Distribution of zooplankton in relation to hydrodynamics and environmental factors in a coral reef lagoon under mining activities (New Caledonia)

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Hadrien Roy, Juliette Renaux, Martine Rodier, Marc Pagano, David Varillon, Loic Guilloux, Robert Arfi, Cristèle Chevalier

Aix Marseille University, CNRS/INSU, University of Toulon, IRD, Mediterranean Institute of Oceanography (MIO), UM 110, 13288 Marseille, France

Introduction

The reef-lagoon ecosystems of New Caledonia, considered as one of the main biodiversity hotspots in the world, is threatened by climate change and human pressure such as mining activities (Ni extraction) in the Koné Lagoon. To understand the effects of this mining activity, zooplankton, considered as a good indicator of water quality, was studied in relation to environmental characteristics before (2008 to 2010) and after (2018) the implementation of the mining complex (2010). In this study we analyze changes in zooplankton community structure and abundance in relation to changes in hydrodynamics, environmental characteristics (ie., turbidity, metals, nutrients) and food availability (chlorophyll)).

Methods

Four campaigns results were used: CLAPP 1 and 5 (dry seasons 2008, 2010), CLAPP 2 (wet season 2009) and UECOCOT (wet season 2018). CLAPP sampling was performed in spring tide whereas UECOCOT sampling was split between spring tide (ST1 and 2) and neap tide (NT), ST1 occurring just after a strong rainy event.

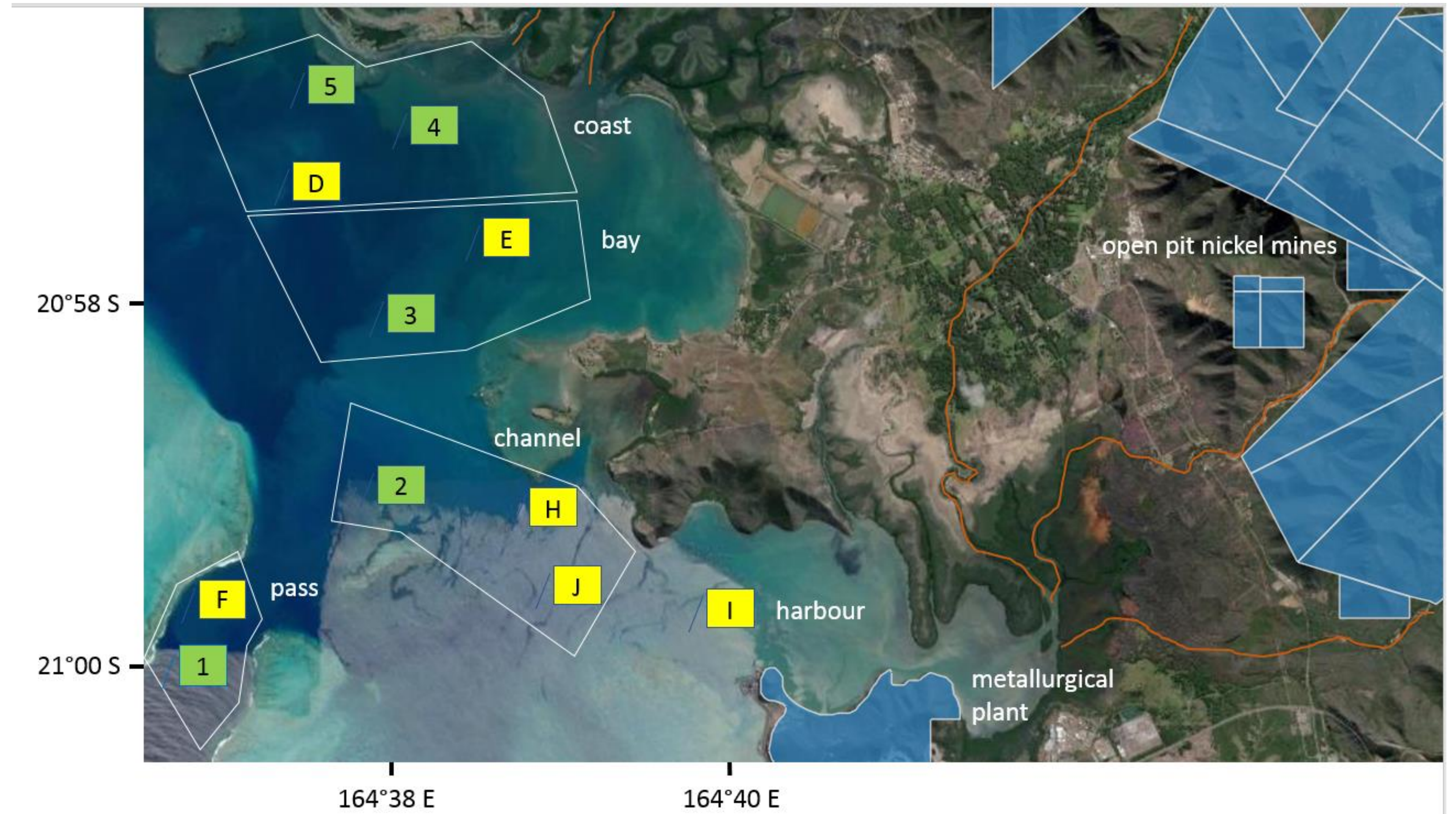

Fig 1 Koné lagoon and stations in 2008-2010 (green) and 2019 (yellow)

Salinity, temperature were recorded using CTD probes and nutrients and chlorophyll were collected with Niskin bottles at different depths (see Rodier et al., 2021). Metals data were obtained through DGT probes immerged for ~166 hours. Zooplankton was sampled with a 80µm mesh-size net and analyzed using a Zooscan (Gorsky et al., 2010) and ECOTAXA software (Picheral et al., 2017).

Results

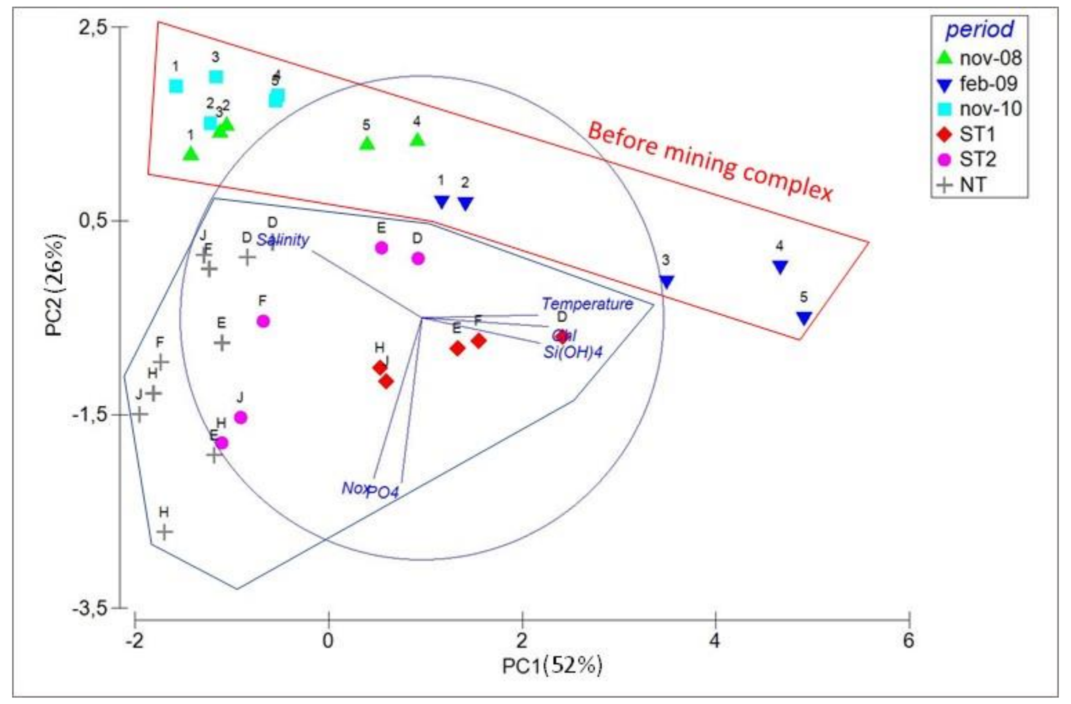

Fig 2. PCA on environmental variables (Primer 7 software)

-1st **PCA** axis (Fig. 2) shows clear variations between seasons in 2008 (dry vs rainy) and periods in 2018 (ST1 after the strong rainy event vs ST2 and NT). In both situations, terrigenous inputs (runoff, rivers) were associated with low salinity and high silicate and Chla.

-2nd axis opposed the conditions before and during the mining activity with higher N-P nutrients in 2018.

Table 1. Metal concentrations (ng L^{-1}) in 2018

	Al	Ni	Fe	Co	Mn	Ag	Cu	Zn	Pb
Harbour	4890	1470	12440	95	860	0.7	45	850	9
Channel	990	280	880	25	200	0.8	24	840	6
Pass	1160	260	1530	42	310	1.8	91	2230	51
Bay	2940	550	4490	55	560	1.06	50	1100	9

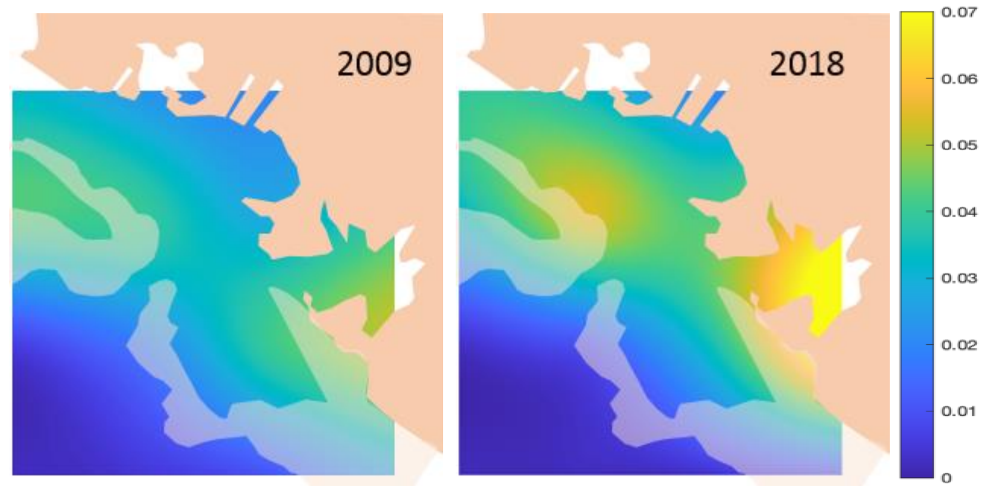

Fig 3. Turbidity from remote sensing

- **Turbidity** strongly increased between 2009 and 2018, near the plant and in the northern part of the lagoon except in the bay (Fig 3).

- **Metal** concentrations in 2018 were up to 6-fold higher in the harbor than elsewhere for Ni and up to 20-fold for Fe (Table 1). Highest concentrations of Ag, Cu, Zn and Pb were recorded in the pass.

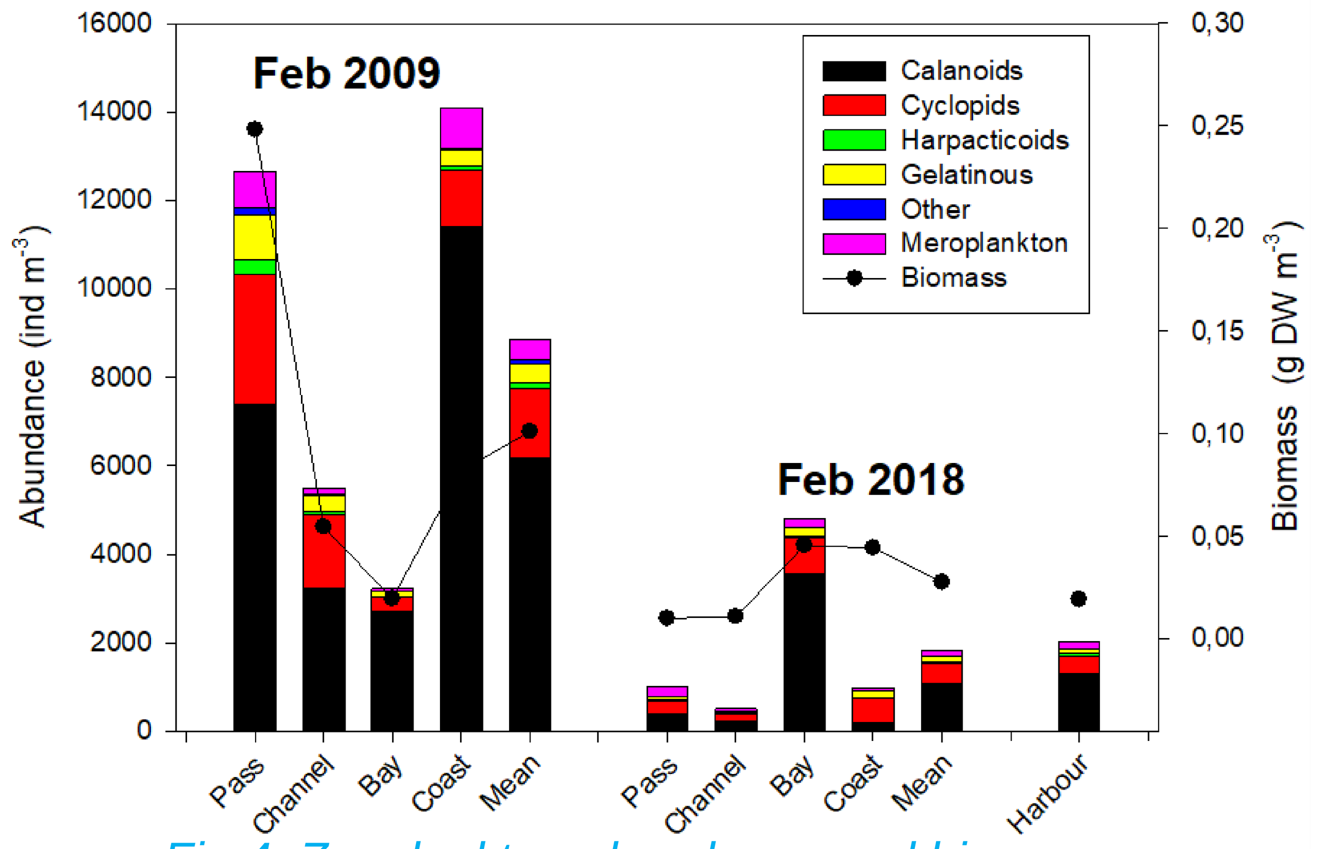

Fig 4. Zooplankton abundance and biomass. (Harbour not sampled in 2009).

- **Zooplankton** abundance and biomass declined strongly in 2018 compared to 2009 (x12 for abundance; x11 for biomass) except in the bay where a slight increase (ca. x2) was observed.
- Community was dominated by copepods followed by appendicularians, chaetognaths, crustacean and mollusk larvae.
- Taxonomic composition remained relatively stable, between periods except at the coast where calanoids were replaced by cyclopids.

In 2018, the zooplankton abundance and biomass were comparable in the harbor and in the lagoon, but with lower diversity in the harbor (12 taxa instead of 16; ostracods, *Microsetella*, *Penilia* and *Copilia* being not recorded)

Discussion and conclusion

Following the implementation of the nickel plant we observed strong decrease of zooplankton biomass and abundance with changes in taxonomic composition. This decrease is not associated to a decrease of phytoplankton biomass despite increase of N-P nutrients, but it corresponds to an increase of turbidity and presumably of trace metals such as Ni and Fe linked to mining activity. Nevertheless, the bay area appeared less impacted due probably to changes of the hydrodynamics (see presentation by Laval et al.).

We can hypothesize that:

- ✓ N-P increase is more anthropogenic (development of urban pressure related to industrialization) than natural (no parallel increase of silicates).
- ✓ The non-increase of phytoplankton biomass despite higher nutrient status, may be due to turbidity-driven light attenuation.
- ✓ The decrease of zooplankton cannot be related to the decrease of food resource (stable Chla) but is probably due to the degradation of food quality: (i) mixing of organic with mineral particles, as suggested by turdidity (Kang, 2012) or (ii) changes in phytoplankton composition (with less edible species) associated to change in nutrients and trace metal composition (Gulati & Demott, 1997).
- ✓ Toxicity linked to metals may also have impacted phyto- and/or zooplankton communities (Jean et al, 2010 ; Coclet et al, 2017 and references herein).

These hypotheses will be tested during a campaign in 2022

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