



Mediterranean Sea Acidification in a changing climate (MedSeA)

UAB
Universitat Autònoma
de Barcelona

Institute of Environmental Science
and Technology

- ★ MedSeA FP7 EU research initiative on ocean acidification >100 PIs from 22 institutes from 12 countries (19 institutes from Mediterranean countries)



EUROPEAN INITIATIVE ON OCEAN ACIDIFICATION
ENDORSED BY



surface ocean

solas
2013

lower atmosphere study



icta

OA a global phenomena with different regional impacts: when MedSeA started nearly no data of Med CO2 chem.

- Increase T
- Overfishing
- Invasion of alien species
- Eutrophication
- Contamination
- **OCEAN ACIDIFICATION**



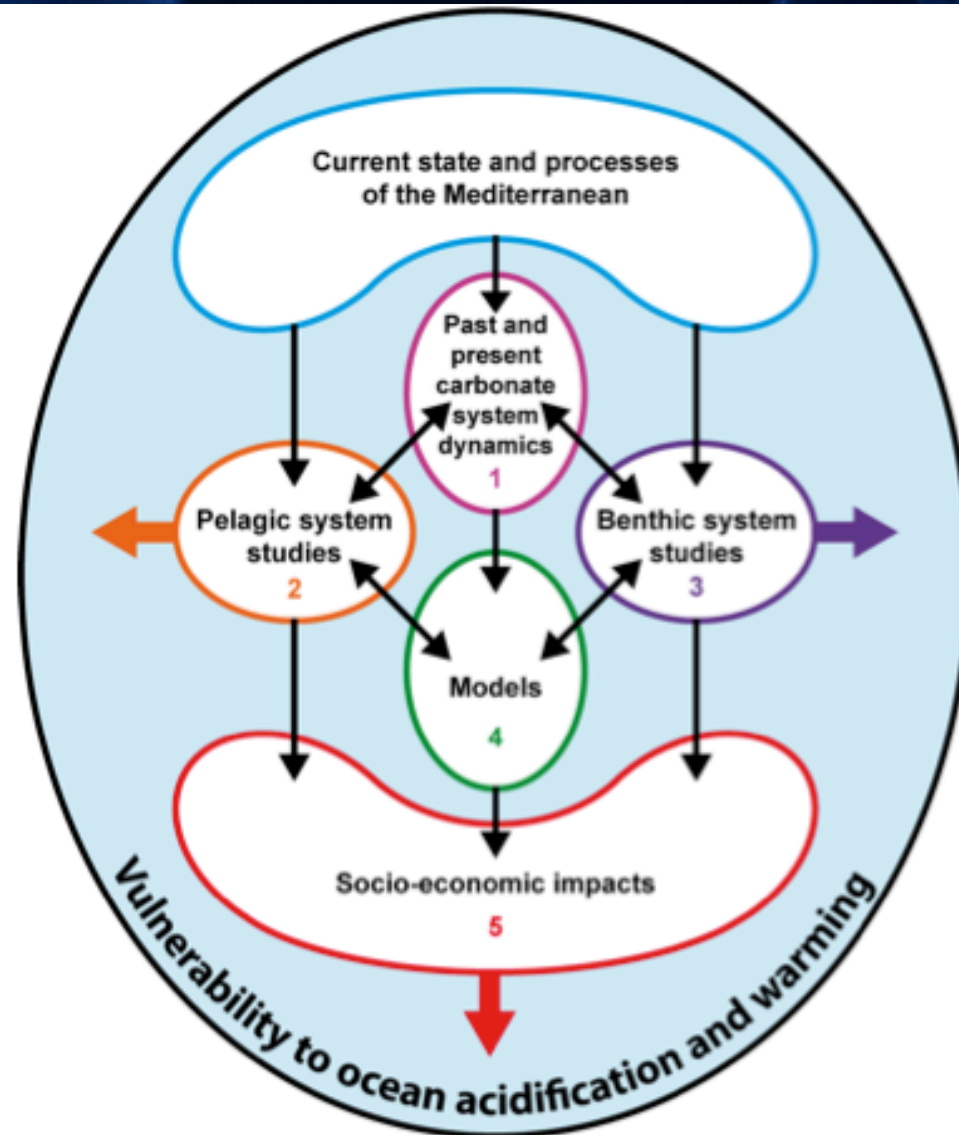
OBJECTIVES

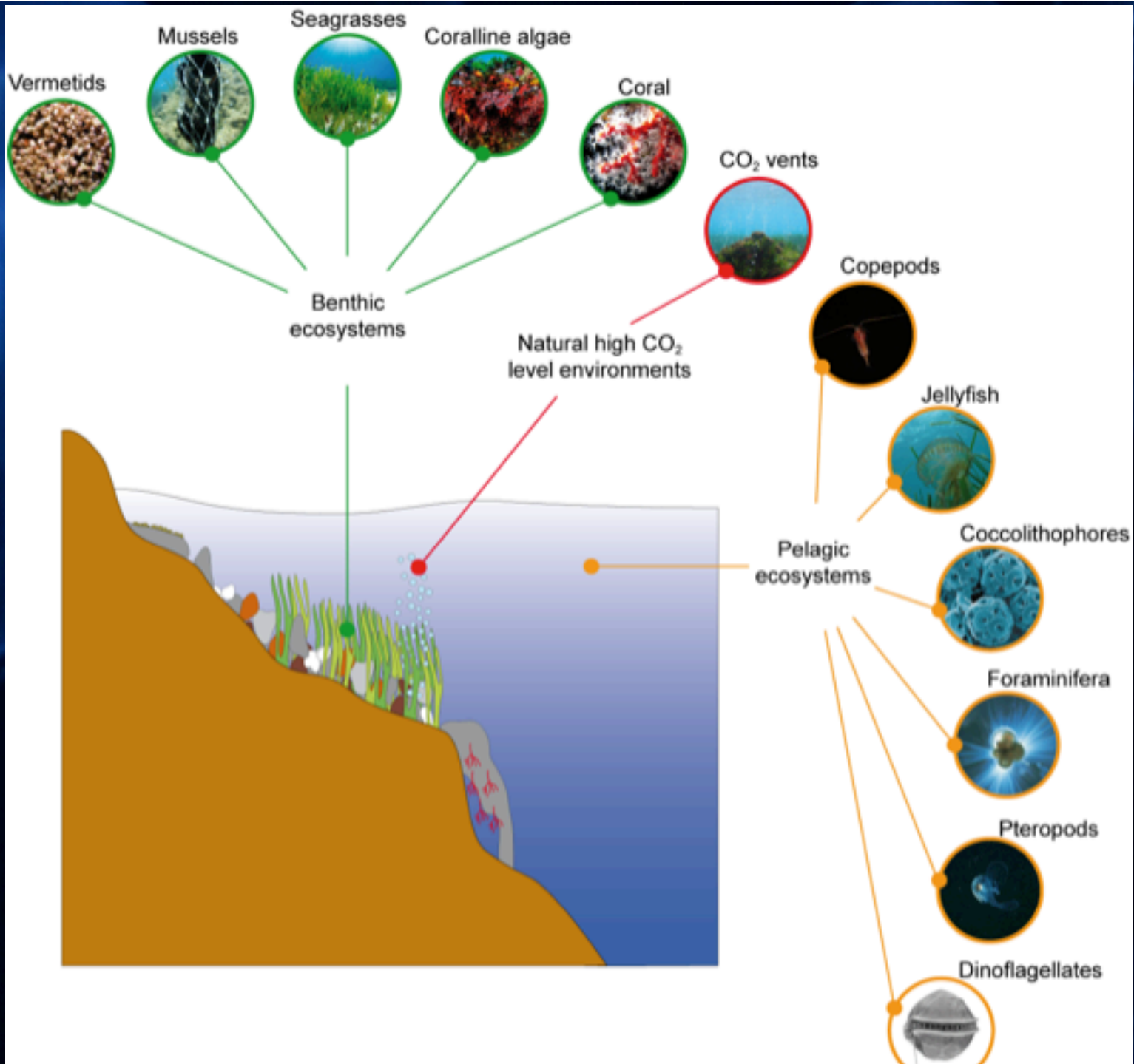
1/ Identifying where the **impacts of acidification on Mediterranean waters will be more significant** (ocean chemistry → marine ecosystems → socio-economic costs).

2/ Provide best estimates and related uncertainties of **future changes in Mediterranean Sea pH, CaCO_3 saturation states, changes in habitat suitability of relevant ecological and economically-important species.**



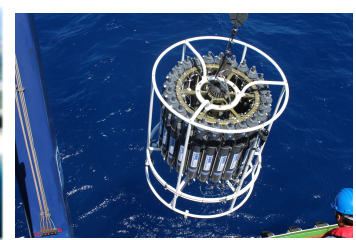
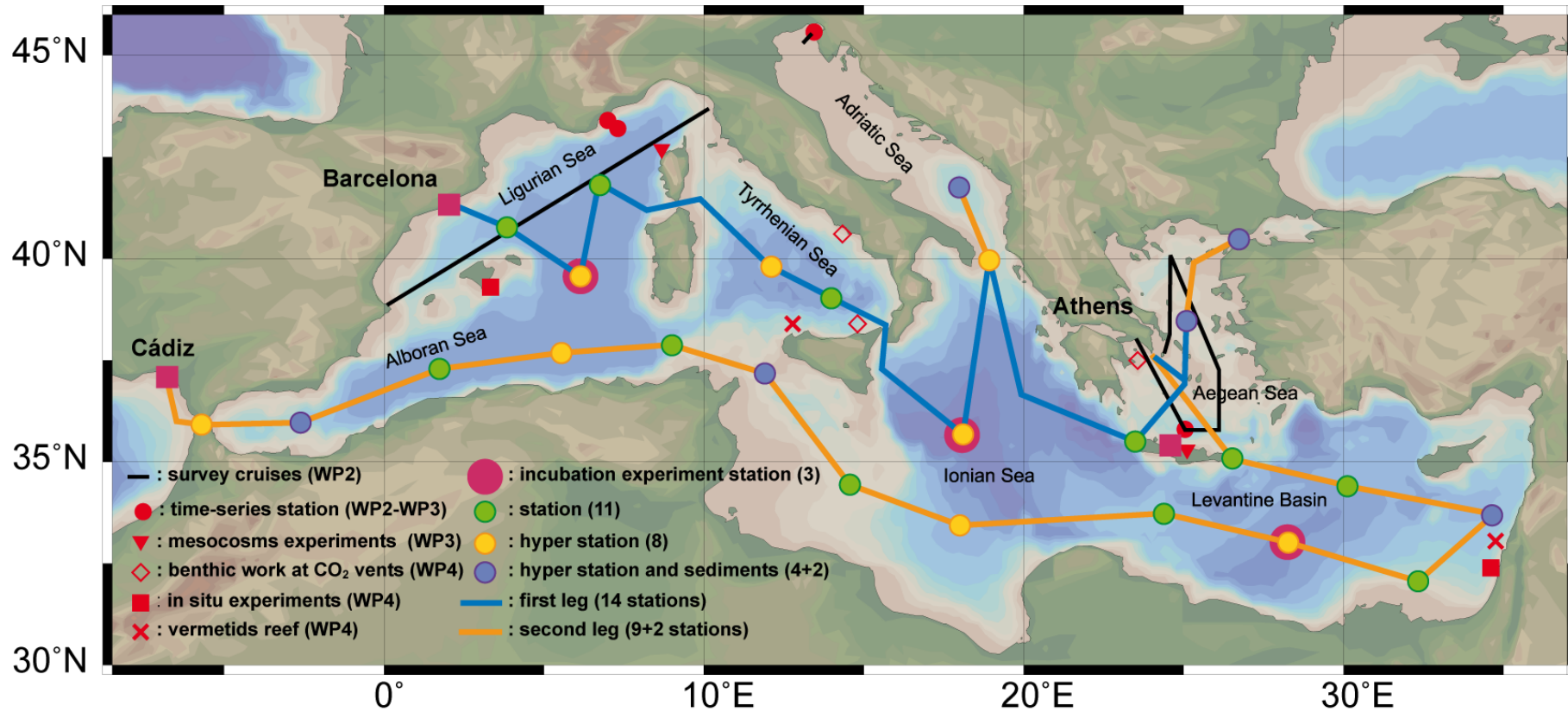
Conceptual scheme of the MedSeA scientific work



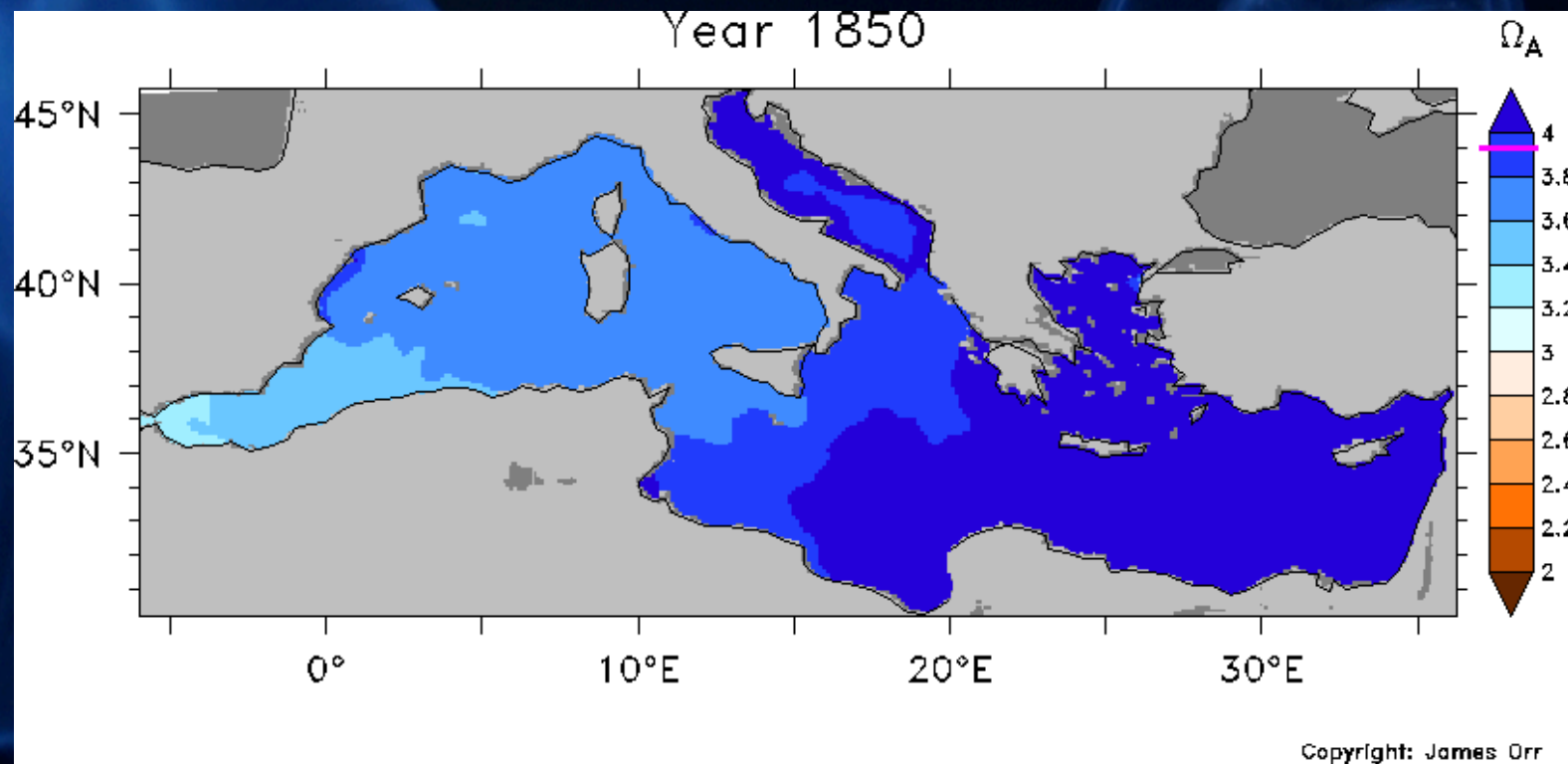




MedSeA Project sites & surveys



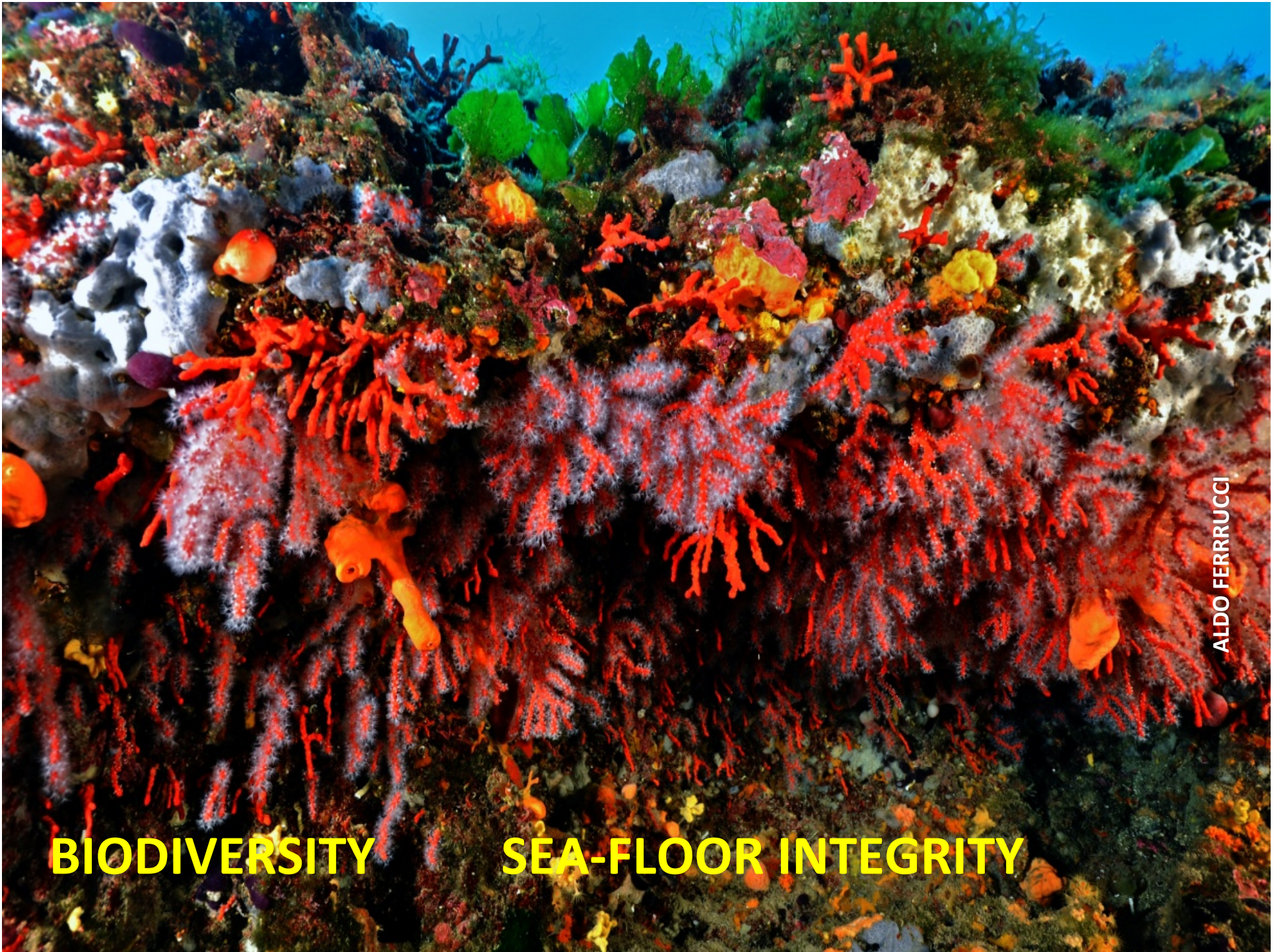
Evolution of Ω_A (1850 – 2099)



James Orr et al., in prep.

Large increases in surface acidity by end of century (A2 scenario)

Surface waters unfriendly to corals and pteropods by mid century



ALDO FERRUCCI

BIODIVERSITY

SEA-FLOOR INTEGRITY

An underwater photograph showing a dense field of green seagrass in the foreground and a coral reef in the background. The water is clear and blue, with many small, bright light reflections scattered throughout. The text "NON-INDIGENOUS SPECIES" and "SEA-FLOOR INTEGRITY" is overlaid in yellow at the bottom center.

NON-INDIGENOUS SPECIES
SEA-FLOOR INTEGRITY

R. RODOLFO-METALPA

COMMERCIAL SHELLFISH



Mediterranean Sea acidification and warming

- **Both warming and acidification altering marine life in the Mediterranean Sea (next decades)**
- **Threaten iconic Mediterranean Sea ecosystems**
- **Benefits that the Mediterranean Sea provides to humans may be endangered:**
 - **aquaculture of shell-forming species is threatened by warming and secondarily by acidification**

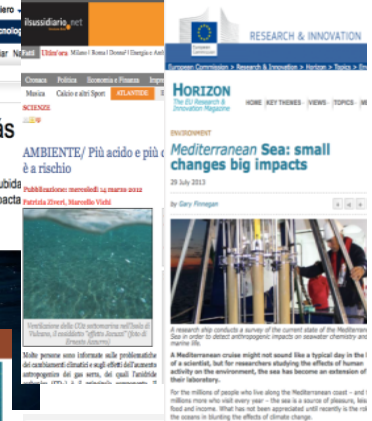
'Good Environmental Status' for Europe's **high CO₂** seas and oceans

- Many biogeochemical processes impacted by high CO₂
- Trophic web dynamics
- Synergism-Antagonism
- Increase ecosystem resilience (Marine protec. areas)
- **ADOPT STRINGENT REDUCTIONS in GHG emissions**
- **WIDER/DEEPER COMMUNICATION PRACTICES**





Communicating OA science



10 FACTS on Ocean Acidification and Warming in the Mediterranean Sea

1. An additional 100 Gt of carbon dioxide (CO₂) is being added to the atmosphere each year, raising the concentration of CO₂ in the atmosphere from 380 ppm in 2005 to 390 ppm in 2010. This has led to a 0.5°C increase in the average surface temperature of the world's oceans since 2000 and 2010. This increase is expected to reach 1.5°C to 2°C by 2100. The Mediterranean Sea is expected to warm by 1.5°C to 2°C by 2100.
2. The Mediterranean Sea has shown an average temperature increase of 0.6°C over the last 20 years. This is a clear sign of global warming. The increase in temperature is expected to reach 1.5°C to 2°C by 2100.
3. Atmospheric CO₂ is projected to reach a concentration of 550 ppm by 2100. This will lead to a 1.5°C to 2°C increase in the average surface temperature of the world's oceans.
4. The increase in CO₂ concentration is leading to a decrease in the pH of the ocean, which is known as ocean acidification. The pH of the ocean is expected to decrease by 0.1 to 0.2 units by 2100.
5. Ocean acidification is expected to have a negative impact on marine life. Many species of marine life are sensitive to changes in pH. The decrease in pH is expected to lead to a decrease in the number of species of marine life.
6. Ocean acidification is also expected to have a negative impact on the productivity of the ocean. The decrease in pH is expected to lead to a decrease in the amount of phytoplankton in the ocean.
7. Ocean acidification is also expected to have a negative impact on the food chain. The decrease in pH is expected to lead to a decrease in the number of fish in the ocean.
8. Ocean acidification is also expected to have a negative impact on the economy. The decrease in pH is expected to lead to a decrease in the amount of fish caught in the ocean.
9. Ocean acidification is also expected to have a negative impact on the environment. The decrease in pH is expected to lead to a decrease in the amount of coral reefs in the ocean.
10. Ocean acidification is also expected to have a negative impact on the climate. The decrease in pH is expected to lead to a decrease in the amount of carbon dioxide in the atmosphere.

10 HECHOS sobre la acidificación oceánica y el calentamiento en el mar Mediterráneo

1. El aumento de CO₂ en la atmósfera está provocando un calentamiento global que afecta a todo el planeta. En el Mediterráneo, esto se traduce en un aumento de temperatura del agua que puede llegar a 1,5°C o 2°C para el año 2100.
2. El Mediterráneo ha experimentado un aumento de temperatura promedio de 0,6°C en los últimos 20 años. Este es un claro signo de calentamiento global.
3. Se proyecta que el CO₂ atmosférico alcanzará una concentración de 550 ppm para el año 2100, lo que provocará un calentamiento adicional de 1,5°C a 2°C.
4. El aumento de CO₂ está provocando una disminución del pH del océano, conocida como acidificación oceánica. Se espera que el pH del Mediterráneo disminuya entre 0,1 y 0,2 unidades para el año 2100.
5. La acidificación oceánica se espera que tenga un impacto negativo en la vida marina. Muchas especies de organismos marinos son sensibles a los cambios de pH.
6. La acidificación oceánica también se espera que tenga un impacto negativo en la productividad del océano. Se espera que disminuya la cantidad de fitoplancton.
7. La acidificación oceánica también se espera que tenga un impacto negativo en la cadena alimentaria. Se espera que disminuya el número de peces.
8. La acidificación oceánica también se espera que tenga un impacto negativo en la economía. Se espera que disminuya la cantidad de peces capturados.
9. La acidificación oceánica también se espera que tenga un impacto negativo en el medio ambiente. Se espera que disminuya la cantidad de arrecifes de coral.
10. La acidificación oceánica también se espera que tenga un impacto negativo en el clima. Se espera que disminuya la cantidad de CO₂ en la atmósfera.

سفن ومحتضن وانكسار النظام البيئي

كيف حال أكبر النظم البيئية على الأرض؟

البحر الأبيض المتوسط هو من بين أكبر النظم البيئية على الأرض. ومع ذلك، فإن النظام البيئي للبحر الأبيض المتوسط يواجه تحديات كبيرة. من بين هذه التحديات: ارتفاع درجة حرارة المياه، وتحمض المياه، وانخفاض مستويات الأكسجين، وتلوث المياه، وفقدان التنوع البيولوجي.

Your awareness can make a difference

Learn more about ocean acidification and warming in the Mediterranean Sea. Visit our website for more information.

THE MEDITERRANEAN: BENEATH THE SURFACE

The famous sea faces challenges from climate change, pollution, overfishing, and tourism – no name just a few.

Faire pencher la balance: le CO₂ et la mer Méditerranée

Inclinando la balanza: CO₂ y el mar Mediterráneo

ترجيح كفة التوازن: ثاني أكسيد الكربون والبحر المتوسط

Tipping the balance CO₂ and the Med

L'Approche Écosystémique dans la Méditerranée

EU-funded research on the Carbon Cycle

Presented at the 9th International Carbon Dioxide Conference (ICDC9) Beijing, China 3-7 June 2013

Ecosystems of the Mediterranean Reference User Group

What is 'Ocean Acidification'? Benefits expected from the MRUG. Why the Mediterranean Sea? Examples from the MRUG action plan.

Mediterranean Reference User Group

MRUG members, MRUG contact persons, MRUG project website.

Rising concerns about Ocean Acidification and Warming in the Mediterranean Sea

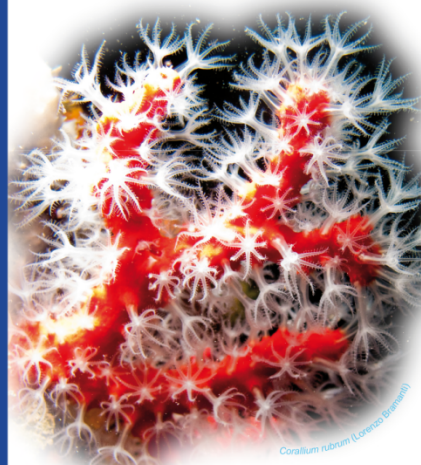
Executive summary of the MedSea project

This fact sheet has been compiled as part of the European project Mediterranean Sea Acidification in a changing climate (MedSea). It is intended to aid scientists, science communicators, and science policy advisors. The MedSea project included more than 100 scientists from 22 institutions in 12 countries. For information and contacts please consult www.medsea-project.eu.

1. As carbon emissions increase and carbon dioxide levels (CO₂) in the atmosphere rise, so does the concentration of CO₂ in the ocean. The ocean has been very efficient in absorbing CO₂ and this has decreased the accumulation of CO₂ in the atmosphere and thus reduced the potential 'warming' effect on our climate. However, we have reached a point where the ocean is absorbing so much CO₂ that it is changing the chemistry of the ocean resulting in 'ocean acidification'. This poses a threat to open ocean and coastal marine ecosystems, including the Mediterranean Sea.

2. The Mediterranean Sea has shown an average temperature increase of 0.67°C over the last 25 years. This deep semi-enclosed sea is characterized by an active exchange of waters from the surface to depth, a process known as 'ventilation', which effectively distributes the heat and anthropogenic carbon to the interior of the basin so not only are the deep waters warming but they are acidifying too.

3. Atmospheric CO₂ is projected to reach a concentration of 550 parts per million (ppm) by 2050 if urgent measures to reduce carbon emissions are not implemented. There is a high level of certainty



that this change to the atmosphere will lead to an average surface warming from 1 to 1.5°C in the Eastern Mediterranean, Aegean and Adriatic Sea between 2000 and 2050. In summer, the average surface temperature is very likely to constantly exceed 29°C in the South Eastern Mediterranean.

4. Absorbing anthropogenic CO₂ from the atmosphere is by far the largest driver of the acidification of Mediterranean Sea surface waters. The few, available, data sets from the Northwestern Mediterranean Sea indicate that in the 18-year period 1995–2013 alone, acidity has already increased more than 10%. Projections of CO₂ emissions indicate a sustained uptake of anthropogenic carbon in the ocean and a 30% increase in acidification between years 2010 and 2050 if we continue to emit CO₂ at the same rate. This implies, since the industrial revolution and within only a few decades, acidification of the Mediterranean Sea is likely to increase by 60%, and by 150% at the end of the century.

5. Both ocean warming and acidification are altering the marine life of the Mediterranean Sea. Consequences for Mediterranean Sea warming are already apparent, including northward shifts of species from the southeastern shores of the basin and increasing incidences of marine organisms dying during unusually warm summers. The risks posed by warming and acidification are expected to become more acute in the next decades.

6. Impacts of ocean acidification on marine organisms will vary, because different groups exhibit a wide sensitivity. Several planktonic organisms are affected by acidification suggesting that Mediterranean plankton food web may be altered in the future. Several plankton organisms are essential in the diet of fish larvae and consequently this can also have a negative impact on fisheries population. Acidification and warming modify the abundance and the functioning of both phytoplankton and zooplankton groups living in the Mediterranean, including those of shell-forming organisms like pteropods and coccolithophores. Other marine biota, like viruses and bacteria appear less sensitive. Warming will probably have a more important effect than acidification on plankton, and may enhance the effect of acidification on the planktonic ecosystem functioning.

7. Iconic Mediterranean ecosystems such as sea grass meadows, Coralligene reefs and Vermetid snail reefs are threatened by ocean acidification and warming. These ecosystem-building species create rich key habitats and homes to thousands of species, and also protect shores from erosion as well as offer a source of food and natural products to society. Sea grass meadows are essential habitat as feeding ground and nursery areas for many fisheries species. These hot-spots of Mediterranean Sea biodiversity prospered over millennia and served human populations in the region, but are now facing considerable decline. The slowly growing Mediterranean red coral (*Corallium rubrum*) is extremely sensitive to ocean acidification conditions. This has major implications for the Red Coral industry which has not only economic significance but also cultural importance in the Mediterranean region.

8. Impacts of ocean acidification and warming may extend to several Mediterranean marine and coastal ecosystem services, including providing food, supporting recreational activities, absorbing carbon, climate regulation, and coastal protection. Coastal areas with economic activities directly depending on marine resources may face serious impacts on employment and benefits in sectors like aquaculture, open sea fisheries and tourism which is relevant to many Mediterranean countries. In addition, coastal protection by Vermetid reefs may be negatively affected by ocean acidification, which is relevant to certain areas in south central and eastern Mediterranean.

Adaptation and mitigation strategies, and policies at global, regional and local scales need to be implemented as they are the only certain, effective way to reduce CO₂ emissions to the atmosphere and associated ocean acidification. Mediterranean Sea acidification may be more severe in areas where human activities and impacts, such as nutrient runoff from agriculture, further increase acidity. Agricultural run-off from land and other pressures linked with human activities on Mediterranean ecosystems needs to be more strictly regulated. In addition, adaptation policies are required as an increase in atmospheric CO₂ concentration seems unavoidable. The combination of mitigation and adaptation can assure that the Mediterranean can continue to sustain livelihoods, provide food and protect shorelines.



This project has received funding from the European Union's Seventh Programme for research, technological development and demonstration under grant agreement No 2651103



This document was produced jointly by MedSea scientists and members of the Mediterranean Reference User Group (MRUG) (medsea-project.eu/mrug/). All suggestions or comments to these talking points should be addressed to pr.medsea@uab.cat or patrizia.ziveri@uab.cat.

9. Sensitivity of shell-forming species such as bivalve mollusks (e.g. mussels, clams and oysters) to changes in pH and temperature represent a threat to the aquaculture sector of this region, which is an important source of income, employment and food. Total production of this sector amounts to about 153,000 tons in 2012, representing a total value of approximately € 225 million. Increasing of jellyfish outbreaks could also determine the total mortality of the fishes in the cages as it is already occurred in some areas of South of Mediterranean.



Mussels farming (Andrea Ciambra)

10. Tourism may be affected by ocean acidification and warming through degradation of marine ecosystems (loss of iconic species from the coralligenous, such as gorgonians - soft coral) on diving experiences and through jellyfish outbreaks. Initial cost estimates for such effects have been obtained. For example, on the Israeli coast, a jellyfish outbreaks would reduce the number of beach trips between 3% and 10.5%, corresponds to an annual monetary loss in the range of € 2.4–6.2 million. In the marine protected area of Medes Islands (Spain) an assessment of the behaviour of scuba

divers under conditions of sea warming and ocean acidification gave the following results: disappearance of gorgonians was regarded as the most undesirable environmental change requiring a compensation of approximately €4 million for all dives in a year; abundance of stinging jellyfish would increase this compensation with €2 million.

An underwater scene with sunlight filtering through the water, creating a blue and white color palette. The sun's rays are visible as bright spots and streaks in the upper half of the frame. The water is a deep, clear blue, and the overall atmosphere is serene and natural.

TESTING THE WATERS

ACIDIFICATION IN THE MEDITERRANEAN