



Contents lists available at ScienceDirect

# Marine Pollution Bulletin

journal homepage: [www.elsevier.com/locate/marpolbul](http://www.elsevier.com/locate/marpolbul)

## Editorial

### Tropical lagoon multidisciplinary investigations: An overview of the PNEC New Caledonia pilot site

New Caledonia archipelago is located between latitudes 19 and 23° S and longitudes 163 and 168° E, just North of the Tropic of Capricorn, in the Southwest Pacific Ocean. It hosts one of the largest reef structures worldwide, which ecological value was recently acknowledged through its inscription as a UNESCO World Heritage site. The marine area of New Caledonia (EEZ and Territorial Waters) extends over 1,450,000 km<sup>2</sup>. The main island, Grande Terre, is a large island (ca. 400 × 50 km) surrounded by 1100 km of barrier reefs delimiting lagoons of approximately 22,000 km<sup>2</sup> (Andréfouët et al., 2009). Being close to the Philippines marine biodiversity hot spot, New Caledonia lagoons are known for their high level of biodiversity. The remoteness of the islands further favored the appearance of endemic species amounting to 5% of all marine species, this percentage being even higher within groups with low dispersal capacities like sponges, where up to 71% of the identified species are endemic (Lévi et al., 1998).

As in all island settings, cultural and economic ties with the sea are strong in New Caledonia and marine environments are receiving increasing attention from scientists who have been doing significant research in physical and biological oceanography for over 50 years (Fromaget and Richer de Forges, 1992; Payri and Richer de Forges, 2007). The first available data on New Caledonia coral reefs goes back to James Cook's 1774 expedition that drew the first cartography of the main island reefs and lagoons (Payri and Richer de Forges, 2007). More knowledge, particularly on marine organisms, was brought later by explorers and missionaries but it is only in 1946, when the Nouméa IFO (Institut Français d'Océanie) research centre was founded, that scientific investigations on geomorphology, geology and marine ecology really developed. The IFO Centre was subsequently renamed as the ORSTOM (Office de la Recherche Scientifique et Technique Outre-Mer) and now IRD (Institut de Recherche pour le Développement) Centre. Pioneering work on marine ecology started with René Catala (e.g. Catala, 1948), who later founded the Nouméa aquarium.

The first intensive scientific operation on New Caledonia reefs and lagoons took place in 1960–1963 with the Singer Polignac Foundation exploration (Taisne, 1965). Research on lagoon hydrology and water circulation, water mass properties and functioning started during the 70s (Dandonneau et al., 1981; Rougerie, 1986) and developed at the beginning of the 80's thanks to ship facilities (R/V Dawa, Vauban and Alis) and new scientific programs specifically dedicated to the lagoons: SNOM and its successor, SMIB (Substances Marines d'Intérêt Biologique) and LAGON.

From 1999 to 2007, PNEC (Programme National Environnement Côtier) initiated a New Caledonia pilot site based on a multidisciplinary approach including hydrodynamic and biogeochemical

process studies, the effects of metal contaminants on biology, and an assessment of human use of the lagoon.

This special issue presents four review articles covering most of the different aspects studied during the program. Ouillon et al. (this issue) review the state of knowledge on hydrodynamic processes. Fichez et al. (this issue) discuss the variability of lagoon water biogeochemistry and Le Borgne et al. (this issue) the temporal variability of hydrology and plankton, related to climate. Finally David et al. (this issue) address economic, ecological and political issues related to the complex status of New Caledonia. These articles are followed by 22 selected contributions grouped by thematic, including the general features of New Caledonia geography and climatology, lagoon environmental drivers, pelagic and benthic processes, and the potential effect of terrigenous and anthropogenic inputs. The special issue ends with a set of articles dealing with living resources and environmental management. This special issue therefore aims at providing a state-of-the-art of knowledge about New Caledonia lagoons and reef ecosystems and should provide a benchmark around which more detailed surveys and studies will be developed. It also lends itself to presenting the following list of lacks in knowledge or future research needs, although it is far from being exhaustive.

- (1) Some hydrodynamic processes have not being circumspectly studied but are supposed to be important locally or at the lagoon scale. For instance, wave breaking over the barrier reef, vertical turbulence, aggregation/flocculation of particles, the coupling of wind and wave currents inducing resuspension, and heat exchanges at the air-sea interface are processes that deserve further attention.
- (2) Concerning numerical modeling of the circulation, it appears that forcing with actual wind conditions needs to be included and water temperature, considered as a state variable. Temperature may indeed impact biogeochemical processes even in the low range of temperature variations as those encountered in the lagoon.
- (3) Effect of atmospheric inputs can have profound consequences on the specific dynamic of the lagoon surface micro-layer and water column.
- (4) At present, planktonic diazotrophy in the lagoons interferes to an unknown extent with nutrient cycling, pelagic productivity through nutrient and/or carbon limitation. Although the PNEC program allowed the first diazotrophy measurements, we need more observations, particularly on pico- and nanophytoplankton, which appear to be potentially important.

- (5) A single study showed that Ultra Violet radiations severely affects both primary production (mostly UV-A) and heterotrophic microbial production (mostly UV-B) during short (several h) incubations of the SW lagoon. Such short-term measurements of UV photoinhibition may be difficult to translate into long-term ecological effects due to photo-repair, photo-adaptation, increased pigmentation and/or rapid vertical mixing. Clearly more work is needed to assess the long-term effect of UV in the pelagic functioning of the relatively clear and shallow waters this low latitude ecosystem is characterized by.
- (6) The role of benthic–pelagic coupling has been roughly taken into consideration through the quantification of nutrient fluxes and mineralization at the sediment water interface. A comprehensive investigation of the mineralization processes in the sediments and the use of diagenetic models including benthic primary production and diazotrophy have to be considered as a next step. The concept of a “benthic microbial loop” could be applied to several biotopes where the nutrient budgets fail to be balanced.

This tropical archipelago is increasingly affected by serious anthropogenic and environmental changes with related ecological and social consequences and some significant actions have been taken to promote the sustainable development of the main island. During the course of the PNEC program, different areas of New Caledonia lagoons and reefs were inscribed on the UNESCO World Heritage List. On the specific topic of mining impact, the National Centre for Research and Technology (CNRT) on “Nickel and its environment” was officially created in 2009 as an original scientific structure partly funded by mining companies but altogether ensuring the development of independent and peer reviewed research work on mining activities. Beside some strategic plans developed towards Integrated Coastal Zone Management, the lagoon actors need to set up a large-scale observational system for the long-term survey of key indicators. Only continuous monitoring of environmental data will help to separate the effects of climatic and anthropogenic changes versus natural fluctuations. Moreover, combined to other initiatives in neighboring systems, a modern network of environmental data providers, exploiting the most recent observation techniques and technologies, could lead to the development of edge-cutting information products to end-users. A first initiative was taken in 2010 at a national scale by launching the GOPS (Great Observatory of terrestrial and marine biodiversity of the South Pacific), which coordinates the resources and scientific projects of thirteen French research institutes and universities in the region.

Finally this special issue is also considered as a way to acknowledge all the participants who contributed to the program and the different institutes for their financial supports. Without any specific ranking or priority we are indebted to Institut de Recherche pour le Développement (IRD), Centre National de la Recherche Scientifique (CNRS) through their Research Institutes: Institut National des Sciences de l'Univers (INSU) and Institut Ecologie et Environnement (INEE), and the different Universities that all contributed through the French Program on Coastal Environments (PNEC). On a more local but as important scale, we benefited from substantive supports from ZoNeCo (Zone économique de Nouvelle-Calédonie), a multidisciplinary program launched jointly by the Government of France, the Territory of New Caledonia and the three Provinces in association with the research institutes. This work took advantage of the proficiency of the crew and Captains of the RV Alis from IRD and of some smaller boats. Finally this special issue benefited from the expertise of more than 80 international reviewers who agreed with spending a long time on earlier versions of the manuscripts and contributed greatly, although anonymously, to the quality of this special issue.

## References

- Andréfouët, S., Cabioch, G., Flamand, B., Pelletier, B., 2009. A reappraisal of the diversity of geomorphological and genetic processes of New Caledonian coral reefs: a synthesis from optical remote sensing, coring and acoustic multibeam observations. *Coral Reefs* 28, 691–707.
- Catala, R., 1948. Contribution à l'étude des poissons de la Nouvelle-Calédonie. Observations sur *Coris angulata*, Lacépède. Doc. Multigraph. Institut Français d'Océanie, Nouméa (3p).
- Dandonneau, Y., Dugas, F., Fourmanoir, P., Magnier, Y., Rougerie, F., Debenay, J.-P., 1981. Le lagon de la Grande Terre. Présentation d'ensemble, sédimentologie et hydrologie du sud-ouest. In Atlas de la Nouvelle-Calédonie et dépendances, ORSTOM Paris.
- David, G., Léopold, M., Dumas, P.S., Ferraris, J., Herrenscheidt, J.B., Fontenelle, G., this issue. Integrated coastal zone management perspectives to ensure the sustainability of coral reefs in New Caledonia. *Marine Pollution Bulletin*.
- Fichez, R., Chifflet, S., Douillet, P., Gérard, P., Gutierrez, F., Jouon, A., Ouillon, S., Grenz C., this issue. Biogeochemical typology and temporal variability of lagoon waters in a coral reef ecosystem subject to terrigenous and anthropogenic inputs (New Caledonia). *Marine Pollution Bulletin*.
- Fromaget, M., Richer de Forges, B., 1992. Catalogue indexé du milieu marin de Nouvelle-Calédonie, 2ème éd. Cat.: Sci. Mer., ORSTOM, Nouméa, 274p.
- Le Borgne, R., Douillet, P., Fichez, R., Torretton J.-P., this issue. Hydrography and plankton temporal variabilities at different time scales in the southwest lagoon of New Caledonia: a review. *Marine Pollution Bulletin*.
- Lévi, C., Laboute, P., Bargibant, G., Menou, J.-L., 1998. Sponges of the New Caledonian Lagoon. Orstom, Paris. 214 p.
- Ouillon, S., Douillet, P., Lefebvre, J.P., Le Gendre, R., Jouon, A., Bonneton, P., Fernandez, J.M., Chevillon, C., Magand, O., Lefèvre, J., Le Hir, P., Laganier, R., Dumas, F., Marchesiello, P., Bel Madani, A., Andréfouët, S., Panché, J.Y., Fichez, R., this issue. Circulation and suspended sediment transport in a coral reef lagoon: the southwest lagoon of New Caledonia. *Marine Pollution Bulletin*.
- Payri, C., Richer de Forges, B., 2007. Compendium of marine species from New Caledonia. Documents Scientifiques et Techniques Centre IRD de Nouméa II 7 (391p).
- Rougerie, F., 1986. Le lagon sud-ouest de Nouvelle-Calédonie: spécificité hydrologique, dynamique et productivité. Etudes et thèses, ORSTOM, Paris (234p).
- Taisne, B., 1965. Organisation et Hydrographie. In: Expédition Française sur les récifs coralliens de la Nouvelle-Calédonie. Editions de la Fondation Singer-Polignac, Paris (pp. 5–131).

C. Grenz

IRD, Universidad Autonoma Metropolitana,  
Departamento de Hidrobiología,  
Av. San Rafael Atlixco 186, Col. Vicentina C.P. 09340,  
Iztapalapa, México DF,  
Mexico

Aix Marseille Université – CNRS UMR 6535 LOPB,  
Station Marine Endoume, rue de la batterie des lions 13007 Marseille,  
France  
Tel.: +33 0 4 91041641; fax: +33 0 4 91041643  
E-mail address: christian.grenz@univmed.fr

R. Le Borgne

Centre IRD de Nouméa,  
B.P. A5, 98848 Nouméa Cédex,  
New Caledonia

R. Fichez

IRD, Universidad Autonoma Metropolitana,  
Departamento de Hidrobiología, Av. San Rafael Atlixco 186,  
Col. Vicentina C.P. 09340,  
Iztapalapa, México DF,  
Mexico

Aix Marseille Université – CNRS UMR 6535 LOPB,  
Station Marine Endoume, rue de la batterie des lions 13007 Marseille,  
France

J.-P. Torretton

IRD – UMR 202 ECOLAG,  
Van Phuc Diplomatic Compound Appt. 202,  
Bldg. 2G-298, Kim Ma,  
Ba Dinh,  
Hanoi, Vietnam