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Productivity, Blue Carbon and nutrient cycling of marine macrophytes in Reunion Island - MACRORE

[Visiting team: Dr. Irene Olivé (IP), Dr. Emilio García-Robledo, Dr. João Silva

Host team: Dr. Pascale Cuet, Dr. Patrick Frouin]

INTRODUCTION AND MOTIVATION

Seagrass meadows are one of the most valuable submarine ecosystems. They provide a number of essential ecosystem services, such as primary production, nutrient cycling and carbon sequestration while supporting fisheries and providing habitat for commercially important and emblematic endangered species (e.g. turtles, manatees and dugongs) (Orth et al. 2006).

Unfortunately, these ecosystems are threatened worldwide by anthropogenic actions, such as physical habitat removal, nutrient loading, and climate change. This is particularly concerning since seagrasses also play an important role as buffers and mitigators of climate change impacts by removing CO_2 via photosynthesis and storing it deep within the sediment (Fourqurean et al. 2012). Thus, they provide refugee areas for calcareous organisms contributing to reefs maintenance (Unsworth et al 2012).

Despite their recognized importance, seagrasses have been somewhat overlooked. This is particularly evident in tropical areas, where large gaps in data persist (Orth et al. 2006), while coral reefs and even mangroves have caught more attention from science (Duarte et al. 2008). Seagrass beds remain a low priority in terms of conservation status with no specific international regulation applicable.

The Mascarene Islands (including Reunion Island) have been identified one of the 10 Marine Biodiversity Hotspots (Roberts et al. 2002) and are a unique biogeographic entity displaying a high level of endemism (Myers et al. 2000). The marine environment of Reunion holds a relatively small diversity of biotopes, due to a limited coastal shelf, but includes meadows of the seagrass *Syringodium isoetifolium*. Long-term monitoring of marine macrophytes has been performed in Reunion (Naim et al. 2013, Cuvillier et al. 2017) but the evaluation of the ecophysiologial status of seagrasses needs further research.

SCIENTIFIC OBJECTIVE

Assess the ecological condition and the anthropogenic pressure on metabolic-related variables (i.e. productivity, blue carbon and nutrient cycling) on seagrass meadows in Reunion Island.

METHODOLOGY AND EXPERIMENTAL SET-UP

Project approach

A scaling-up approach from individual organism, to community water-sediment fluxes up to the ecosystem was used to evaluate the ecological condition of seagrass meadows in Reunion and the effect of potential anthropogenic pressure, namely sewage and nutrient loading. The seagrass *Syringodium isoetifolium* was selected as model species and oxygen as main descriptor across the different levels.

Three experimental locations were selected along the Reunion reef lagoon, at the North-West coast of Réunion (Fig. 1). Locations were chosen based on the expertise of the host team at University of Reunion as a

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representative of meadows experiencing different anthropogenic pressure associated to sewage or river discharge. The sampling sites selected were “Saint-Gilles” (MNS) as a low pressure location, “Passe Ermitage” (PAS) as a high anthropogenic pressure with elevated nutrient load expected, and “Saline-Les Bains” (SAL) as intermediate impact location. At each location, a minimum of 3-5 replicates were sampled for each parameter.

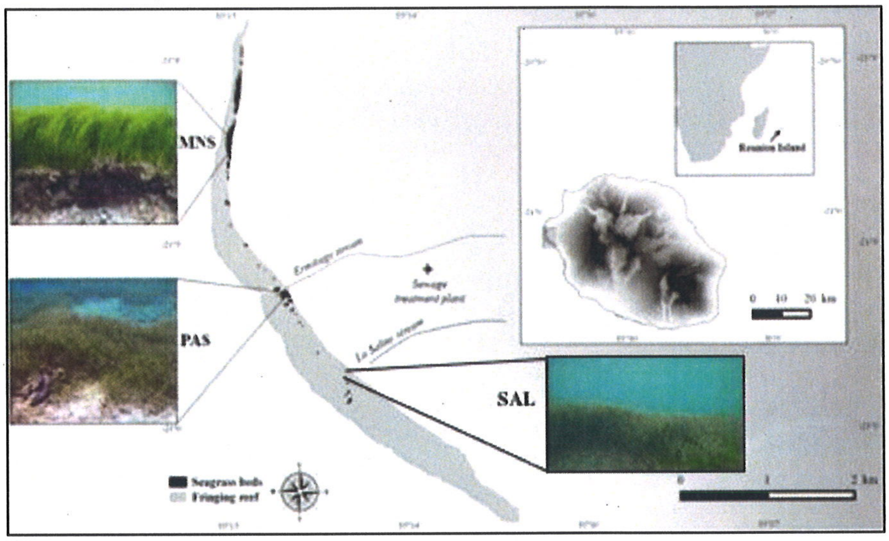

Figure 1. Sampling locations at Reunion Island. Sites MNS - Saint Gilles; PAS- Passe Hermitage; SAL – La Saline-Les Bains (modified from Cuvillier et al. (2017).

Work plan and methodology:

The following multidisciplinary descriptors were measured:

a) General physico-chemical description of the meadow.

Descriptors of the water mass around the seagrass meadows (in the lagoon) were monitored using a combination of autonomous sensors and analytical techniques. Temperature, salinity, oxygen and pH were measured with a multiparameter sonde. Irradiance was measured with *in situ* loggers. Water samples were taken for alkalinity analysis at University of Reunion. Water nutrient samples were taken at the sampling locations and quickly frozen and stored until analysis at University of Reunion.

b) Ecophysiology and productivity of seagrasses.

Net productivity and respiration of seagrass individuals were evaluated using *in situ* incubations chambers (Olivé et al. 2017) measuring oxygen evolution with optodes. Seagrass structural descriptors (biomass and length) were also recorded for productivity normalization. Samples of plants were also collected, freeze-dried and stored for description and quantification of fatty acids at University of Glasgow.

c) Benthic community metabolism and water-sediment fluxes

The physico-chemistry, the water-sediment fluxes (O_2) and the productivity of the sediment-associated phytobenthos community were evaluated using microelectrodes at the laboratory from cores collected at the selected locations (García-Robledo et al. 2012). Denitrification and sediment-water nutrient fluxes were determined using N^{15} isotopes.

d) Carbon sink capacity (Blue carbon).

Sediment cores (5 cm long) were collected and organic matter content was analysed in the laboratory by combustion. Samples of plants were also collected, freeze dried and kept for analysis of carbonates at University of Glasgow.

Samples of sediment were collected, freeze dried and kept for analysis of microplastics and organic pollutants from anthropogenic origin (e.g. antibiotics) at University of Cadiz.

PRELIMINARY RESULTS AND CONCLUSIONS

a) General physico-chemical description of the meadow.

Dial fluctuations in physico-chemical parameters (oxygen and temperature) were recorded along the whole project period in the lagoon (Fig. 2). Oxygen showed large natural fluctuations in the lagoon, values ranged from circa 50% saturation at night up to circa 200% saturation at noon (Fig. 2 left). Seawater temperature stayed relatively high for the season (above 25.0 ºC) with dial fluctuations ranging 25.0 - 28.0 ºC (Fig. 2 right). The complete pool of physico-chemical data from each sampling location is under processing.

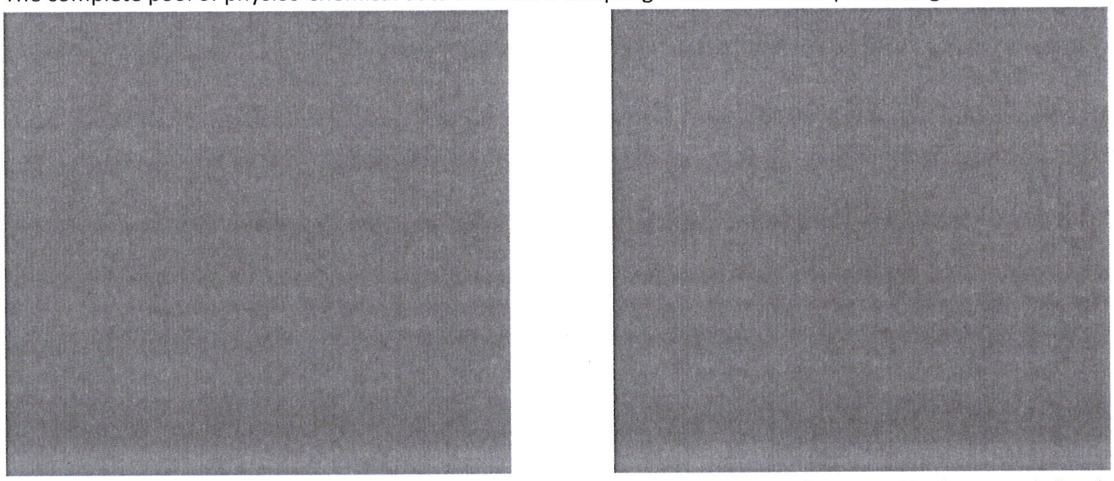

Figure 2. Seawater dissolved oxygen concentration (%) (left) and temperature (ºC) (right) measured in the water during the sampling period. (Figure available upon request).

b) Seagrass productivity

Seagrass morphotypes and meadow structure differed across the 3 locations sampled (personal observation). Net plant production (NPP) and respiration differed among locations (Fig. 3). Highest productivity was recorded in the MNS station while lowest NPP and highest respiration were recorded in PAS, according to the anthropogenic pressure gradient expected.

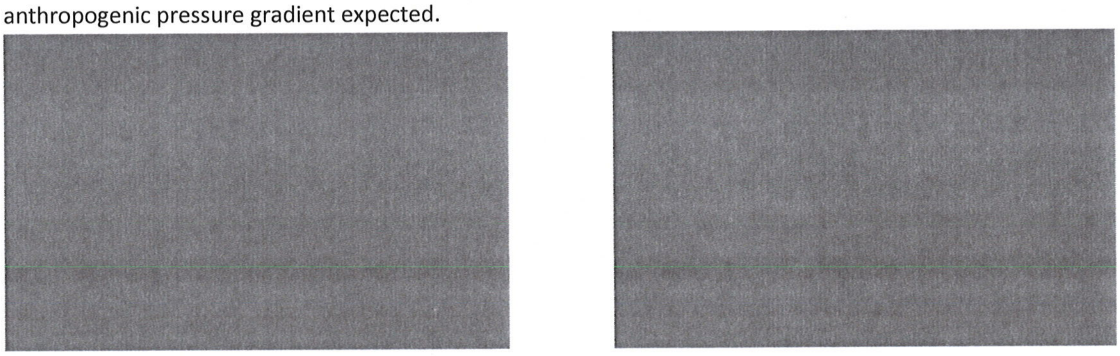

Figure 3. Net plant production (NPP) (Left) and Respiration (Right) of S. isoetifolium measured with incubation chambers. (Figure available upon request).

c) Benthic community metabolism and water-sediment fluxes

<u>Net community metabolism and nutrient fluxes</u>

Benthic community (i.e. microbial community, seagrasses, epiphytes and benthic infauna) was net autotrophic in light conditions, releasing oxygen at a rate of 1.4-1.9 µmol m^{-2} h^{-1}, and similar in the three sites (Fig. 4). In darkness, oxygen was consumed at rates of -1.2-4 µmol m^{-2} h^{-1}, with site SAL showing the highest consumption rates. In general, the benthic community consumed both ammonium and nitrate in light and dark conditions. In light, both nutrients were consumed at higher rates at site SAL whereas a slight net production was measured at site MNS (Fig. 4).

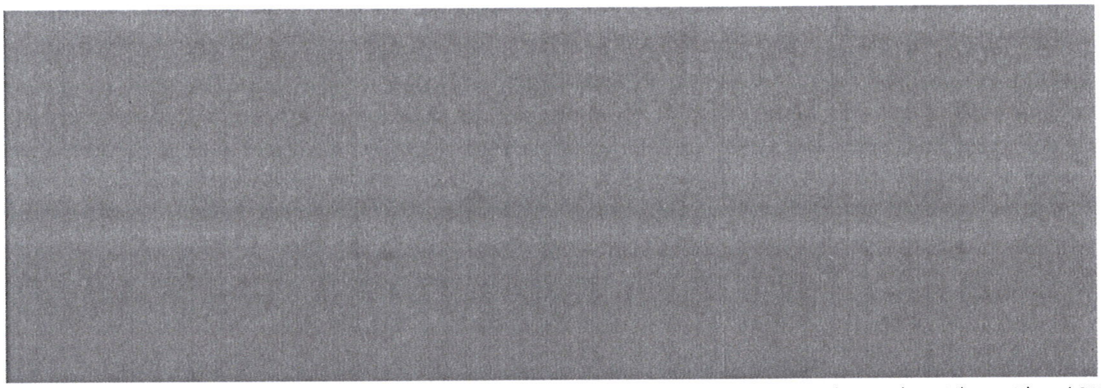

Figure 4. Net community oxygen, ammonium and nitrate fluxes measured in the sites MNS (Zone A), PAS (Zone B) and SAL (Zone C). Positive rates mean net release from the community to the water column whereas negative values represent net consumption rates from the benthic community. (Figure available upon request).

<u>Oxygen microprofiles</u>

Oxygen was quickly consumed in the first 2-3 mm of the sediment from the three sampling sites. In the sites MNS and PAS, net production profiles with a clear production peak below the sediment-water interface were measured, extending the oxygen penetration depth to 3-4 mm. PAS site showed the lowest oxygen penetration depth, being as low as 1 mm in some dark profiles (Fig. 5).

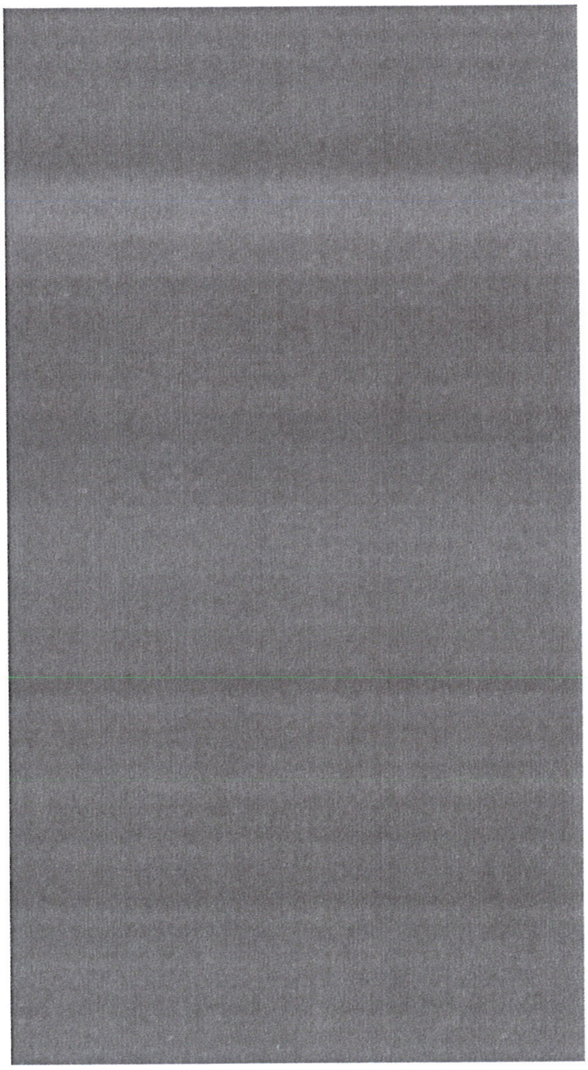

Figure 5. Oxygen microprofiles measured at the sediment-water interface in sediment cores collected in the sites MNS (Site A), PAS (Site B) and SAL (Site C). Profiles were measured in light (left panels) and dark (right panels) conditions. Each line is a replicate. (Figure available upon request).

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d) Carbon in the sediment (Blue carbon)

Organic matter content in the sediment was significantly higher in SAL station, though no pattern related with anthropogenic pressure was found (Fig. 6).

Figure 6. Organic matter content per unit of dry weight in the first 5 cm of the sediment. (Figure available upon request).

Preliminary conclusions

Large daily oxygen variability (50 – 200 % O_2 saturation) inside the lagoon revealed a significant metabolic activity in the ecosystem. Results point to a significant contribution of seagrasses to the positive net metabolic balance of the lagoon (i.e. autotrophic). However, the net metabolic balance of the sediment compartment was slightly negative (i.e. heterotrophic). Metabolism of seagrasses and the associated benthic community varied among locations. Results point to higher oxygen consumption in anthropogenic influenced (i.e. nutrient enriched) stations. Further analysis is required to determine the ecological condition of the lagoon.

MULTIDISCIPLINARY APPROACH

This project was conceived and designed as a multidisciplinary project. MACRORE combined different research areas related with marine ecology and ecosystem functioning. The research team included chemists, biologists and marine sciences researchers holding recognized expertise in marine ecology, oceanography, chemistry, biogeochemistry, ecophysiology and seagrass biology. The project also pursued internationalization and networking by gathering an international team of researchers from France, Portugal, Spain, and United Kingdom.

A scaling-up approach from individual organism, through the associated community up to ecosystem was applied. To reach this objective, a combination of instrumentation and methodologies from different disciplines was implemented including autonomous physico-chemical probes, oceanographic chemical analysis, high precision microelectrodes and optodes (see "work plan and methodology").

The use of all the data obtained from different domains is key to understand the role that seagrasses play in the Reunion lagoon and the implications for the ecosystem functioning. It will also provide valuable insights on the bottom-up and top-down mechanisms taking place in the lagoon pointing to future lines of interdisciplinary research.

OUTCOME AND FUTURE STUDIES

The project pursued diffusion favouring integration among multidisciplinary research domains.

During the mission, dissemination was completed online on social media via Twitter posts (#MACROREproject). Further diffusion of the project has been made via ResearchGate and SeagrassSpotter.

Scientific results have been presented at international conferences (7th ENVRI week, Riga) and are envisaged to be presented in further conferences and published in international high-impact peer-reviewed open-access journals. ENVRIplus support is acknowledged in all dissemination actions.

Continuity of the research collaboration started with the MACRORE project is foreseen via TNA Access calls associated to next ENVRI project as well as other national and international funding agencies.

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