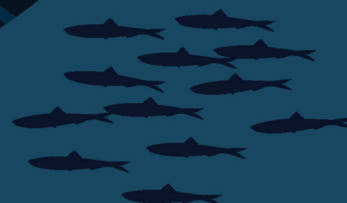
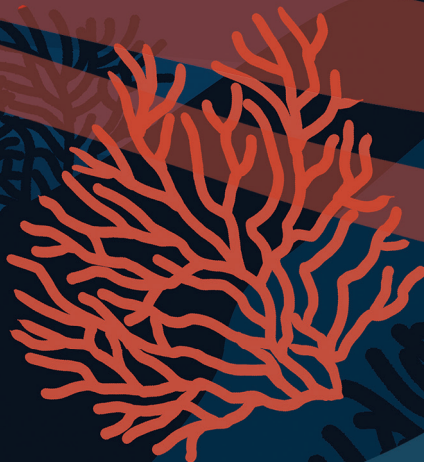


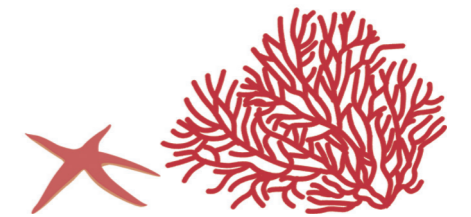
BOILING MEDITERRANEAN

Marine Protected Areas facing climate change –
illustrated facts and ideas

Written by Ernesto Azzurro – Illustrations by Marina Troise

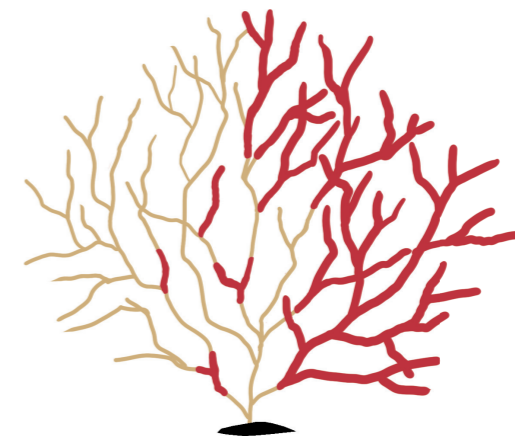
Scientific contributions by: Manuela D'Amen, Antonio Di Franco, Joaquim Garrabou





BOILING MEDITERRANEAN

Marine Protected Areas facing climate change –
illustrated facts and ideas



 edizioni
Consiglio Nazionale delle Ricerche

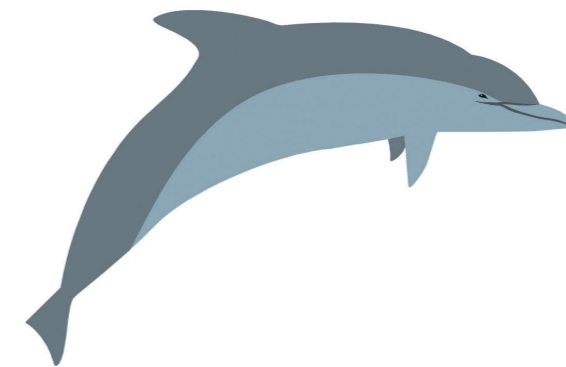
Written by Ernesto Azzurro – Illustrations by Marina Troise

Scientific contributions by: Manuela D'Amen, Antonio Di Franco, Joaquim Garrabou

ISBN printed version: 978-88-8080-479-6, ISBN digital version: 978-88-8080-480-2

*It is a remarkable time to be alive
but it also carries great responsibility to act decisively
We have no time to lose. What we do between 2020 and 2030... will be
the decisive decade for humanity's future on Earth.
The future is not determined.
The future is on our hands.*

D. F. Attenborough
COP26 Climate Change Summit



WHAT'S UP?

... the evidence is all around

The sea between the lands, the cradle of world civilization, home to around 480 million people, is now under a severe threat due to human-induced global warming. Mediterranean waters are heating up three times faster than the global average, and this book illustrates some of the most tangible consequences of climate change and what this means for Mediterranean people. These stories are not future projections, they're facts described by the work of hundreds of scientists, and witnessed today by coastal communities. Mediterranean warming is clearly visible, and we need to explain why this matters.

Do we fully understand the scope of this drama? Can we come up with solutions? Will we be able to change our unsustainable lifestyle, our destructive economy, and rethink our relationship with the natural environment? Every day, nature gives us a warning and this illustrated book gives a voice to the many Marine Protected Areas (MPAs), which suffer the catastrophic consequences of a 'boiling sea'. Several Mediterranean MPAs, designed to achieve long-term nature conservation, are already facing major biodiversity and functional alterations due to climate change, whereas others are expected to be impacted in the next few decades. There is, therefore, an urgency to mitigate these risks and consider adaptation options. The later we act, the greater the danger.

Mediterranean MPAs are privileged sites for the monitoring of the impacts of climate change, and to support global efforts towards climate change adaptation and mitigation. They are also the best places to engage local communities, and to promote a behavioral and economic transition toward a sustainable and healthier relationship with the natural world.



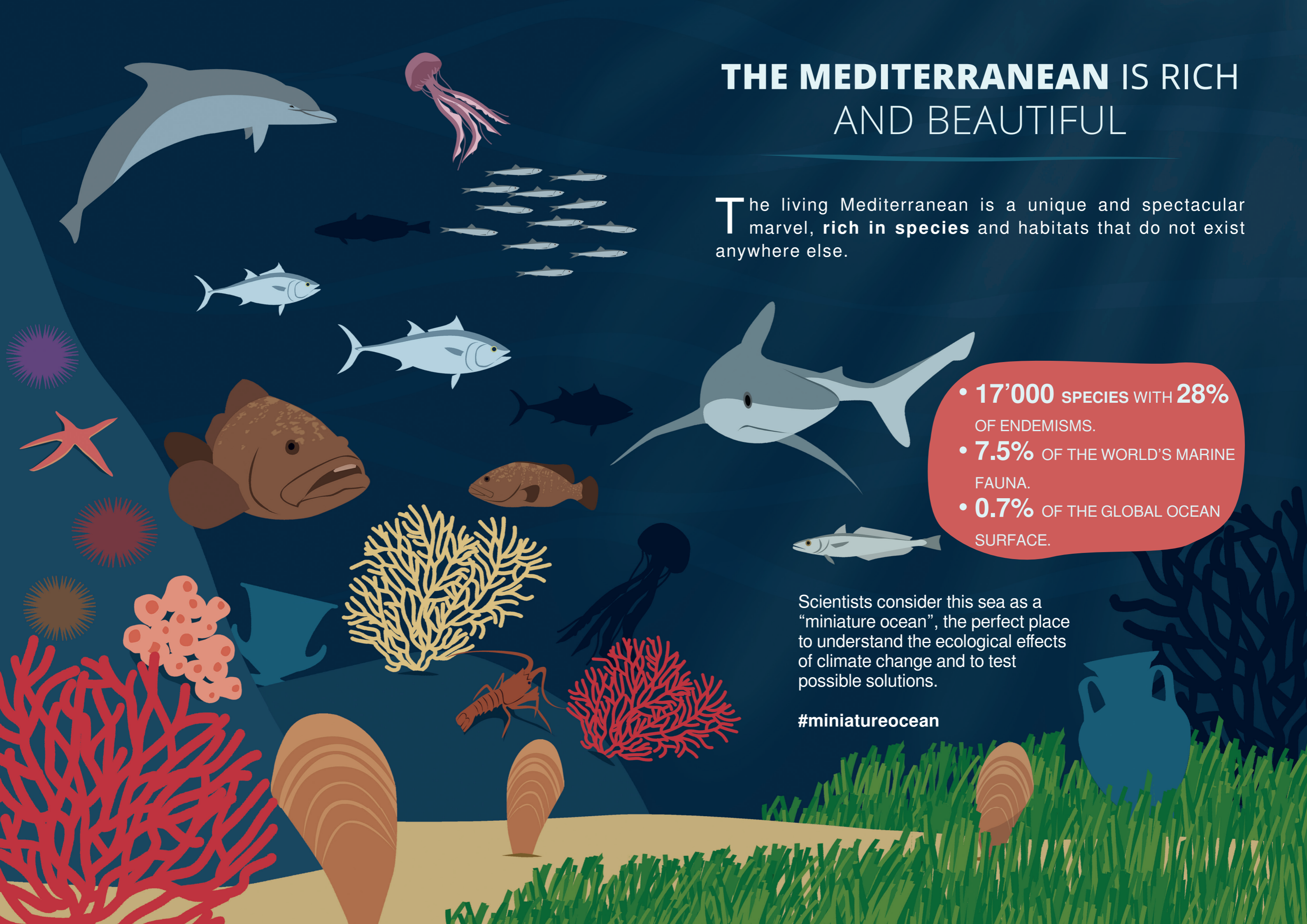
THE MEDITERRANEAN IS RICH AND BEAUTIFUL

The living Mediterranean is a unique and spectacular marvel, **rich in species** and habitats that do not exist anywhere else.

- **17'000** SPECIES WITH **28%** OF ENDEMISMS.
- **7.5%** OF THE WORLD'S MARINE FAUNA.
- **0.7%** OF THE GLOBAL OCEAN SURFACE.

Scientists consider this sea as a “miniature ocean”, the perfect place to understand the ecological effects of climate change and to test possible solutions.

#miniatureocean



AN OVERHEATING SEA UNDER MULTIPLE PRESSURES

The Mediterranean Sea is increasingly impacted by **multiple threats** that do not act in isolation but can combine and break the stability of natural ecosystems. Adding a **changing climate** into this mix, the problems become even worse.

- WARMING **THREE TIMES FASTER** THAN THE GLOBAL AVERAGE.
- PAST 7 YEARS SET TO BE THE **WARMEST** ON RECORD.
- IN AUGUST 2021, **48.8 °C** IN SYRACUSE, WARMEST TEMPERATURE IN EUROPE.

The choice is ours: **empowering MPAs** to contribute to mitigate these problems or accelerate them through the unsustainable use of the sea!

#empoweringMPAs



EXTREME WEATHER

Climate change is fueling **powerful storms**. Combined with sea level rise, it represents one of the major threats for coastal regions, causing submersion, erosion and increased vulnerability.

- **MEDICANES** ARE MEDITERRANEAN HURRICANES.
- SEPTEMBER 2020: A MEDICANE OVER ZAKYNTHOS, WIND AT **100 km/h**.
- OCTOBER 2021: A **CYCLONE** OVER SICILY, THREE PEOPLE KILLED.

Extreme weather events will intensify in the near future. Mediterranean MPAs can promote a more **stringent climate policy** and adaptation measures.

#medicanes

MERIDIONALIZATION & CLIMATE-CHANGE REFUGIA

As waters become warmer, **warm adapted species** become more abundant and widespread, while **cold adapted species** are losing ground.

- MORE THAN **50** NATIVE FISHES HAVE SHIFTED THEIR DISTRIBUTION NORTHWARDS.
- SALEMA AND SEA-URCHINS ALREADY DISAPPEARED FROM THE HOTTEST AREAS.
- SEVERAL ENDEMIC SPECIES **RISK EXTINCTION.**

How can protection help?
Because of their reduced human pressure, MPAs host less disturbed ecosystems and offer **refuge to endangered species.**

#meridionalization



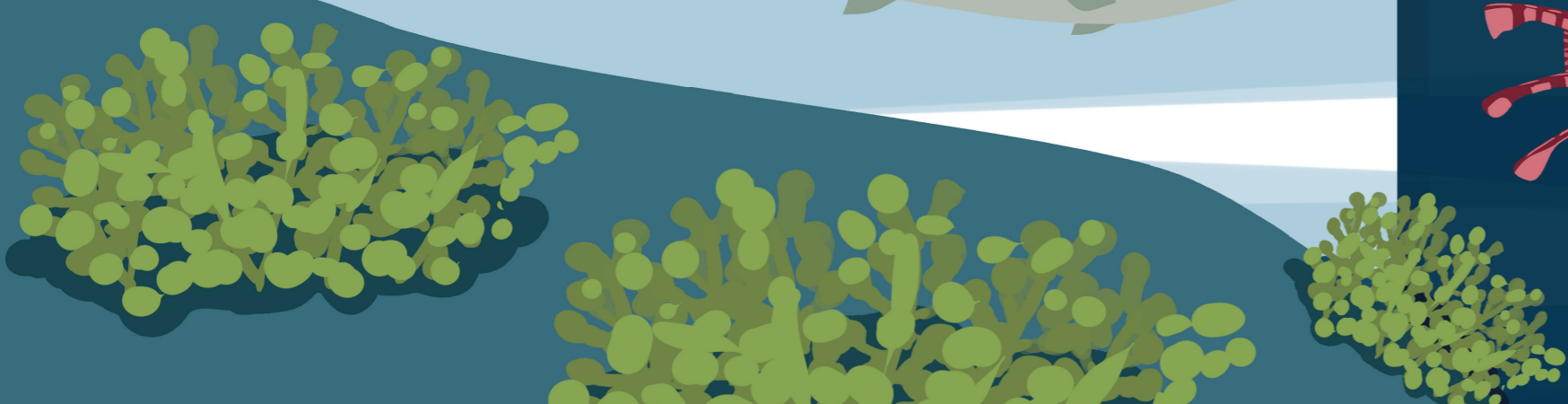
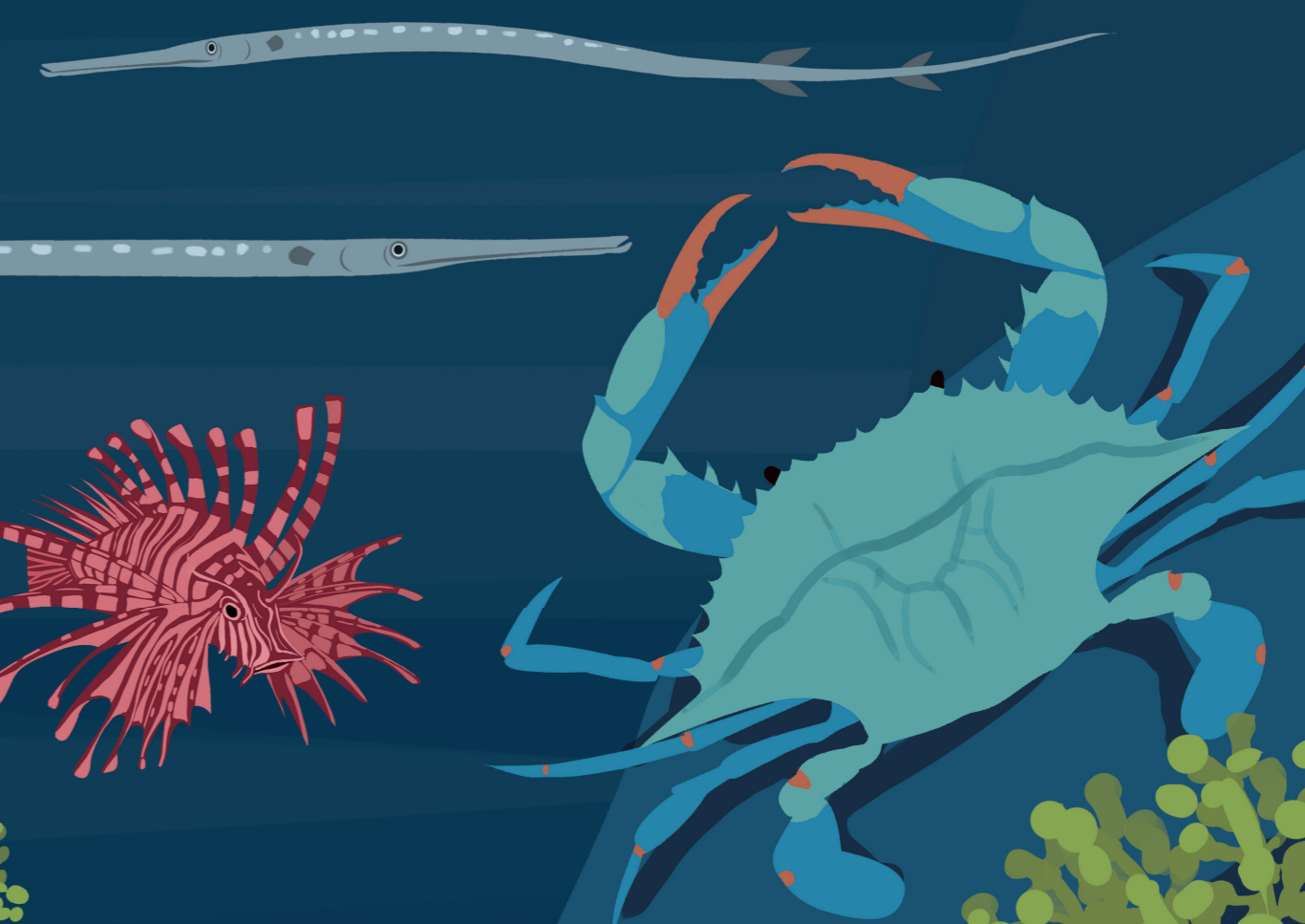
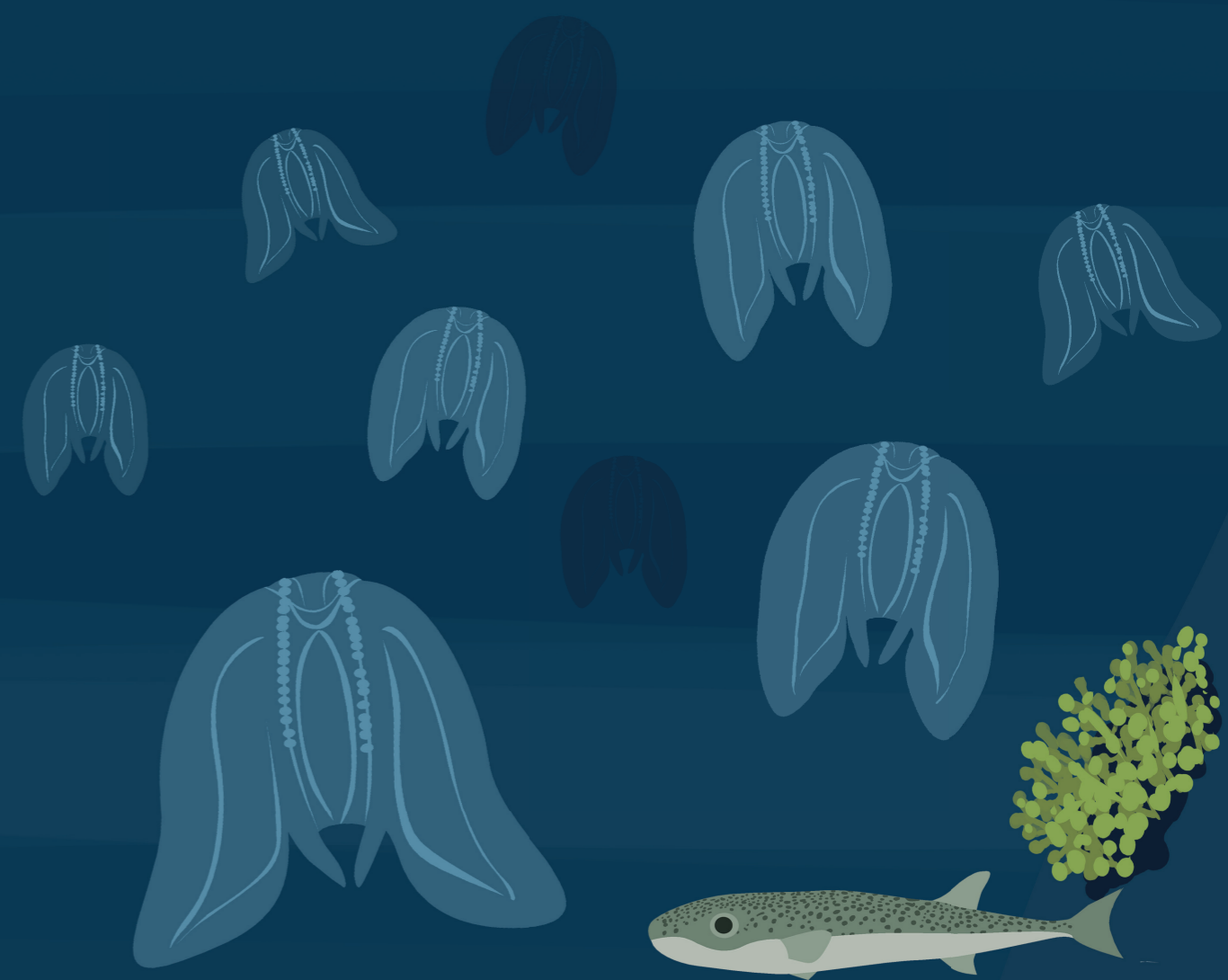
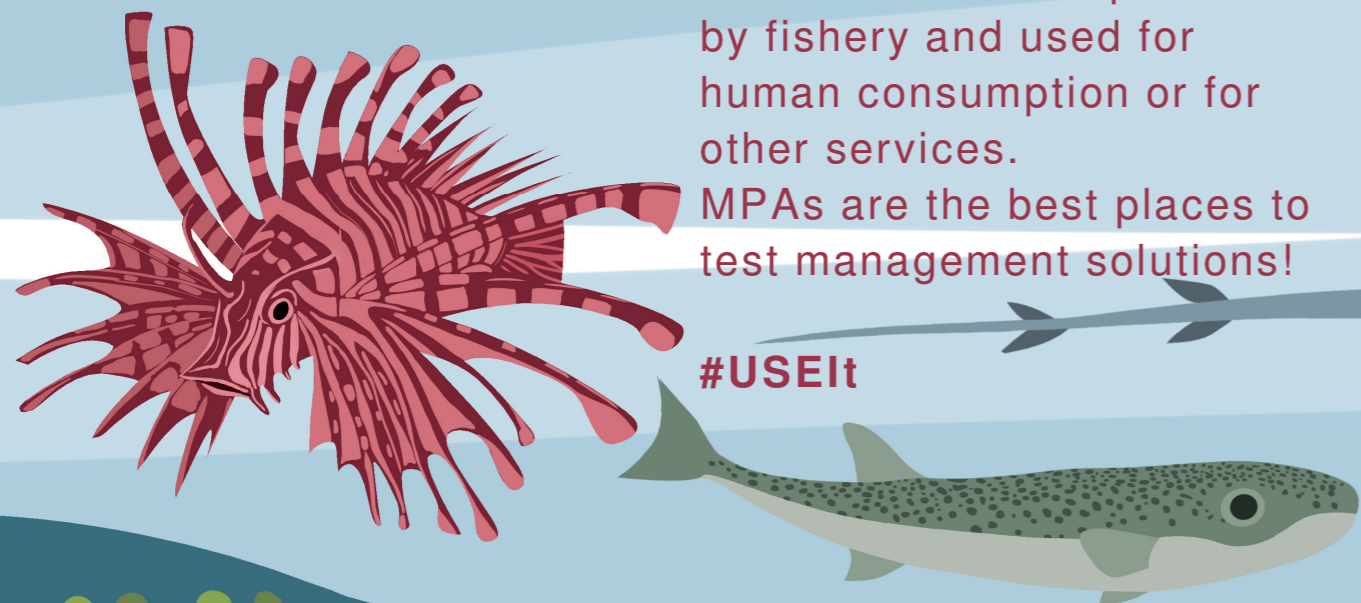
TROPICAL INVASIONS

The Mediterranean Sea has become the **World's hotspot** for biological invaders. Most of these species have a **tropical origin** and are causing severe ecological and socio-economic impacts.

- ABOUT **1000** NON INDIGENOUS SPECIES ENTERED THE MEDITERRANEAN.
- MORE THAN **700** HAVE ESTABLISHED PERMANENT POPULATIONS.
- MORE THAN **100** TROPICAL FISHES HAVE ENTERED THROUGH THE SUEZ CANAL.

What can we do? Some invaders can be exploited by fishery and used for human consumption or for other services. MPAs are the best places to test management solutions!

#USEit



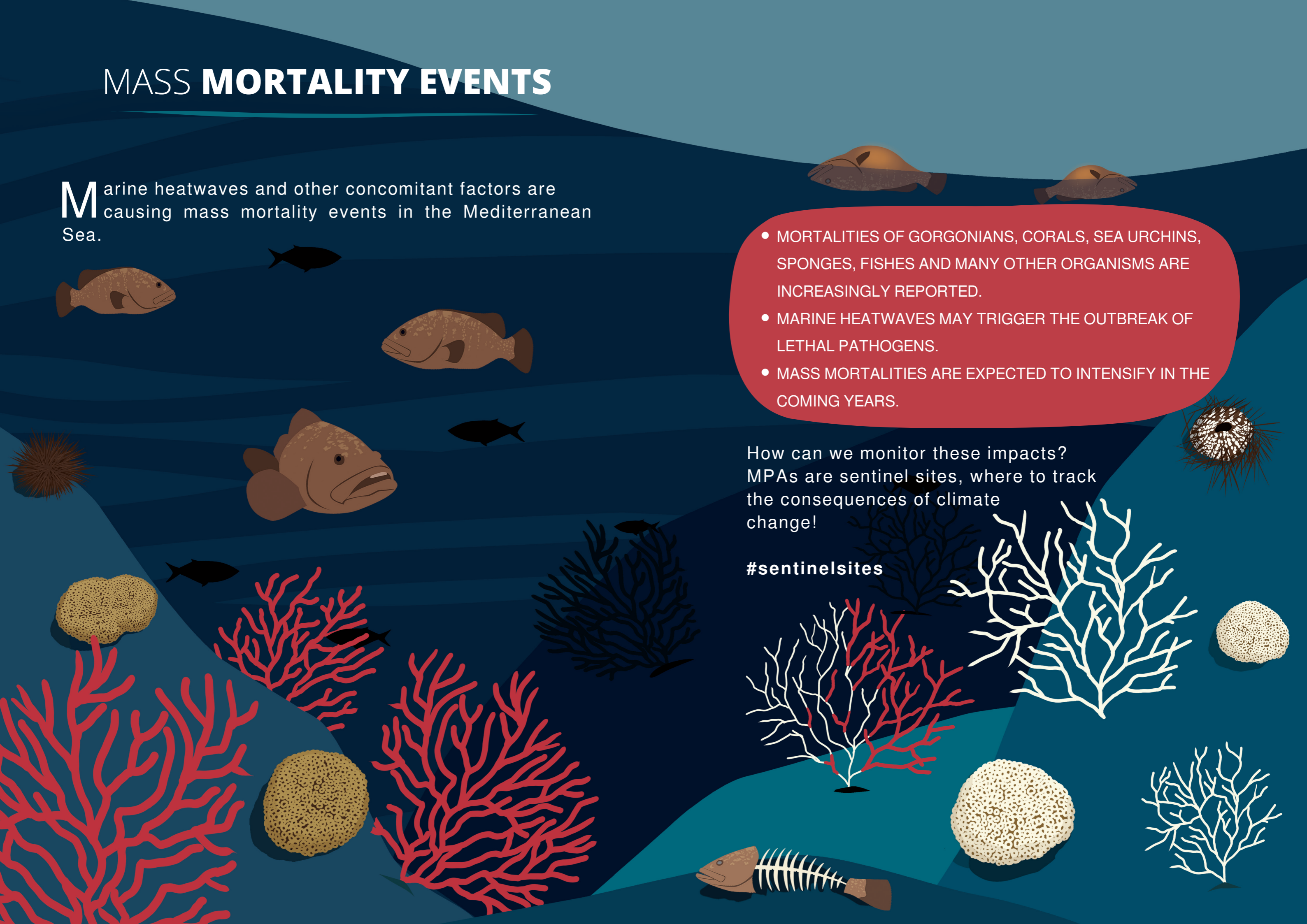
MASS MORTALITY EVENTS

Marine heatwaves and other concomitant factors are causing mass mortality events in the Mediterranean Sea.

- MORTALITIES OF GORGONIANS, CORALS, SEA URCHINS, SPONGES, FISHES AND MANY OTHER ORGANISMS ARE INCREASINGLY REPORTED.
- MARINE HEATWAVES MAY TRIGGER THE OUTBREAK OF LETHAL PATHOGENS.
- MASS MORTALITIES ARE EXPECTED TO INTENSIFY IN THE COMING YEARS.

How can we monitor these impacts? MPAs are sentinel sites, where to track the consequences of climate change!

#sentinelsites



PINNA NOBILIS CRISIS



The largest bivalve in the Mediterranean is undergoing a catastrophic mortality caused by a new pathogen under the synergic effects of warming temperatures. This endemic and iconic species is risking extinction.

- SPAIN 2016: THE FIRST OUTBREAK KILLED AROUND **99%** OF THE POPULATION.
- **80-100%** *PINNA NOBILIS* LOST ACROSS MANY MEDITERRANEAN REGIONS.
- *PINNA NOBILIS* HAS BEEN LISTED AS **CRITICALLY ENDANGERED** ON THE IUCN RED LIST.

Monitoring, protecting and reproducing healthy individuals, is **our only hope** to save the noble pen shell.

#savethenoblepenshell

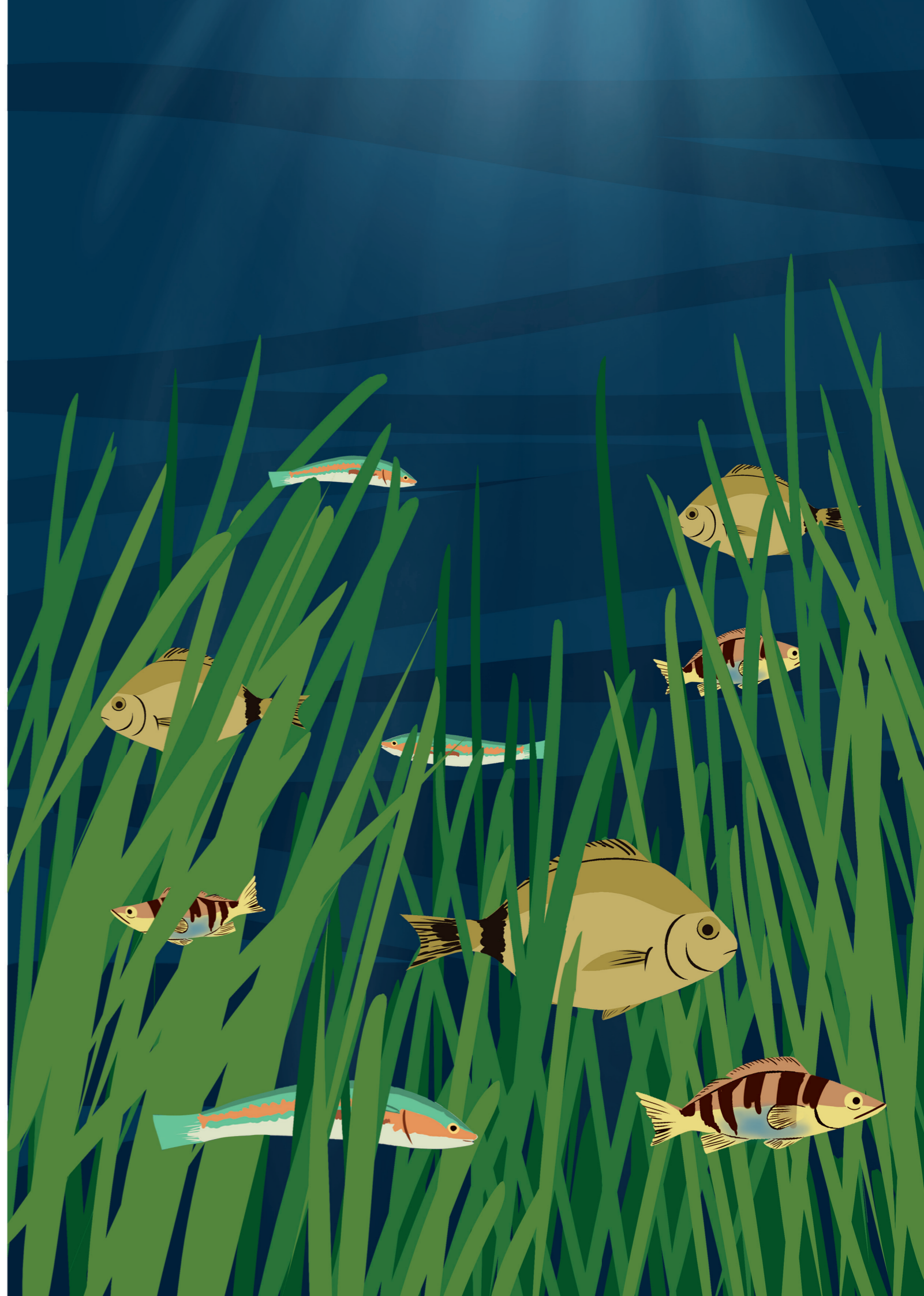
SEAGREASSES FACING AN **UNCERTAIN FUTURE**

Meadows of *Posidonia oceanica*, an endemic plant to the Mediterranean, rank amongst the **most valuable coastal ecosystems** and represent significant carbon sinks. Habitat destruction, climate change, and other anthropogenic activities pose this species in danger.

- IN THE LAST **50** YEARS POSIDONIA MEADOWS DECLINED BY **34%**.
- POSIDONIA MEADOWS ARE DISAPPEARING **4** TIMES FASTER THAN TERRESTRIAL FORESTS.
- SEA TEMPERATURES HIGHER THAN **28°C** INDUCE *P. OCEANICA* THERMAL STRESS.

Marine Protected Areas have a key role for protecting seagrasses and **increase awareness** of their key ecosystem-wide role.

#protectseagrasses



GELATINOUS SEA

Blooms of gelatinous organisms have been known since ancient times but their frequency has recently increased, with serious repercussions on fishery and tourism.

A **sea full of jellyfish** is becoming a reality.

- JELLIES ARE **95% WATER**, DON'T HAVE BRAINS, INTESTINES, OR LUNGS.
- JELLYFISH PREDATE ON FISH EGGS AND LARVAE AND COMPETE WITH FISH LARVAE AND JUVENILES BY FEEDING ON THEIR FOOD.
- WHILE MOST SPECIES SUFFER, **JELLYFISH THRIVE IN WARM WATERS.**

Should we start eating jellyfish? Probably! Alternatively, we need to act directly on the causes of these phenomena: overfishing, warming waters, and eutrophication. MPAs promote concrete actions to counter the causes of the *Jellyfication!*

#gelatinousea



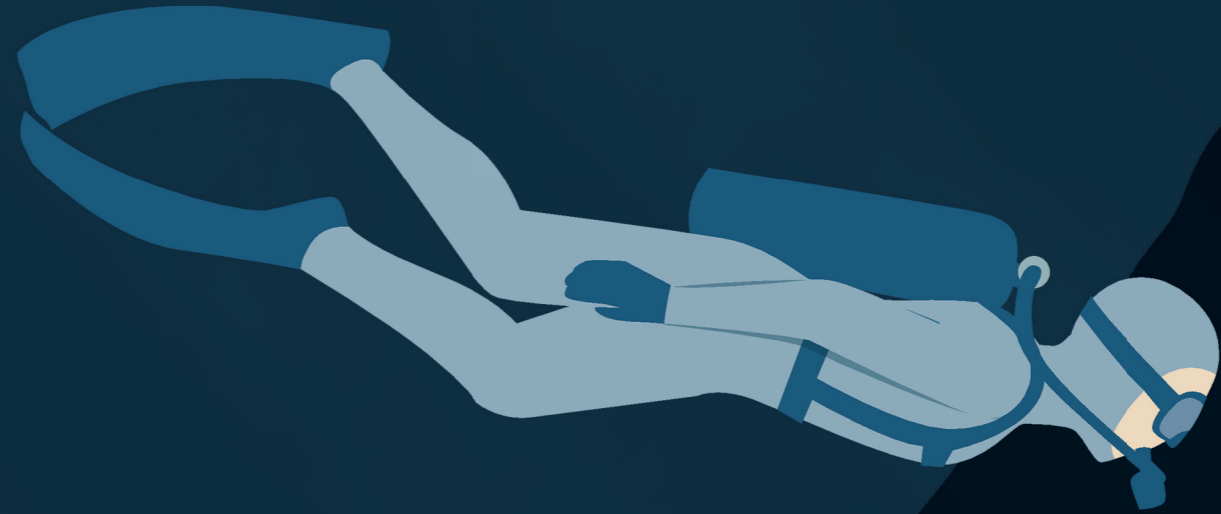
UNDERWATER DESERTS

Overfishing of predators, outbreaks of grazers, and global warming can have devastating effects on marine ecosystems. This happens when rich algal forests are replaced by underwater deserts dominated by encrusting organisms.

- ABOUT **90%** OF THE SHALLOW NATIVE MOLLUSCS IN THE EASTERN MEDITERRANEAN ARE LOST.
- UNDERWATER DESERTS ARE CALLED 'BARRENS'.
- OVER CERTAIN THRESHOLDS RESTORATION IS NOT ACHIEVABLE.

When restoration is not achievable, biodiversity loss is only counteracted by invasive species.

#underwaterdeserts



MARINE PROTECTED AREAS FACING CLIMATE CHANGE



What we are witnessing today are the symptoms of a new situation, a warning that the sea is giving us. IT'S TIME TO WAKE UP. SCIENCE IS CLEAR ON THE FACTS.

**THERE IS NO INFINITE GROWTH
ON A FINITE PLANET!**



A CALL FOR ACTION

Climate change is everybody's business: you have a role to play, too

Mediterranean MPAs have both a privileged role and a responsibility in climate change mitigation, resilience, and adaptation. They can offer nature-based solutions to support global efforts towards the fight for our future. The following recommendations are based on facts, deliberations, and recommendations from the project MPA Engage and are intended to consolidate their role in the era of global warming.

If you are a Marine Protected Area you are suggested to:

1. Regularly monitor climate change impacts

Act as sentinel sites to regularly assess the ecological consequences of climate change on marine ecosystems and on the related human uses. You can join the network of MPAs applying the monitoring protocols developed and tested in the framework of the MPA Engage project.

2. Build/empower partnership with local communities

Establish a permanent and evolutive collaboration with local stakeholders such as local communities, fishers, divers, and tourism actors. Create a breeding ground for achieving a successful climate governance, based in participatory processes.

3. Promote ocean literacy

Improve public understanding of marine ecosystems, for the adoption of values and attitudes based on that knowledge, at an individual and societal level. Promote those activities that allow experiencing and learning about nature, fostering environmental and cultural appreciation and awareness.

4. Promote cultural and behavioral changes

Set good examples to change how people consume the goods and services that come from natural resources. Promote non-consumptive uses of nature, like snorkeling and other low impact activities. Promote locally-oriented economies, such as eating local food fished with sustainable, small scale fishery.

5. Cut waste and ban single-use plastics

Implement efficient strategies and rules to engage visitors and staff in reducing waste production, banning single-use plastics and promoting reusable alternatives.

6. Speak up!

Do not hide the problems of your MPA; Talk about the change you made, make your voice heard by those in power.

Without dramatic actions in the current decade, we are unlikely to keep global warming below 1.5° C compared to pre-industrial levels. Even if all human emissions of heat-trapping gasses were to stop today, Earth's temperature would continue to rise for a few decades. This means that the climate crisis can't be stopped, thus we must mitigate the effects and adapt. If you are a MPA manager, check how to develop adaptation actions plans for climate change in your MPA.

If you are a Citizen

1. Make your voice heard

You must encourage your MPA, but also local, regional and national policy makers, to undertake a proactive policy towards sustainability. Make your voice heard on issues you care about.

2. Get involved

Participate in the actions led by MPAs, local communities and authorities related to the sustainable use of resources, environmental protection, and climate change.

3. Be the change you want to see

This means, for example, reducing overconsumption, recycling useless or unnecessary stuff, reducing meat consumption, avoiding and refusing single-use materials and reuse as much as possible instead, sharing items and tools, preferring public transport, carpooling, walking or cycling whenever possible.

4. Engage in the actions of marine citizen science

Engage in data collection, and produce scientific evidence about the impacts of climate change. Everyone can get involved. Public participation in scientific research is becoming more and more crucial in increasing everyone's understanding of science and its benefit to society. Check out our citizen science initiatives and Facebook groups!

If you are a Diver working in a Marine Protected Area

Divers working in MPAs should support a sustainable dive industry and increase public awareness through the magic of underwater experiences. Diving centers can involve their customers in a series of citizen science initiatives aimed to track climate-related impacts. This would provide new possibilities for work, while promoting ocean literacy. Diving clubs will also strengthen the collaboration with the hosting Marine Protected Areas, and be part of a large research network.

If you are a Fisher

Fishers are the experts of the sea. They spend a considerable portion of their lives in close contact with the marine environment, and their personal experience, gained through daily observations, needs to be taken into consideration. This knowledge is important to complement scientific data and to better understand ongoing changes in the marine environment. If you are a fisher, your voice deserves to be heard when deciding how to manage sustainably ecosystems over long time periods. Thus, do not be afraid of speaking with scientists and MPA managers. We need to work together to understand and face the consequences of climate change on your life and on the future of your community.

If you are a Mediterranean Scientist

In the middle of a climate crisis, Mediterranean scientists play different roles, also engaging in the communication of their findings to the public. If you are a Mediterranean scientist, do not hesitate to speak out to fuel and influence the public debate and decision makers at all levels.

As a researcher you can contribute to track climate change effects across the Mediterranean. The proposed monitoring protocols are easy to apply and cost-effective. A series of tools for training on field activities, data management and interpretation have been developed. Check our monitoring protocols and join our network of Mediterranean scientists!

If you are a Scholar or a young researcher

Young people have the potential to develop a new understanding to face the climate crisis. Think of the Mediterranean as a privileged place to study climate change effects. Take a look at the tools we developed. Many Mediterranean students have adopted our monitoring protocols for their master thesis. These tools are easy to apply and they can be implemented independently at very low cost. Resulting data can be particularly informative and interesting. Our network needs enthusiasm and participation!

If you are a Local/National Authority

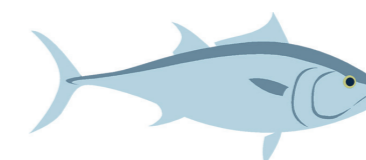
If you are a local or national Authority, then you know that we must act now to avoid future impacts. You can promote the implementation of recommendations to face climate change in the Mediterranean area.

If you are an Organization working at a regional level

You can promote the adoption of an operational framework to enhance the resilience of the Mediterranean marine ecosystems facing climate change.

If you are a Teacher and/or environmental educator

You can use this book and all its online resources, to raise awareness on Mediterranean climate change and to promote a path towards sustainability to the young generations.



USEFUL LINKS

Monitoring climate change impacts in Mediterranean MPAs:

A series of consolidated monitoring protocols, training tools, and video tutorials is available and freely downloadable at <https://mpa-engage.interreg-med.eu>. Join our network, let your MPA be part of a network of ecological and climate monitoring stations. Researchers and master students are also invited on board.

See also our protocols at www.t-mednet.org

Citizen science initiatives:

Seawatchers: The citizen science portal for marine research
<https://www.seawatchers.net>

Climate fish project:

How to involve recreational divers in monitoring climate change impacts
<https://www.observadoresdelmar.es/Projects/View/17>.

Reef check: A citizen science network for the Mediterranean
<https://www.reefcheckmed.org>

Facebook groups:

Oddfish: An active community of members among fishers, researchers, and lovers of the sea interested in invasive species, unusual observations and all the curiosities of the Mediterranean sea.

Videos

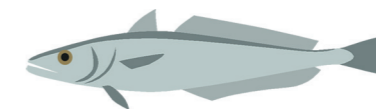
All the documentaries and videopills produced by the MPA Engage project are available at the youtube channel of Stazione Zoologica di Napoli. Check also our page for the full list of video products.

The interactive IPCC climate ATLAS:

A novel tool for flexible spatial and temporal analyses of much of the observed and projected climate change information, including a regional-level perspective on the Mediterranean Sea
<https://bit.ly/IPCC-Interactive-Atlas-SST-MedSea>

At this page you can visualize/download all the documents and materials cited by this book ...and many more!

<https://mpa-engage.interreg-med.eu/what-we-achieve/boiling-mediterranean-book-let/>



Further readings

Albano, P.G., Steger, J., Bošnjak, M., Dunne, B., Guifarro, Z., Turapova, E., Hua, Q., Kaufman, D.S., Rilov, G. and Zuschin, M., 2021. Native biodiversity collapse in the eastern Mediterranean. *Proceedings of the Royal Society B*, 288(1942), p.20202469.

Azzurro, E., Sbragaglia, V., Cerri, J., Bariche, M., Bolognini, L., Ben Souissi, J., Busoni, G., Coco, S., Chryssanthi, A., Fanelli, E. and Ghanem, R., 2019. Climate change, biological invasions, and the shifting distribution of Mediterranean fishes: A large-scale survey based on local ecological knowledge. *Global change biology*, 25(8), pp.2779-2792.

Boero, F., 2013. Review of jellyfish blooms in the Mediterranean and Black Sea. *General Fisheries Commission for the Mediterranean. Studies and Reviews*, (92), p.I.

Cavicchia, L., von Storch, H. and Gualdi, S., 2014. Mediterranean tropical-like cyclones in present and future climate. *Journal of Climate*, 27(19), pp.7493-7501.

Cerrano, C., Bavestrello, G., Bianchi, C.N., Cattaneo-Vietti, R., Bava, S., Morganti, C., Morri, C., Picco, P., Sara, G., Schiaparelli, S. and Siccardi, A., 2000. A catastrophic mass-mortality episode of gorgonians and other organisms in the Ligurian Sea (North-western Mediterranean), summer 1999. *Ecology letters*, 3(4), pp.284-293.

D'Amen, M. and Azzurro, E., 2020. Lessepsian fish invasion in Mediterranean marine protected areas: a risk assessment under climate change scenarios. *ICES Journal of Marine Science*, 77(1), pp.388-397.

Garrabou, J., Gómez-Gras, D., Ledoux, J.B., Linares, C., Bensoussan, N., López-Sendino, P., Bazairi, H., Espinosa, F., Ramdani, M., Grimes, S. and Benabdi, M., 2019. Collaborative database to track mass mortality events in the Mediterranean Sea. *Frontiers in Marine Science*, 6, p.707.

Garrabou, Joaquim, Jean-Baptiste Ledoux, Nathaniel Bensoussan, Daniel Gómez-Gras, and Cristina Linares. "Sliding Toward the Collapse of Mediterranean Coastal Marine Rocky Ecosystems." In *Ecosystem Collapse and Climate Change*, pp. 291-324. Springer, Cham, 2021

Golani D., Azzurro E., Dulčić J., Massutí E. and Orsi-Relini L. 2021. *Atlas of Exotic Fishes in the Mediterranean Sea*. 2nd edition [F. Briand, Ed.] 365 pages. CIESM Publishers, Paris, Monaco. ISBN number 978-92-990003-5-9

Marbà N., et al., 2014. Mediterranean seagrass (*Posidonia oceanica*) loss between 1842 and 2009. <https://doi.org/10.1016/j.biocon.2014.05.024>

MedECC (2020) *Climate and Environmental Change in the Mediterranean Basin – Current Situation and Risks for the Future*. First Mediterranean Assessment Report [Cramer, W., Guiot, J., Marini, K. (eds.)] Union for the Mediterranean, Plan Bleu, UNEP/MAP, Marseille, France, 600pp. Del Mar Otero, M., Garrabou, J. and Vargas, M., 2013. *Mediterranean Marine Protected Areas and climate change: A guide to regional monitoring and adaptation opportunities*. IUCN.

Simard, F., Laffoley, D. and J.M. Baxter (eds). (2016). *Marine Protected Areas and Climate Change: Adaptation and Mitigation Synergies, Opportunities and Challenges*. Full report. Gland, Switzerland: IUCN.

WWF. 2021. *The climate change effect in the Mediterranean. Six stories from an overheating sea* WWF Mediterranean Marine Initiative, Rome, Italy, 2021

This book is based on facts, deliberations, and recommendations from the project MPA Engage. The MPA Engage project encourages the use and dissemination of this publication, which can be shared, downloaded and printed for the needs of every Mediterranean MPA and for use in non-commercial products or services, providing appropriate acknowledgments given to the MPA Engage project and authors.

We warmly acknowledge Nuno Vaz Silvia, Paolo Guidetti, Emanuela Fanelli, Macarena Marambio, Paolo Azzurro and all the MPA Engage partners for the useful suggestions received during the writing of this book

How to cite this Book:

Azzurro E., D'Amen M., Di Franco A., Garrabou J. 2022. Boiling Mediterranean: Marine Protected Areas facing climate change, illustrated facts and ideas. 42 pp. Edited by © Cnr Edizioni, 2021 P.le Aldo Moro 7 00185 Roma. ISBN printed version 978-88-8080-480-2; ISBN digital version: 978-88-8080-480-2

Request for translation and adaptation rights should be sent to: ernesto.azzurro@cnr.it, Italian National Research Council CNR-IRBIM
Largo Fiera della Pesca, 2, 60125 Ancona AN, Italy



Financed by the
MPA Engage project <https://mpa-engage.interreg-med.eu>
Grant number: 5216 | 5MED18_3.2_M23_007
85% co-funded by the European Regional Development Fund



Project co-financed by the European Regional Development Fund



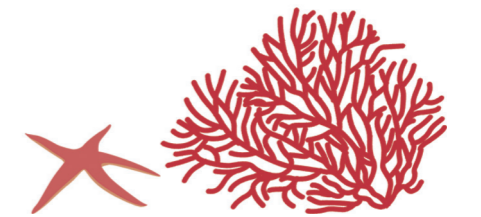
© Cnr Edizioni, 2022
P.le Aldo Moro 7 00185 Roma

Design by Bruna Troise

Consiglio Nazionale delle Ricerche
IRBIM - Istituto per le Risorse Biologiche e le Biotecnologie Marine

©Cnr Edizioni, 2022
P.le Aldo Moro 7
00185 Roma

ISBN printed version: 978-88-8080-479-6
ISBN digital version: 978-88-8080-480-2



The climate crisis is hitting hard our beloved Mediterranean Sea, posing novel challenges for managers and policymakers of the 21st century. Marine Protected Areas (MPAs), designed to achieve long-term nature conservation, have both a role and a responsibility in climate mitigation, resilience, and adaptation. They are the best sites where to develop possible solutions and where to promote behavioral and economic transformations toward a sustainable and healthier relationship with the natural world.

#ActlocallyThinkMediterranean

The overwhelming majority of scientists the world over warns us that our climate is abruptly changing, due to the impact of our economic activities. World summits describe global warming as a most worrisome emergency. So why do some people think that scientists have very different opinions on this topic, while they clearly speak with one voice? This book is about climate change facts, and it takes into account science's indisputable conclusions.

Mario Tozzi
Consiglio Nazionale delle Ricerche

A well-written book, which, on the basis of rigorous scientific data, tells with simple words and effective graphics, what happens under the eyes of everyone, but which many still do not realize. A booklet that, taking advantage of the example of Marine Protected Areas, indicates the path towards the 'true' sustainability we should take, changing the current socio-economic growth model, to defend the nature that has always supported us, us as humans along with all the other species that accompany us in our journey on Earth.

Paolo Guidetti
Stazione Zoologica Anton Dohrn

ISBN printed version: 978-88-8080-479-6
ISBN digital version: 978-88-8080-480-2