Ocean Acidification observations - contributions from the Mediterranean community

The Ocean Acidification Mediterranean-Hub (OA Med-Hub)

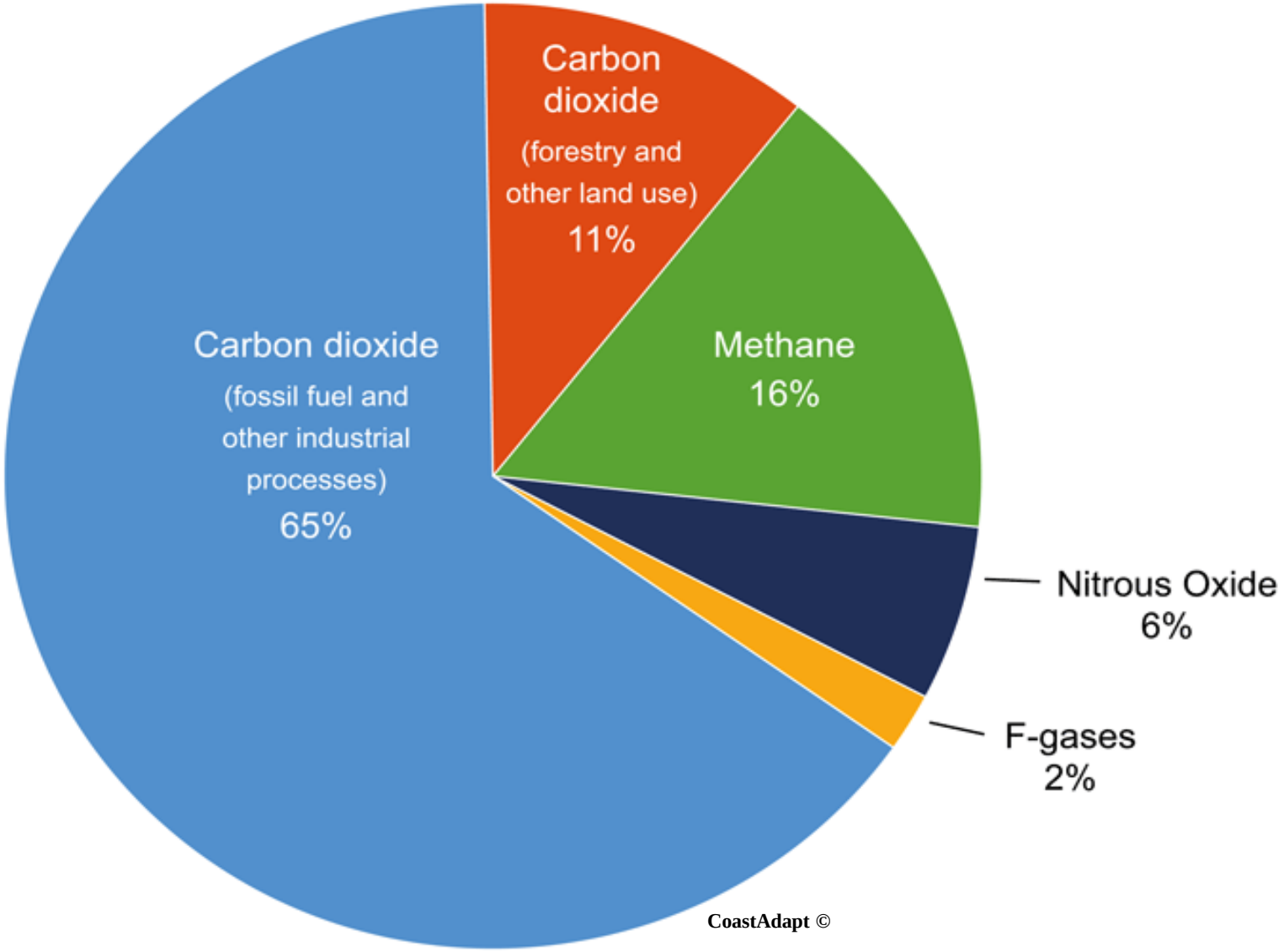
Abed El Rahman HASSOUN (GEOMAR/CNRS-L, Lebanon/Germany), Nayerah SHALTOUT (NIOF, Egypt), Fatima Zohra BOUTHIR (INRH, Morocco), Iris E. HENDRIKS (CSIC, Spain), Steeve COMEAU (SU-CNRS, France), Nina BEDNARSEK (NIB/Marine Biological Station, Slovenia), Michele GIANI (OGS, Italy), Evangelia KRASAKOPOULOU (U.Aeagean, Greece), Sarah FLICKINGGER (IAEA, Monaco)

❖General context: Climate change?

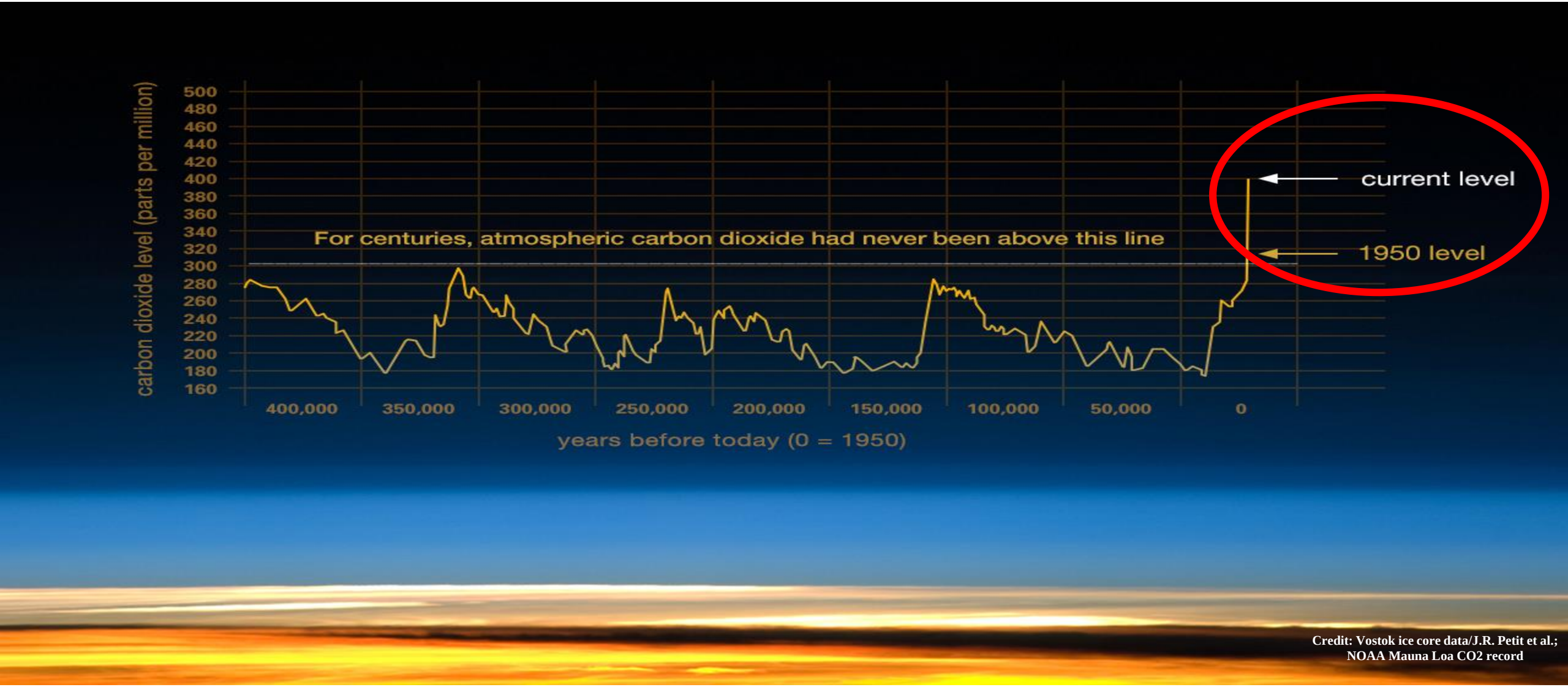
- Climate change is a modification in the statistical distribution of weather patterns and average weather conditions for an extended period of time (i.e., decades to millions of years).
- In 1966, the World Meteorological Organization (WMO) proposed the term "climatic change" referring to all forms of climatic variability on time-scales longer than 10 years.
- Climate change is attributed to many natural factors such as variations in solar radiation received by Earth, plate tectonics, and volcanic eruptions.
- **However**, certain human activities have been identified as primary causes of ongoing climate change.

❖General context: Causes of Climate change

❖General context: Causes of Climate change



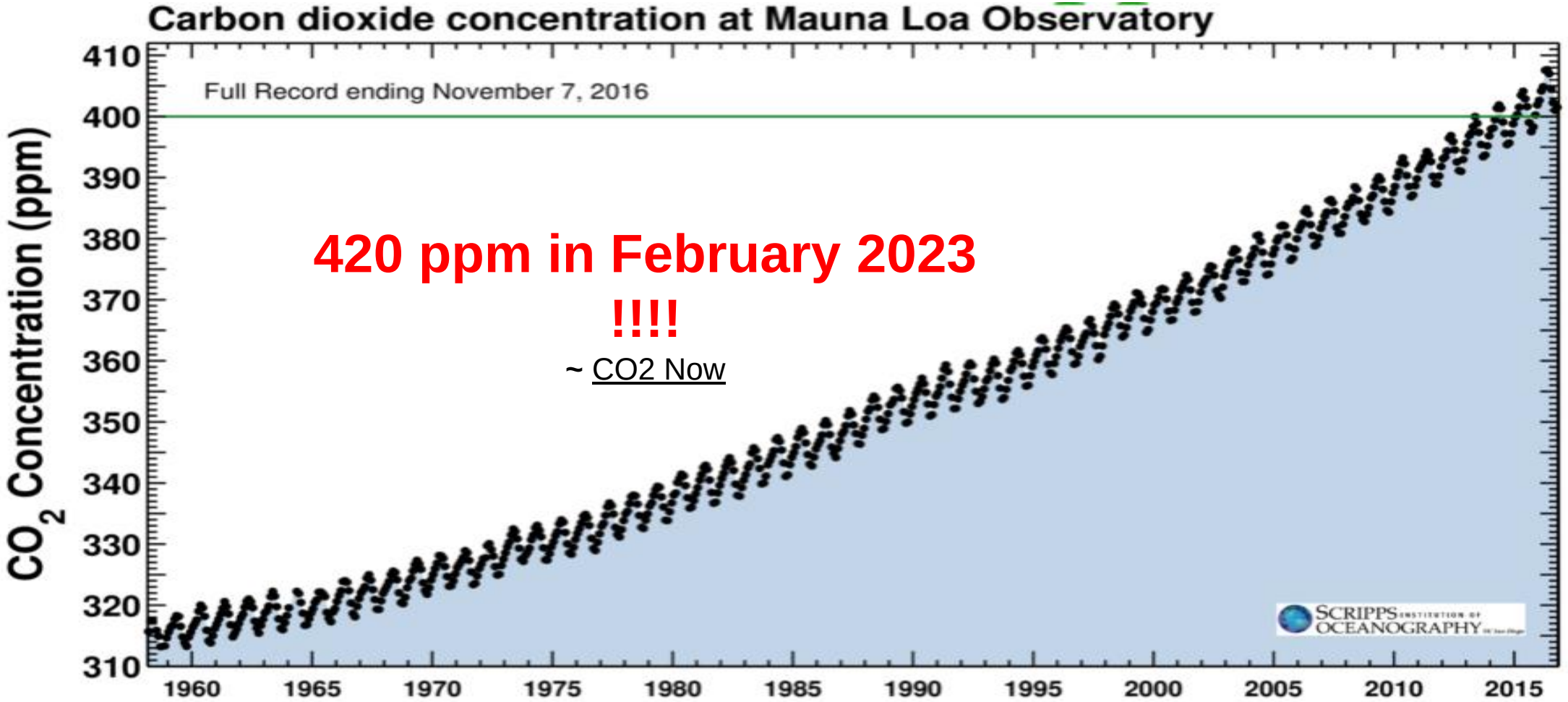
❖Climate change & CO_2 levels



This graph, based on the comparison of atmospheric samples contained in ice cores and more recent direct measurements, provides evidence that atmospheric CO2 has increased since the Industrial Revolution

❖Climate change & CO_2 levels

"Today's rate of increase is more than **100 times faster** than the increase that occurred when the last ice age ended."
~ NOAA Media Release (2013)
~ Scripps (SIO UCSD) News Release (2013)



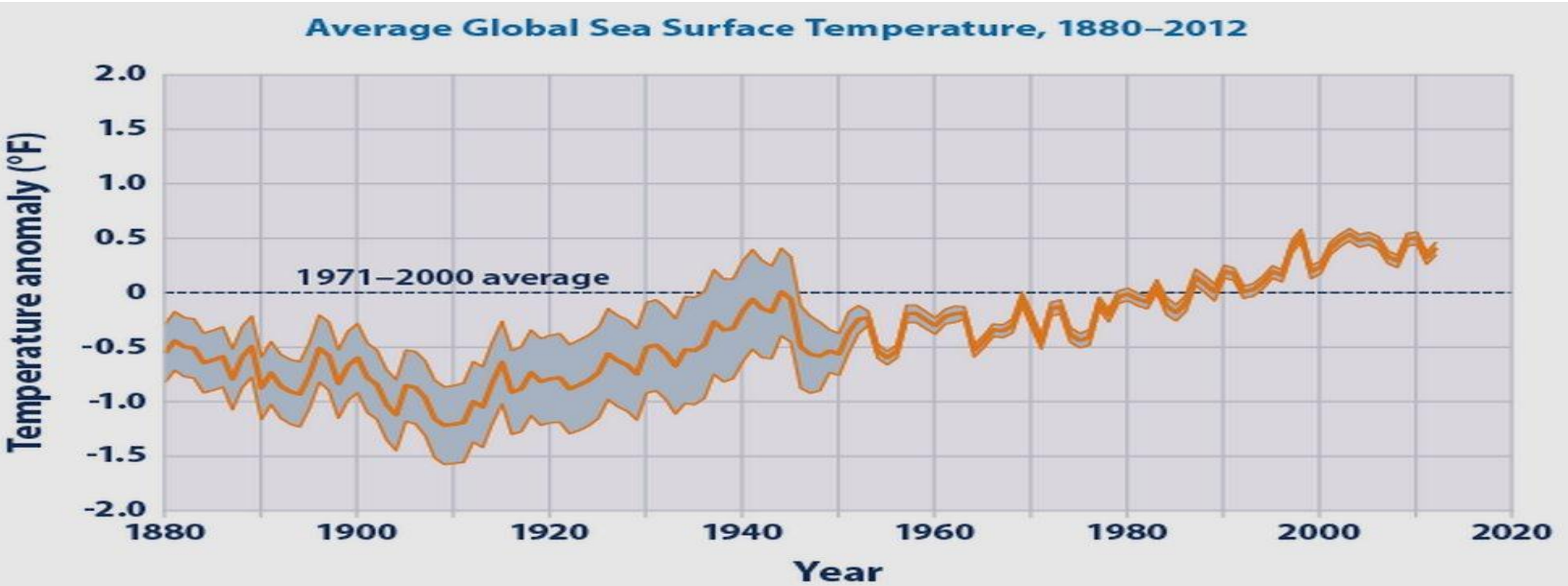
420 ppm in February 2023 !!!!

~ CO2 Now

❖Climate change & CO_2 levels

- **Consequences of the elevated atmospheric CO_2:**

✔ **SST**



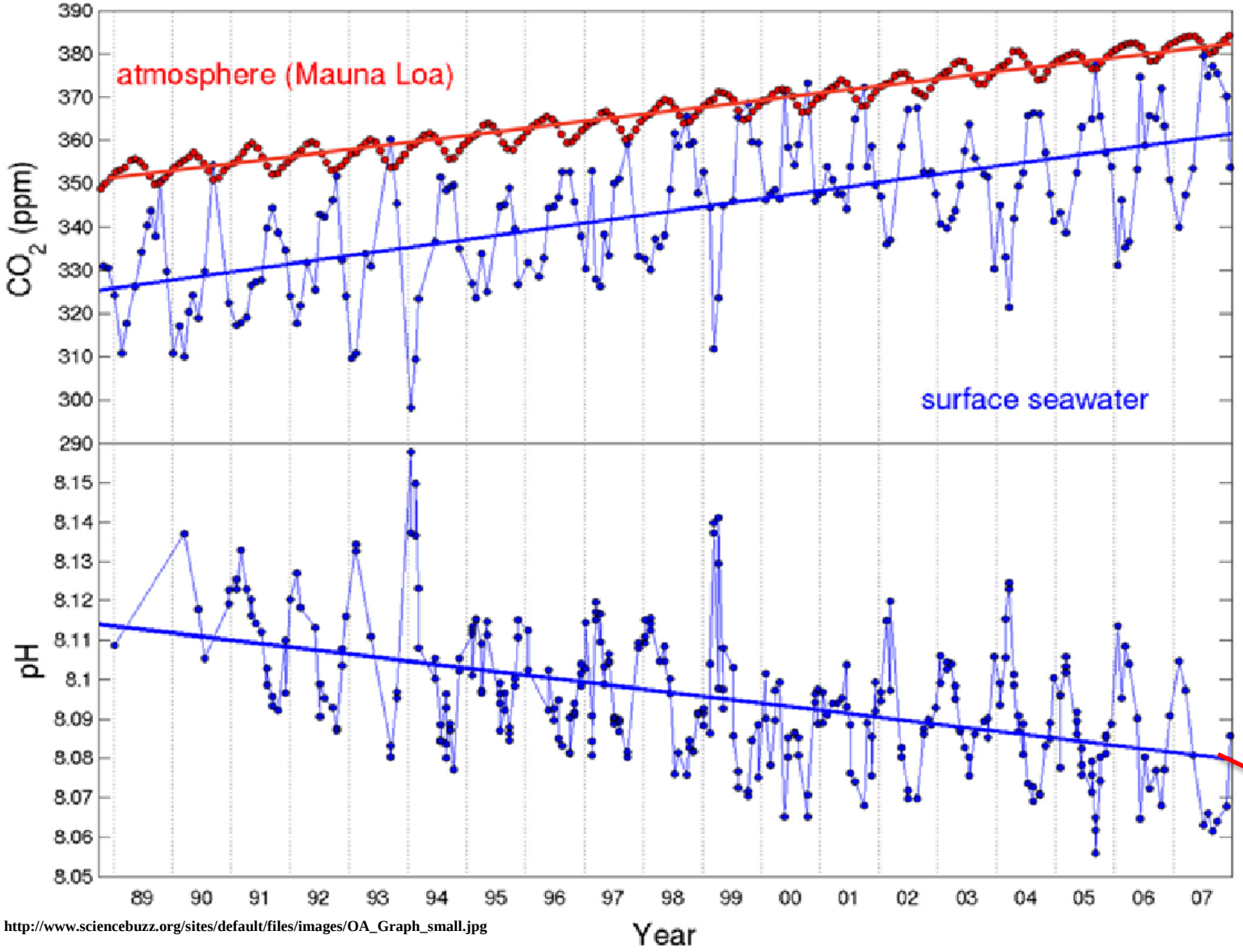
Data source: NOAA (National Oceanic and Atmospheric Administration). 2013. Extended reconstructed sea surface temperature (ERSST.v3b). National Climatic Data Center. Accessed February 2013. www.ncdc.noaa.gov/ersst/.

For more information, visit U.S. EPA's "Climate Change Indicators in the United States" at www.epa.gov/climatechange/indicators.

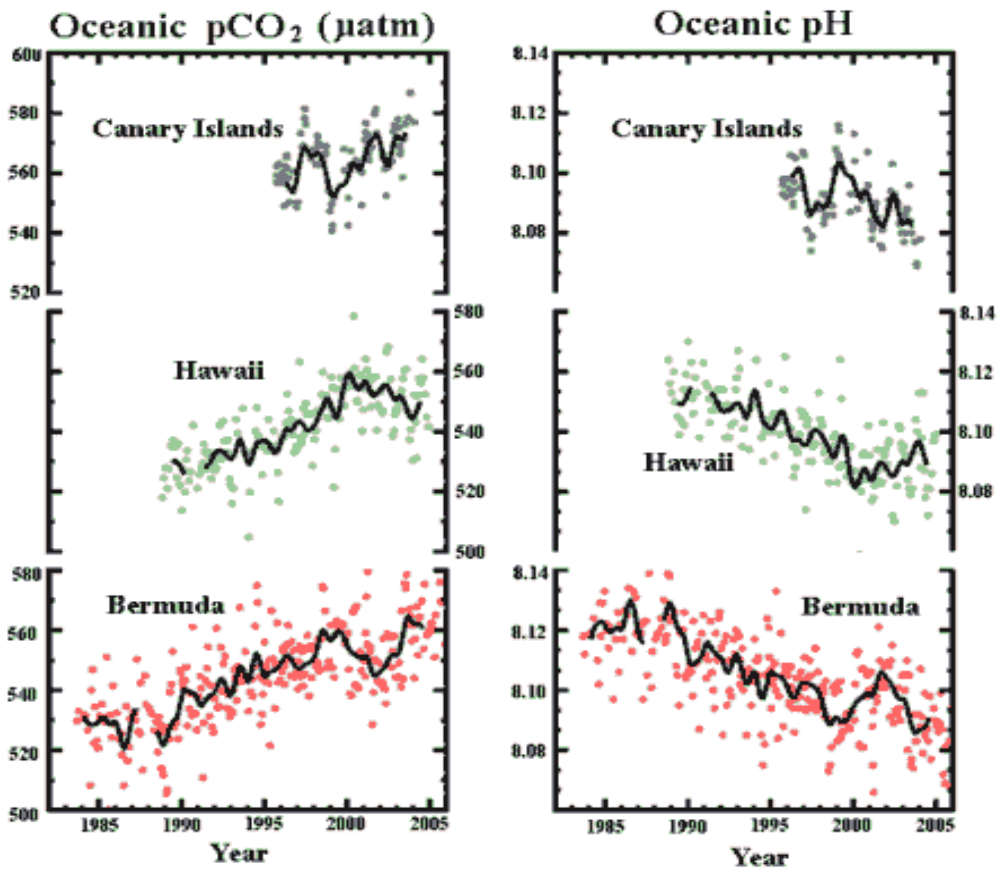
❖What is the ocean/sea acidification

- **Consequences of the elevated atmospheric CO2:**

✔ Seawater pH

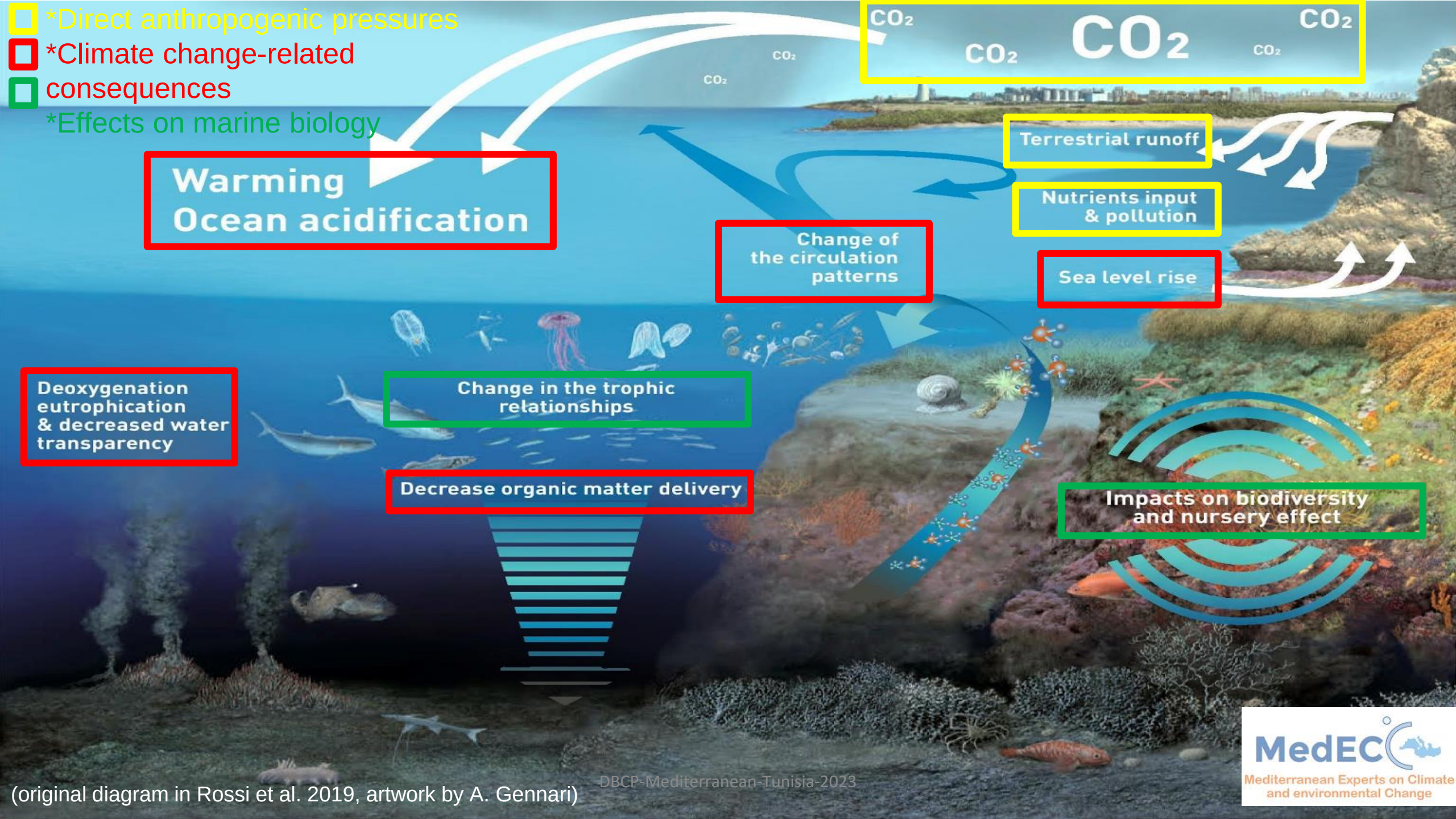


http://www.sciencebuzz.org/sites/default/files/images/OA_Graph_small.jpg



Source:
IPCC 2007: The Physical Basis for Climate Change

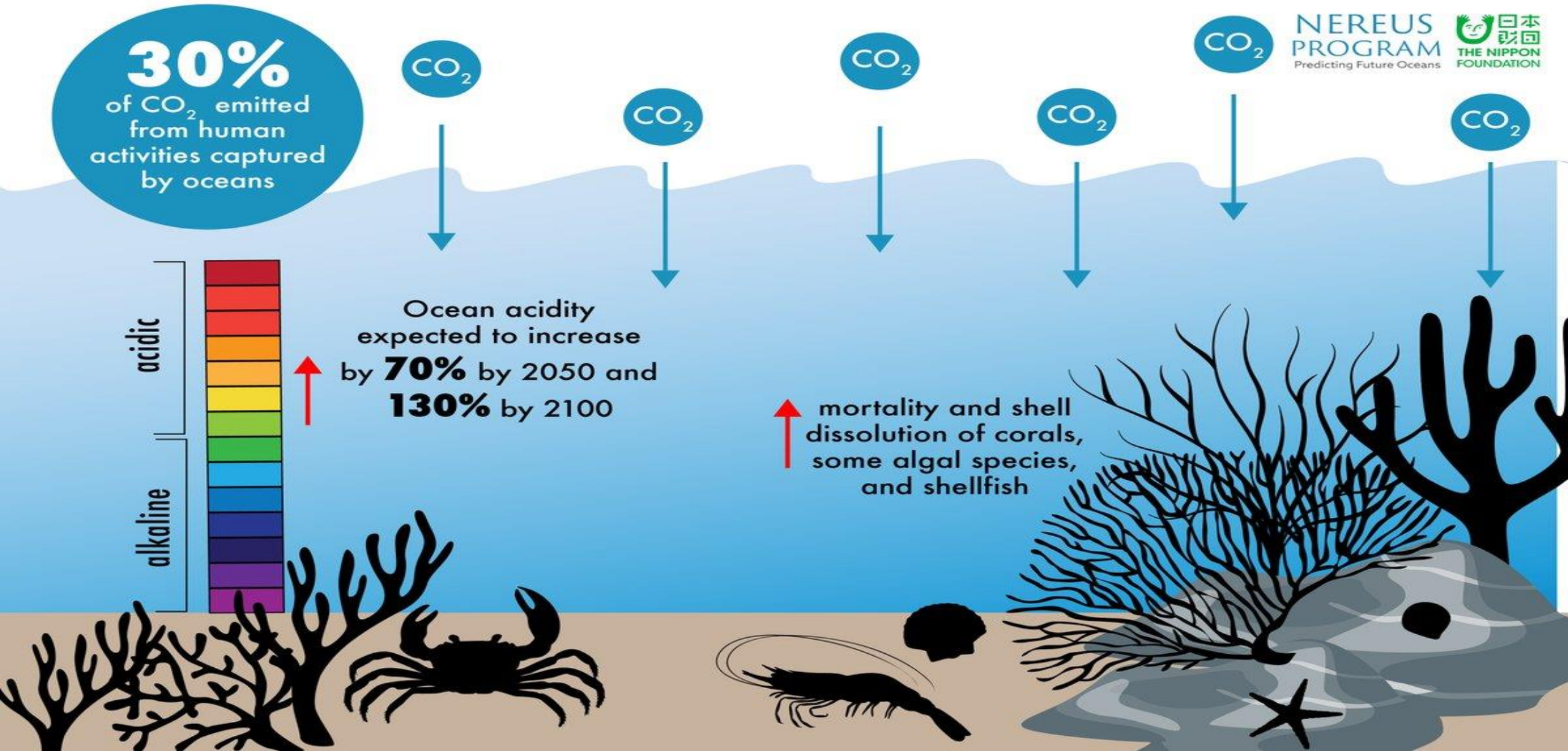
Acidification!



(original diagram in Rossi et al. 2019, artwork by A. Gennari)

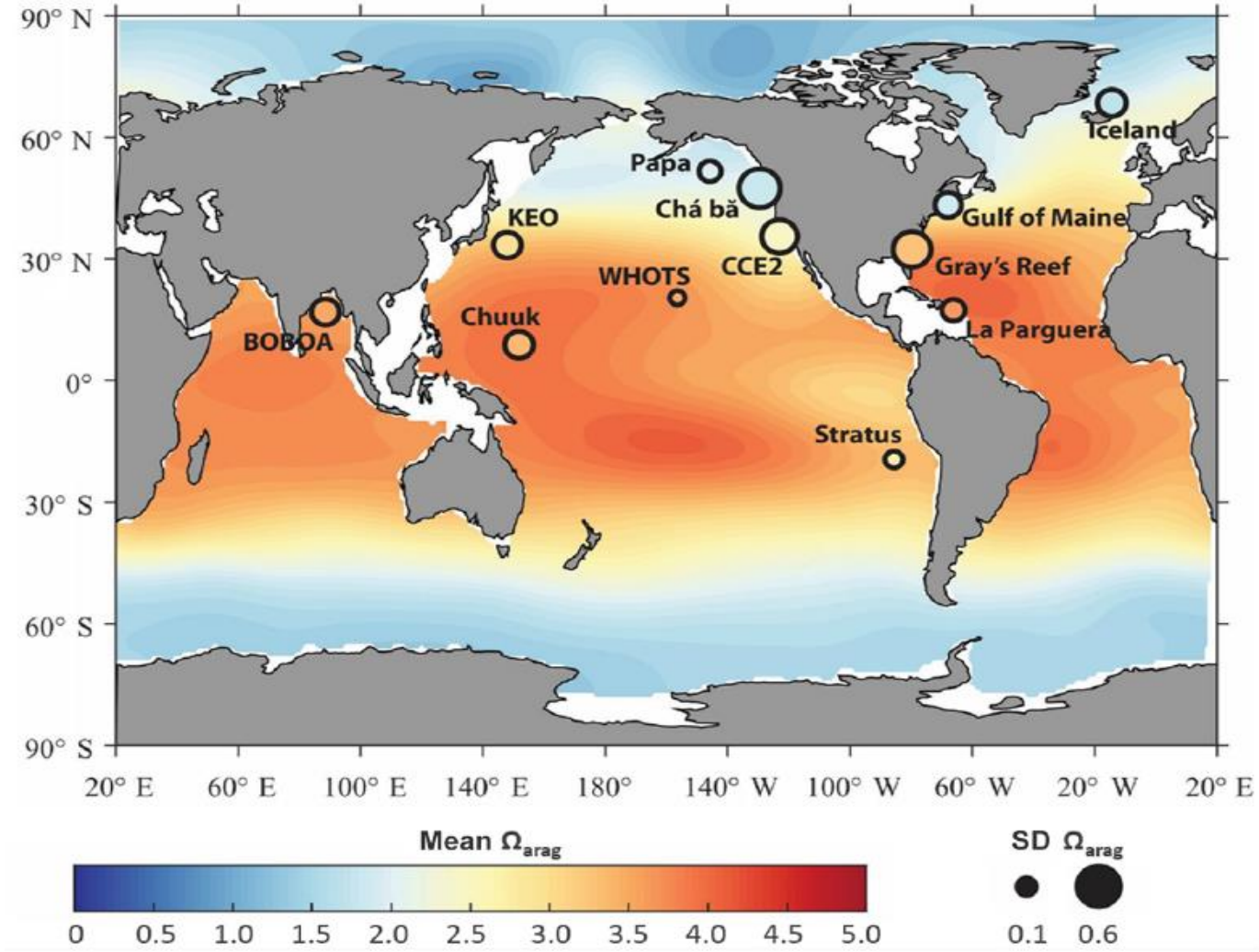
MedEC
Mediterranean Experts on Climate and environmental Change

❖ Ocean/sea acidification



Why is a global approach needed?

- to understand ocean acidification (OA) and its drivers correctly.
- to identify patterns across systems in how OA is unfolding, especially along the coasts
- to collect sufficient data to develop early warning systems
- to develop data products that inform local to global policy to reduce CO2 and mitigate its impacts



Sutton et al. 2016, *Biogeosciences*: www.biogeosciences.net/13/5065/2016/

❑ GOA-ON vision

www.goa-on.org

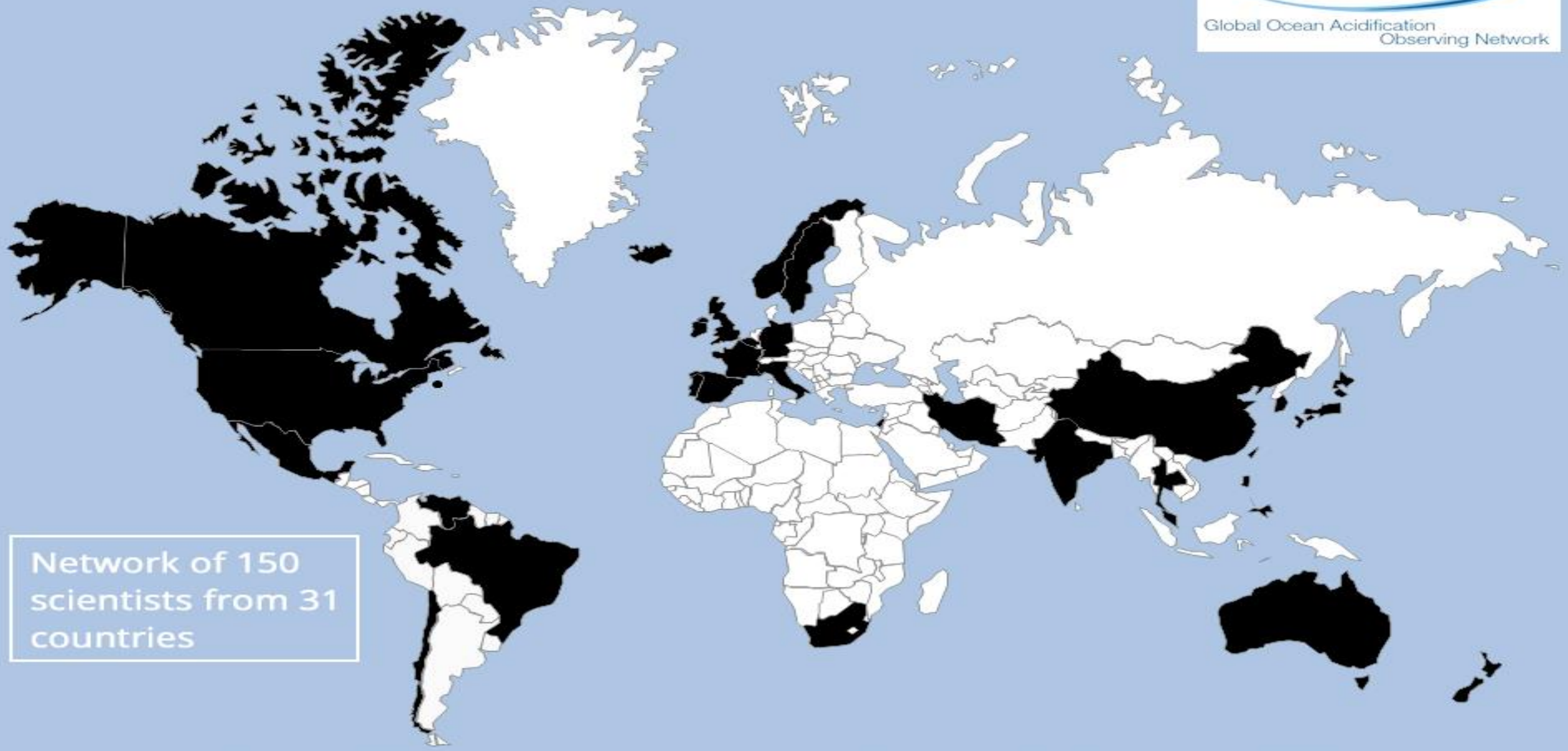
GOA-ON
Global Ocean Acidification Observing Network

Sharing OA expertise, data, and information, we aim to provide the world with a scientifically valid status of OA, biological responses, and forecasts on local scales globally.

GOA-ON Workshop, Hobart, 2016

GOA-ON in 2013

GOA-ON
Global Ocean Acidification Observing Network



Network of 150 scientists from 31 countries

Data from validated 1st & 2nd GOA-ON workshop participant lists (Seattle, Washington 2012 & St. Andrews, UK 2013)

GOA-ON in 2022

GOA-ON
Global Ocean Acidification Observing Network

+900 scientists > x5
105 countries > x3

Data from **www.goa-on.org** current members list

Excluding representatives of UN bodies

Mediterranean civilizations have been always interested by their shared sea!

Mare nostrum = Our Sea

Mare nostrum = Our Sea is over-fished!

Snapshot of fisheries – Mediterranean Sea

Total estimated economic contribution
USD 8.8 billion

Total estimated annual revenue
USD 3.4 billion

Total catch
787 900 tonnes

76 300
Total number of vessels

Composition of the fleet

- Small-scale — 82.1%
- Trawlers & beam trawlers — 7.9%
- Purse seiners & pelagic trawlers — 5.5%
- Other fleet segments — 4.6%

Vulnerable Communities

Every coastal village has a fisher

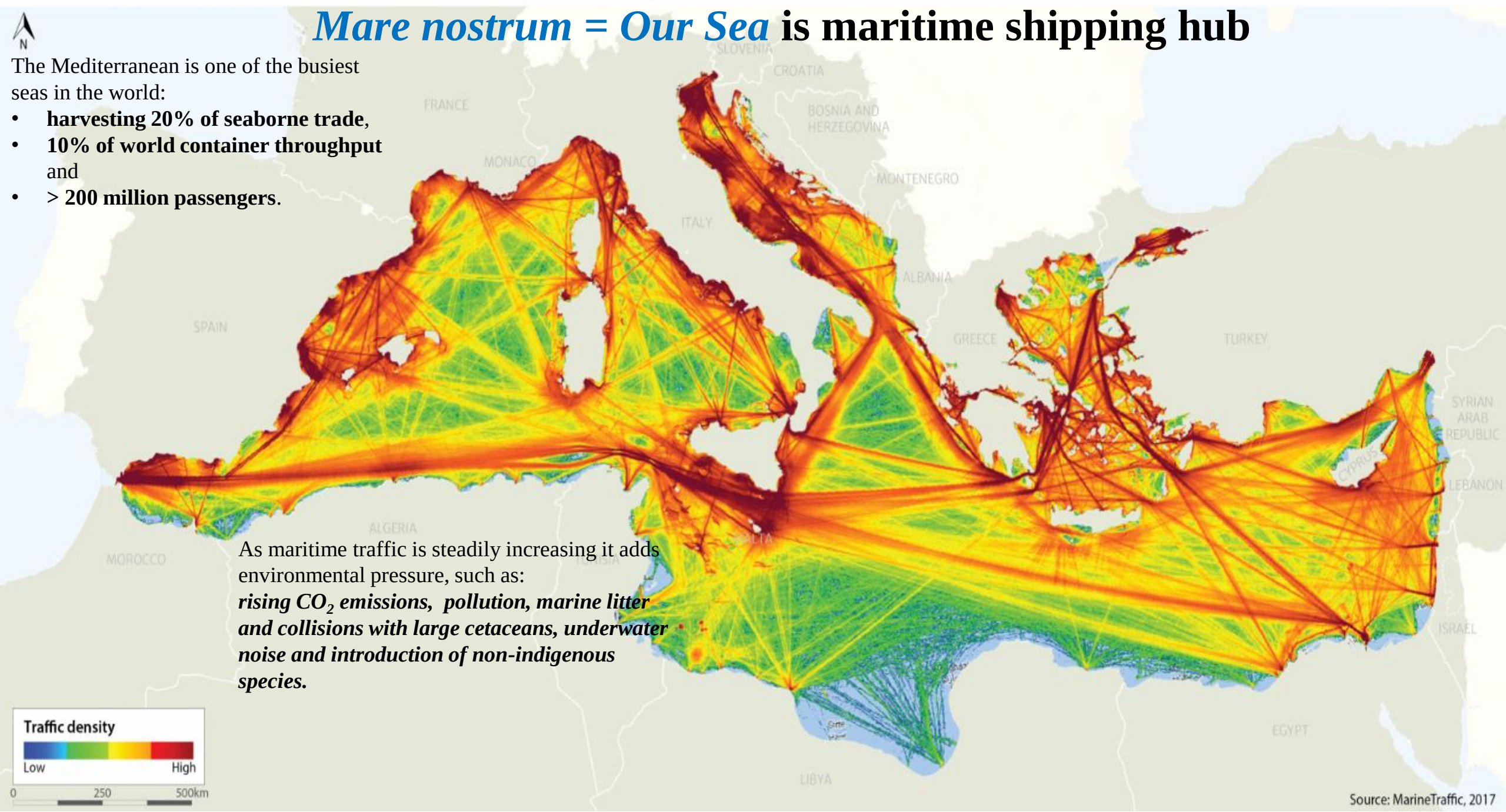
As many as 1 in every 100 coastal residents in some areas

Source: FAO/GFCM, The State of Mediterranean and Black Sea Fisheries 2020

Mare nostrum = Our Sea is maritime shipping hub

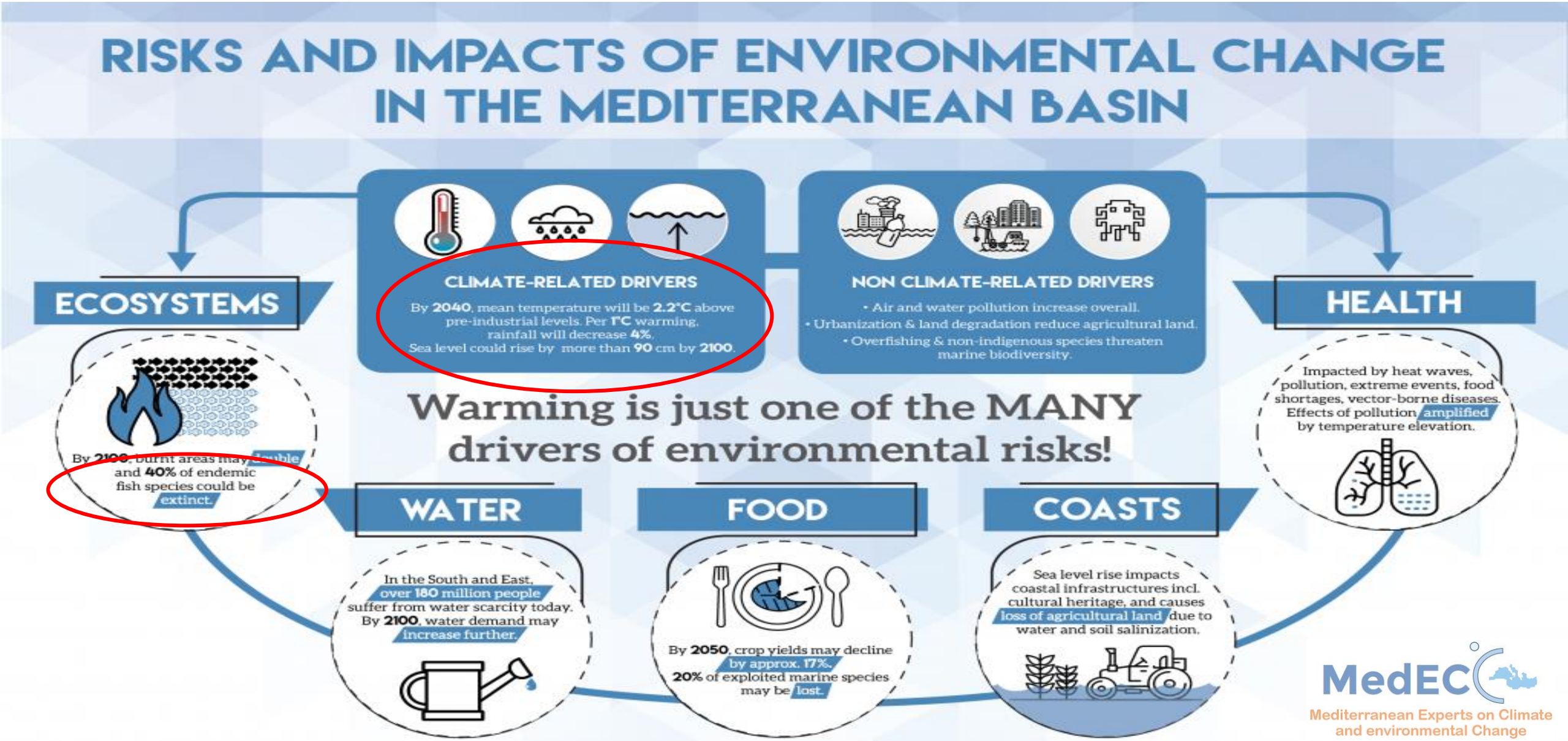
The Mediterranean is one of the busiest seas in the world:

- **harvesting 20% of seaborne trade**,
- **10% of world container throughput** and
- **> 200 million passengers**.



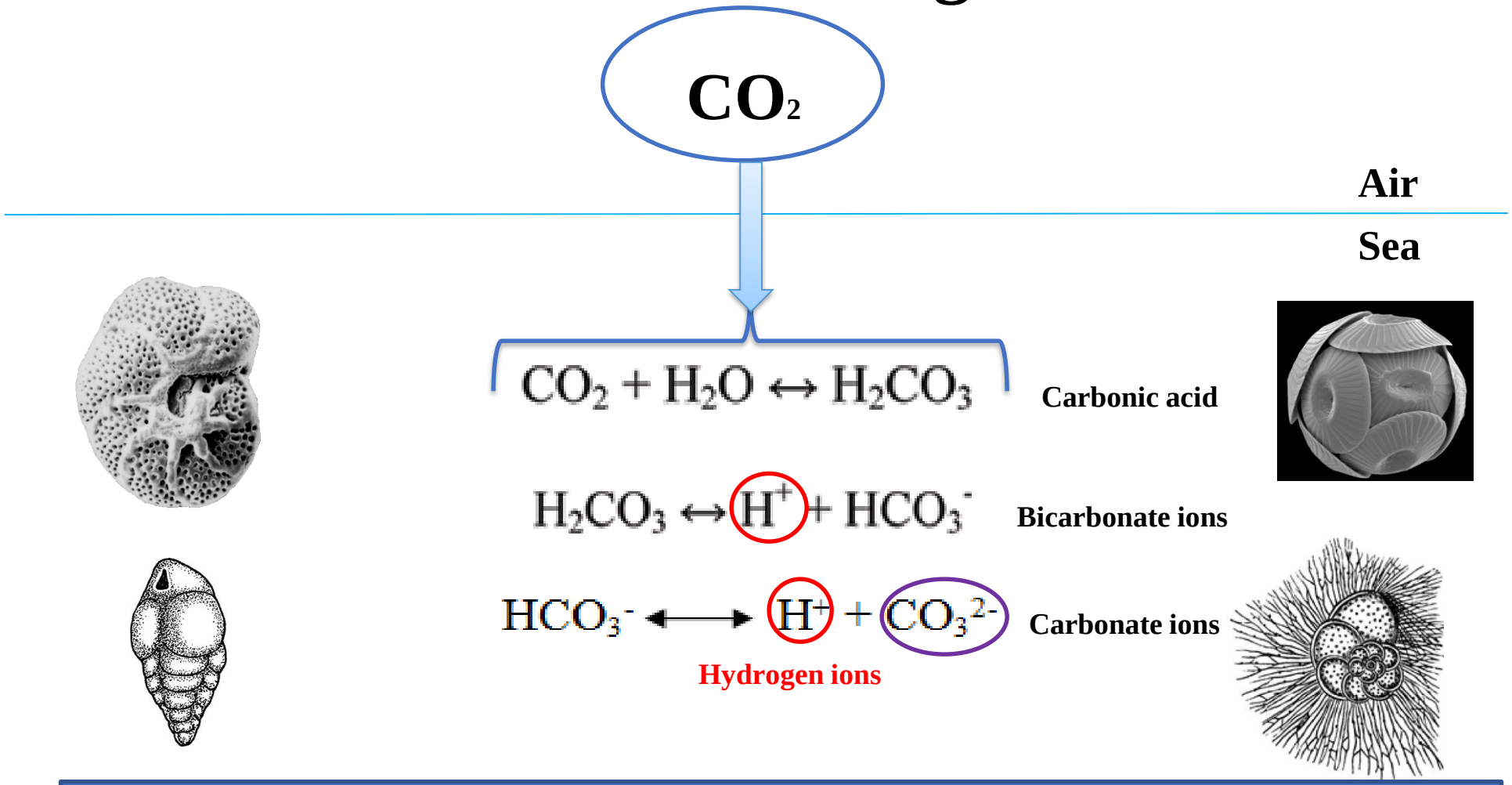
As maritime traffic is steadily increasing it adds environmental pressure, such as:
rising CO_2 emissions, pollution, marine litter and collisions with large cetaceans, underwater noise and introduction of non-indigenous species.

Mare nostrum = Our Sea is under multiple pressures!



Find out more on https://www.medecc.org

Mare nostrum = Our Sea is facing Ocean Acidification!



Carbonate ions are the basic building blocks for the shells of many marine organisms. Thus the formation of bicarbonate through this chemical reaction removes carbonate ions from the water, making them less available for use by many marine organisms.

❖ Risks on marine ecosystems

Mediterranean coral bleaching

Photos: D. Kersting

Necrosis in Cladocora caespitosa in the Columbretes Islands Marine Reserve

MedEC
Mediterranean Experts on Climate and environmental Change

GOA-ON Regional Hubs

www.goa-on.org

"OA is a global condition with local effects"

The Global Ocean Acidification Observing Network (GOA-ON) has encouraged grass-roots formation of regional hubs:

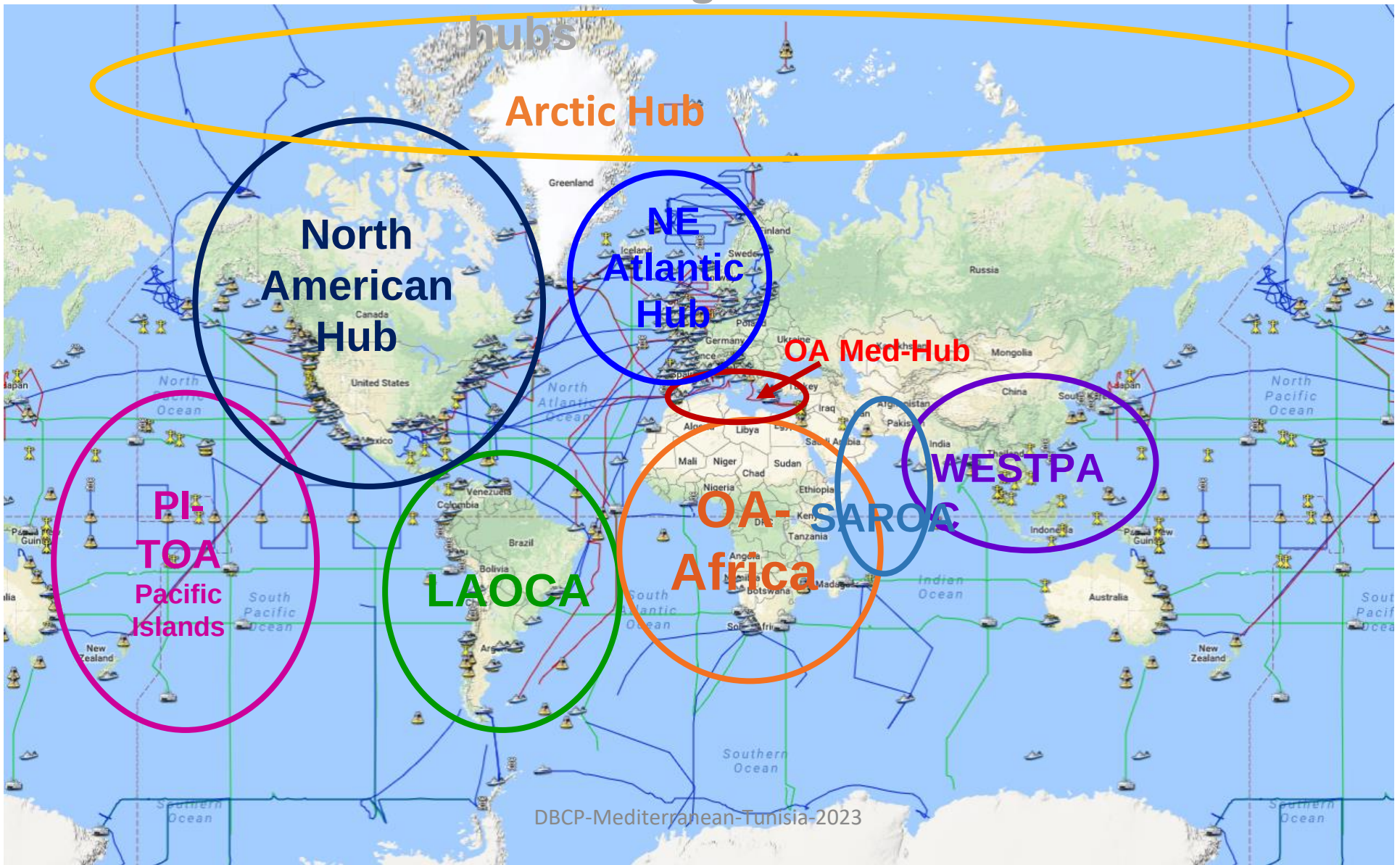
9 GOA-ON regional hubs gathering scientists from various oceanic areas

GOA-ON Regional Hubs

www.goa-on.org

GOA-ON
Global Ocean Acidification Observing Network

We're 9 regional hubs



The **Mediterranean Ocean Acidification Hub** is a network that connects Mediterranean scientists who are working and are interested in ocean acidification in the Mediterranean Sea:

Algeria, Croatia, Cyprus, Egypt, France, Greece, Italy, Lebanon, Malta, Monaco, Morocco, Slovenia, Spain, and Türkiye

~ 100
members

14
countries

GOALS

- Improve the communication between the Mediterranean OA members to better study and understand the ocean acidification and its consequences in the Mediterranean through collaborations and projects
- Promote community "best practices" consistent with GOA-ON
- Support the Mediterranean OA community via capacity building and trainings
- Work together as a community to provide OA-related messages (social, biological, and physical impacts and implications of ocean acidification) for policy-makers and the public

Lebanon

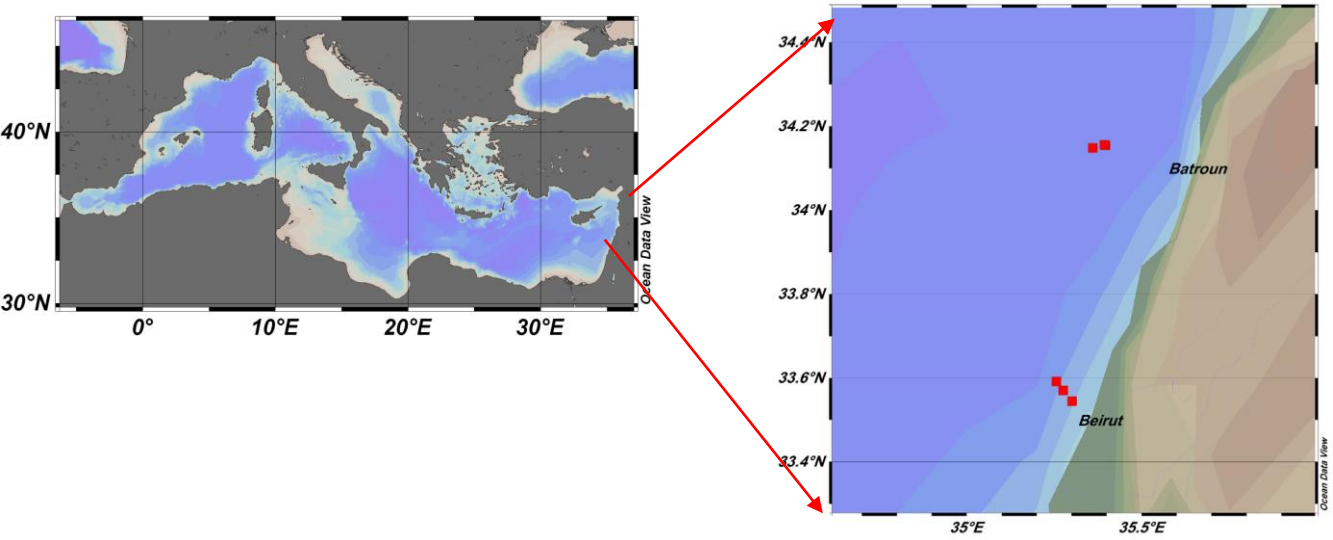
***Ship-based time-series stations** since 2012:
B1, B2, A3

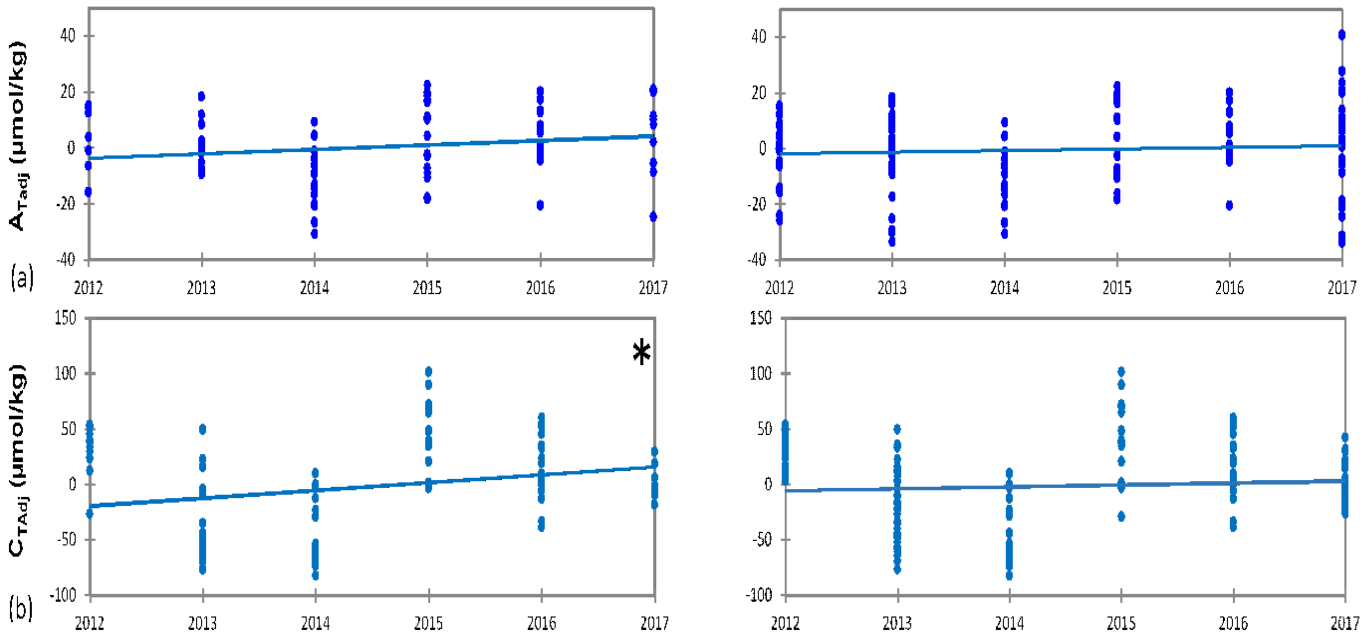
Parameters:
T, S, nutrients, pH, AT, DIC, DO, Chl.a, plankton, etc.

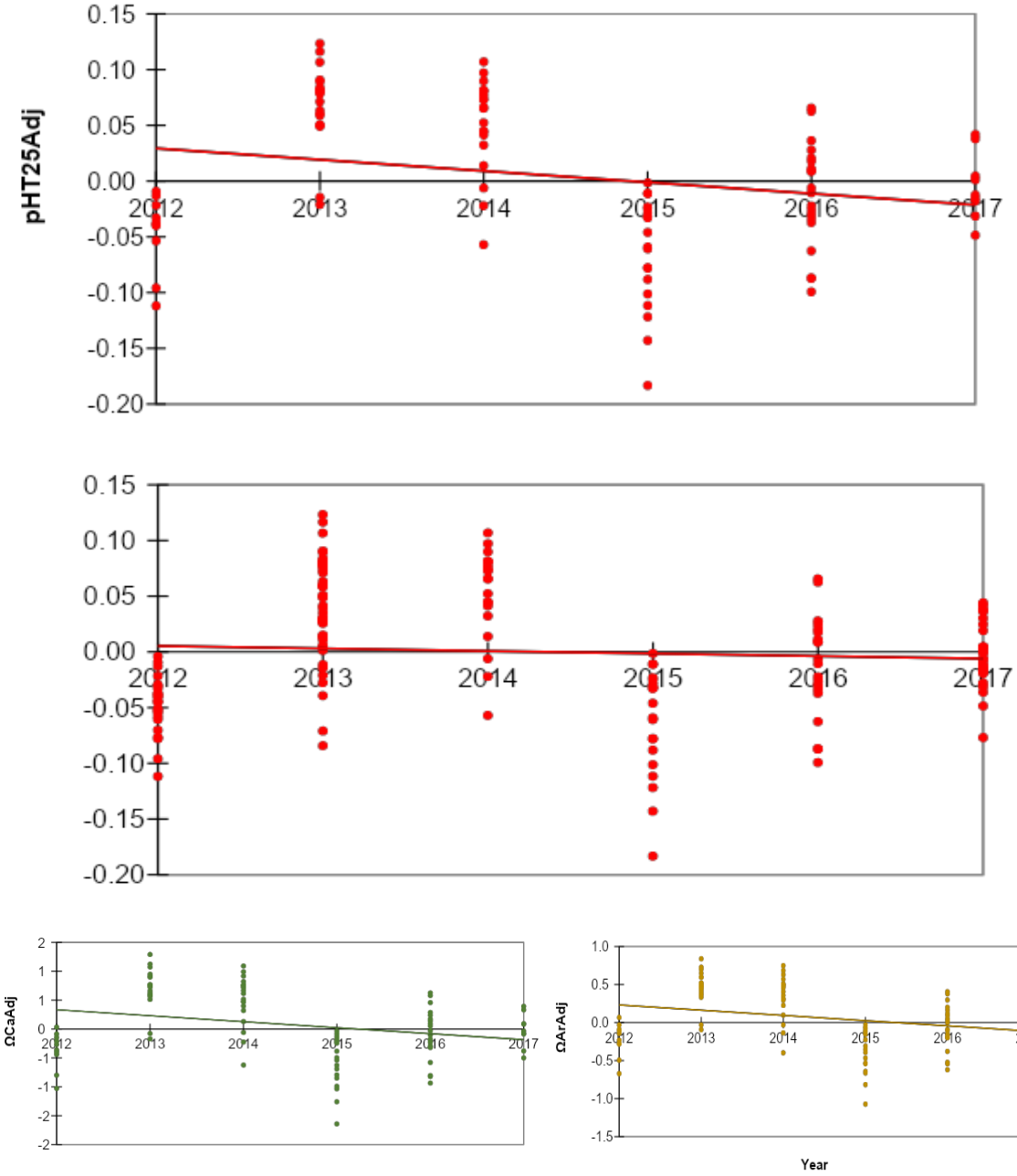
Contact:
Abed El Rahman Hassoun
abedhassoun@cnrs.edu.lb
ahassoun@geomar.de

Steering committee member:
Abed El Rahman HASSOUN, CNRS-L/GEOMAR

❖ Climate change research in Lebanon: (Hassoun et al., 2019, DSR)







France

**Ship-based Time Series*
REPHY
Contact Name
Dominique Soudant
Catherine Belin
Contact Email
Dominique.Soudant@ifremer.fr
Catherine.Belin@ifremer.fr

Villefranche Point B (Cote d'Azur)
Contact Name
Laure Mousseau
Contact Email
laure.mousseau@imev-mer.fr

MOOSE-GE
Contact Name
Pierre Testor
Contact Email
pierre.testor@locean-ipsl.upmc.fr

SOLEMIO (Marseille)
Contact Name
Dominique Lefevre
Contact Email
Dominique.lefevre@univ-amu.fr

Thau Lagoon (Mediterranean)
Contact Name
Yves Collos
Contact Email
Yves.Collos@univ-montp2.fr
CocoriCO2 project
Frédéric Gazeau
frederic.gazeau@imev-mer.fr
https://wwz.ifremer.fr/cocorico2_en/Donnees/

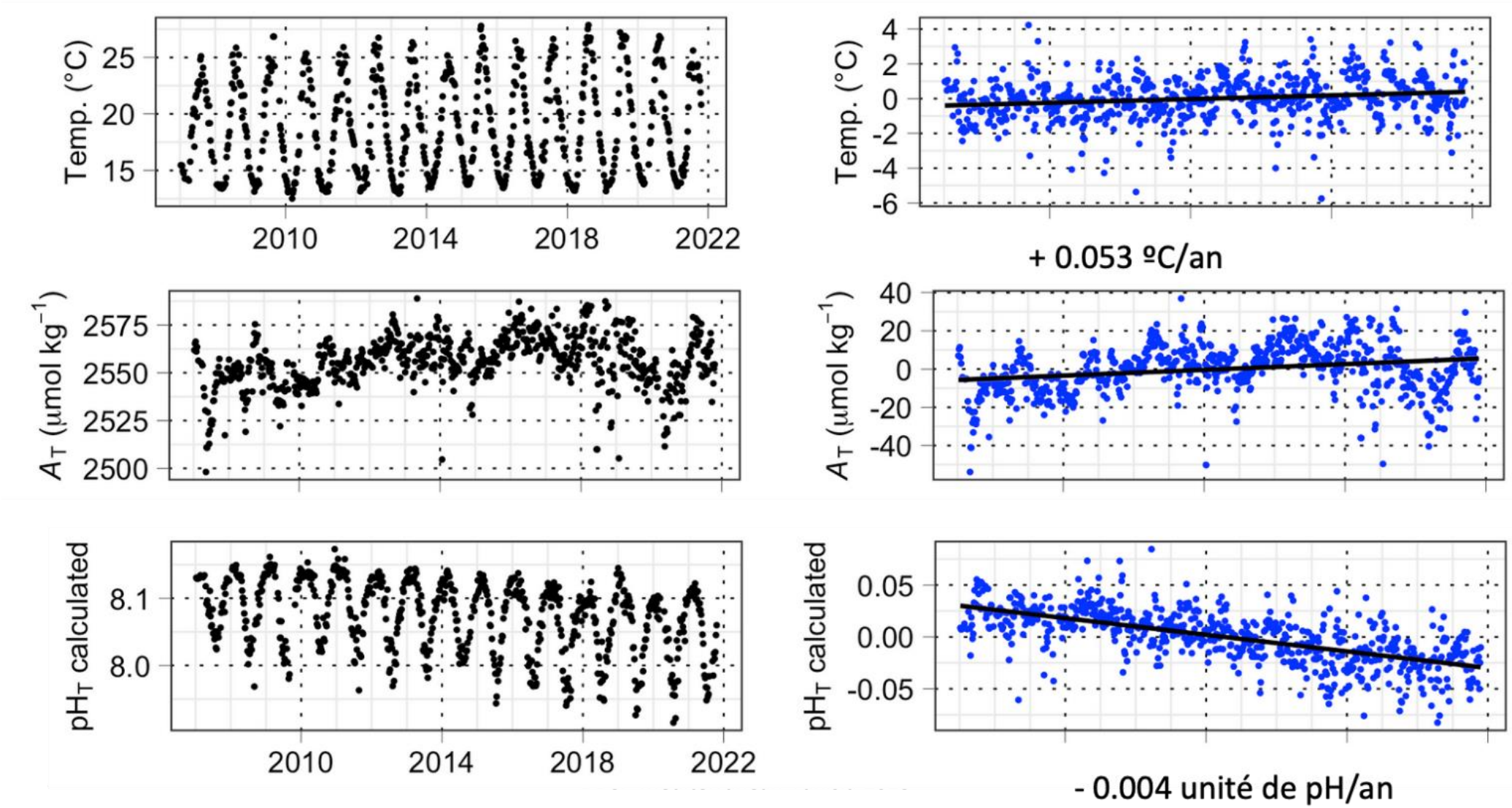
Gulf of Lyon (North-west Mediterranean Coastal)
Contact Name
Ian Salter
Pascal Conan
Contact Email
ian.salter@obs-banyuls.fr
pascal.conan@obs-banyuls.fr

**Mooring*
DYFAMED (Ligurian Sea)
Contact Name
Laurent Coppola
Contact Email
coppola@obs-vlfr.fr

Steering committee member:
Steeve COMEAU, CNRS

Point B time serie (Villefranche - 5km West of Nice, France):

- Longest time serie in the Med Sea
- Weekly sampling since 2007
- Two depths 1 m and 50 m



Spain

SAMI-pH moorings

Ship-based sampling

Other OA time series and analyses

Medes-Estartit; Blanes

Balearic Sea Ocean Acidification Time Series (BOATS)

GIbraltar Fixed Time series (GIFT)

Marta Álvarez - Instituto Español de Oceanografía (IEO CSIC)
Eva Calvo - Institut de Ciències del Mar (ICM CSIC)
Iris Hendriks - Instituto Mediterráneo de Estudios Avanzados (IMEDEA - CSIC-UIB)
Maribel García-Ibañez - Institut de Ciències del Mar (ICM CSIC)
Carles Pelejero - Institut de Ciències del Mar (ICM ICREA CSIC)
Fiz Fernandez Perez - Instituto de Investigaciones Marinas – (IIM CSIC)
I. Emma Huertas - Instituto de Ciencias Marinas de Andalucía- (ICMAN CSIC)
Patrizia Ziveri - Universitat Autònoma de Barcelona-Institute of Environmental Science and Technology (ICTA-UAB and ICREA)

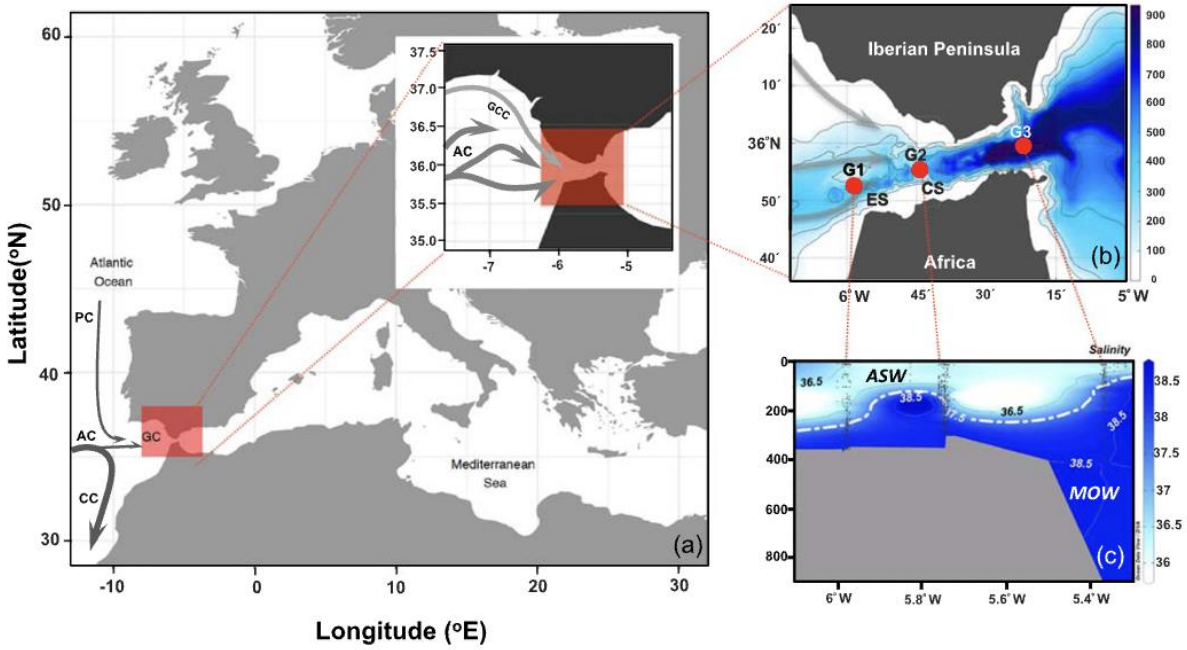
Steering committee member:
Iris HENDRIKS (IMEDEA - CSIC-UIB)

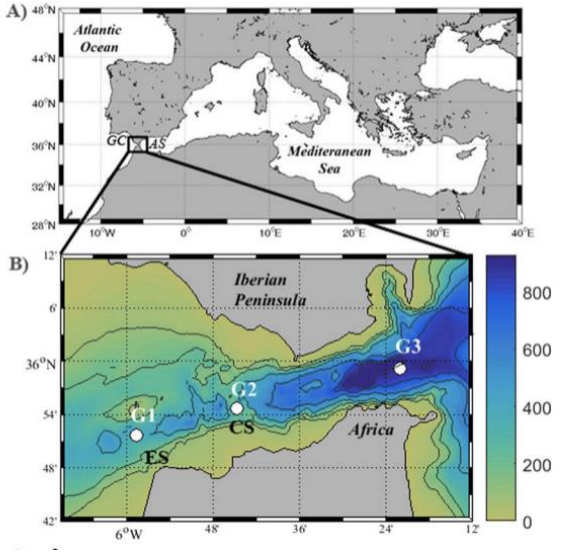
Shipbased, Fixed stations
GIFT since 2012, BOATS since 2018

Parameters:
T, S, nutrients, pH, AT, DOC, DO, Chl.a

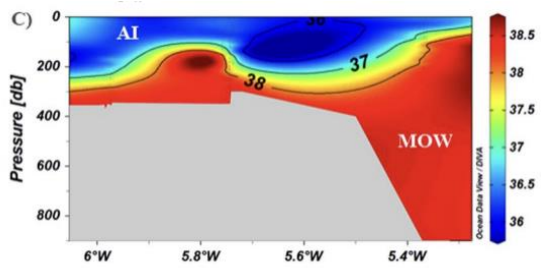
CSIC Interdisciplinary Thematic Interdisciplinary Platform OCEANS+

10.1029/2020GL089601Geophysical Research Letters ÁLVAREZ-SALGADO ET AL.

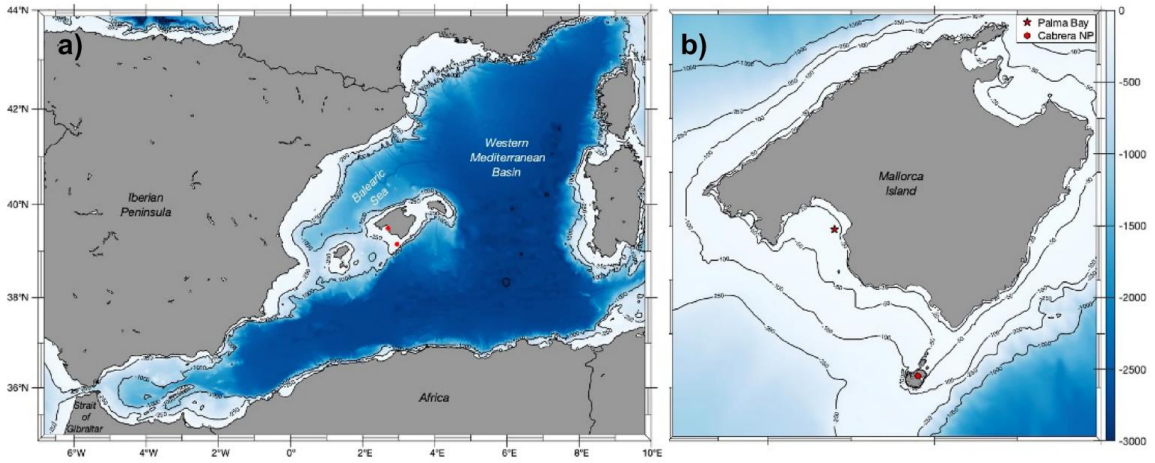


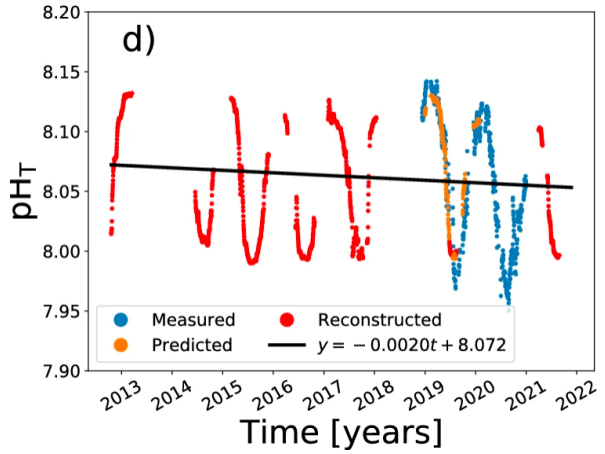


https://doi.org/10.1038/s41598-019-52084-x FLECHA ET AL. 2019



GIFT





BOATS

https://doi.org/10.1038/s41598-022-17253-5 FLECHA ET AL. 2022

Greece

Steering committee member:
Eva KRASAKOPOULOU, UAegean

**Ship-based time series:*

✔ MSFD GR stations in the Ionian (4 stations) and Aegean (6 stations) Seas
C_T and A_T sampling, Several depths, Every 6 months, since 2018.
Contact Name
Kalliopi Pagou
Christina Zeri
Contact Email
popi@hcmr.gr
chris@hcmr.gr

✔ Saronikos Gulf (Aegean Sea) stations S11, S7, S1, S2 and S16
C_T and A_T sampling, Several depths, bimonthly, since 2021.
Contact Name
Soultana Zervoudaki
Aleka Pavlidou
Contact Email
tanya@hcmr.gr
aleka@hcmr.gr

✔ HCMR-RV-M3A
C_T, A_T sampling, Several depths, Every 12 months
Contact Name
Constantin Frangoulis
Contact Email
cfrangoulis@hcmr.gr

✔ HCMR-RV-HCB
C_T, A_T, pH Surface sampling, Every 1 month
C_T, A_T sampling, Several depths, Every 12 months
Contact Name
Constantin Frangoulis
Contact Email
cfrangoulis@hcmr.gr

**Mooring (M):*

✔ HCMR-fixed platform-HCB
pH. Subsurface sensor. Every 3 hrs
CO_2 water. Subsurface sensor. Every 6 hrs
CO_2 air. Above surface sensor. Every 6 hrs
Contact Name
Constantin Frangoulis
Contact Email
cfrangoulis@hcmr.gr

Turkey

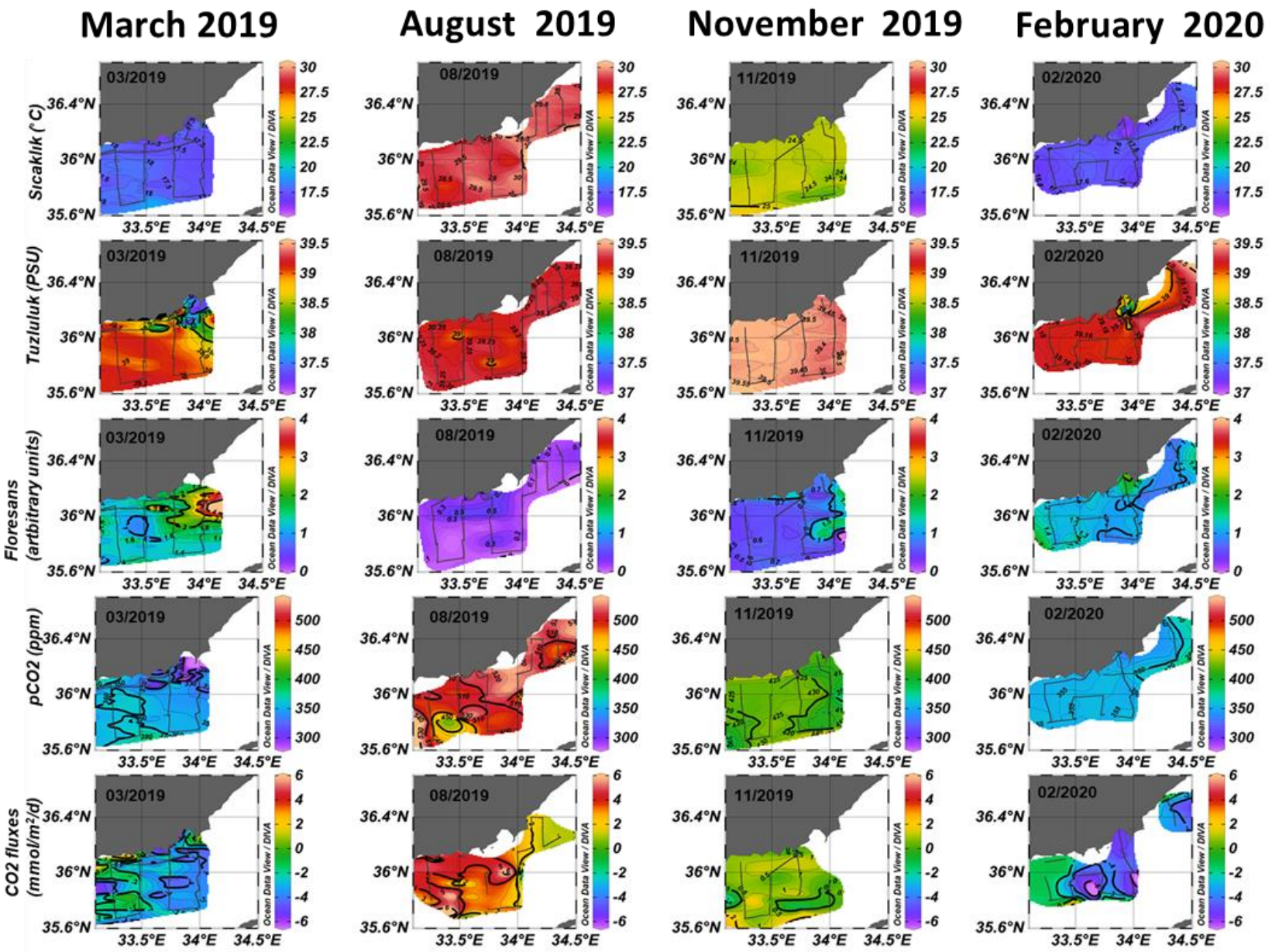
***Ship-based time-series stations**
since 2019:

North-East Levantine Basin; Marmara Sea

Parameters:
T, S, nutrients, pH, TA, pCO_2, DO, Chl*a*, etc.

Contact:
Valeria Ibello
valeria.ibello@ims.metu.edu.tr

Steering committee member:
Valeria IBELLO, METU-IMS



•First assessment of the **annual budget of the air-sea CO_2 fluxes** in the Northeastern Levantine basin

•

•**<u>Clear seasonality</u>** in the air-sea CO_2 fluxes

•Winter à CO_2 sink, biological uptake of CO_2, low temperature (high solubility)

•Summer à CO_2 source, high temperature (thermodynamics of CO_2 species, possible mineralization)

•

•On an annual budget the Northeastern Levantine basin is a **<u>net sink of CO_2</u>** (2019-2020). Different patterns in respect to other nearby areas

Italy

Parameters:
T, S, nutrients, pH, AT, DO on discrete water samples
automatic T, S, O2, $pCO2_{sw}$ measurements at ICOS FOTS station

Steering committee member:
Michele GIANI, OGS

**Fixed Ocean Time Series (FOTS)*

✓ **Paloma (ICOS, Northern Adriatic)**

Anna Luchetta, anna.luchetta@ismar.cnr.it

Carolina Cantoni, carolina.cantoni@ismar.cnr.it

✓ ***MIRAMARE* (ICOS, Northern Adriatic)**

Michele Giani, mgiani@ogs,it

✓ **SAILOR-E2M3A (South Adriatic)**

Vanessa Cardin, vcardin@ogs.it

Giuseppe Civitarese, gcivitarese@ogs.it

✓ **W1M3A (ICOS, Ligurian Sea)**

Roberto Bozzano, roberto.bozzano@cnr.it

Sara Pensieri, sara.pensieri@cnr.it

✓ **Lampedusa (ICOS, Sicily Channel)**

Alcide Di Sarra, alcide.disarra@enea.it

**Ship-based time series:*

✓ **LTER-C1 Gulf of Trieste (Northern Adriatic)**

Bruno Cataletto, bcataletto@ogs.it

✓ **PALOMA Gulf of Trieste (Northern Adriatic)**

Carolina Cantoni, carolina.cantoni@ismar.cnr.it

**Acidification impact on marine ecosystems in proximity of vents:*

✓ **Panarea (ECCSEL, South Tyrrhenian Sea)**

Cinzia De Vittor, cdevittor@ogs,it

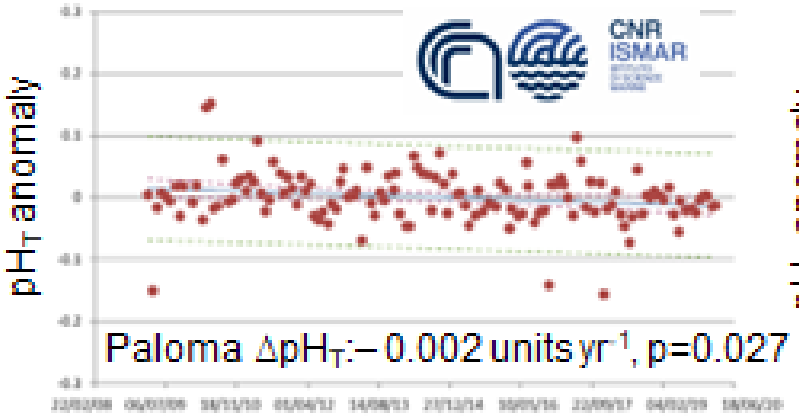
✓ **Ischia (Tyrrhenian Sea)**

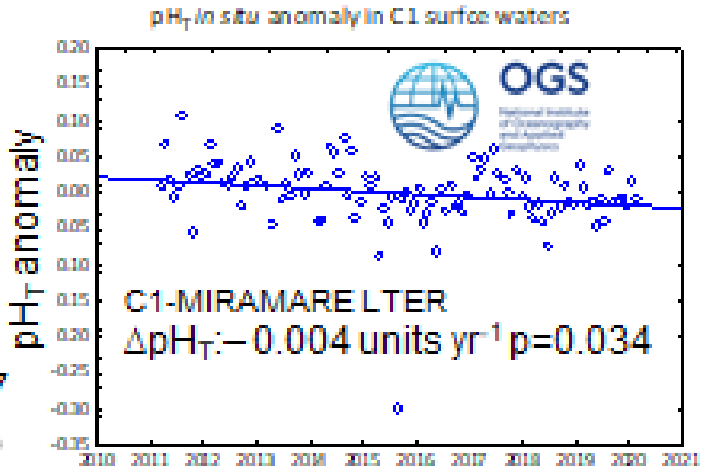
Mariacristina Buia, mariacristina.buia@szn.it

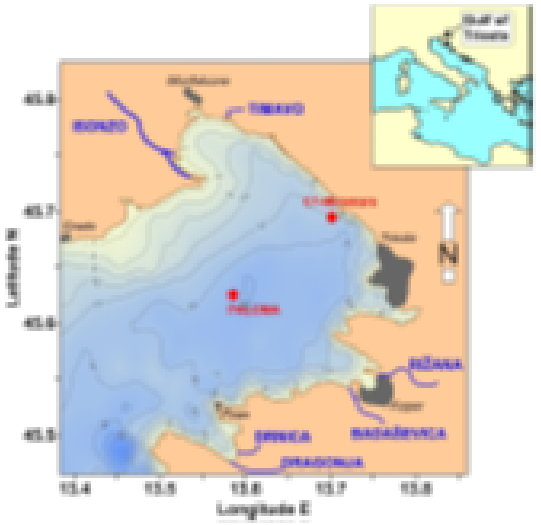
Nuria Teixido, nuria.teixido@szn.it

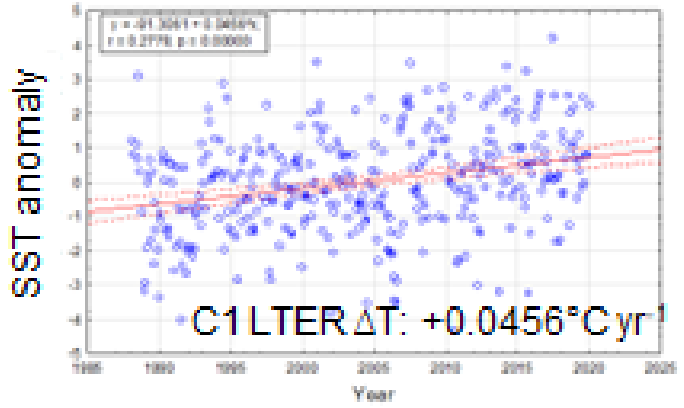
Adriatic Sea

- High seasonal pH variations driven by temperature, biological activity, riverine input ΔpHT>0.4
- Dense water formation contributes to CO_2 influx from the atmosphere and to its transfer southwards to the South Adriatic Sea and to the Eastern Mediterranean Deepwaters
- Signficant warming and acidification trends in surface waters of the northern Adriatic Sea









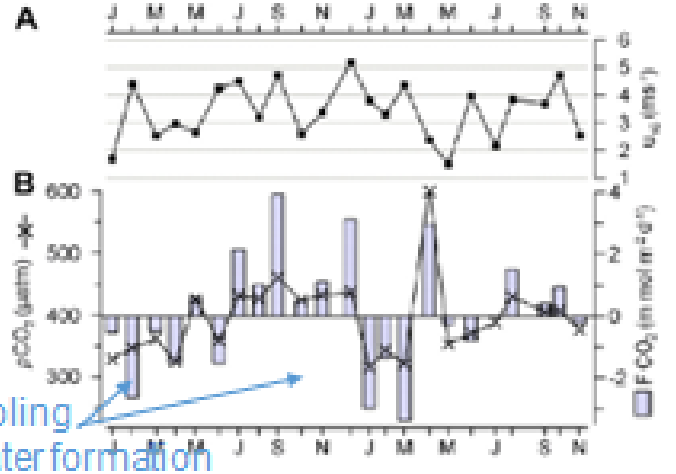
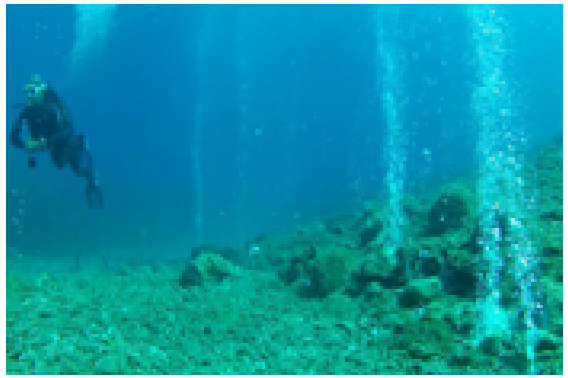


Fig. 8. (a) Daily averaged wind speed during the days of sampling measured at PAL-OMA meteorological station, at 10 m above sea level (u_{10}). (b) pCO_2 in the surface waters and air–sea CO_2 fluxes (FCO_2) during the days of sampling.

from Cantoni et al., 2012

Panarea: a Natural Laboratory to study OA

The relative proportion of the number of individuals of the various functional guilds change along the OA gradient. Invertebrates inhabiting the **low-pH zone** are mainly composed of **weakly or non-calcified species**, with small size, burrower/tubicolous habit, omnivorous or suspension feeders, and with direct development and brooding habit. In the stations **with higher pH, heavily calcified forms**, and greater size, herbivore an herbivore/detritivore prevail (Esposito et al., 2023).



Egypt

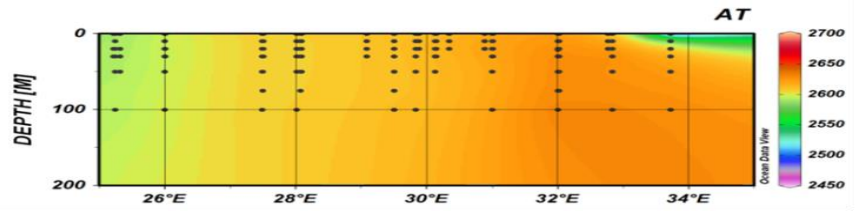
Steering committee member:
Nayerah SHALTOUT
National Institute of Oceanography and Fisheries

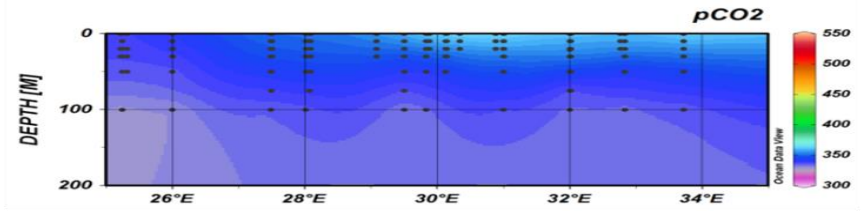
***Ship-based time-series stations** since 2008 on seasonally for 18 sectors perpendicular to Egyptian Mediterranean coast at four depths intervals till 200m for a total no of samples 176.
Measured Parameters:
T, S, pH, DO, nutrients, AT, Chl.a.
Contact:
Associate Prof Nayerah Shaltout
nshaltout@gmail.com

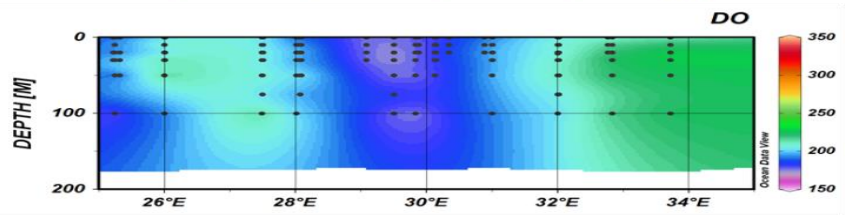
***Ship-based time-series stations** Egypt northern lake, Lake Idku, 2012-2013 seasonally, 32 stations for surface and bottom sample.
Measured Parameters:
T, S, pH, DO, nutrients, AT, Chl.a.
Contact:
Associate Prof Nayerah Shaltout
nshaltout@gmail.com

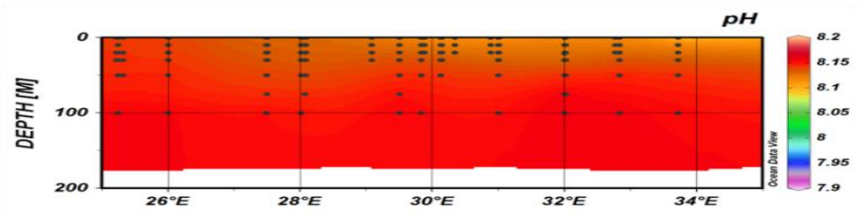
Ship-based time-series stations Egypt northern lake, Lake Burulus, 2020-2022 seasonally, 16 stations for surface and bottom sample.
Measured Parameters:
T, S, pH, DO, nutrients, AT, Chl.a.
Contact:
Associate Prof Nayerah Shaltout
nshaltout@gmail.com

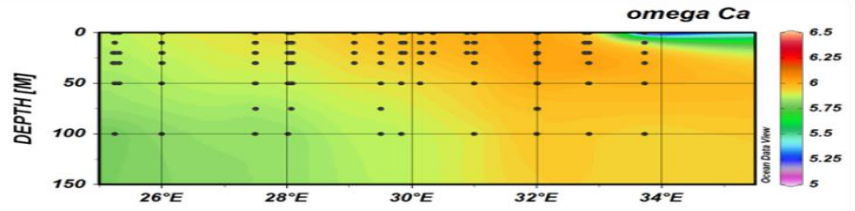
Vertical distribution spring 2008, 16 sectors

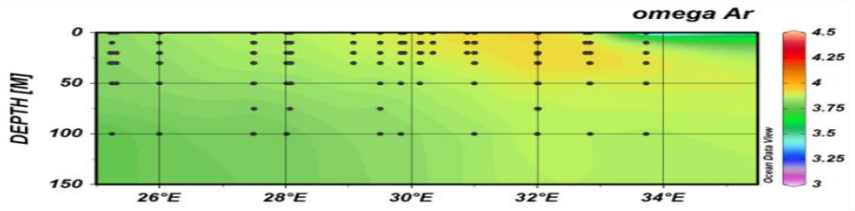




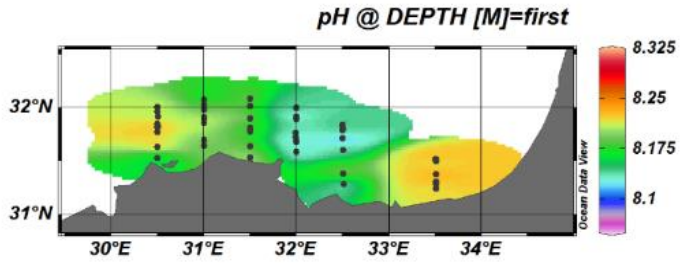


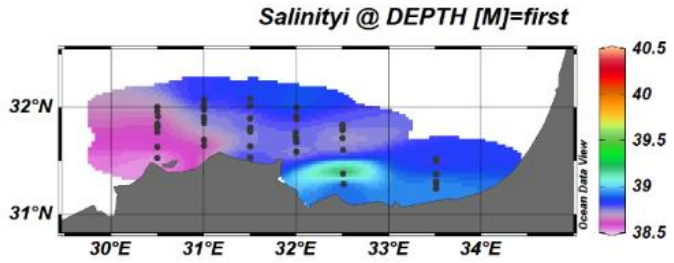


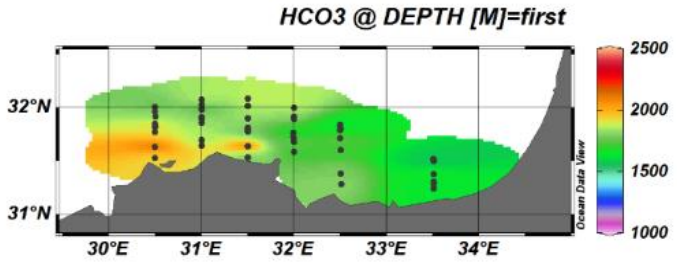


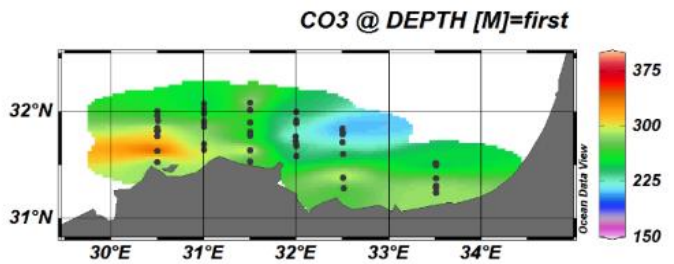


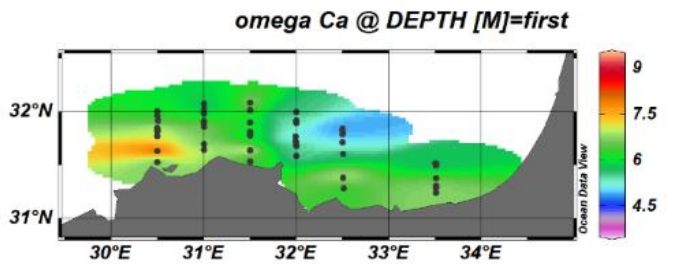
Surface distribution autumn 2014, 6 sectors

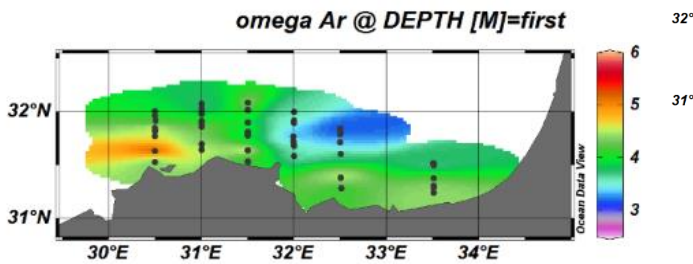


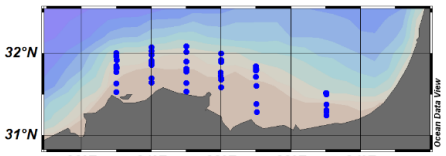












Morocco

Ship-based time series: **on seasonally**

Parameters:
T, S, nutrients, DO, Chl.a, plankton, etc.

pH, TA: methods under development

Contact:
Fatima Zohra BOUTHIR
bouthir@inrh.ma

Steering committee member:
Fatima Zohra BOUTHIR, INRH

Collecting samples:

CTD SBE911+ (Conductivity, Temperature Depth) + Rosette SBE32 connected at CTD

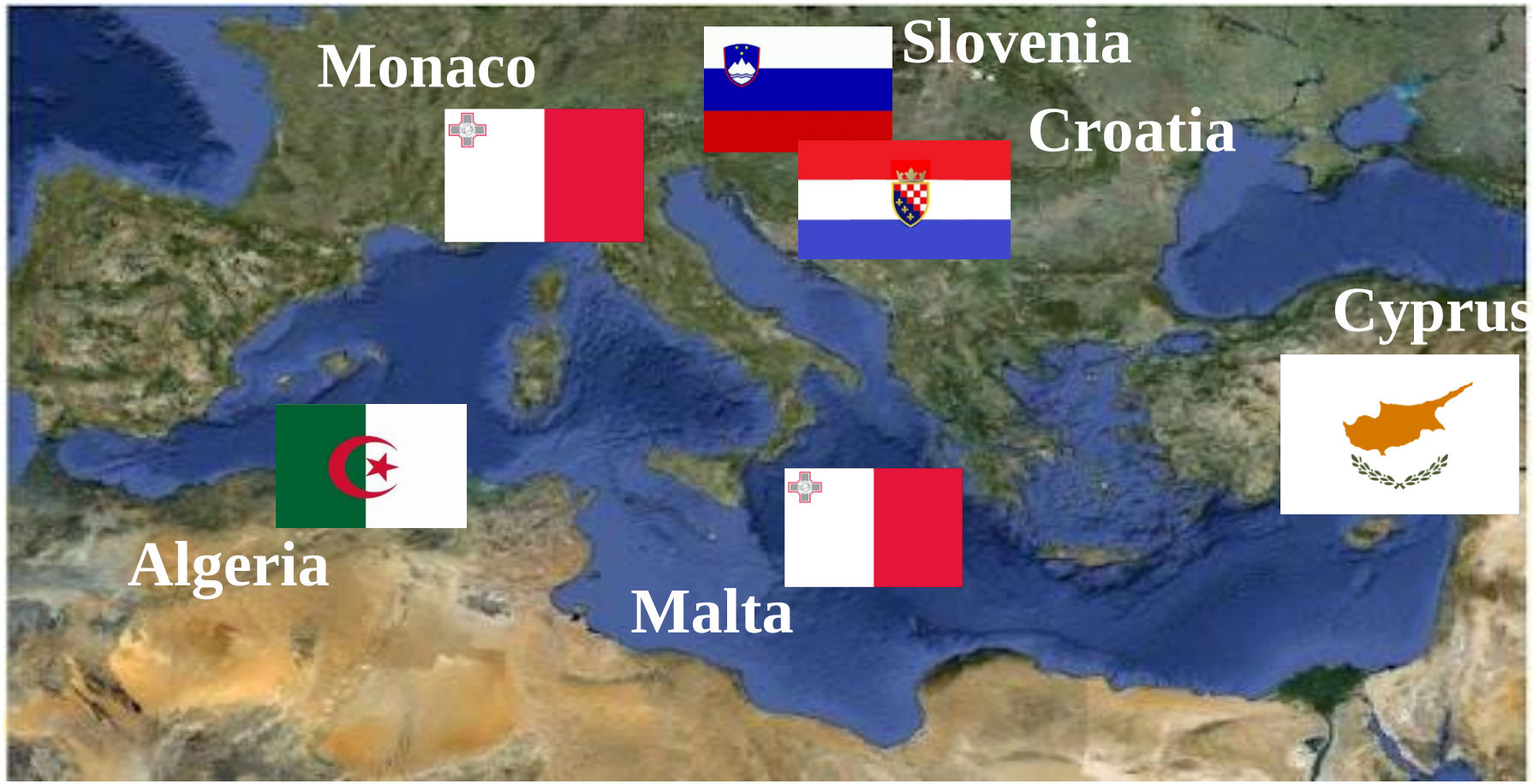
Equipments:

Automated Infra Red Inorganic Carbon Analyser (Airica) with Licor 7000

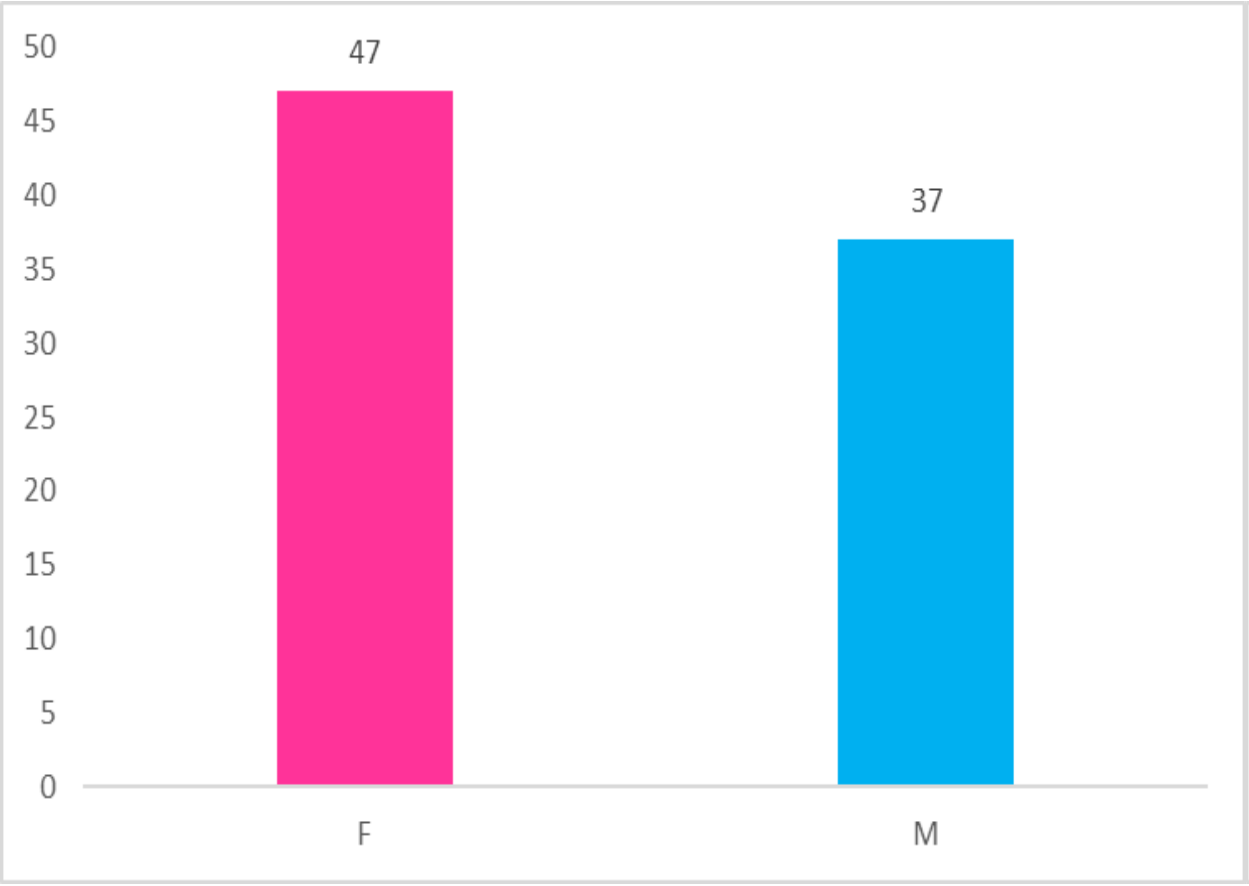
UV spectrophotometers (Shimadzu UV 1280 with UV Probe Software & 6 cells)

Titrator (Metler toledo G20S)

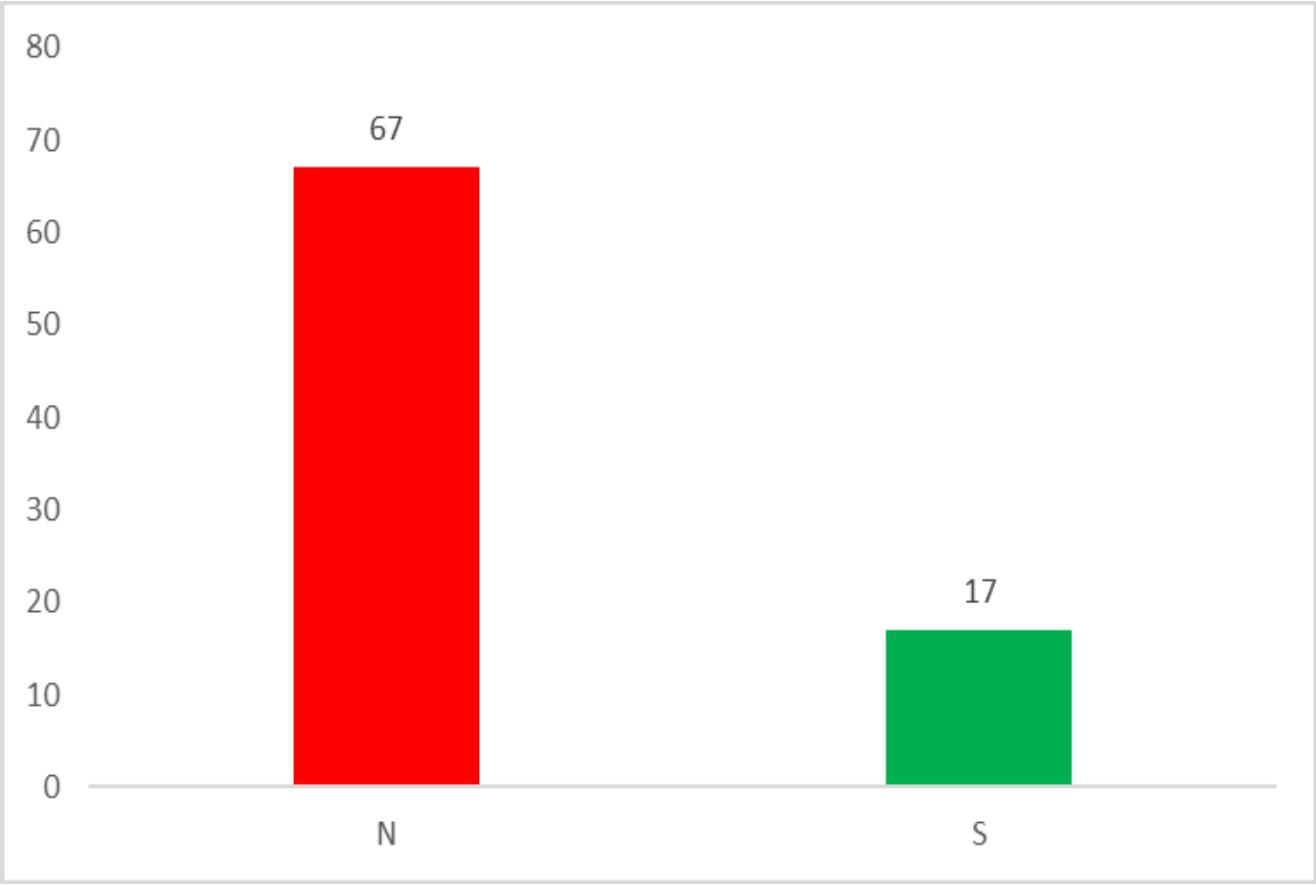
New Entries!

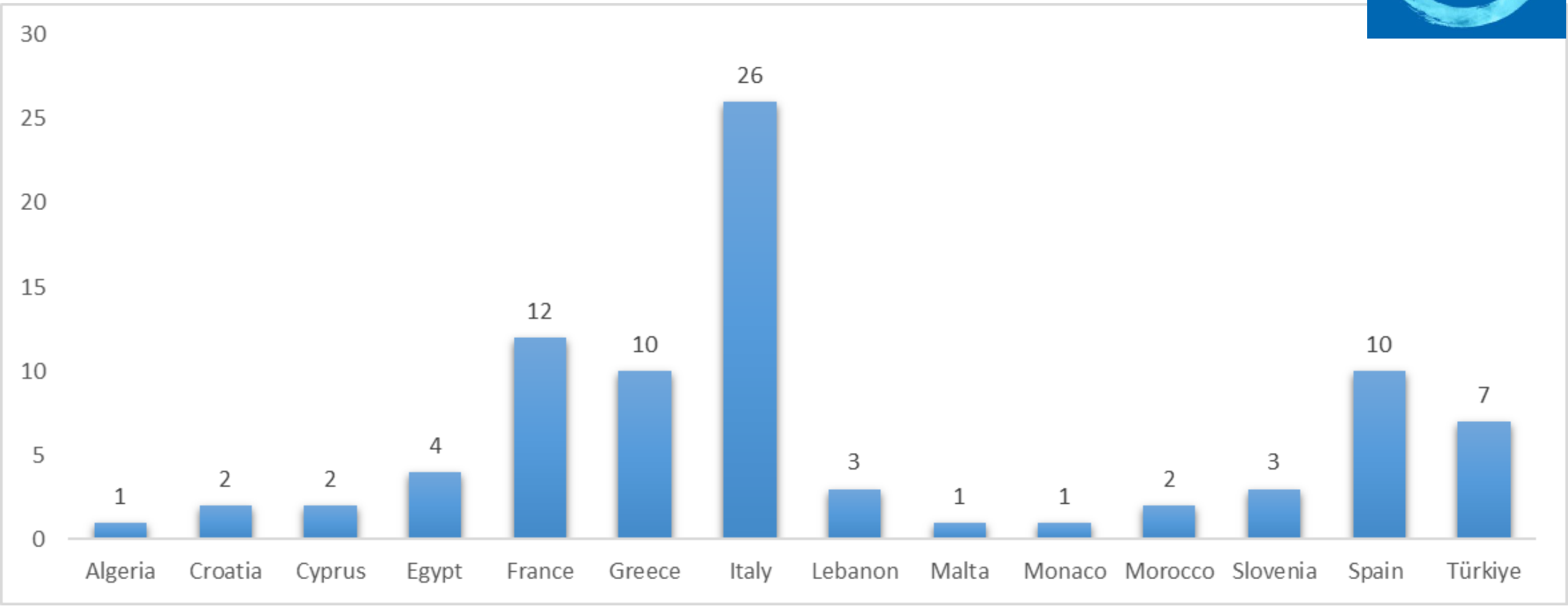


Gender



N *vs.* S

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Croatia
Cyprus
Egypt
France
Greece
Italy
Lebanon
Malta
Monaco
Morocco
Slovenia
Spain
Türkiye

OA Med-Hub, a GOA-ON regional hub & UN V.C., is on:

Facebook https://www.facebook.com/OAMedHub

Twitter @oa_medhub

Instagram @oa_medhub

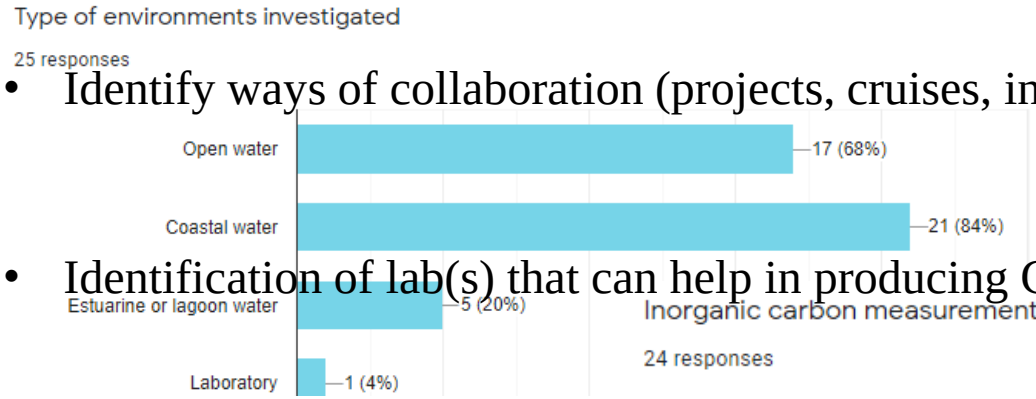
abedhassoun@cnrs.edu.lb / s.flickinger@iaea.org

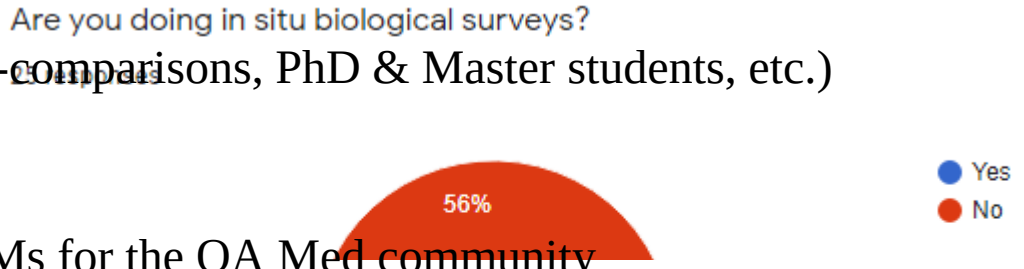
Ocean Acidification Information Exchange

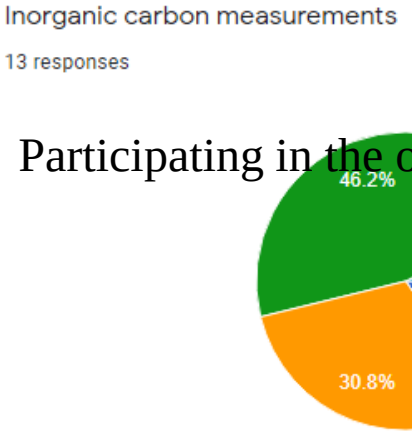
https://www.oainfoexchange.org/

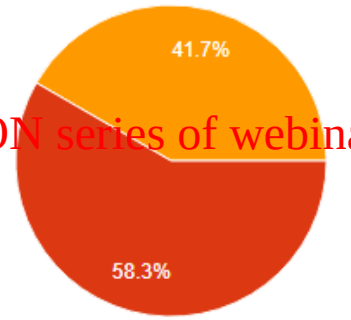
What have we done so far as a hub?

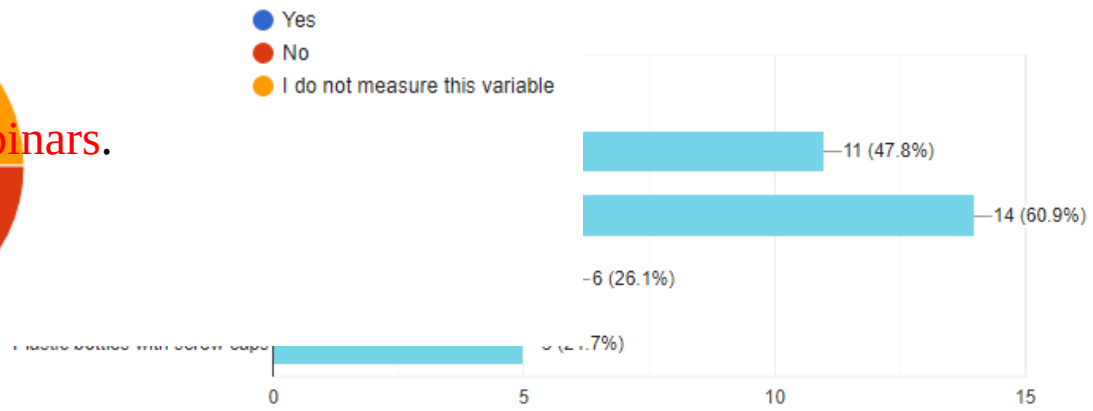
- We launched a survey to know "**Who's doing what in the Med.**" (to identify what methods are being used, what monitoring efforts are underway, major projects people are working on, etc.)
- Identify ways of collaboration (projects, cruises, inter-comparisons, PhD & Master students, etc.)
- Identification of lab(s) that can help in producing CRMs for the OA Med community
- Participating in the organization of GOA-ON series of webinars.











#ASLO2021

ASLO 2021 Aquatic Sciences Meeting
22–27 June 2021
Virtual Meeting

SS84 Ocean acidification: trends and effects from local to regional scales

Steeve Comeau, Laboratoire d'Oceanographie de Villefranche, steeve.comeau@obs-vlfr.fr
Abed El Rahman Hassoun, National Council for Scientific Research (CNRS-L)-National Center for Marine Sciences, abedhassoun@cnrs.edu.lb
Michele Giani, National Institute of Oceanography and Experimental Geophysics (OGS), Trieste, Italy, mgiani@ogs.trieste.it

Ocean acidification (OA) is getting more attention among the scientific community as new evidence is highlighting its effects on marine biogeochemistry, as well as on key marine ecosystems. The interplay of ocean acidification, warming, deoxygenation, and direct anthropogenic pressures is perturbing all ecosystems and putting the livelihoods, health, well-being and prosperity of people relying on marine resources under threat. This is why regional cooperations are key to further understand OA effects at local, regional, and global scales, an idea that is supported through GOA-ON (Global Ocean Acidification-Observing network) regional hubs (i.e. OA Med-Hub, OA-Africa, LAOCA, and many more). These hubs aim to connect scientists who are working on ocean acidification in a particular region and who are willing to cooperate to better understand the different aspects of OA from chemistry to biology, during present, future, as well as the past via paleo-studies of carbonate chemistry dynamics. This session aims to highlight the latest OA research globally, with a particular attention to marginal seas such as the Mediterranean Sea, which is considered a natural laboratory where synergistic trends of warming, OA and other drivers are already highlighted. We anticipate this to be a highly multidisciplinary session, with contributions from a range of fields including biology, chemistry, biogeochemistry, paleo-climatology, and modeling with a particular focus at local and regional levels.

UNITED NATIONS

HOME

REGISTRY COMMUNITIES OF OCEAN ACTION REGISTER COMMITMENT SHARE UPDATE ABOUT & RESOURCES

Ocean Acidification Mediterranean Hub (OA Med-Hub)

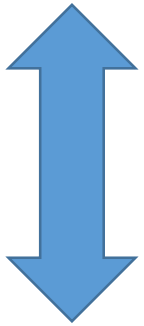
by The Global Ocean Acidification Observing Network (GOA-ON) (Scientific community)

DESCRIPTION | SDG 14 TARGETS COVERED | DELIVERABLES | RESOURCES MOBILIZED

The Mediterranean Ocean Acidification Hub is a network that connects Mediterranean scientists who are working and are interested in ocean acidification in the Mediterranean Sea. This VC is helpful in terms of bridging gaps between Mediterranean scientists, and to build a common ground that would help in creating collaborations to strengthen the ocean acidification research in the Mediterranean area.
The OA Mediterranean Hub includes scientists from eight countries in the Mediterranean so far (Egypt, France, Greece, Italy, Lebanon, Spain, Tunisia, and Turkey), and more than 45 scientists.

OA Med Hub

OA Science



OA diplomacy

Deliverables and status of the UN VC

NOVEMBER/2019: DONE

Organizing and coordinating meetings to guarantee a good collaboration and ultimately submit a common proposal for a Mediterranean collaboration related to OA

DECEMBER/2019: DONE

Expanding the network members

JANUARY/2020: DONE

Doing a survey to gather information about the Mediterranean OA scientific community

DECEMBER/2021: DONE

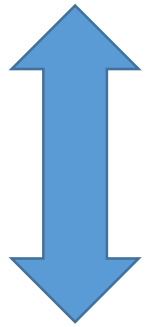
Preparing an overview paper to report the OA trends in the Mediterranean and its effects on marine life

AAAS

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

OA Med Hub

OA Science



OA diplomacy

AAAS annual meeting in February 2022

“Examples of science diplomacy in the OA Med-Hub”

Ocean Acidification International Coordination Centre

OA-ICC

OA Med Hub

Science

Society

Oceans and you

General Public perception of the Oceans, Climate Change and Ocean Acidification

OA Med Hub

> 200 attendees in 2020 & > 50 in 2021.

GOA-ON YouTube channel: https://www.youtube.com/watch?v=9wH7JLlURS0

monaco ocean week

IUCN

OA Med Hub

PRINCE ALBERT II OF MONACO FOUNDATION

Event Invitation - Save the Date

Future Priorities for Addressing Ocean Acidification in the Mediterranean: from Research to Policy

March 24th @ 14:00 - 15.30 CET

Join us to get the latest updates about ocean acidification science, policy gaps and possible actions in a Mediterranean context through short diverse presentations and a panel discussion with panelists from the Mediterranean region and beyond.

Joining instructions will be posted soon on our social media accounts and the Monaco Ocean Week website.

Translation into French available

https://www.youtube.com/watch?v=YiQ5tBguD3c&fbclid=IwAR0u1f7qWmxRFpUZa6havctY1hVighPSiGCdnlMOjND2lQHpDaHJn88oQ4g

Latest OA research & gaps in the Mediterranean

IAEA | Ocean Acidification International Coordination Centre OA-ICC

- **> 500 research papers on OA in the Med. during the period 1999-2021**
- **on OA biology**
- **on OA chemistry**
- **on OA socio-economy, policy, governance, and other OA aspects!**

SYSTEMATIC REVIEW article

Front. Mar. Sci.
Sec. Marine Biogeochemistry
doi: 10.3389/fmars.2022.892670

This article is part of the Re
The Changing Carbonate Syster
Areas and Marginal Seas
View all 3 Articles >

Ocean Acidification Research in the Mediterranean Sea: Status, Trends and Next Steps

Abed El Rahman Hassoun[1, 2*], Ashley Bantelman[3], Donata Melaku Canu[4], Steeve Comeau[5], Charles Galdies[6], Jean-Pierre Gattuso[5, 7], Michele Giani[4], Michael Grelaud[8], Iris E. Hendriks[9], Valeria Ibello[10], Mohammed Idrissi[11], Eva Krasakopoulou[12], Nayrah Shaltout[13], Cosimo Solidoro[4, 14], Peter W. Swarzenski[3], Patrizia Ziveri[8, 15]

[1]GEOMAR Helmholtz Center for Ocean Research Kiel, Helmholtz Association of German Research Centres (HZ), Germany, [2]National Centre for Marine Sciences, National Council for Scientific Research, Lebanon, [3]IAEA International Atomic Energy Agency, Monaco, [4]Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (Italy), Italy, [5]UMR7093 Laboratoire d'océanographie de Villefranche (LOV), France, [6]Division of Rural Sciences and Food Systems, Institute of Earth Systems, University of Malta, Malta, [7]Institut du développement durable et des relations internationales, France, [8]Institute of Environmental Science and Technology (ICTA-UAB), Universitat Autònoma de Barcelona, Spain, [9]Mediterranean Institute for Advanced Studies, Spanish National Research Council (CSIC), Spain, [10]Institute of Marine Sciences, Middle East Technical University, Turkey, [11]Institut National de Recherche Halieutique (INRH), Morocco, [12]Department of Marine Sciences, School of Environment, University of the Aegean, Greece, [13]National Institute of Oceanography and Fisheries (NIOF), Egypt, [14]The Abdus Salam International Centre for Theoretical Physics (ICTP), Italy, [15]Catalan Institution for Research and Advanced Studies (ICREA), Spain

OA Med Hub

Our 1st systematic review article is in press!

frontiers About us Journals

Ocean Acidification Research in the Mediterranean Sea: Status, Trends and Next Steps

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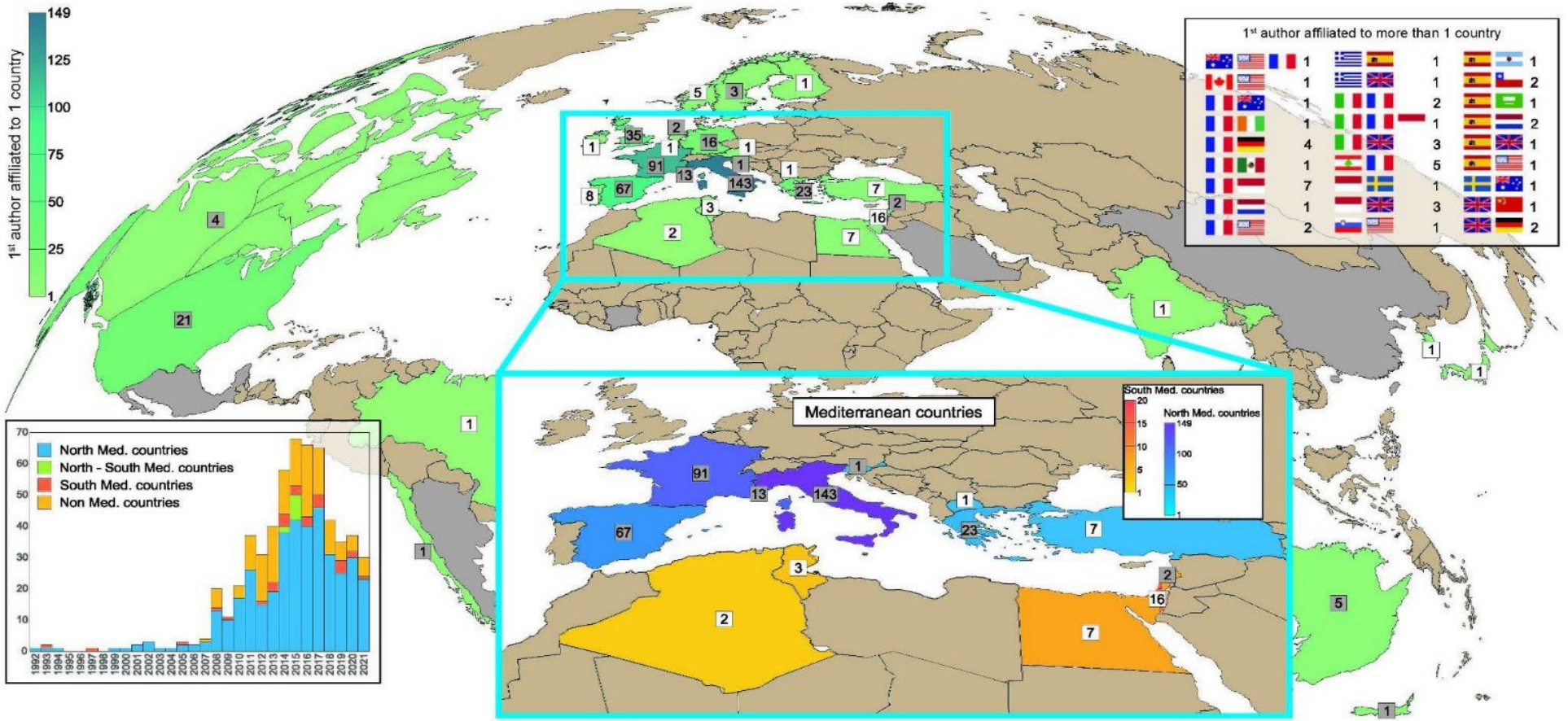

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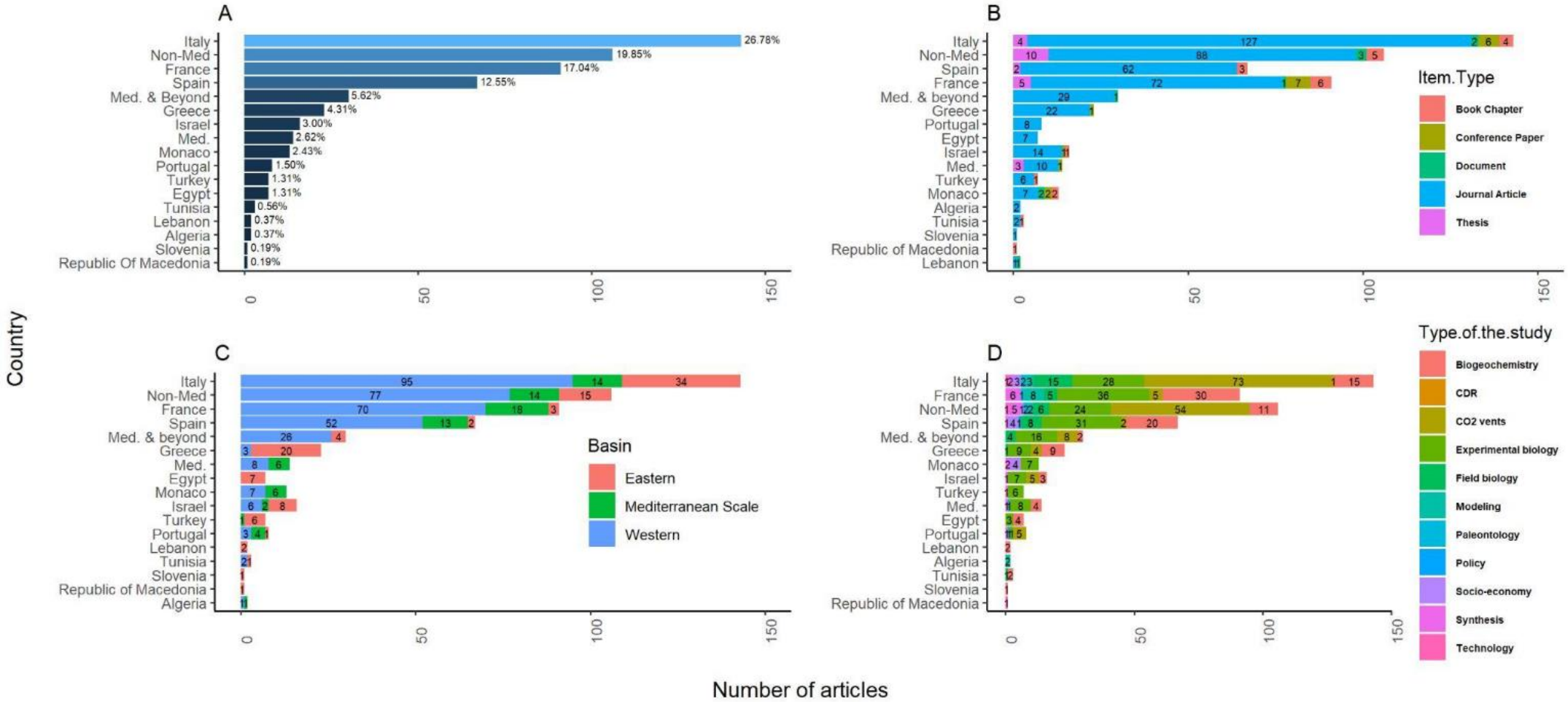

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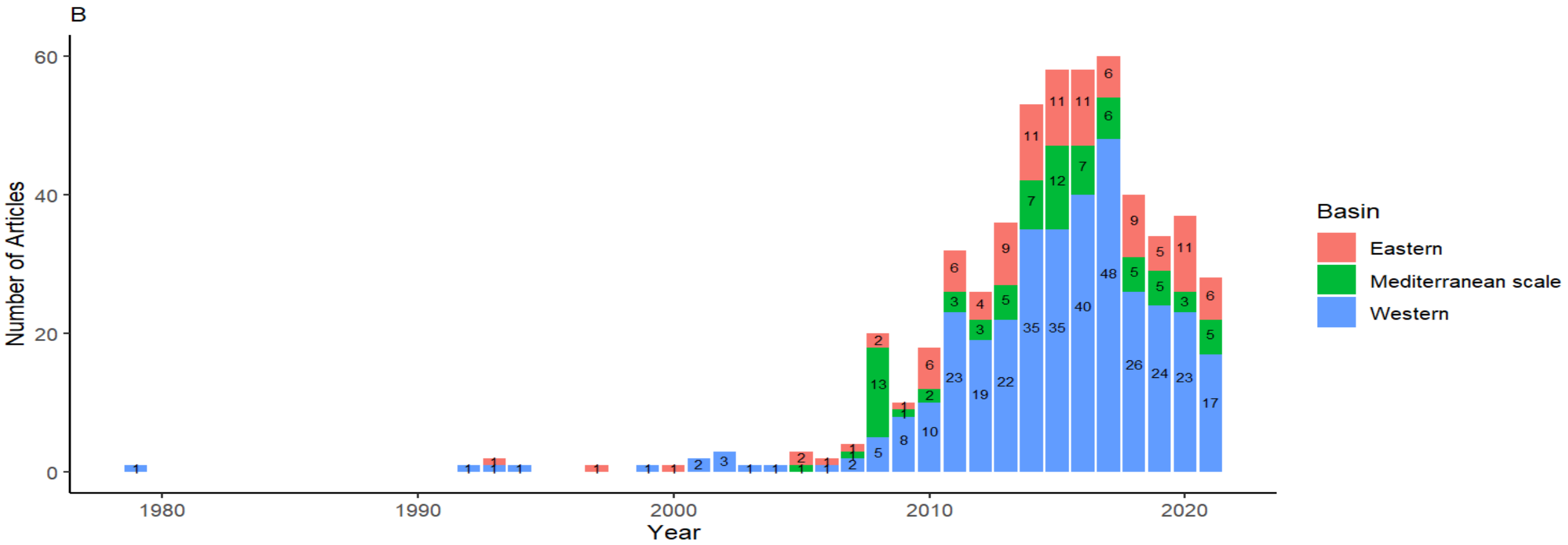
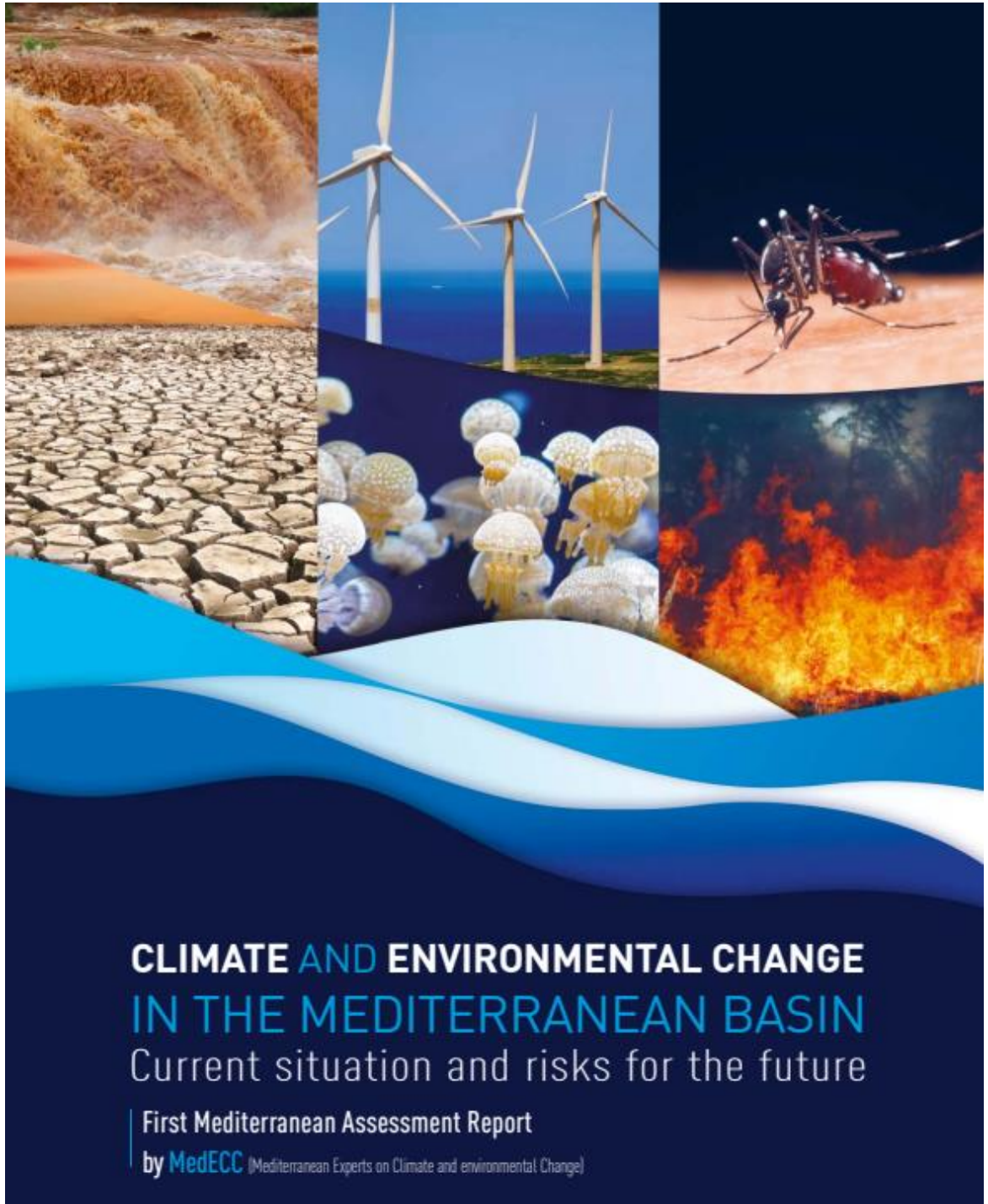


The importance of networking for the Mediterranean Sea!



MedEC
Mediterranean Experts on Climate and environmental Change

OA Med Hub

Coordinating Lead Authors:
Mario V. Balzan *(Malta)*, Abed El Rahman Hassoun *(Lebanon)*

Lead Authors:
Najet Aroua *(Algeria)*, Virginie Baldy *(France)*, Magda Bou Dagher *(Lebanon)*, Cristina Branquinho *(Portugal)*, Jean-Claude Dutay *(France)*, Monia El Bour *(Tunisia)*, Frédéric Médail *(France)*, Meryem Mojtahid *(Morocco/France)*, Alejandra Morán-Ordóñez *(Spain)*, Pier Paolo Roggero *(Italy)*, Sergio Rossi Heras *(Italy)*, Bertrand Schatz *(France)*, Ioannis N. Vogiatzakis *(Cyprus)*, George N. Zaimes *(Greece)*, Patrizia Ziveri *(Spain)*

Contributing Authors:
Marie Abboud-Abi Saab *(Lebanon)*, Aitor Ameztegui *(Spain)*, Margaretha Breil *(Italy)*, Thierry Gauquelin *(France)*, Ilse R. Geijzendorffer *(France)*, Aristeidis Koutroulis *(Greece)*, Jürg Luterbacher *(Germany)*, Mohammad Merheb *(Lebanon)*, Cesar Terrer Moreno *(Spain)*, Marco Turco *(Spain)*, Elena Xoplaki *(Germany)*

MedEC
Mediterranean Experts on Climate and environmental Change

OA Med Hub

Award Ceremony of the North-South Prize of the Council of Europe awarded to the MedECC for this report, next 9 December 2021, Lisbon

Some species are proven to improve the resilience of their habitat to various drivers. For example, *Paramuricea clavata* forests may enhance bioconstruction processes and increase the resistance and resilience of benthic assemblages in Mediterranean coralligenous habitats (Ponti et al. 2014b, 2018). The lack of available food, rising temperature and decreasing pH trends will be essential to understanding future population dynamics. Bioengineering as a possible adaptation strategy includes techniques to mitigate chemical effects of increased atmospheric CO_2 concentrations on the oceans. These chemical changes may have a variety of important biological consequences, including some potentially negative impacts, which are controversial and surely require further consideration. These ideas have never been tested *in situ* (Ziveri et al. 2017).

In conclusion, any kind of action that improves marine ecosystem health, resilience or biodiversity could delay and reduce the adverse effects of climate drivers. This includes the implementation

4.1.3.5 Regional observation networks as a tool for adaptation

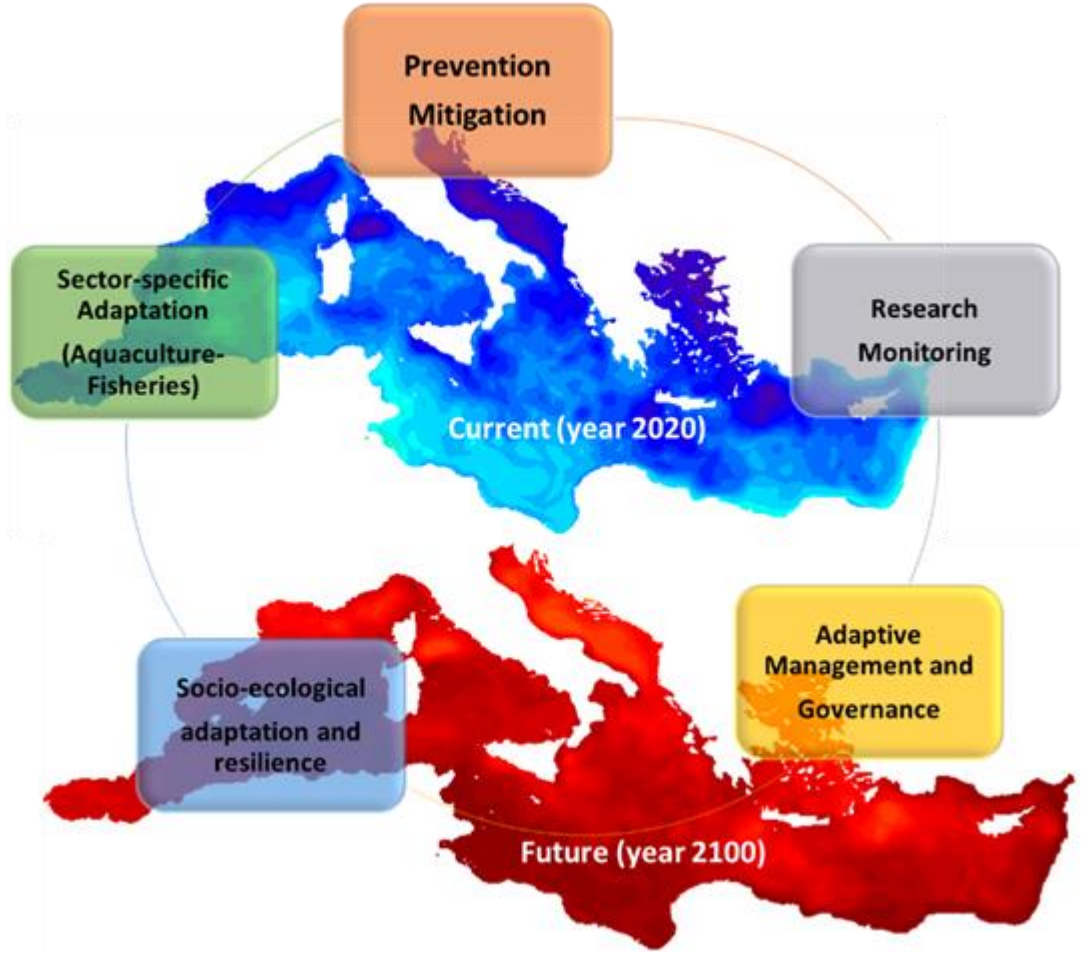
Another aspect that might improve the effectiveness of managed adaptation strategies is the establishment of active regional and local observation networks. Local observation programs and regional networks that include scientists from different Mediterranean countries/sub-basins create a solid platform for peers to collaborate in monitoring climate change drivers and impacts, enhance data sharing policies and accessibility, and improve capacity-building among the members of their scientific community.

Furthermore, long-term active hubs would definitely help in deriving more robust findings about the different environmental trends in the Mediterranean, which will provide more comprehensive and conclusive results for decision makers. Within the Global Ocean Acidification-Observing Network (GOA-ON), a regional Mediterranean hub has been recently established, called the Ocean Acid-

ification Mediterranean Hub[31] (OA Med-Hub). This hub could be an important platform for providing robust ocean acidification-related results for the scientific community, the general public and decision-makers, which would help to create relevant future adaptation actions in Mediterranean countries.

Moreover, these regional networks could be an effective tool for improving public awareness and enhancing capacity-building among scientists who are not able or do not have the appropriate tools/equipment to monitor specific phenomenon. Thus, such hubs could unify the methodologies and tools adopted to measure and monitor short- and long-term climate change trends, and their effects on local and regional marine resources and ecosystems. They could also help obtain funds for laboratories that do not have the capacities to properly survey climate change drivers and impacts. For example, GOA-ON published recently an implementation strategy document[32] to provide guidance that will harmonize sampling and analysis procedures, to compare results and trends. Creating similar networks that could target other phenomena, such as deoxygenation, warming, etc., and good communication between these hubs will be crucial for developing suitable and holistic key messages that could be provided to policymakers.

Ocean Acidification as a Governance Challenge in the Mediterranean Sea: Impacts from Aquaculture and Fisheries (Bednaršek et al., 2023)



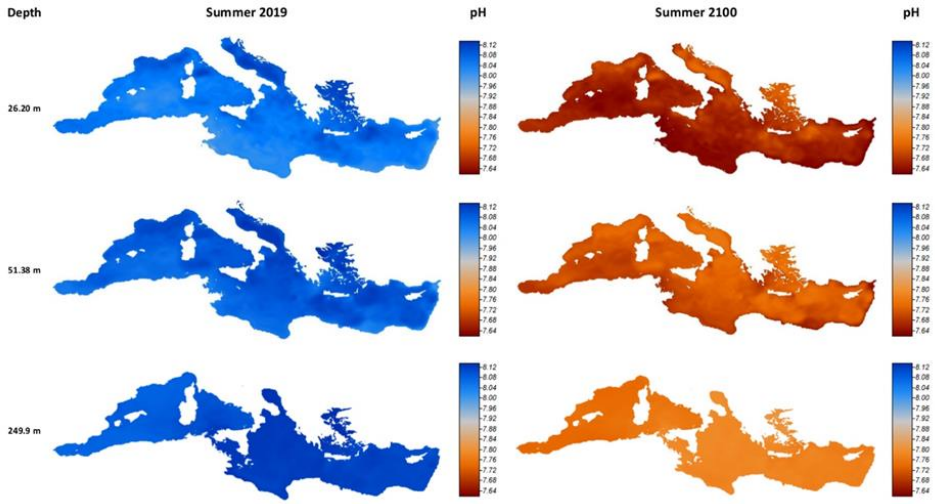
The study is unique to establish the interdisciplinary link between:

- the current and future physical-chemical conditions
- identified biological risks for the aquaculture and the fisheries
- governance and management challenges
- with the insights aimed at their improvement.

The premise of this research is that by understanding the risks under future OA scenarios and improved governance, we can improve informed near-term management response to allow for sustainability of the ecosystem services.

Ocean Acidification as a Governance Challenge in the Mediterranean Sea: Impacts from Aquaculture and Fisheries (Bednaršek et al., 2023)

Evaluated changes in pH between current and future 2100 conditions



changes in pH spatially correspond important aquaculture facilities - risks

Support holistic *in situ* scientific information supply and monitoring to enable better-informed decision-making:

- Continuous, local carbonate chemistry monitoring, characterising seasonal patterns, pH variability; co-occurence of multiple stressors
- Strengthen regional and financially incentivize coordinated and institutionalized network of monitoring stations through the Mediterranean hub of the Global Ocean Acidification Observing Network to map the vulnerability of coastal areas to OA and to extend monitoring to near-shore systems relevant to management jurisdictions;
- Set up initiatives in each EU coastal State to assess the threat of OA to ecosystem health and human livelihoods and to evaluate strategies to mitigate local drivers (*sensu*, Strong, 2014);
- Identify and fund multi-disciplinary research related to the socio-ecological impacts of OA or evaluating the adaptive capacity and the resilience of regional institutions and law to slow onset and abrupt environmental changes within the next research and innovation framework programme (Horizon Europe).
- Substitute and diversify fish and aquaculture species, when permanently or temporarily possible by compensating losers (e.g. fishermen), providing transitional support, and stimulating innovation to accelerate emergence of alternatives and technical replacement solutions
- Develop adaptive and climate friendly fisheries management, modernize the fisheries Common policy through, for e.g., adapting quotas and TAC management systems to OA, limiting or stopping overfishing and rebuilding fish stocks, reallocating to new or underutilized fish species.

Climate change consequences know no boundaries! So we have to collaborate to save the future of our shared sea and resources!

Regional hubs are crucial to understand local OA trends and effects, thus a continuous support is always needed!

Implementing UN SDG 14.3 is essential in "Protecting Communities and Livelihoods from the Threat of a Changing Sea" such as the significantly changing Mediterranean

We need funds to better understand OA in the changing Med., to improve the collaboration between its scientists, and to consolidate bridges of communication between scientists, policymakers, stakeholders and the public.

OA Med-Hub, a GOA-ON regional hub & UN V.C., is on:

Facebook https://www.facebook.com/OAMedHub

Twitter @oa_medhub

Instagram @oa_medhub

abedhassoun@cnrs.edu.lb / s.flickinger@iaea.org

Ocean Acidification Information Exchange

https://www.oainfoexchange.org/