

# Monitoring coastal uses of the Marine Reserve of La Reunion using aerial surveys, Reunion Island, France, West Indian Ocean

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## Introduction

Founded in 2007, the Marine Reserve of Reunion Island (RNMR) aims to preserve and add value to a fringing reef which has long suffered strong anthropogenic pressures. These reefs suffer from a massive coastal urbanization which has increased these last 25 years because of good climatic conditions and seaside assets. Overcrowding, strong coastal urbanization, discharge of agriculture pollutants and the lack of a suitable drainage system have worsened the situation. In addition to human pressures, natural factors of stress have also added to the damage of coral reefs (rise of sea temperature, ENSO, hurricanes, etc.) Accordingly, coral cover decreased from 55% in 2000 to 32% in 2007. In 2008, half of Reunionese reefs were considered as damaged (Ahamada et al., 2008).

In this context, managers of the RNMR have to face new issues: on the one hand they are supposed to ensure rational development of the fisheries and on the other hand, they have to make uses (whether recreational or non-recreational) compatible with the protection of marine biodiversity for a sustainable use of resources and activities in the Marine Protected Area (MPA). This requires building a comprehensive view of activities and ensuring a rational management of uses and tourism in the RNMR. Over the last decade, fifteen uses have been identified on this territory (Mirault, 2006) and new ones recently appeared (e.g. paddle). Few measures of coastal activity have been carried out (Mirault, 2006) but diagnostics were either sparse in time and space, or too labor intensive. Since then, no uses were sustainably monitored. In Reunion Island, aerial surveys are used in ecology to measure and monitor turtle populations since the 1990's (Jean et al., 2010). Because of the "instantaneous" dimension this tool brings, it is now more and more used in coastal uses monitoring and especially useful when dealing with strong densities of users (Smallwood et al., 2011).

## Method

From January to July 2010 and January to July 2011, fifteen uses including sunbathing, swimming, fishing and water sports were regularly monitored using aerial surveys and photos. 48 flights were planned over this period each year, and stratified by time (holidays, weekdays, week-end, and morning/afternoon). Data were entered into a Geographic Information Basis (GIB) incorporating a Geographic Information System (GIS) offering a range of spatial or temporal analysis tools. Results are twofold: data can be exploited either through the prism of science in assessing and spatializing anthropogenic pressures on reef environment, or

through a management prism in contributing to optimize management (e.g. surveillance, communication, awareness policies, etc.) and assessing governance effectiveness. In the reserve management plan 2012, managers determined 4 specific uses to focus on, depending on specific reasons. We also put the emphasis on these uses in this presentation:

- All fishing uses (boat fishing, traditional angling and spearfishing) because they are directly linked to resource sustainability issues and, for some, still rooted in tradition (e.g. traditional angling) and managers are responsible for their continuation.
- Coastal uses (e.g. swimming and sunbathing) and water sports because of the significant localized pressures they induce on the reef (Epstein et al., 2004).
- Scuba diving for its well-documented impact on coral reefs essentially by direct physical damage to the coral (Barker and Robert, 2004).
- Surfing is particularly at risk to shark attacks. The number of attacks suddenly increased in 2010 (6 in a year as against an average of 1.1 per year usually). The point here is to encompass spatial and temporal dynamics of these users in order to draw a map of shark risk.

## Results

General distribution of users within the reserve is heterogenic in time and space. From one year to another, maps and statistical results highlight a "differential activity" in time and space. Sites that consistently gather the most of sunbathers and swimmers are Hermitage, Saline North, Boucan-Canot and Etang-Salé: they account for 50% of users of the total coast users even though they represent only 8% of the coastline. Except for Boucan-Canot, sites where pressure is high were found to be near no-take zones (sanctuary zones of Ermitage, Saline and Etang-Salé). A finer scale analysis reveals the trends and dynamics of spatio-temporal distribution of each use. In order to highlight areas with management issues, spatial distribution uses was analyzed in regard to the representation degree of each use within each area. A typology of impact risks was built through the prism of uses per area (figure 1). High sampling resolution allowed us to analyze spatio-temporal dynamics for each use and each area.

The ways to assess governance effectiveness of Reunionese MPA with this protocol are numerous. For instance, it offers an overview of users' distribution in time and space, thus infringements as well, whether in no-take zone, or in non-fishing zones. Managers plan field surveys during which infringements are recorded and registered in a da-

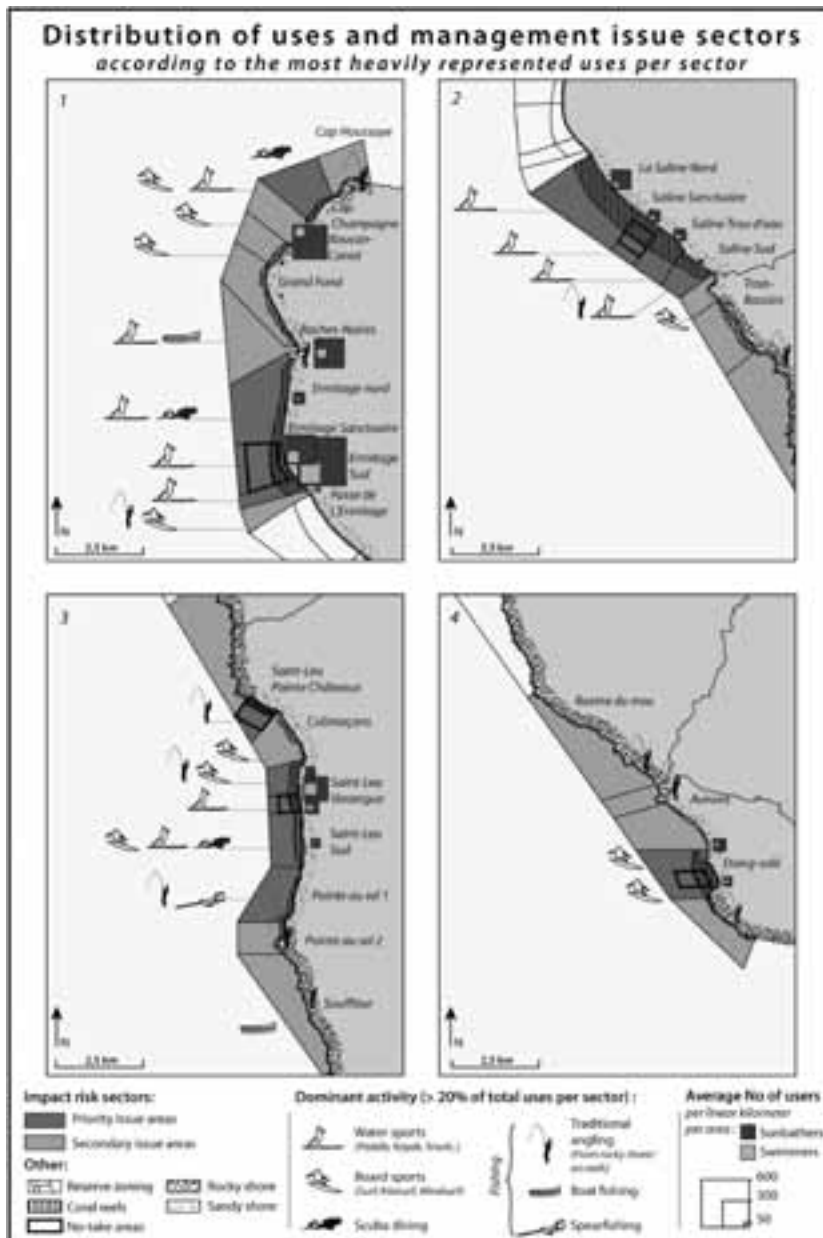


Figure 1. Mapping of uses spatial distribution and management issue areas in regard to the representation degree of each use per area.

tabase. Nevertheless, these observations are quite punctual and sparse in time and space. Moreover, the surveillance effort is focused on Ermitage-Saline area (68% of total surveys). All in all, 2010 and 2011's infringements, observed from the air, totaled 1,327 observations (70 % in

non-fishing zones, 24 % in no-take zones). Between 2010 and 2011, we noticed a decrease of infringements of 40 %. Similarly, a tendency to decrease (- 32 %) was also observable in management data, proving that both methods are complementary.

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