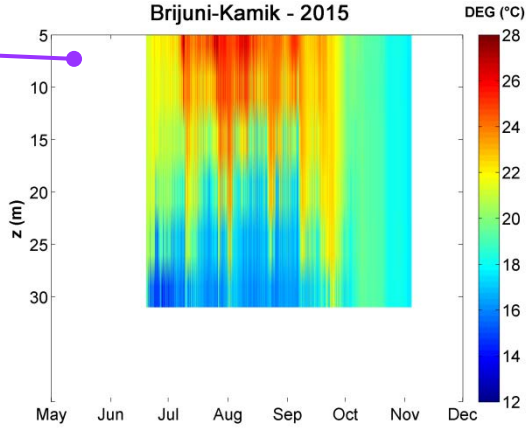
2015

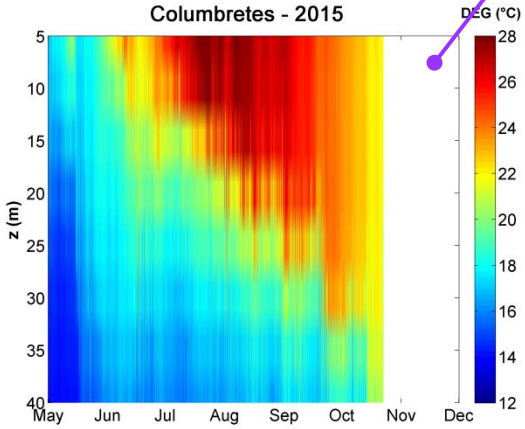


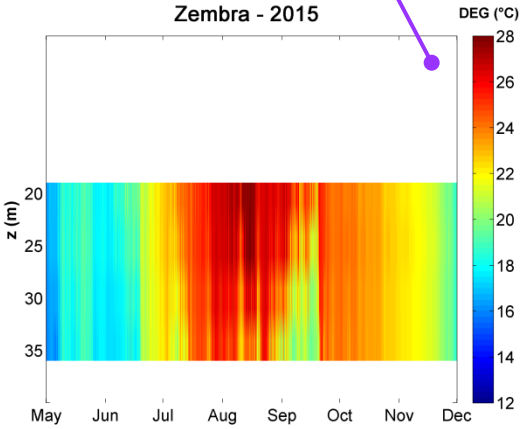


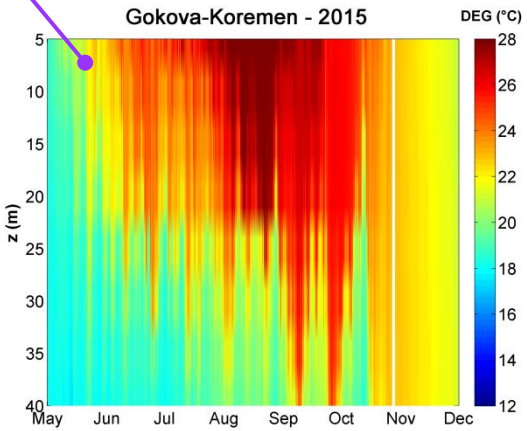




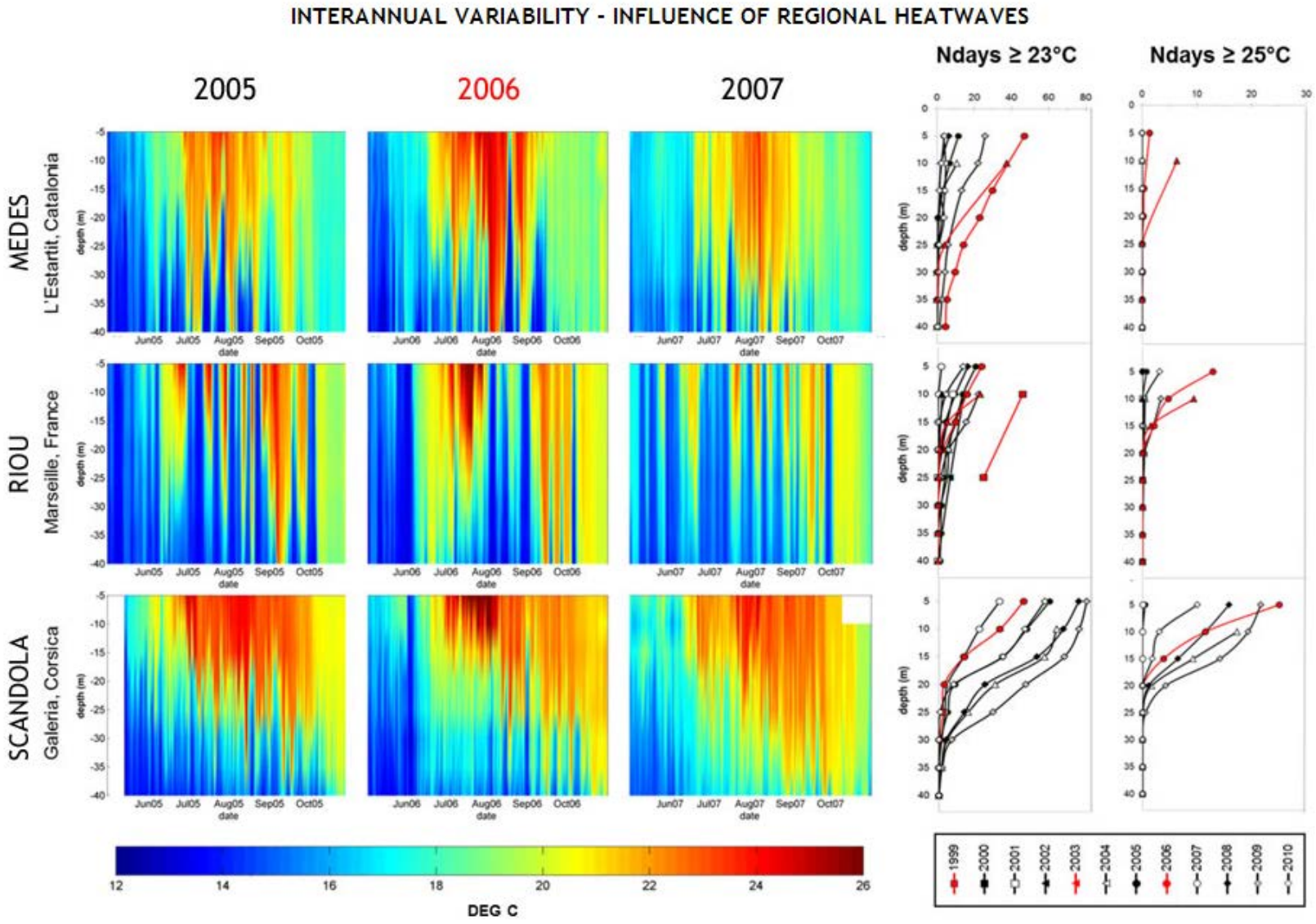




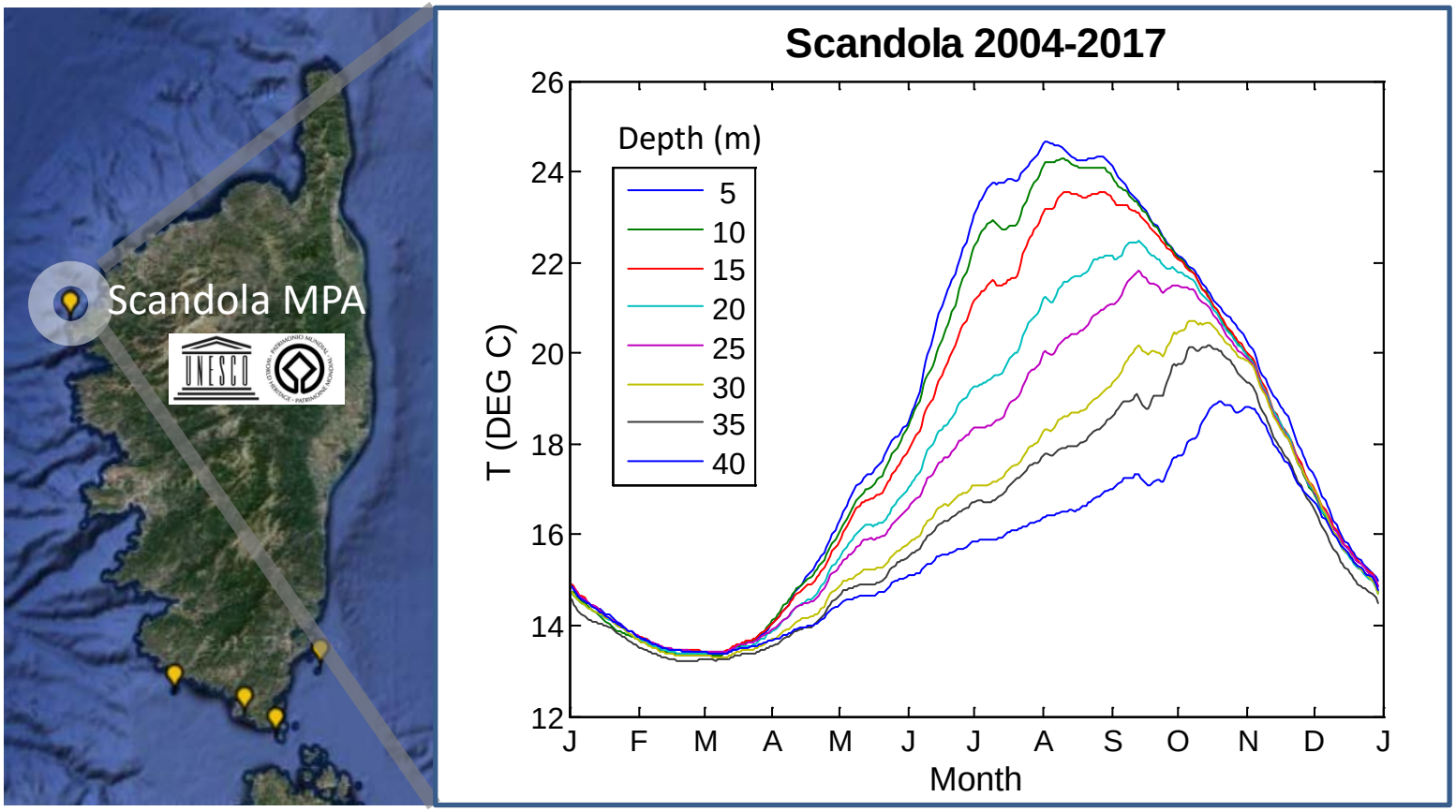




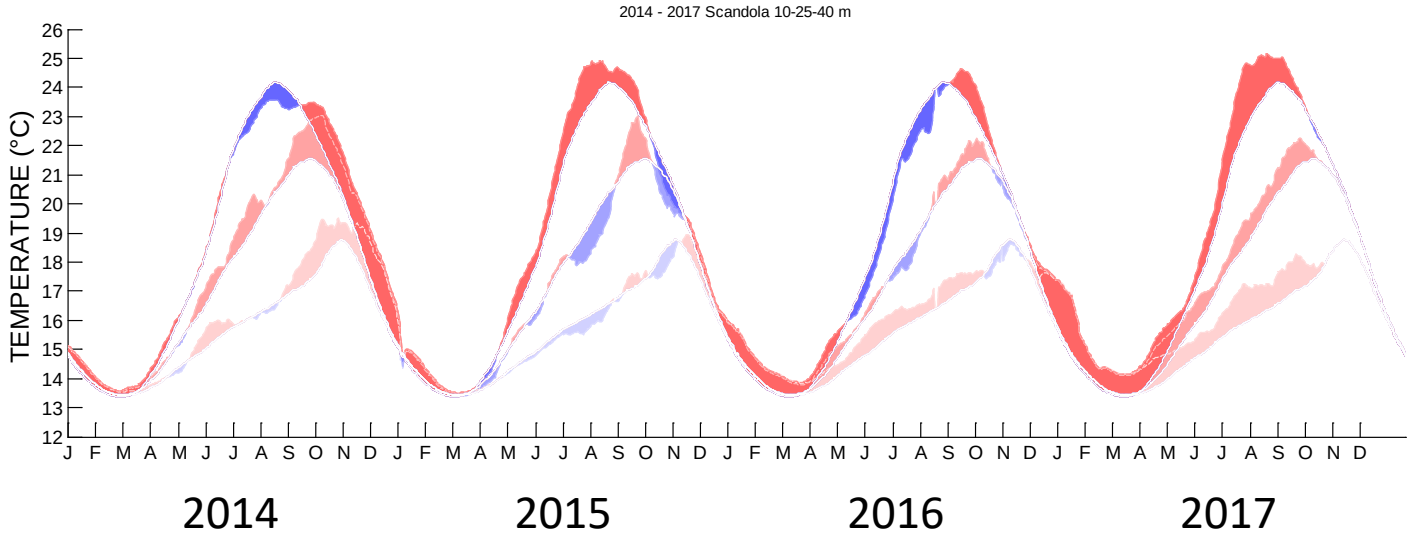
- **Interannual variability – influence of regional heatwave**

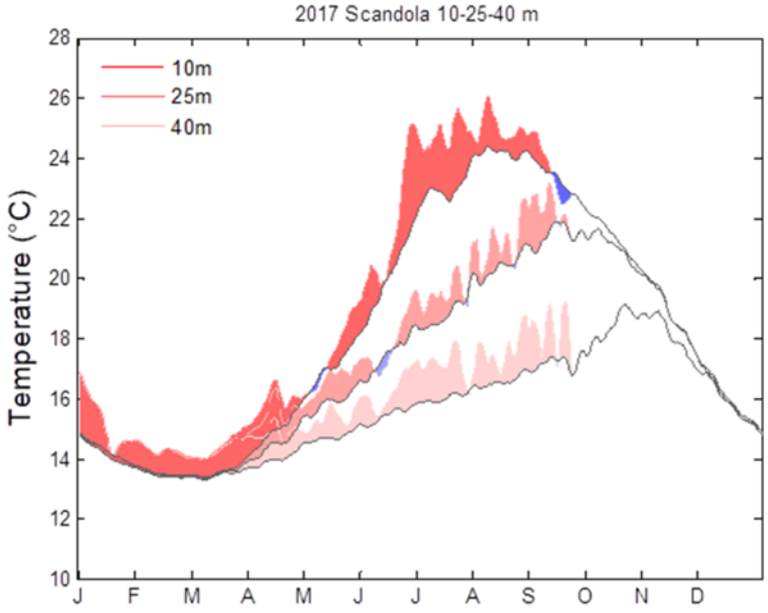


- **Build robust baselines on T-conditions at depth**
  - Marine « climatologies », mean, inter-annual variability
  - Contrasted seasonality (timing, amplitude)
  - Actual extreme warm conditions (percentiles)



- **Detect in situ anomalies**

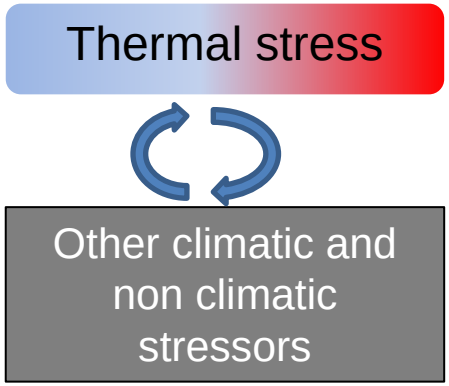


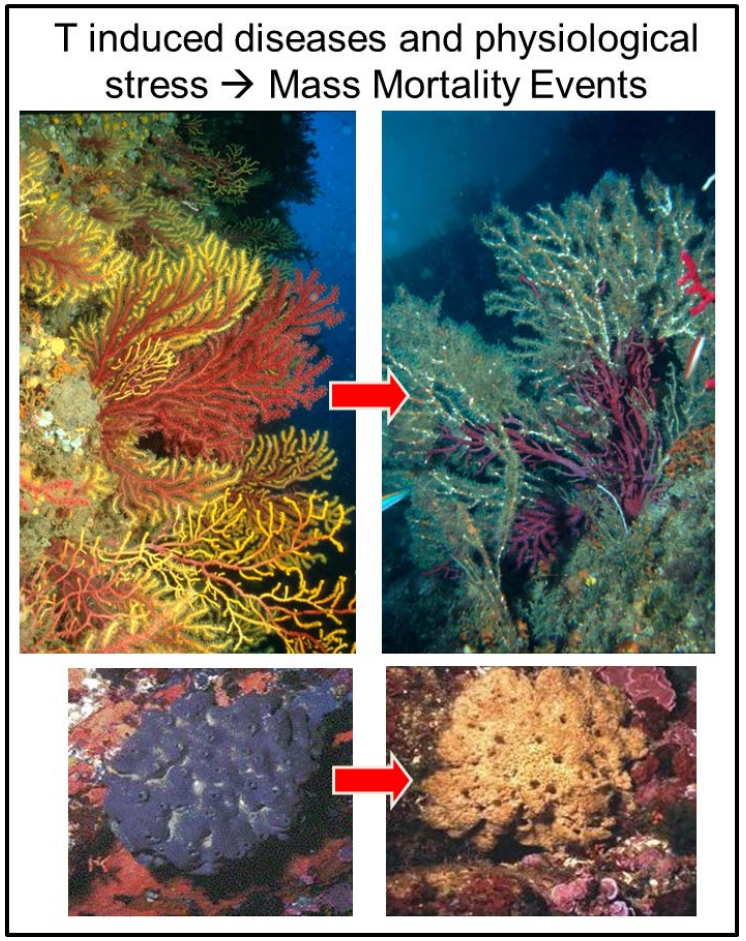


- **Explore relationship with biological indicators**

- Changes in species distribution
- Changes in phenology
- Mass Mortality Events (MMEs)

Combined effects on essential habitats ?

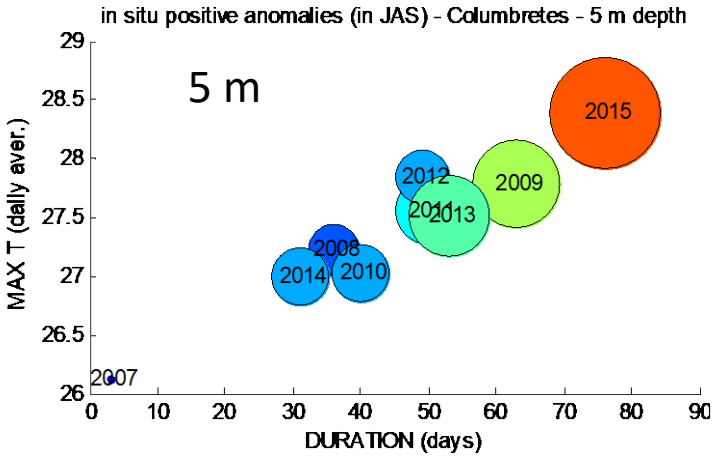


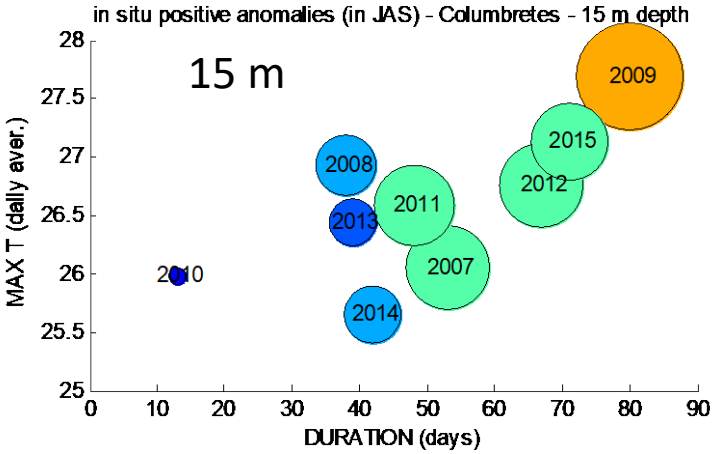


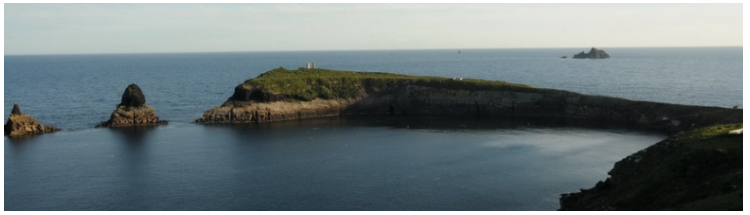
2003 heat wave triggered mortality of at least 25 macro invertebrate benthic species:

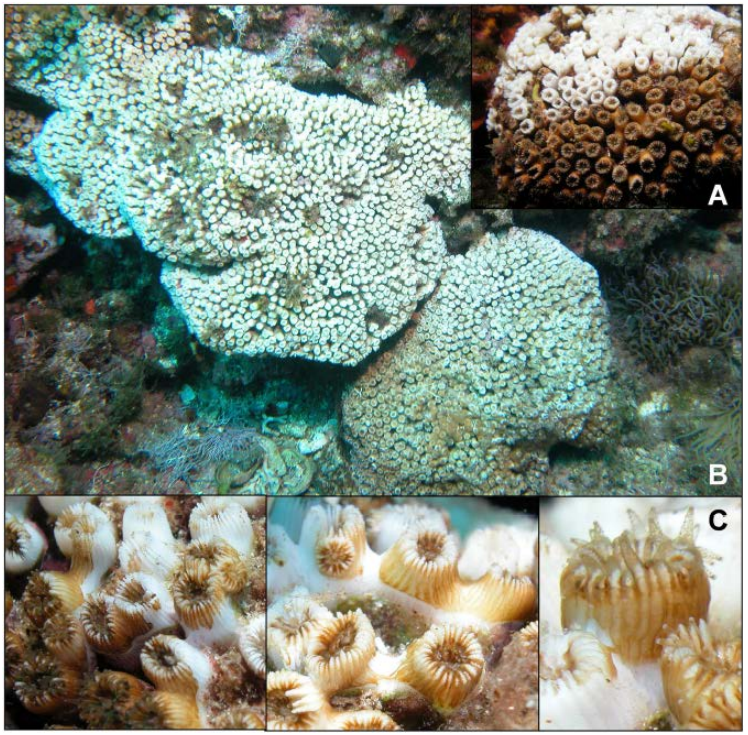
Garrabou et al. 2009 Global Change Biology

- **Explore relationships with biological indicators**
  - Mass mortality of benthic invertebrates









Kersting et al. 2013 PLOS ONE

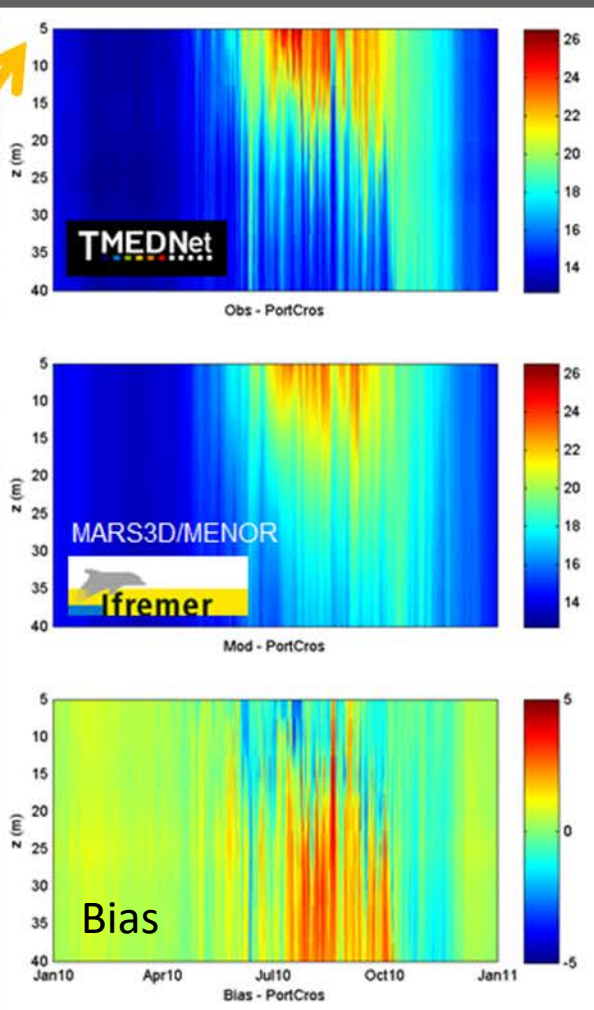
- **SST & Model validation / statistical downscaling**

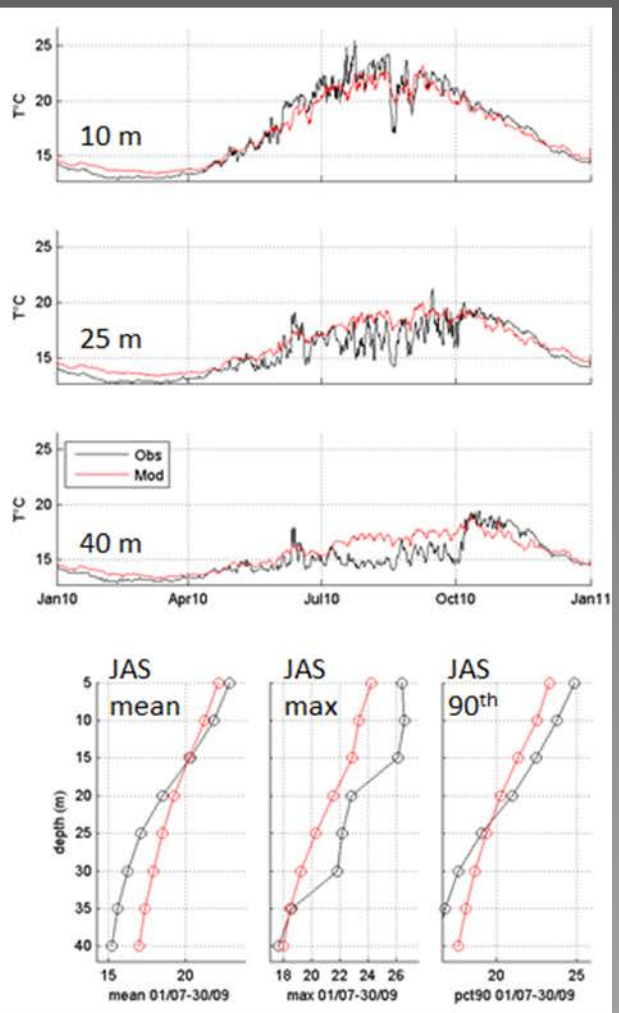
  Diagnosis and exploratory tools for CC VIA studies in complex and highly dynamic coastal zone

Different simulations from regional and basin models of different resolution

Ifremer
MARS3D
400m, 1200m

CNRM-GAME
NEMO MED8
1/8° degrès

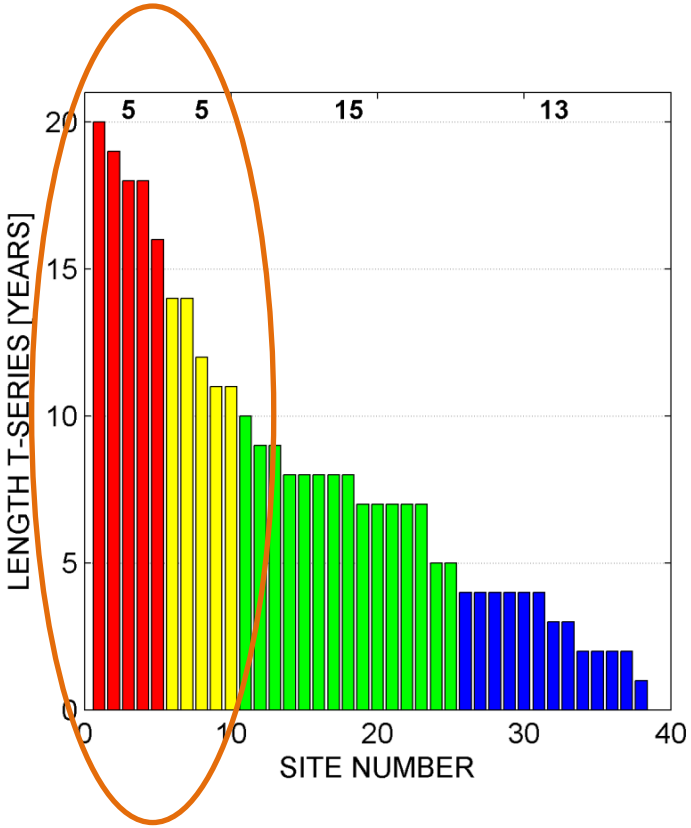


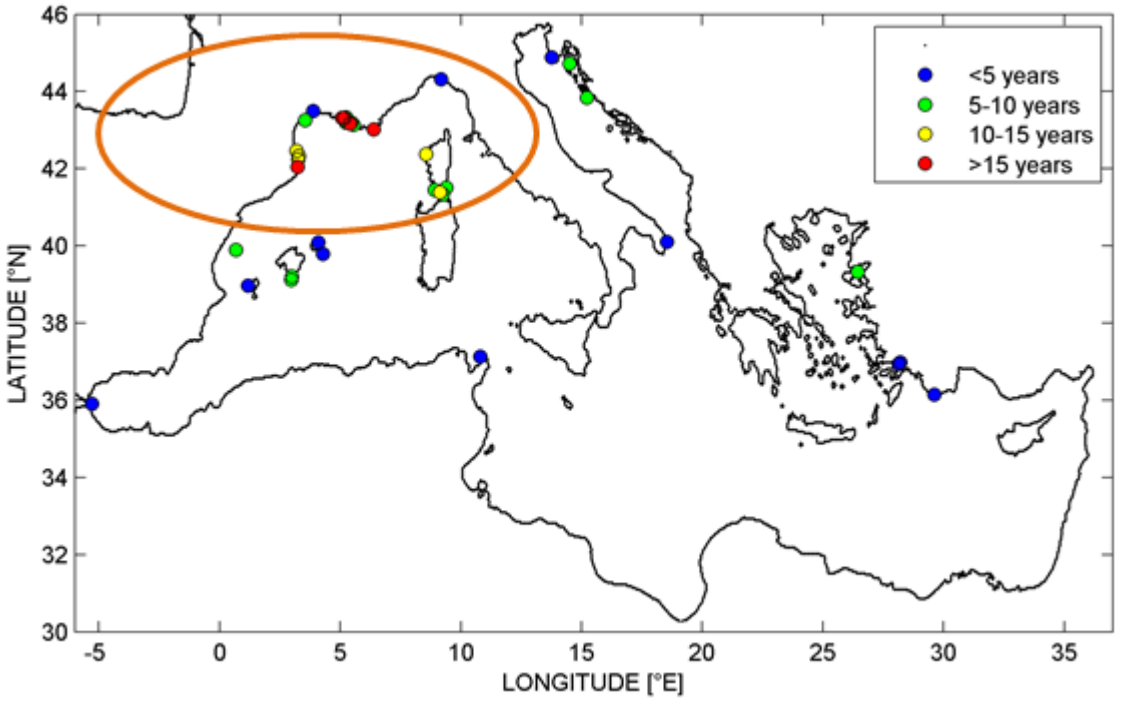


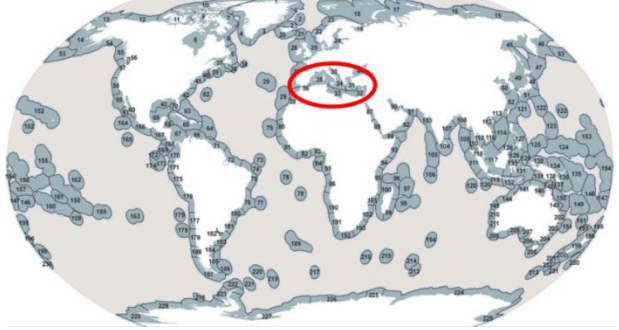
Wish: long homogenous hindcasts

Warming signals

- **Continuous observation effort and long-term commitment**
  - Long-term HR T-series (>10 years) in the NW-Mediterranean Sea
  - Pluri-annual HR T-series in different Mediterranean ecoregions

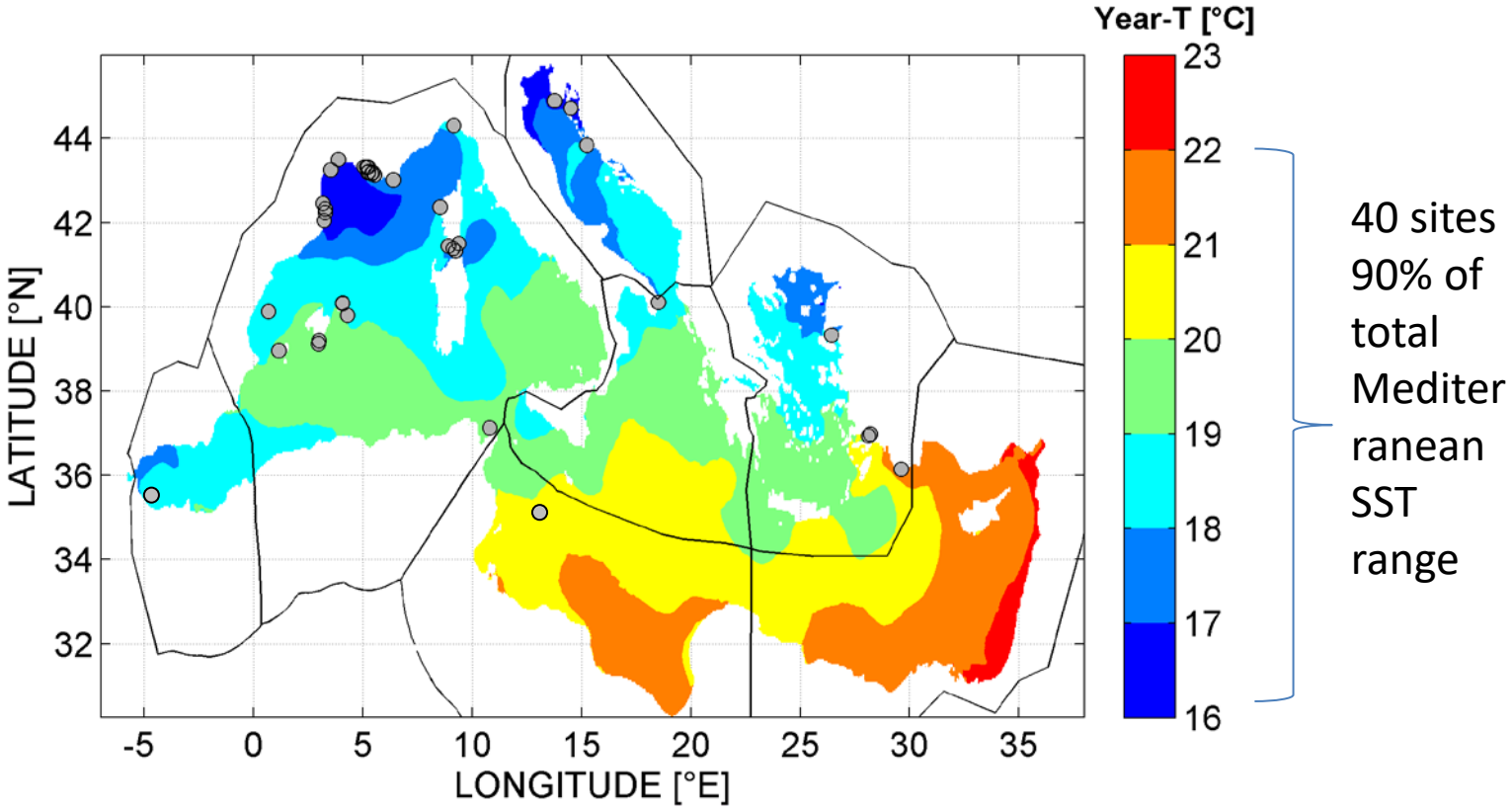




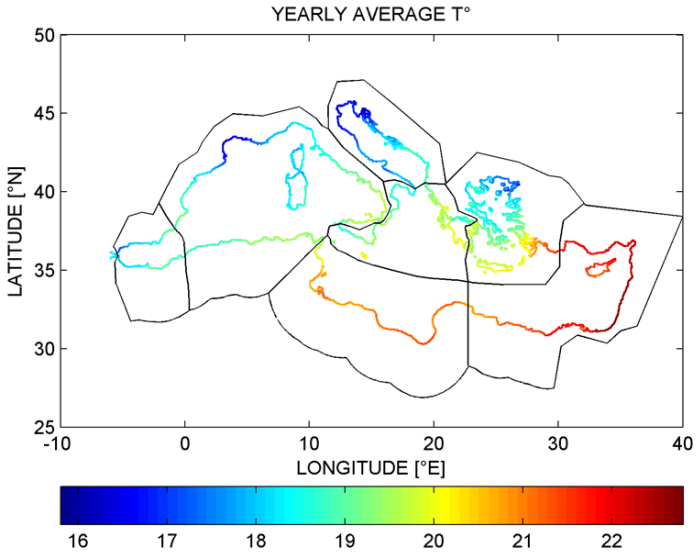


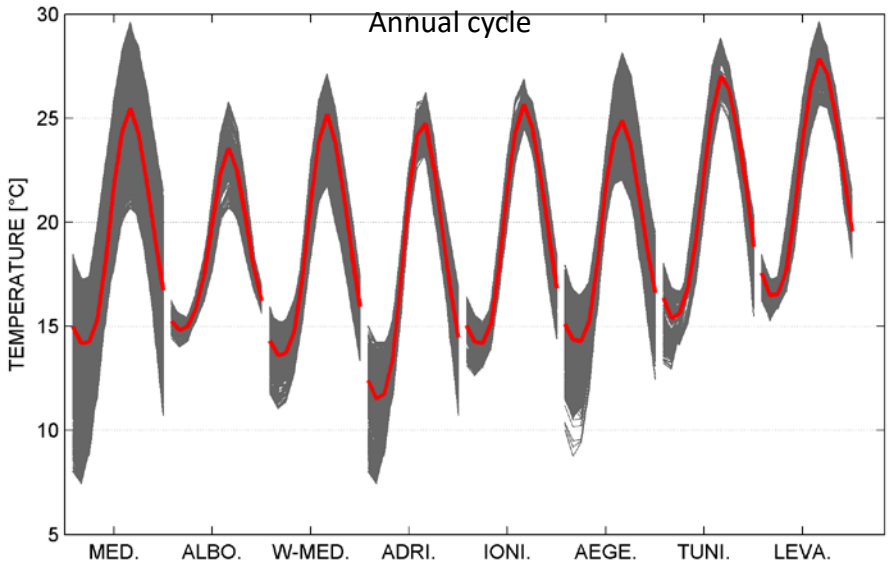
- **HR T-series considered**
  - T-MEDNet T-series (in situ vertical profiling 0-40m)
  - Satellite SST reanalysis 1982-2016 (CMEMS product)

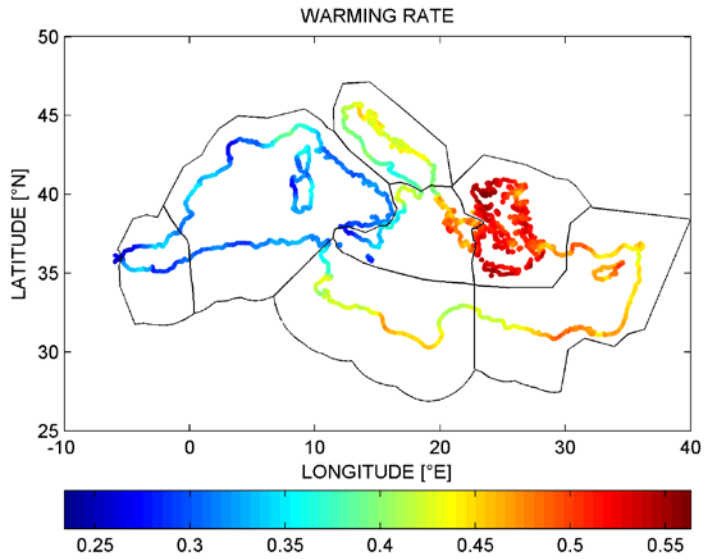
  - Conducting a regional to sub-regional (MEOW) to local (T-MEDNet sites) approach.

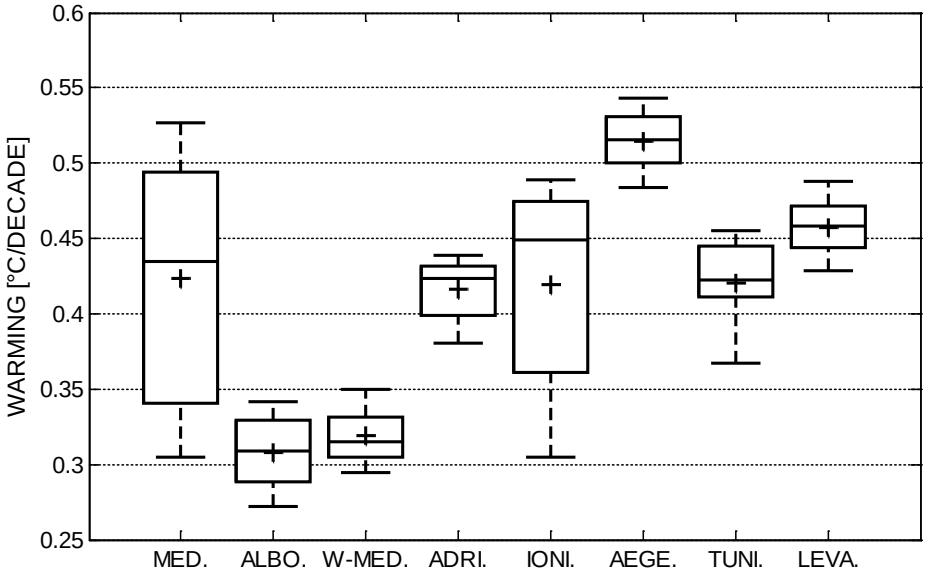


- **Regional to sub-regional coastal SST annual cycle and trends**





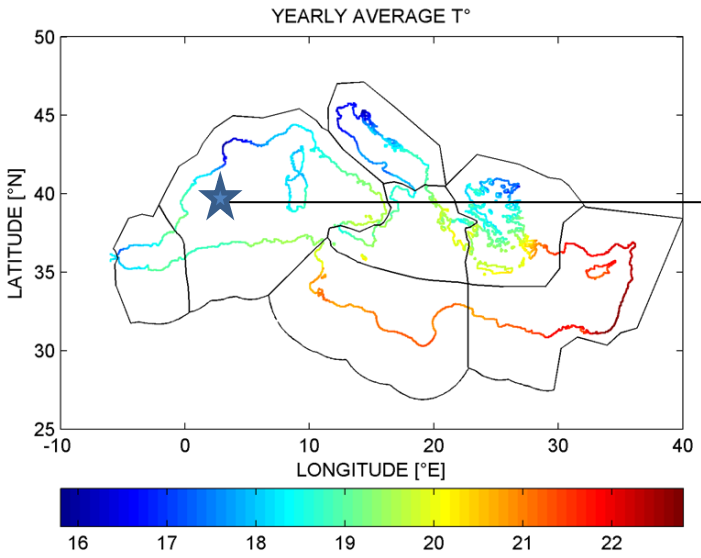


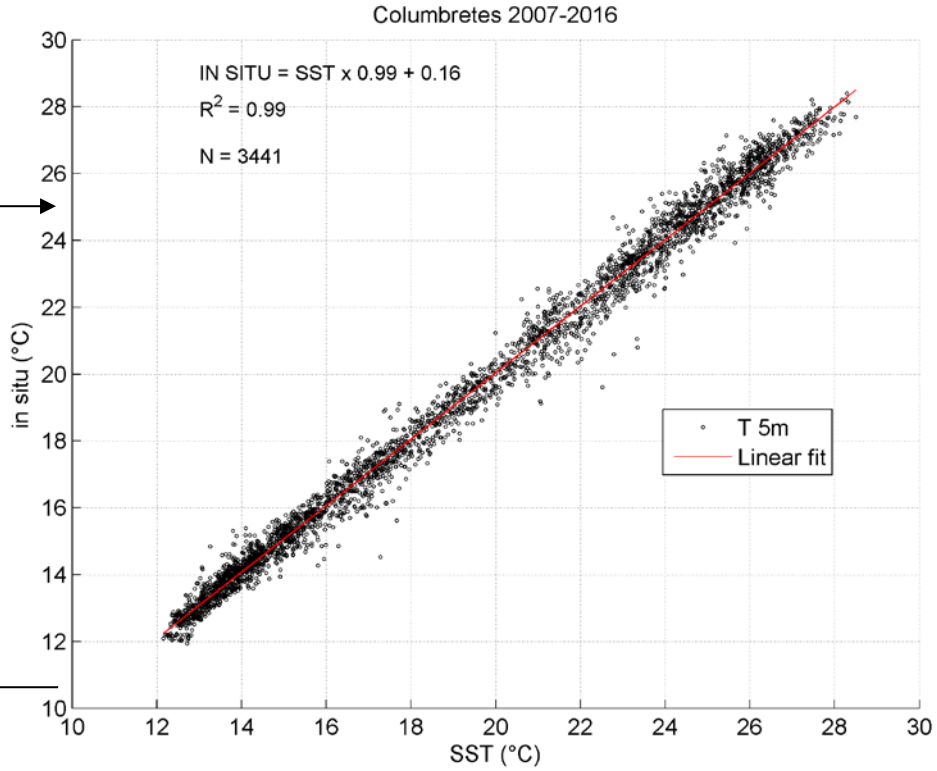


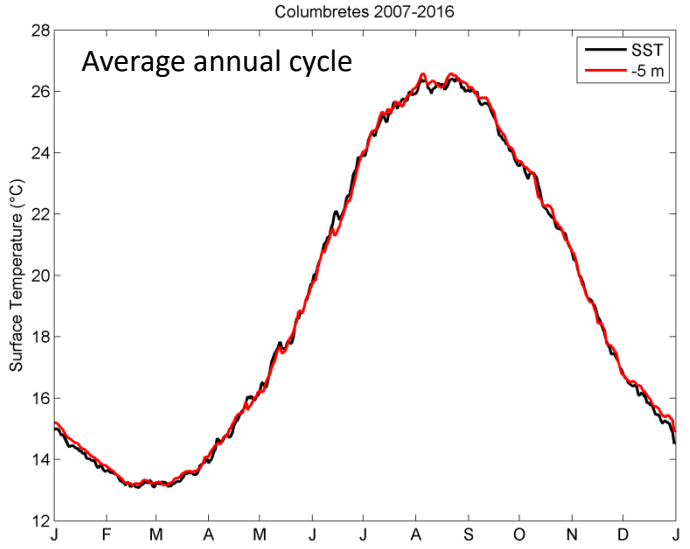
Bensoussan et al. In prep.

Site-specific surface validation (SST observations and products)

- SST vs site-specific conditions

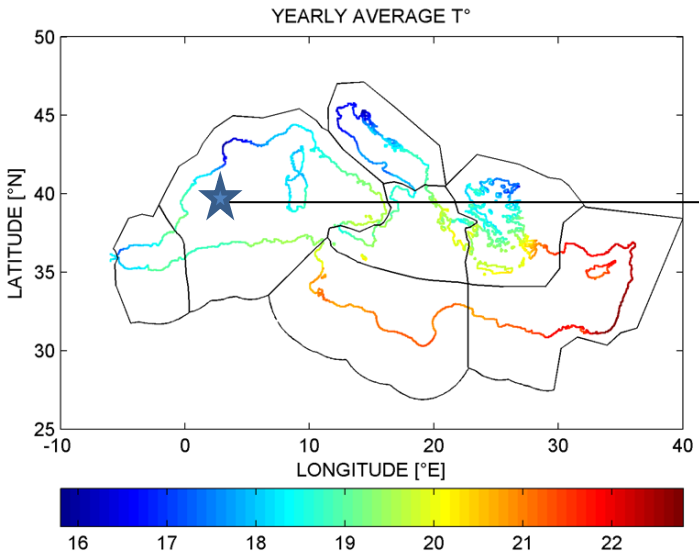


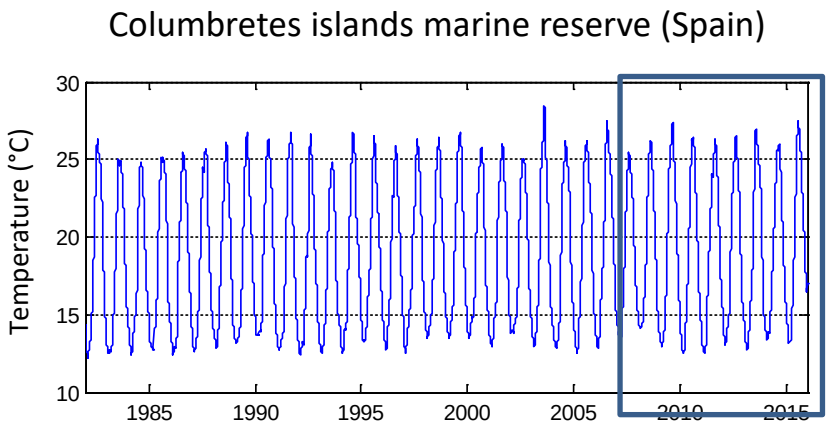




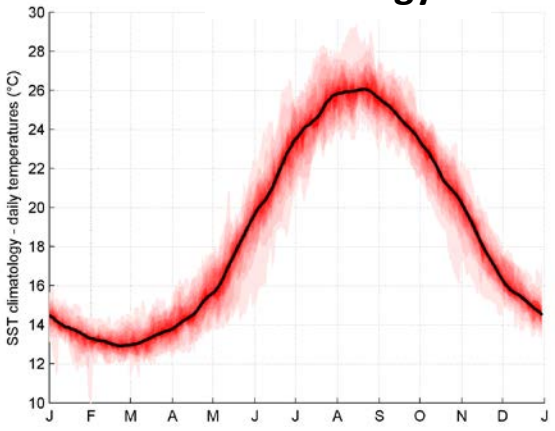
Bensoussan et al. In prep.

- **Validated SST reveal more than warming**
  - Climatology, warming, shift in the distribution of extreme warm days

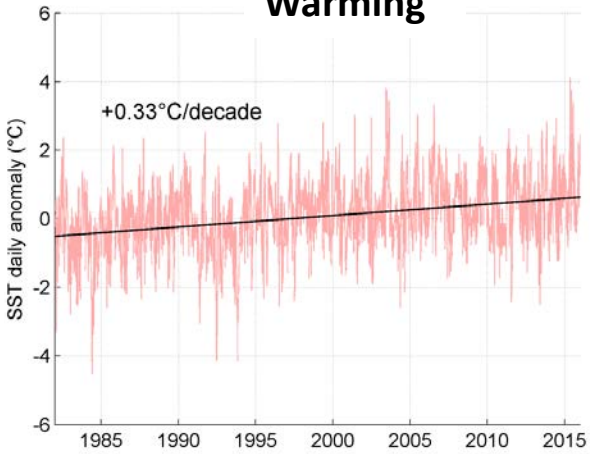




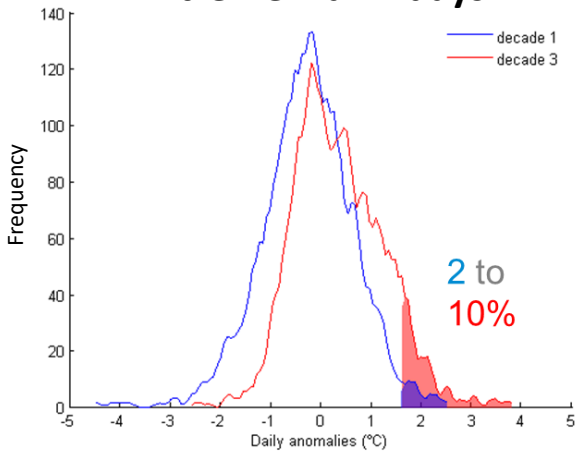
Climatology



Warming



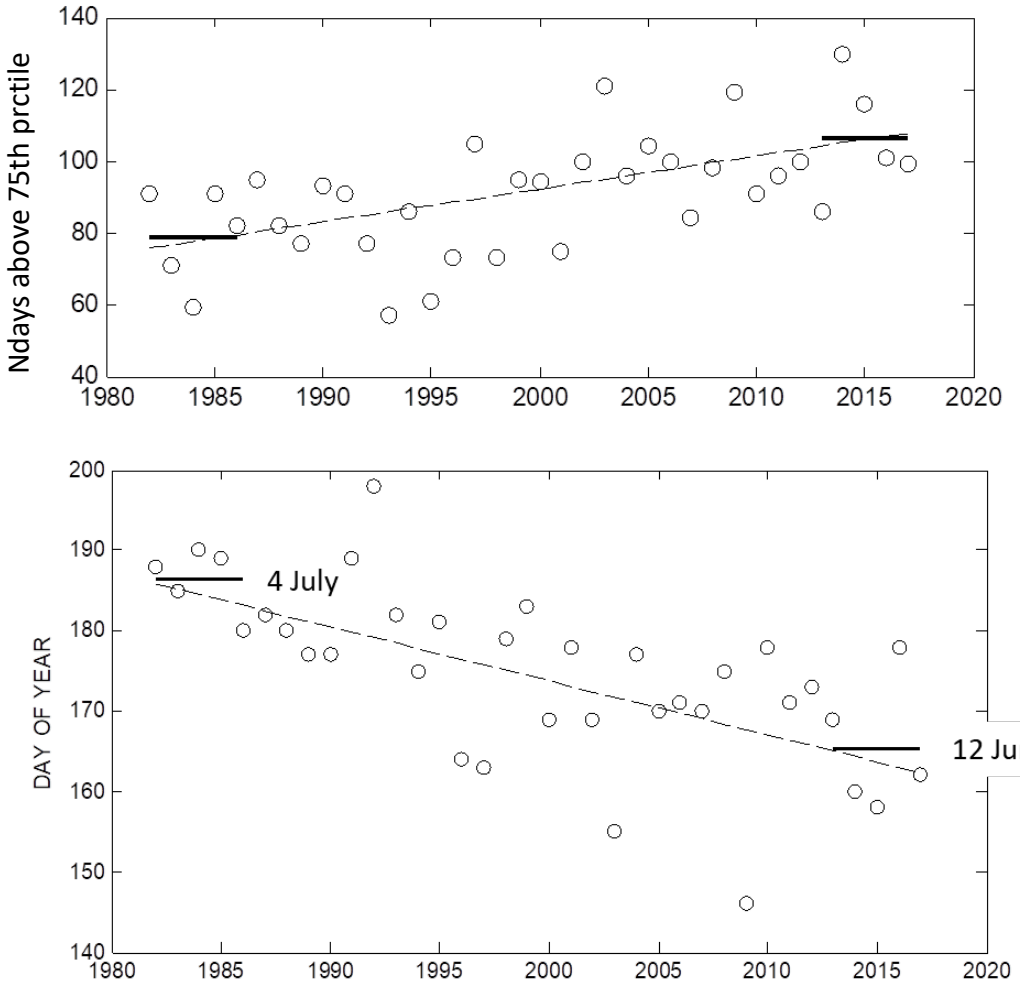
Extreme warm days



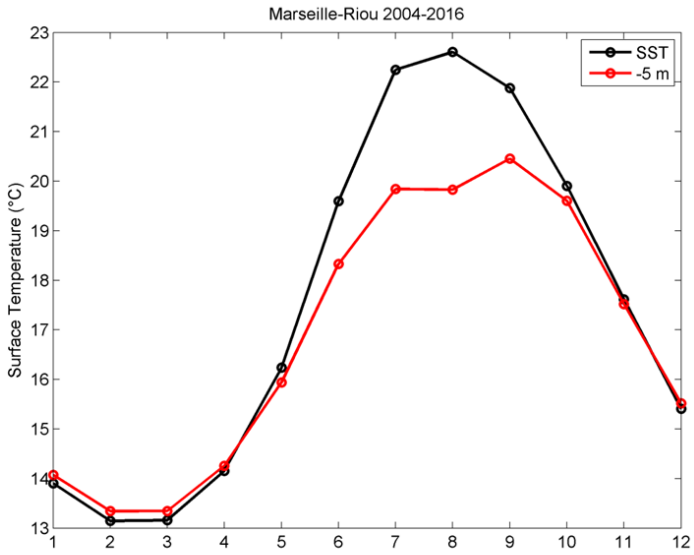
SST data source:CMEMS

Bensoussan et al. In prep.

- **Validated SST reveal more than warming**
  - Longer and earlier warm conditions

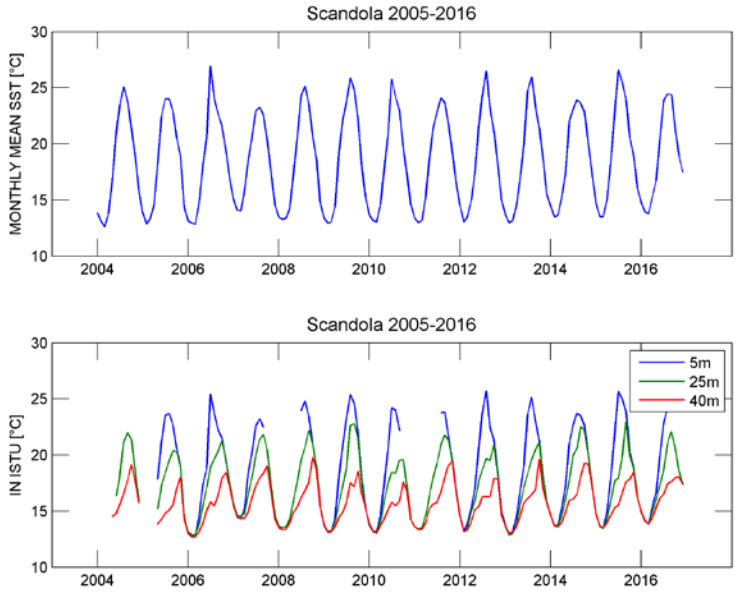


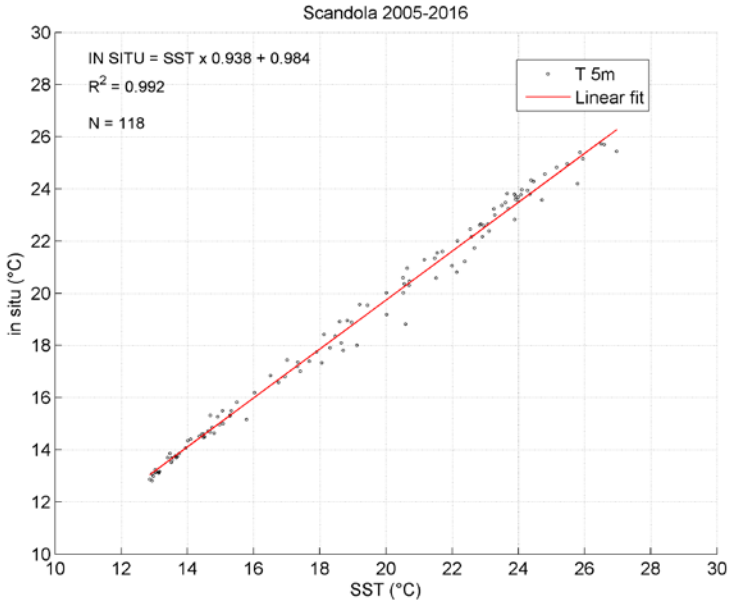
But nothing is so easy.
Evaluation is being implemented at network scale.

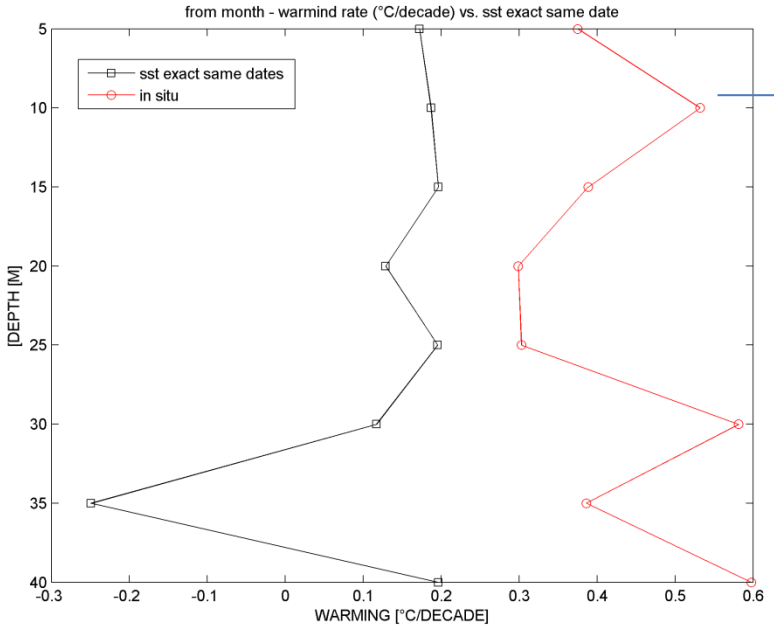


Bensoussan et al. In prep.

• TRENDS: in situ vs SST – Scandola MPA, PNRC



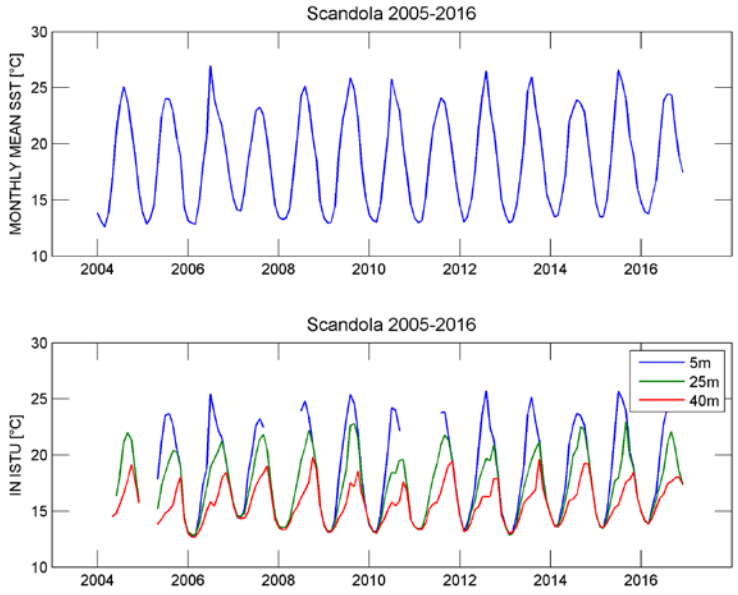


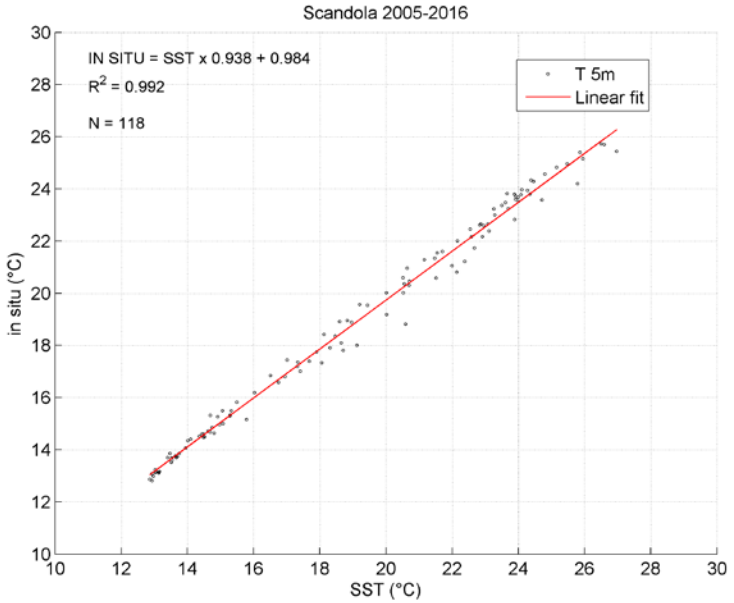


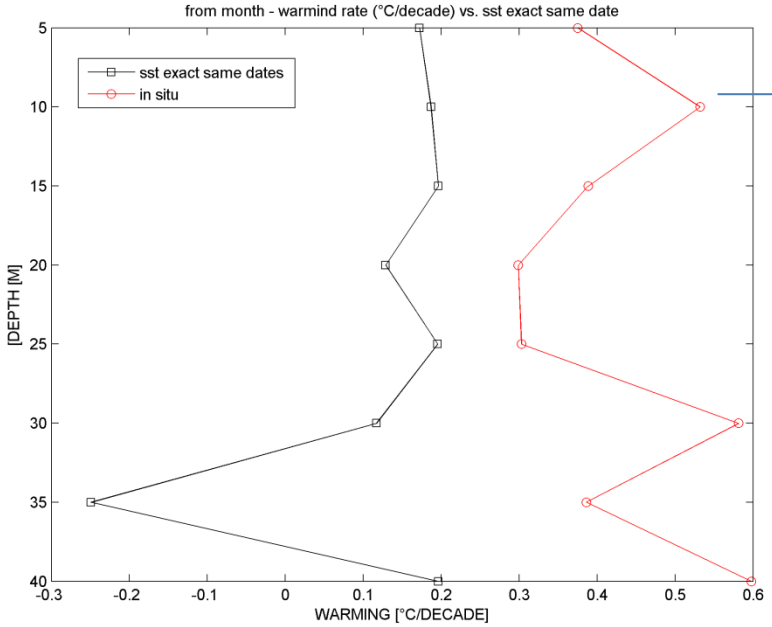
- Significant surface warming 2004-2016
- In situ warming is higher than rates infered from satellite SST

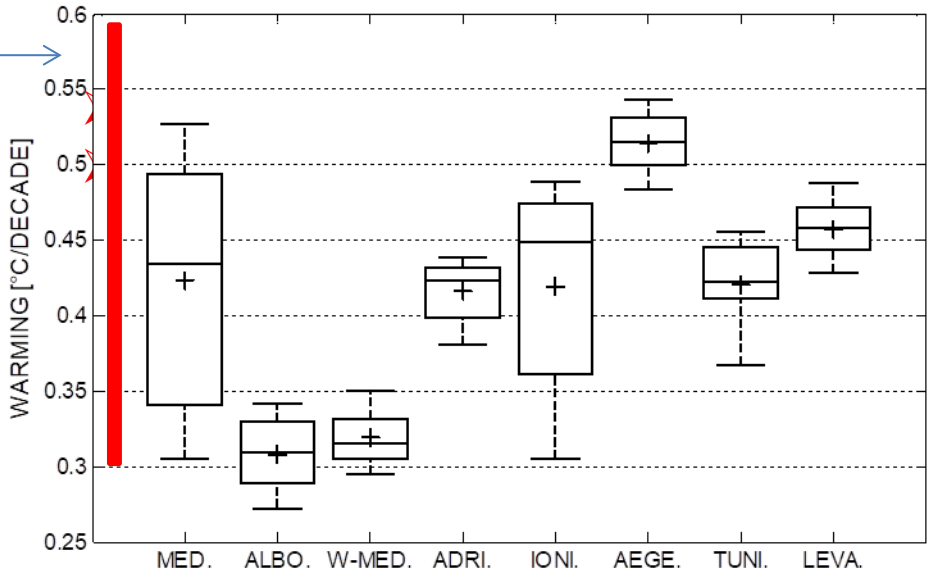
Bensoussan et al. In prep.

TRENDS: in situ vs SST – Scandola MPA, PNRC



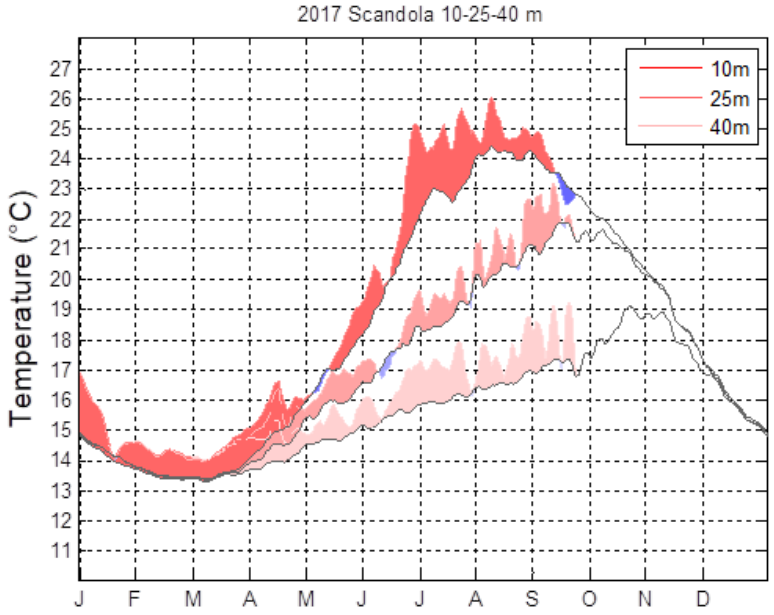


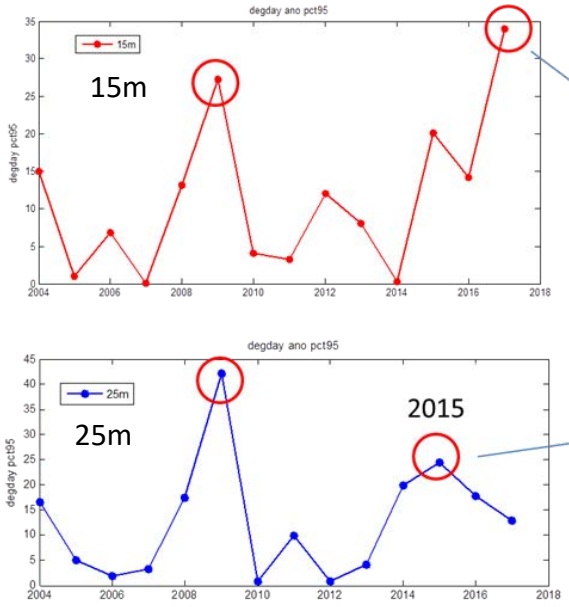




Conclusion and perspectives

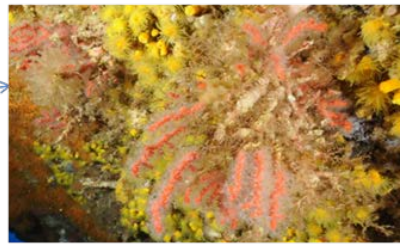
- Mass Mortality Events of sensitive macrobenthic invertebrates are occuring now in Spain, France, including Corsica, and Italy under a very particular T-regime.
- Compared to 1999 and 2003, observation infrastructures and baselines data acquired should permit better impact assessment and to deepen understanding of driving factors and potential synergies in view of vulnerability assessment.
- Recurent MMEs at the different depth levels are likely to cause shifting down of upper distribution limit of sensitive and associated species.
- Statistical downscaling (coastal transfer functions) and vulnerability assessment under MedCordex 21st century scenario represent a challenging and promising devlopment with potential application to other biological models and processes.





Sponges mortality

Red coral mortality



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Thank you for your attention

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