INTERNATIONAL CORAL REEF INITIATIVE (ICRI)
32nd General Meeting
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Member's report on activities related to ICRI

PRINCIPALITY OF MONACO

Reporting period November 2016 – November 2017

1. **Contribution to the ICRI Plan of Action 2016-2018.** *Your responses to the following questions will assist the Secretariat in assessing contributions towards the major themes of the current ICRI Plan of Action (http://www.icriforum.org/icri-secretariat/current)*

On a general note, it is important to note that the Principality of Monaco has signed a financial agreement for 2017 and 2018, with UN Environment in order to support the implementation of the International Coral Reef Initiative (ICRI) Plan of Action 2016-2018: Joint ICRI-UN Environment Grant Program for demonstration projects that protect and safeguard coral reef climate change refugia, build resilience, and/or restore damaged reef area through direct interventions.

The main objectives of this joint ICRI-UN Environment program are:
- To demonstrate practical approaches to supporting coral reef recovery and resilience, by applying innovative tools for decision support and implementing priority actions at target sites;
- To promote replication and scaling up of these approaches;
- To deliver concrete actions towards achievement of UNEA resolution 2/12, paragraph 11 and 12; as well as ICRI Plan of Action 2016-2018, Theme 3.

Theme 1 – "Help raise awareness of how coral reefs and related ecosystems help to fight climate change"

- *Goal 1-1: highlight the contribution of coral reefs, mangroves and seagrasses to mitigate and adapt to climate change and its impacts*

Question: Do you have examples of solutions provided by coral reefs and coastal systems to mitigate and adapt to climate change?

The Centre Scientifique de Monaco (CSM), the Monegasque Institute of Research, develops for more than 30 years, fundamental research for a better knowledge of the physiology of reef-building corals in normal and under environmental stress conditions. For this purpose, the Monegasque center possesses huge coral culture facilities and develops methods to propagate under controlled conditions. Tropical coral species are maintained in an aquarium room containing 5 large-10000 liter aquaria. In addition, five experimental rooms containing a total of 78-thirty liter aquaria, allow testing the effects of various environmental parameters on coral biology. All aquaria are equipped with pH, temperature and oxygen sensors and are supplied with fresh seawater (about 10 m3/h) supplied by a pumping system drawing water from 50 meters deep in the sea in front of Monaco-Ville. After circulating through the aquaria, the seawater is UV-sterilized before being returned to the

sea. The sensors are connected to a central alarm to signal problems in their regulation and are remotely monitored via the web. In total, the aquaria hold more than 20 tons of seawater on the top floor of the building. Among species cultured in the aquaria, the CSM regularly champions the use of the tropical coral, Stylophora pistillata, which has become the "coral lab rat" model species since used by many other research teams. Using these unique facilities, scientists from the CSM are working to understand how increase in surface seawater temperature and ocean acidification (OA) affects reef-building corals and how these organisms may adapt to these new environmental conditions.

Our results show for example that under long-term culture (5 years) under OA conditions, the model coral Stylophora pistillata continues to extent linearly at the same rate than control ones, but modify the structure of its skeleton (Tambutté et al. 2015; Venn et al. 2015). The physiological mechanism involved in this process relies on the capacity of corals to control the pH of the extracellular calcifying medium (ECM) where biomineralization takes place (Comeau et al. 2017: Venn et al. 2013). We therefore develop a mathematical model allowing to calculate the aragonite saturation state (Ωarag) of the extracellular calcifying medium and carbonate system ion concentration using measurements of calcification rate, seawater characteristics (temperature, salinity and pH) and ECM pH (Raybaud et al. 2017). The characteristics of the ECM for each coral species may buffer the effect of acidification and explain why certain corals continue to produce CaCO3 even when seawater chemistry is less favorable. More recent studies (unpublished data) suggest that coral adaptation to global change may be achieved by modulation of gene expression by epigenetic mechanisms.

In addition to scientific research, the CSM publish numerous general public papers on the mechanism of adaptation of reef-building corals (Allemand 206, 2017; Allemand et al. 2017).

References:

Allemand D, Tambutté S, Zoccola D. 2017. Y aura-t-il encore des coraux dans la mer ? La Recherche. 521: 52-7.

Allemand D. 2016. Coral reefs and climate change. Ocean and climate change, Scientific Notes. Second Edition, Tome 2. p. 32-39.

Allemand D. 2017. Les récifs coralliens peuvent-ils s'adapter au changement global ? In : Lavorel et al. Eds, Académie des Sciences. Les mécanismes d'adaptation de la biodiversité aux changements climatiques et leurs limites, pp. 99-104.

Comeau S, Tambutté E, Carpenter RC, Edmunds PJ, Evensen NR, Allemand D, et al. 2017. Coral calcifying fluid pH is modulated by seawater carbonate chemistry not solely seawater pH. Proceedings of the Royal Society B: Biological Sciences. 284(1847): doi.org/10.1098/rspb.2016.1669

Raybaud V, Tambutté S, Ferrier-Pagès C, Reynaud S, Venn AA, Tambutté É, Nival, P; Allemand, D. 2017. Computing the carbonate chemistry of the coral calcifying medium and its response to ocean acidification. Journal of Theoretical Biology. 424: 26-36. doi: 10.1016/j.jtbi.2017.04.028.

Tambutté É, Venn AA, Holcomb M, Segonds N, Techer N, Zoccola D, Allemand D., Tambutté S. 2015. Morphological plasticity of the coral skeleton under CO_2-driven seawater acidification. Nat Commun. 6: 7368. doi: 10.1038/ncomms8368. PubMed PMID: 26067341.

Venn AA, Tambutté E, Holcomb M, Laurent J, Allemand D, Tambutté S. 2013. Impact of seawater acidification on pH at the tissue-skeleton interface and calcification in reef corals. PNAS. 110(5): 1634-9.

Venn AA, Tambutté É, Tambutté S. 2015. Plasticity of coral physiology under ocean acidification. Oncotarget. 6(21): 18248-18249.

Question: Are you planning to add in your NDC the importance of coral reefs / mangroves?

Theme 3: "Help to reduce human threats to coral reefs and associated mangroves and seagrasses, by making greater use of regulatory tools"

Since 2014, a partnership between the Government of the Principality of Monaco and *Ole Siosiomaga Society* has been initiated in order to support the restoration of mangrove in targeted villages in Samoa. The objectives are to assist in the cumulative efforts of OLSSI and other partners in further raising the understanding and awareness of the targeted coastal villages on the value of conservation, rehabilitation, restoration, and sustainable use of coastal mangrove areas and resources emanated from these key ecosystems. This holistic and integrated approach will lead to sustainability in these individual but collective efforts and ensure the mangrove areas are further increased in terms of the total area percentage of Samoa covered by this key ecosystem for the benefit and the sustainable livelihood of our peoples in the long term future.

- *Goal 3-5: review issues related to the impact of sunscreens and other endocrine disruptors on coral reefs, and encourage the production of sunscreens that are proven not to damage coral reefs*

Question: are you working on this topic? If yes, could you please share with us your work. Please note that the information provided will help us to develop a recommendation for the next ICRI General Meeting. Please send us information as soon as possible.

Thanks to its facilities with coral culture, the CSM is developing a new method to test the physiological impact of UV filters contained in sunscreen lotions. This work is performed in collaboration with Researchers from the L'Oreal Research & Innovation Department. This new method involves nubbins (microcolonies) of the model coral, *Stylophora pistillata*. The nubbins are incubated in closed-circuit 15-liters aquariums under controlled conditions for 5 weeks in the presence of varying concentrations of the xenobiotic to be tested (from 10 µg/L to 5 mg/L) with weekly seawater renewal. Photosynthetic efficiency as measured by PAM Fluorimetry is used as indicator the health state of the coral holobiont, as it has been shown that this parameter is an early sign of coral bleaching. The real concentration of the xenobiotic is checked by an analytical methodology, developed combining automated solid phase extraction with UPLC-UV detection, to monitor the water UV filters concentrations, all along the exposure period.

Using this method, our preliminary results showed that the largest impact for the lowest concentration tested (0.1 µg) was observed for the inorganic filter ZnO. Exposure to 0.1 µg ZnO for 40 days led to a significant decrease of the Fv/Fm down to a value of 0.35, which was estimated to then induce coral bleaching and the loss of its photosynthetic capacities. Octocrylene, also induced a significant decrease in the Fv/Fm after 4-5 weeks at concentrations as low as 0.2 µg l-1. The other filters tested, avobenzone, mexoryl XL and

SX, as well as uvinul, showed low toxicity both for the coral symbionts or for the animal tissue (Fel et al. 2016, 2017).

References:

Fel J.-P., Béraud É., Bensetra A., Lacherez C., Mezzache S., Léonard M., Allemand D., Ferrier-Pagès C. 2016. Predictive laboratory methodology to assess coral bleaching Application to UV filters. 13th International Coral Reef Symposium, ICRS 2016, Hawaill.

Fel J.-P., Bensetra A., Mezzache S., Béraud É, Ferrier-Pages C., Allemand D., Léonard L. 2017. Methodology to screen chemicals for their potential bleaching effects on corals, Application to UV filters. European Coral Reef Symposium, Oxford, December 2017.

SETAC (Society of Environnemental Toxicology & Chemistry) – Nantes - 22-26 Mai 2016

Theme 4: "Monitor the state of reefs in order to better manage them"

- *Goal 4-2: better monitor the phenomena of coral bleaching*

Question: How did you implement the recommendation on addressing the decline in coral reef health due to global bleaching events?

1. The Centre Scientifique de Monaco is particularly involved in the scientific study of the impact of this environmental change on coral reefs since the 90's, developing studies from the molecular mechanism of action of OA to socio-economic impacts on coastal human societies. Scientific research at the CSM is associated within the *Association Monégasque pour l'Acidification des Océans* (AMAO), which includes media and funding activities carried out in the Principality of Monaco to communicate, promote and facilitate international actions on ocean acidification and other global stress factors affecting the marine environment fully supported by HSH Prince Albert II.

The CSM organized a workshop in Monaco in October 2017, bringing together international experts, scientists, economists, lawyers, NGOs, international organizations, to propose, on the basis of the best available science, practical solutions for coral reefs, and other threatened ecosystems. The goal of this workshop, organized in partnership with IAEA and supported by the Prince Albert II of Monaco Foundation and the French Ministry of Environment, was to determine mitigation and adaptation solutions to OA – and other stressors - impacts on coral reef ecosystems and the services they offer, at several different scales and levels: chemistry (e.g. geo-engineering), socio-economic (e.g. fisheries and selective aquaculture, cultural and anthropological, tax incentives), biological (e.g. selection of resistant species, reef restoration), technological (e.g. development of sensors and monitoring systems), legal (e.g. creation of protected areas and coral parks, "blue carbon", governance and coastal waters law), communication sciences (e.g. new technologies) and psychology (e.g. behaviour of agents). Workshop participants considered potential short-, medium- and long-term solutions, according to the level of political decision (local, national, regional and international). The conclusions of this workshop will be delivered to policy-makers at the international level, in particular in developing countries. This workshop was part of one voluntary commitment of the CSM at the UN Conference on Oceans in New-York.

2. On the opening day of the Our Ocean conference in St Julian, Malta on 5 October, 2017, His Serene Highness Prince Albert II of Monaco was joined by His Royal Highness the Prince of Wales and Her Majesty Queen Noor of Jordan, and by the Heads of State and Government, Ministers and High Level representatives of 12 countries[1] signatory to the CORAL REEF LIFE DECLARATION a joint statement facilitated by the Prince Albert II of Monaco Foundation. The meeting was held to celebrate the importance of coral reef ecosystems as key indicators of ocean and planetary health. The countries that have signed the declaration on the invitation of Monaco have all in common a significant coral reef cover in waters within their national jurisdiction, and they recognize their environmental, economic, social and cultural values.

In the non-binding Coral Reef Life Declaration, they agree to:

1. Submit, as part of their Paris Agreement commitments, nationally determined contributions that promote the ambitious climate action required to avoid damaging coral reefs any further and to help, through protection and conservation, reef-dependent people to adapt and increase ecological resilience to climate change.
2. Accordingly, they encourage the International Panel on Climate Change (IPCC) to highlight the role and fate of coral reef ecosystems and to explore and promote solutions.
3. They also pledge to promote high-level multidisciplinary research and to support local and regional adaptation and management strategies, and aim to develop environmentally sustainable business models that promote the health of coral reefs and reduce coral-related investment risks, as well as identify and promote the financial benefits of investing in coral reefs as assets of a sustainable blue economy.

3. On the International level, the Ministry of Foreign Affairs and Cooperation of Monaco is supporting, financially, projects related to natural habitat restoration, such as coral reefs, in Small islands developing countries, as a mean to mitigate climate change impact such as sea level rise and land salinization. One of the main supports is given to Secretariat of the Pacific Regional Environment Programme (SPREP) to build coastal communities' resilience to ocean acidification through the Pacific Partnership on Ocean Acidification project.
Monaco commits financially support this integrated approach in favor of ocean acidification monitoring, strategies to strengthen the resilience of local communities, and concrete actions to adapt to and mitigate ocean acidification. The Partnership with the SPREP seeks to achieve outcomes through three outputs and associated actions:

1. Assessment of regional vulnerability to ocean acidification, research and ecosystem monitoring data to inform policy and adaptation;
2. Practical adaptation actions identified and carried out in pilot project areas ;
3. Ensure that Pacific islands capacity is built to understand and adapt to ocean acidification as well as help raise awareness on this issue.

[1] The Coral Reef Life Declaration was signed by the following countries (alphabetic order): Australia, Cook Islands, Fiji, France, French Polynesia, Grenada, Indonesia, Mexico, Monaco, Niue, Palau, Seychelles. Two more countries (Ecuador and Costa-Rica) signed the document in November.

Theme 5: "Progress via education"

- *Goal 5-1: prepare for the 2018 International Year of the Reef (IYOR)*

Question: How did you implement the Recommendation designating 2018 as the third International Year of the Reef? Please let us also know what are you planning to celebrate IYOR2018.

Many actions are planned during the year 2018, including a photographic exhibition in Monaco, animations directed to the general public during the Monaco Ocean Week, animations and visits of the coral culture facilities of the CSM all year for schools ...

Please also list the educational material that you've developed in the past, so we can share it on the IYOR website.

Question: Would you like to report on one of your activities during the ICRI GM meeting?

Yes. Following the organization of the International Workshop 'From Sciences to Solutions for Reefs" held in Monaco in October 2017, we wish to present its preliminary conclusions during this General Assembly.

This workshop fits in the framework of the United Nations Sustainable Development Goal 14 and places itself as a response to the coral reef declaration launched on October 5, 2017 at the Our Ocean Conference in Malta by HSH Prince Albert II and HRH Prince Charles.

The Ocean Acidification Workshops were born from the Monaco Declaration (2008), which aimed to raise awareness among policy-makers on the issues of ocean acidification and encourage interdisciplinary research efforts in this area[2]. Organized by the Scientific Center of Monaco (CSM) and the IAEA Environment Laboratories, with the support of the Prince Albert II Foundation, the Government of Monaco, the French Ministry of Ecological and Solidarity Transition, the Oceanographic Institute - Prince Albert I Foundation, Prince of Monaco, Central Caribbean Marine Institute, the Monegasque Water Company and the Monegasque Association on Ocean Acidification (AMAO), this edition "From Science to Solutions" brought together about sixty experts in natural and social sciences, from 23 countries[3] with highly diverse and complementary skills and experiences. Passionate and very productive discussions led to a series of solutions applicable to each of the six regions studied:

1. Red Sea
2. Indian Ocean and South-East Asia (Indonesia, Maldives, Micronesia)
3. French Polynesia and New Caledonia

[2] The workshops follow the line of the opening of the Centre Scientifique de Monaco (CSM) to transdisciplinary research. Indeed, the CSM has been enriched by several departments and topics: in 2010, the environmental economics that laid the foundation for this series of workshops, the department of polar biology in 2012 and the department of medical biology in 2013. The topic of this fourth workshop reflects the major expertise of the CSM for these last 30 years, coral reef and ocean acidification.

[3] Algeria, Germany, Kingdom of Saudi Arabia, Australia, Canada, Egypt, France, Iceland, Israel, Italy, Japan, Jordan, Kenya, Lebanon, Monaco, New Caledonia, Palau, French Polynesia, United Kingdom, Sweden, Thailand, Turkey, USA

4. Australia
5. Caribbean and West Atlantic (Puerto Rico, Bahamas, Florida)
6. Non-French Pacific Islands (Guam, Hawaii, Japan, Palau, Fiji, Marshall Islands, Samoa).

For each of these regions, the ecological or socio-economic impacts and solutions, were listed.

These regions are at very different stages of development and environmental awareness, and have different demographics (more or less inhabited regions). The reefs are also very diverse depending on their location and their health is not the same from one region to another. All this has consequences for suggested solutions that as a result cannot be the same from one region to another. Starting from the same initial guidelines, the experts of each region developed unique approaches adapted to the local circumstances.

For example, the Caribbean region is geographically the most diverse and has already experienced coral bleachings, hurricanes and an increase in ocean acidification that have impacted coral health. Therefore, there are already a number of programs to protect and restore corals. On the other hand, for certain regions (Red Sea for example), the effects of the warming of the waters are less pronounced, and these regions could therefore be "sanctuaries" in the future.

As another example, some Pacific countries (French Polynesia, New Caledonia ...) share a strong economic and institutional link with France, but are geographically different, as they composed of either atolls or "high" islands. Also, in this region, reefs are generally healthy, with few bleaching episodes, or, if these episodes do occur, the corals have the ability to "regenerate".

Ultimately, local solutions, some of which are still experimental, can be applied to solve specific problems. Among these, some appear frequently in the conclusions of the working groups: ecological engineering (reef restoration), development of marine protected areas (with a strict definition of the choice of sites), development of selection methods for resistant corals, protection / restoration of blue carbon sequestration zones (mangroves, seagrass meadows). With regard to socio-economic solutions, we can mention the development of economic and fiscal incentives to induce attitudinal changes in order to reduce carbon emissions and protect reef areas, the development of educational initiatives for schoolchildren and the general public, the involvement of the general public in the implementation of protective measures, collaboration with local populations the most affected by these issues, the adoption of tailored legal tools, the creation of interdisciplinary and inter-regional networks for the exchange of knowledge and data. However, all experts agree that the real long-term solution is to reduce CO_2 emissions. In the short and medium term, it is also possible to reduce CO_2 concentrations in seawater, for example by protecting and / or restoring seagrass beds and mangroves that capture and sequester CO_2 (blue carbon).

- **Publications.** Please list relevant publications/reports (related to the ICRI plan of action) you have released during this reporting period.

- **General Information.** (Note that this information will be posted on the ICRI website on your member page: http://www.icriforum.org/about-icri/members-networks.)

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