Long-term ecoacoustic monitoring of a pristine coral reef: when data-intensive ecology responds to management objectives

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Context

The coral reefs of Europa Island (SW Indian Ocean) are among the few coral reefs that remain in near pristine conditions. Their conservation is both a priority and a logistic challenge due to their isolation.

Ecosystem management requires regular information from the field to :
1) apprehend the natural dynamics of their biological communities;
2) detect disturbances, and understand their origins and mechanisms;
3) regulate human activities (eco-tourism, research) to avoid disturbances;
4) implement ecosystem conservation and restoration actions to counteract biodiversity and ecosystem functions losses.

Ecoacoustics is a new and promising tool for monitoring marine habitats and associated biodiversity. The CORCOPA project, funded by the EU BEST 2.0 programme, proposes long-term continuous ecoacoustic monitoring to provide Europa Island's managers (i.e. *Terres Australes et Antarctiques Françaises*, TAAF) with information to implement their conservation strategy.

Material and Methods

In April 2018, an acoustic monitoring station was installed at 12 m depth. Consecutive 5 min sound samples are recorded at 100 kHz and 16 bits and stored on an external drive. Ecoacoustic indices for marine biodiversity and habitat assessments (Sound Pressure Level and Acoustic Complexity Index) are calculated for several frequency bands. Specific events (e.g., scraping by parrotfish, vessel noise, …) are also analysed. Learning and classification tools can be developed to respond to management objectives.

Soundscapes and ecological communities were characterised at nine reef sites around Europa. Correlations between acoustic and ecological indices are analysed to specify the ecological meaning of acoustic indices for Europa island, in order to better understand future temporal variations detected by the continuous monitoring.

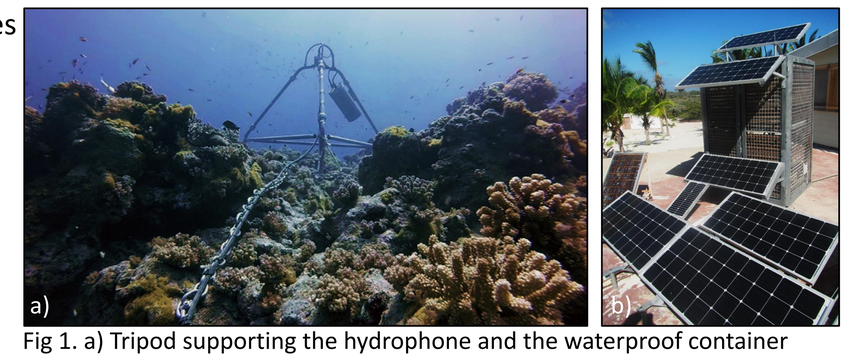

Fig 1. a) Tripod supporting the hydrophone and the waterproof container (data acquisition chain); b) terrestrial interface (power supply, data storage)

Results

Management objective 1: knowledge of the initial state and functioning

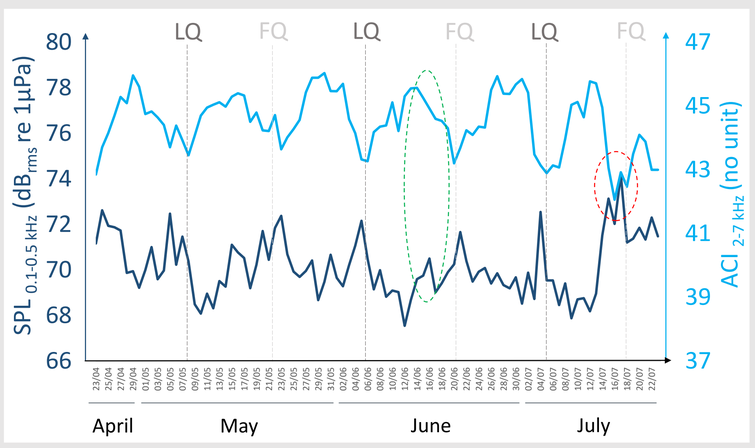

Fig 2. Temporal variations of the daily mean values of 2 acoustic indices at site EU10 from April 23th to July 23th; FQ and LQ: First and Last Quarter

- sound amplitude (SPL)
- sound complexity (ACI)

on various bandwidths

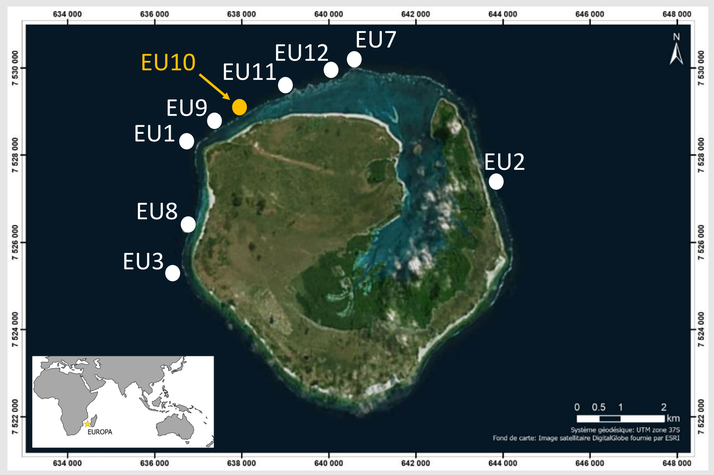

Fig 3. Location of the nine sites sampled in April 2018

Correlations?

- $SPL_{0.1\text{-}0.5kHz}$, $ACI_{0.5\text{-}1kHz}$, $SPL_{1\text{-}2kHz}$, $SPL_{2\text{-}7kHz}$ and $ACI_{2\text{-}7kHz}$
- Diversity, abundance and biomass of fishes; cover and diversity of corals, habitat complexity

Permanent monitoring at site EU10

Acoustic and ecological surveys at nine sites

1.1) General acoustic temporal patterns and their ecological interpretation
ANALYSIS : temporal clustering (see Philipps *et al.* 2018)
e.g.: a cluster characterised by high values of $SPL_{0.1\text{-}0.5kHz}$ could indicate a period with high fish activity (see e.g. Kennedy *et al*. 2010)

Crude acoustic data:

consecutive 5min sound samples (.wav)

Acoustic database with scraping events identified by video analysis

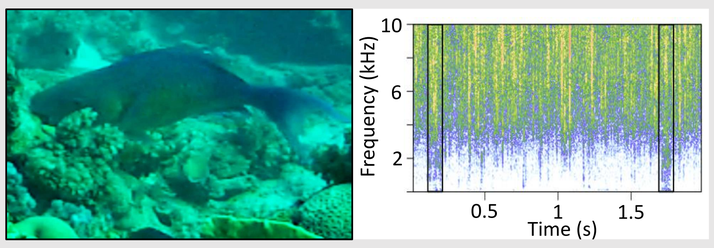

Fig 4. Parrotfish scraping at EU10 and associated spectrogram

1.2) Monitoring of key biological activities
ANALYSIS : deep learning
e.g.: automatic detection of scraping events over the year. (scraping is considered as a critical function ensuring coral reef resilience; Green & Bellwood 2009)

Management objective 2: detection of disturbances

Anchorage of a vessel from 14 to 18 June → Make database with samples containing vessel noises → 2.1) Automatic detection of vessels frequentation
ANALYSIS: deep learning

Analysis of outliers

Metereological events? Thermal stress? → Make database with disturbed samples over the years → 2.2) Automatic detection of natural disturbances
ANALYSIS: deep learning

Impact?

Management objective 3: regulation of human activities to avoid ecological impacts

e.g. definition of SPL thresholds to be respected by vessels, and control with the permanent monitoring

Resilience ?

Management objective 4: implementation of ecosystem conservation and restoration actions to counteract biodiversity and ecosystem functions losses

Conclusions

Europa Island reefs have been surveyed opportunistically using traditional *in situ* visual methods. Such field surveys are accurate but logistically complex and costly, making regular monitoring unfeasible. To understand the natural temporal dynamics of these ecosystems and to evaluate ecosystem responses to intense disturbances (e.g. coral bleaching, hurricanes), field data are required on a regular basis.

Associating continuous ecoacoustic monitoring with powerful new tools such as deep learning, provides a unique opportunity to enhance the conservation strategy for isolated ecosystems like Europa Island's reefs. CORCOPA is a pilot project that aims to demonstrate the viability and relevance of this approach, by analysing the ecological meaning of spatial and temporal variations of ecoacoustic indices on a long-term basis.

References

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Acknowledgements

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