A Case Study Of The Application Of Sustainability Science For A Better Reef Conservation, Restoration And Compensation (Mayotte, WIO)

Authors : Aline Tribollet[1], François Guilhaumon [2], Georgeta Stoica[3], Philippe Charpentier[4], Isabel Urbina-Barreto[2], Anne Chauvin[6], Lionel Bigot[7], Thomas Claverie[8], Swanne Gontharet[9], Clément Lelabousse[10]
[1]Institut De Recherche Pour Le Développement - UMR LOCEAN,[2]Institut De Recherche Pour Le Développement (IRD) - UMR ENTROPIE,[3]CUFR Mayotte - UMR ICARE,[4]CUFR Mayotte,[5]Institut De Recherche Pour Le Développement (IRD) - UMR LOCEAN,[6]University Of Reunion Island - UMR ENTROPIE,[7]CUFR-Mayotte, UMR MARBEC,[8]Sorbonne University - UMR LOCEAN,[9]Marine Park Authority Of Mayotte (OFB)

E-mail Address: aline.tribollet@ird.fr

ID: 12368

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Background

Coral reef ecosystems are in extreme jeopardy due to climate change and local anthropogenic stressors. The last SROCC report (2019) strongly suggests that coral reefs will pretty much disappear by the middle of the century under the 'business as usual scenario' of greenhouse gas emissions. There is therefore an urgent need to simultaneously reduce greenhouse gas emissions, limit local disturbances, and to better understand reef functioning and its capability of resilience and adaptation. To increase our chances to better preserve and maintain what is left of coral reefs on Earth while allowing a sustainable development of local populations, developing innovative and sustainable effective conservation approaches while simultaneously raising the awareness and the implication of society at large (from children to authorities and politics) in reef protection are one of the key stones.
The transdisciplinary project 'Future Maore Reefs' which is implemented in Mayotte, a French island located in the Comoros Archipelago in the Mozambique Channel, implies several partners including young children from different elementary schools, scientists from social and human sciences (anthropology and educational sciences), marine biology-ecology and bio-geochemistry, functional ecology, molecular biology, paleoclimatology, and modeling, as well as private companies, environmental awareness associations and stakeholders such as the Marine Park Authority of Mayotte. The main goals of the project are : 1/ to better understand the influence of environmental conditions on major processes involved in reef functioning over the Anthropocene era, 2/ to determine the functional composition of reef-building coral communities and their contribution to reef structural complexity in various environments, 3/ to test several coral nubbins assemblages on sustainable artificial reefs in three contrasted environment to identify the most resilient and efficient assemblages at reproducing natural local reef complexity and species-functional diversity for reef restoration or compensation purposes, 4/ to study the possible effects of such experimental design on the natural nearby reefs, water column and sediments, 5/ to develop innovative substrates for artificial reefs allowing both the development of a sustainable economy and resilient coral reefs, 6/ to develop new approaches to raise and imply more the local population in reef protection, and 7/ to

evaluate the efficiency of new educational and awareness approaches in relation to coral reefs protection and improve them if necessary. This last step relies on an interdisciplinary scientific approach involving researchers in anthropology, educational science and reef ecology.
Here, we will present an overview of the work accomplished within a year by the Future Maore Reefs' research team and its partners with a special focus on environmental changes and their impacts on coral growth and bioerosion processes in Mayotte over the last decades, the identification of the main coral functional morphotypes in the three natural reef studied sites which will allow testing various coral nubbins assemblages on artificial reefs, and the impact of the new educational and awareness approach.

Method

To study the impacts of climate change (ocean warming and acidification) on the main processes involved in the reef carbonate budget, i.e. coral calcification and bioerosion over the last decades, cores were collected in massive slow growing coral colonies in the northern part of Mayotte lagoon. Geochemical and microbial analyses were then carried out to reconstruct past ocean surface temperature and pH, to measure coral growth and to determine the abundance of boring microflora, one of the main agents of reef dissolution (Tribollet et al. 2019). To identify the main functional coral morphotypes involved in the complexity and resilience of the studied natural coral reefs (n = 3), the underwater photogrammetry by Structure from Motion (SfM) was used. This approach provides relevant information to propose functional goals of restoration and can optimize restoration efforts. Finally, to raise awareness of children and the general public, 2 classes from an Elementary school located in Mayotte (Pamandzi 2) and 2 classes from an Elementary school located in metropolitan France (Bondy, Boulloche school) were involved over the school year 2021-2022. One class from each school, called 'control class', benefited of a scientific animation and an educational field trip (at the Mayotte's lagoon or at the Porte Dorée Tropical Aquarium in Paris) to observe corals and reef ecosystems. The other classes, called 'test class', benefited of the full innovative approach developed in the project, i.e. several scientific animations (on coral biology, reef ecology, climate change, coral fragging, coral reefs and cultural issues….), coral fragging practice, photogrammetry practice to survey coral nubbins' growth over several weeks, experience exchanges with the other class (via visioconference) and the preparation of artworks and videos to be presented to the general public in Paris between the 10 and 12 of June as part of the Ocean Day and in Mamoudzou (Mayotte) on the 23rd of June as part of a dedicated event hosted by the Tourism office. The results of coral nubbins' growth as well as of the double study in social and human science concerning the impacts of our new approach on children, teachers and the general public will be briefly presented.

Results

Results show here that 1/ Mayotte's lagoon is increasingly warming and acidifying (see Lo Monaco et al. 2021) impacting both massive coral growth and the abundance of boring microflora in living corals which may have great implications on those main reef framebuilders' resilience, 2/ the three studied reefs showed various dominant coral morphotypes (stress-tolerant vs weedy vs competitive vs generalist species) depending on local environmental conditions, and 3/ branched coral nubbins surveyed by children grew over time and were healthy. Those from Mayotte

were used to create a new marine educational trail for the general public in Mayotte. The two events organized by the children, their teachers and the scientific team were also a great success with more than hundreds of persons aware of coral reef challenges.

Conclusion

This first year applying sustainability science to Mayotte coral reef case is a great success. It provides important results for improving reef restoration and conservation plans, and shows the efficiency of our innovative interdisciplinary educational approach to raise children and public awareness.