Climate -resilient corals : *Tara Coral* , a major scientific expedition in the Coral Triangle

Credit : *Pierre de Parscau - Fondation Tara Océan*

Ten years after the launch of Tara Pacific and in a context of increasing coral bleaching, the scientific schooner *Tara* is leaving its home port of Lorient for its next expedition: Tara Coral. For 18 months, *Tara* will navigate through the Coral Triangle — the true Amazon of the Ocean — to understand why and how certain corals withstand global warming, and to help guide future coral conservation strategies.

"The Tara Pacific expedition (2016 -2018) studied reef biodiversity and its response to climate change and human pressures. The Tara Cora expedition (2026 -2028) continues this work with a transdisciplinary approach, in collaboration with local stakeholders, in an area that had not been studied before: the Coral Triangle. What scientists discover could have a fundamental impact on conservation strategies around the world and in this Amazon of biodiversity." **Romain Troublé** , *Chief Executive Officer of the Tara Ocean Foundation*

CORALS RESISTANT TO CLIMATE WARMING

“Unlike previous studies conducted at the global or basin scale, Tara Coral focuses on the only major reef region where hard coral cover has remained relatively stable despite strong warming trends. This provides an extraordinary natural laboratory for identifying the mechanisms of resilience.”

Paola Furla , *Scientific Director, Université Côte d’Azur*

Although they cover only 0.2% of the ocean’s surface, **coral reefs host ~25% of known marine biodiversity.** True oceanic oases, they offer refuge, food, and habitat, and provide numerous ecosystem services that support more than 500 million people—mostly in the Pacific Ocean—with an estimated value of over USD 2.7 trillion per year (Costanza, R. et al., 2014).

More than 40% of coral species are threatened with extinction , facing both global pressures (rising temperatures, ocean acidification, sea-level rise) and local pressures (destructive fishing practices and overfishing, intensive coastal development, land-based pollution). Unlike many other regions of the world where climate warming has triggered widespread coral bleaching, **the reefs of the Coral Triangle have thus far maintained their coral cover.**

This region of the western Pacific, spanning 6 countries across 5.7 million km², is a **true biodiversity hotspot** . **The Coral Triangle contains one-third of the world’s coral reefs and harbors exceptionally high diversity, including about three-quarters of all known coral species (approximately 600 species)** . A conservation priority with fragmented scientific data, the Coral Triangle represents a **strategic challenge for coral conservation** in the face of environmental, social, and economic pressures.

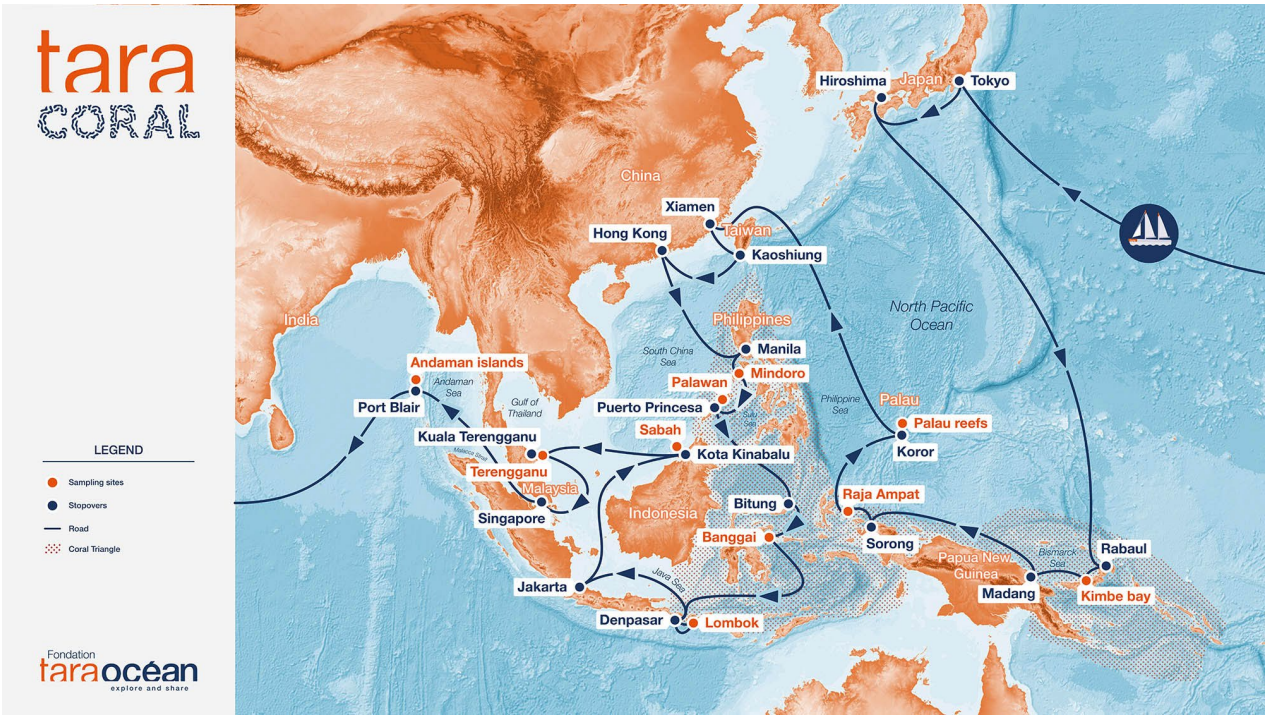
To understand the mechanisms underlying this thermotolerance and identify the corals of tomorrow, the Tara Ocean Foundation and more than 40 scientific partners have designed the transdisciplinary Tara Coral expedition.

TARA CORAL: A MAJOR SCIENTIFIC EXPEDITION

“The time is no longer only for documenting trends and the decline of coral reefs. The Tara Coral expedition aims to uncover the secret of corals that resist climate warming in the Coral Triangle. Their past exposure to thermal stress, the effect of intern al waves, their genetics, their algal symbionts, their microbiome, their diversity, and the way they organize themselves: these are all avenues the expedition will explore to understand what protects the reefs.” **Serge Planes** , Scientific Director, CNRS Research Director

The Tara Coral expedition will test several hypotheses to explain this phenomenon of resistance:

- a greater diversity of organisms within ecosystems
- the presence of more resistant species
- a selection of individuals pre-adapted to climate change due to their local environment and climatic history
- the upwelling of cooler waters (micro-upwelling)



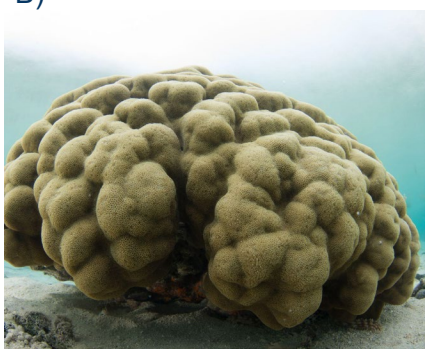
For two years, from 2026 to 2028, a 16-person crew composed of 6 sailors, 8 scientists, 1 artist, and 1 onboard reporter will share this unprecedented human and scientific adventure aboard the schooner Tara.

- **A global approach to the ecosystem**

For 18 consecutive months, the schooner *Tara* will navigate through the Coral Triangle along a 30,000 -nautical-mile route — more than 50,000 km — crossing 6 countries and making a total of 26 stopovers. *Tara* will remain 35 days at each of the 10 planned sampling sites, and the scientific teams will adopt a holistic approach to the ecosystem, focusing on four coral genera (with complementary analyses to characterize the biodiversity at large) : *Acropora*, *Millepora*, *Porites*, and *Pocillopora*.

A)

B)



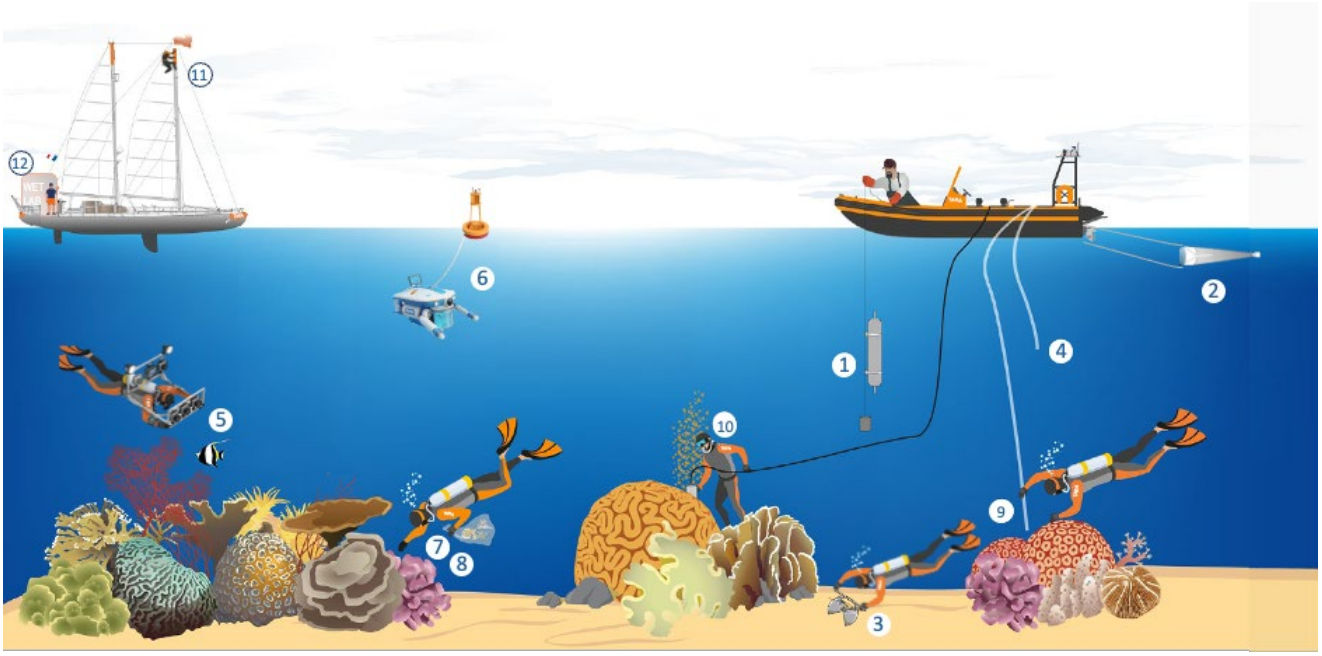
C)

D)

A. *Acropora* spp. (© Vincent Hilaire - Tara Ocean Foundation)/ B. *Porites* spp.(© Lauric Thiault)

C. *Millepora* spp. (© Lauric Thiault)/ D. *Pocillopora* spp. (© Philippe Bourjon)

A comprehensive approach is essential in order to understand which species exist, how they adapt, and how they interact with each other and with their environment. To this end, the scientific work is organized into four components supported by a comprehensive, multi-method field protocol.



Field sampling

1) Water sampling for physicochemical measurements ;
2) Microplastic collection ;
3) Sediment collection ;
4) Water sampling for planktonic biodiversity analysis ;
5) Photogrammetry ;
6) Water filtration for environmental DNA (eDNA) analysis;
7) Coral reef diversity (CORE-DIV) collection ;
8) Targeted sampling of coral colonies ;
9) Collection of seawater around corals ;
10) Drilling of colonies ;
11) Aerosol collection;
12) Coral Bleaching Automated Stress System (CBASS) testing.

1. **Description of the environmental context**

Environmental DNA (eDNA) sampling to describe the overall biodiversity of the reef using a sampling robot, and photogrammetry to describe the 3D structure of the reef.

2. **Characterization of the complexity of the coral holobiont**

Extensive sampling of coral species and associated habitats (coral fragments, algae, sediments, water, aerosols, and sponges) to generate diverse datasets that resolve holobiont structure and function, with a particular focus on symbiosis.

3. **Characterization of heat stress resistance**

Using a CBASS (Coral Bleaching Automated Stress System) system installed on board *Tara*, coral fragments from various colonies are placed in separate tanks and exposed to four different temperature levels (no heat stress, low, moderate, or high heat stress) in order to test the resistance of corals to heat stress and detect biomarkers of cor als that are more resistant to bleaching. This provides a standardized diagnostic heat stress phenotype.

4. **Geochemistry for paleoclimate and paleogenomics**

Coring of massive corals to quantify growth parameters, reconstruct past climate, and analyze long-term genomic responses.

"The Tara Coral expedition is unique due to its combination of scientific scope, methodological standardisation, geographical focus, and integration between disciplines and partners. Now is the time to act to understand, preserve, and strengthen the resilience of coral reefs."

Christian Voolstra, *Scientific Director, Professor at Konstanz University*

- **A transdisciplinary expedition designed in local collaboration**

One of the unique features of the Tara Coral expedition is its comprehensive scientific approach, which brings together a range of scientific expertise : divers, oceanographers, marine biologists, eDNA specialists, genomicists, bioinformaticians, microbiologists, photogrammetry specialists, microplastics specialists, paleoclimatologists, biochemists, modellers, and many others.

Tara Coral is the result of **close local collaboration** involving 67 scientists, 22 women and 45 men, from more than 40 scientific partners, including 11 from the Coral Triangle.

- **Expected scientific results and prospects**

At the end of this expedition, it is expected that there will be a **better understanding of the thermotolerance of corals and the resilience of reefs in the Coral Triangle area**. This will enable the development of standardized protocols, the creation of **open-access resources**, the **transfer of expertise to local stakeholders** (local actors, scientists, managers, policymakers, educators), and the **raising of awareness and mobilization of key players**.

In the longer term, the aim is to strengthen reef protection and restoration capabilities in key biodiversity areas by identifying **naturally resistant coral populations and analyzing the mechanisms, characteristics, and environmental conditions** that underlie their robustness.

AN ADVENTURE FOR SCIENCE AND SOCIETY

- **Sharing, a societal challenge**

Each of the schooner's expeditions provides opportunities to engage society, create innovative tools to reach new audiences, and share the excitement of discovery. The schooner is a wonderful vehicle for telling this story.

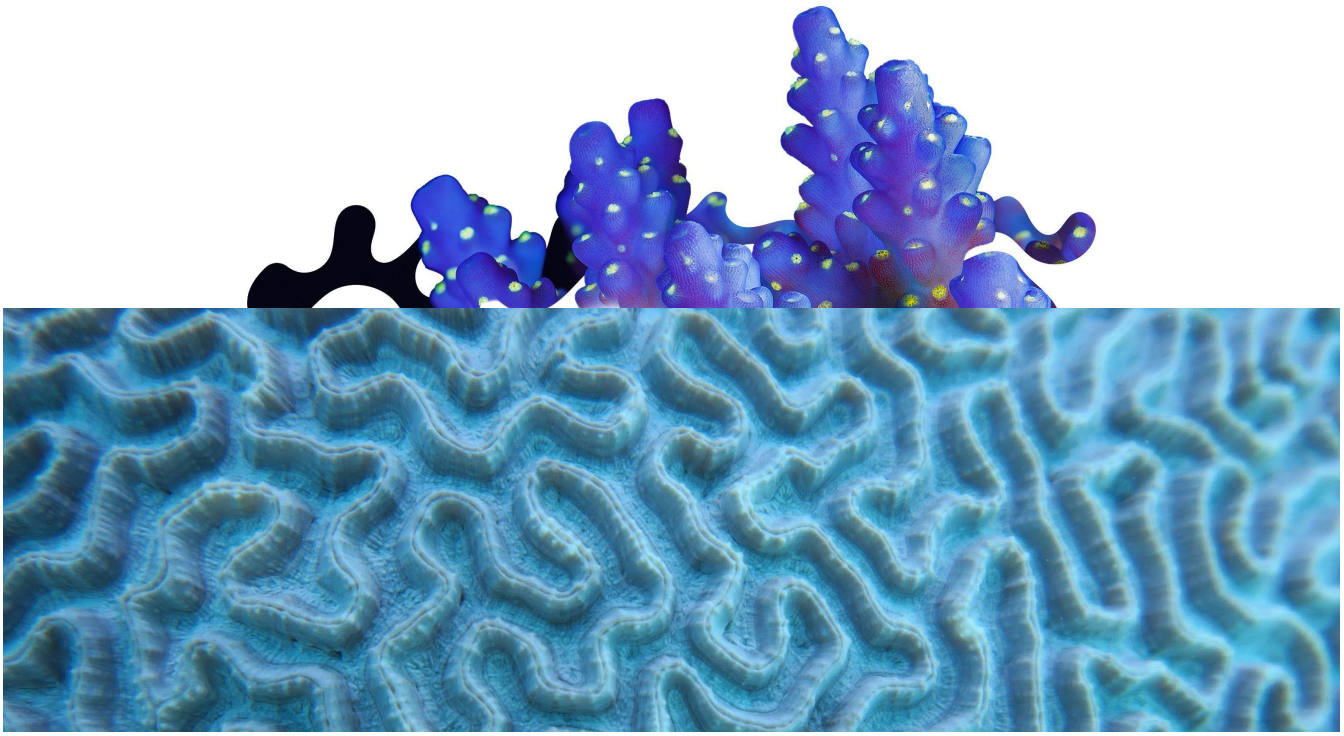
The “Science-to-citizen” program will revolve around two key awareness-raising tools—a traveling exhibition dedicated to the Tara Coral mission and a scientific mediation tool focused on the global importance of coral ecosystems—which will be developed in collaboration with local actors to ensure cultural relevance, inclusiveness, and sustainable use.

- **Strengthening conservation policies at the international level**

Conservation issues will be given high priority by working alongside governments and local stakeholders to identify and protect those reefs that are most resistant to global warming. The Tara Ocean Foundation will organize several science-to-policy workshops during Tara Coral's stopovers and will actively participate in international summits working to conserve coral reefs.

- **Sailing to create**

Because art is part of the Foundation's DNA, artists will embark on residencies alongside scientists. A dozen creators from various disciplines, selected through a call for applications and partnerships with institutions of excellence such as IRCAM and Villa Kujoyama, will take turns on board throughout the mission. This will be a unique period of immersion and experimentation, during which the artists will imagine new relationships with the ocean and coral in collaboration with local artists.



Crédits : ©Vincent Hilaire - Fondation Tara Océan

ABOUT

Tara Ocean Foundation

The Tara Ocean Foundation is France's first recognized public interest foundation dedicated to the ocean. For more than 20 years, it has been striving to bring about a revolution to preserve life, convinced that the ocean is essential to the balance of our planet. Exploring the ocean and sharing scientific discoveries to raise collective awareness is at the heart of the foundation's mission. It conducts scientific expeditions, in partnership with leading international research laboratories, to study marine biodiversity and understand the impacts of climate change and pollution. It raises awareness among citizens, from the younger generations to political decision -

makers. Thanks to its status as a Special Observer at the UN, the foundation actively participates in international ocean governance. Exploring, sharing, and protecting this living ocean is more vital than ever. **Together, let's defend life. Let's protect the ocean. Discover the foundation at https://fondationtaraocean.org/ and in video.**

CNRS

A major player in fundamental research on a global scale, the French National Center for Scientific Research (CNRS) is the only French organization active in all scientific fields. Its unique position as a multi-specialist allows it to combine different scientific disciplines to shed light on and understand challenges of the contemporary world, in collaboration with public and socio-economic actors. Together, the sciences are working towards sustainable progress that benefits society as a whole.
https://www.cnrs.fr/en

Université Côte d'Azur

Université Côte d'Azur is one of nine French universities designated as "IdEx" (Intensive Research Universities) for their intensive research and strong international influence. Structured around innovative internal components, the University Research Schools, whose responsibilities have been increased to allow for greater agility, Université Côte d'Azur bases all of its training and innovation missions on the excellence of its research. Its strong roots in the Côte d'Azur region are one of the driving forces behind its growth model. A founding member of the European Ulysses Alliance, Université Côte d'Azur is the driving force behind an Artificial Intelligence Cluster (Cluster 3IA Côte d'Azur 2030) and has major partnerships with leading national and international players in the field of research. https://univ-cotedazur.eu/

University of Konstanz

The University of Konstanz is one of eleven universities of excellence in Germany. Located on Lake Constance, in one of Germany's most attractive regions, the University of Konstanz is a medium-sized university with flat hierarchies and structures that promote flexibility and encourage interdisciplinary collaboration between the thirteen departments and the administration. Diversity, close dialogue, and effective communication are the driving forces behind our dynamic culture of creativity at all levels. https://www.uni-konstanz.de/en/

Scientific consortium

41 scientific partners, including 11 from the Coral Triangle

Fondation taraocéan
explorer et partager

FOUNDING PARTNER

agnès b.

MAJOR PARTNERS

AXA · CMN · BNP PARIBAS · Capgemini

GREAT PARTNERS

BIC · Fondation VEOLIA · Fondation Didier et Martine Primat · BIOTHERM

SUPPORTERS

Prince Albert II of Monaco Foundation · Explorations de Monaco · bird · France Collectivités · L'ORÉAL · Green Got

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SCIENTIFIC PARTNERS

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SUSTAINABLE DEVELOPMENT GOALS

www.fondationtaraocean.org

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

APPENDIX

Coral

Corals, the functional units of coral reefs, are animals whose physiology depends on an intimate symbiosis with photosynthetic dinoflagellates of the family Symbiodiniaceae (formerly called zooxanthellae), which reside within their tissues and can supply up to 90% of the host's energetic needs. As in humans, who live in association with a complex gut microbiota, corals form a holobiont that comprises the animal host, Symbiodiniaceae, bacteria, archaea, viruses, and fungi. During a bleaching event, the rise in ocean temperature causes a breakdown in the symbiosis with the zooxanthellae, causing the coral to appear pale or white.

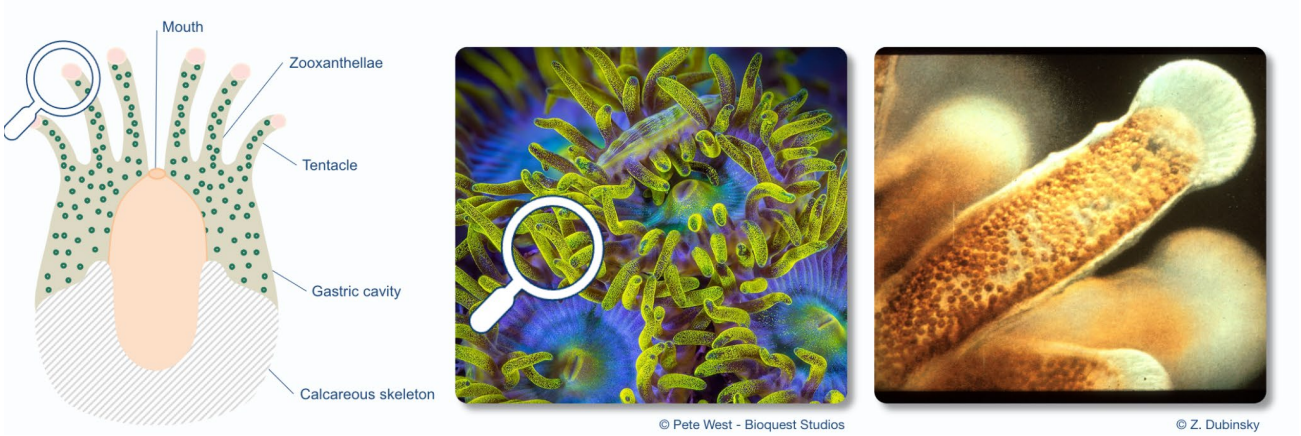


Diagram of a coral with a close-up of a tentacle

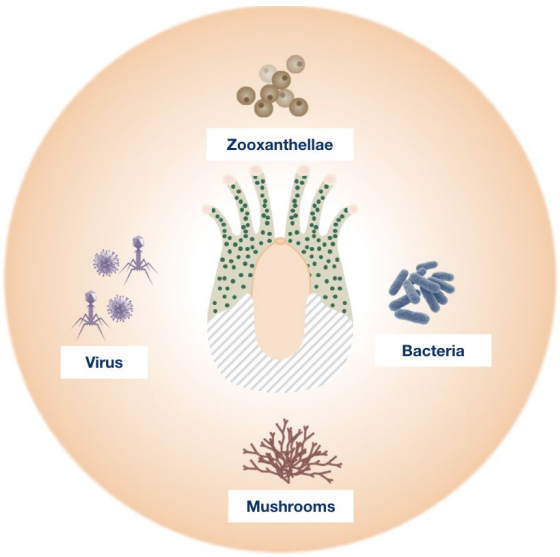
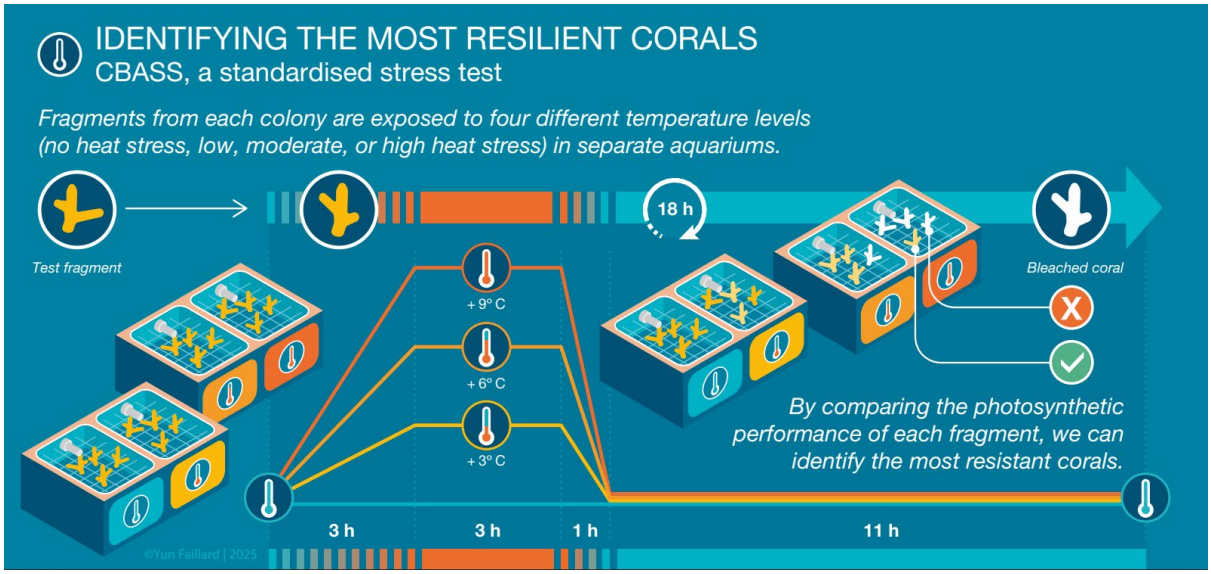


Diagram of the coral holobionte

CBASS ASSAY

CBASS (Coral Bleaching Automated Stress System): Fragments of coral from each tested colony are placed in separate tanks and exposed to four different temperature levels (no heat stress, low, moderate, or high thermal stress). This provides a standardized diagnostic phenotype which allows to identify the corals that are most resistant and most sensitive to heat.



Crédits : ©Yun Faillard

GLOSSARY

Coral: corals are small animals called polyps, which mostly form colonies. These polyps build a shared calcareous skeleton that becomes the foundation of a coral reef.

Source: What is coral? - Oceanographic Institute of Monaco. LINK

Coral reef: underwater formations consisting of calcareous skeletons belonging to the organisms that build them, corals.

Source: Corals and coral reefs - Scientific Centre of Monaco. LINK

Colony: a group of polyps sharing at least some organic tissue.

Source: Coral colony - Wikipedia. LINK

Species VS. Genus: a species represents all individuals that recognise each other as sexual partners and produce fertile offspring, while a genus represents the taxonomic rank that groups together a set of species that share several similar characteristics and originate from a single common ancestor.

Source: What is a species? - National Museum of Natural History. LINK

Source: Genus: definition - AquaPortail. LINK

Resistance: The ability of an organism to withstand a stressor that would normally cause damage or impairment.

Source: Resistance - Dictionary of the French Academy. LINK

Resilience: the ability of a system or organism to absorb disturbance and return to its prior state or function.

Source: Resilience - Géo confluences. LINK

Holobiont: a natural living entity composed of the host and all the microorganisms closely associated with it — its microbiota (bacteria, viruses, archaea, protists and microscopic fungi).

Source: What is a holobiont? And why is INRAE interested in it? - INRAE. LINK

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