TISSUE THICKNESS AS A TOOL TO MONITOR THE STRESS RESPONSE OF MASSIVE *PORITES* CORALS TO TURBIDITY IMPACT ON LIHIR ISLAND, PAPUA NEW GUINEA

Thesis submitted by

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Death is not an option.

ABSTRACT

In massive *Porites* colonies, living tissue invests only a thin layer on the outer perimeter of the skeleton, normally around 25-50% of an annual growth increment in healthy colonies. The depth to which skeleton is occupied by tissue is referred to as 'tissue thickness'. Tissue thickness has been argued to be a sensitive bioindicator that may be potentially used to monitor changes in coral health *prior* to collapse and mortality. The primary goal of this study was to assess the response of tissue thickness in massive *Porites* colonies at Lihir Island (3^{0}05′S 152^{0}38′E) to an anthropogenically increased turbidity regime associated with mining activities. In order to achieve this goal it was also necessary to identify possible sources of natural variability in tissue thickness, both spatial and temporal, and to quantify their influence. Possible sources of tissue thickness variability identified through both literature review and observation included: i) changes in thickness through the lunar month as a function of skeletal growth patterns; ii) change in thickness due to differences in local environmental conditions; iii) change in tissue thickness with differences in colony size and shape. Where possible, the influence of all of these factors was examined in both shallow (<11 m) and deep (>14 m) habitats, across sites around Lihir Island and between years (sampling took place in 2001, 2002, and 2003).

Tissue thickness in massive *Porites* changes over a lunar month as part of skeletal growth processes. This study looked for ways in which allowance could be made and procedures devised for sampling at different times of

the lunar month. Tissue thickness decreased, on average, by 20% on the day after the full moon. Tissue thickness increased, on average, by 0.3 μm per day during the lunar month. These patterns of variation were consistently observed between study sites, at different depths, and in different sampling years. The only exception appeared to be when tissue thickness became critically thin (below 2.2 mm), which was only found at a site heavily affected by turbidity. Hence, growth processes in massive *Porites* were reduced or halted when limited energy reserves were available under stressful conditions. Monthly tissue uplift in the same colonies was resumed when an increase in tissue thickness above the minimum threshold of 2.2 mm was achieved. The consistency of tissue variations throughout the lunar month in all but these very few extremely stressed individuals allowed measurements taken from individuals at different times of the lunar month to be easily adjusted for comparison.

In the second study, changes in tissue thickness in response to increased turbidity were examined by measuring tissue thickness in massive *Porites* colonies along an anthropogenic turbidity gradient in 2001, 2002 and 2003. Tissue thickness was significantly less where turbidity levels reached 15-30mg l^{-1}. This was the maximum turbidity encountered near coral reefs in this study. Tissue thickness was not significantly reduced by lower turbidity levels, but it was always less in colonies in deeper water than in colonies in shallow water. Some variability of tissue thickness was also observed between study sites and years. However, neither spatial nor temporal variability masked the general pattern of decreasing tissue thickness with increasing turbidity.

The final study examined differences in tissue thickness with colony size and shape and looked at environmentally-induced changes in tissue thickness in colonies with different morphologies. Massive *Porites* corals on Lihir Island were found to occur in six distinct growth forms, namely rounded, round-encrusting, pyramidical, pyramid-encrusting, encrusting and vertical encrusting. Some of these shapes could be described quantitatively by height/circumference ratios. However, the angle of substrata slope was found to be a better indicator for changes in shapes with study sites and water depth. Allowing for changes in tissue thickness with depth, colony morphology did not affect tissue thickness. Hence, colony morphology was not a significant factor in sampling for tissue thickness. Similar-sized colonies were selected for sampling. The effects of colony size on tissue thickness were tested and colony size could also be excluded as a factor which significantly affected tissue thickness.

Patterns of change in tissue thickness in *Porites* colonies at Lihir Island indicated that mining activities had affected, and were affecting, corals and coral communities over a much more restricted area than predicted by the mine's environmental impact statement. Tissue thickness patterns corresponded closely with indices of live coral cover and turbidity measurements. Tissue thickness was found to be a simple and reliable bioindicator for turbidity stress on corals on Lihir Island. Changes in tissue thickness indicate when corals are being adversely affected by anthropogenic activities. This gives tissue thickness a huge advantage over other monitoring techniques, because these mostly detect change after it has occurred - and not while it is occurring.

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Für meine Großeltern, die ich über alles liebe und immer vermissen werde.
Oma und Opa, ich hab's geschafft!