CHAPTER 5

CONCLUSIONS

Fish cage aquaculture in the Matang estuaries significantly increases the nutrient concentrations of surrounding water, particularly NH_3-N and to a lesser degree, PO_4^{3-}. Cage aquaculture raises the background nutrient levels of these estuaries to levels that are directly related to the scale of operation of the aquaculture activity. Thus, nutrient concentrations in Sg. Sangga Besar estuary (SSB, high-density fish cage culture) were generally higher than in Sg Jaha estuary (SJ, low-density fish cage culture) and Sg. Sangga Kecil estuary (SSK, no fish cage culture).

Nutrient leaching from uneaten trash fish feed, fish feces and excretion, and decomposition of nitrogenous and phosphate compounds are likely the main sources of nutrient enrichment from fish culture. The close proximity of fish farms impedes tidal flushing and water movement across the farm area. This reduction in water movement apparently traps nutrient plumes, particularly NH_3-N, around the cage farms.

The mean NO_3-N and NO_2-N concentrations at SSB were the highest, followed closely by SSK and SJ which recorded significantly lower concentrations.

Nutrient concentrations are significantly influenced by season (particularly wet) and tide (whether flood or ebb). In the wet season, the mean nutrient concentrations were significantly lower during the ebb tide than during the flood tide, attributable to the higher riverine discharge and estuarine volume, which have a dilution effect on the nutrient concentrations. In the dry season with no dilution effect, no significant difference in the nutrient concentrations was observed, irrespective of tides.

Concentrations of chlorophyll *a* inside cages were not always higher than outside cages. However, in both cage and non-cage sites, chlorophyll *a* concentrations fluctuated and followed a diel cycle in response to light; low during the morning, peaking during the late afternoon and waning during the night. The chlorophyll *a* peaks in cage and non-cage sites differed in magnitude, being higher inside cage sites. Overall, the chlorophyll *a* concentrations in the estuaries are not consistent with the levels of nutrient concentrations. It appears that a higher concentration of chlorophyll *a* is not a good indication of higher nutrient concentration, since turbidity and zooplankton grazing could reduce phytoplankton biomass.

Nutrient and chlorophyll *a* concentrations in cages given pellet and those given trash fish feeds were not significantly different. This does not support the hypothesis that ground trash fish feed is more polluting to the water environment than dry pellet feed.

The present study supports the hypothesis that fish cage culture increases nutrient concentrations in the water column. However, the idea that increased nutrients will cause eutrophication cannot be verified, given the estuarine complexity and dynamics. Under the present fish production level in the Matang estuaries, the cage culture activities have only a short-term, localized impact on the estuarine mangrove ecosystem. On the other hand, any clear impacts were obfuscated by the confounding effects of other discharges from upstream and the mangrove forest. As such, the shortcomings of this limited study are recognized. Instead of nutrient enrichment, aquaculture impacts in estuaries are probably better detected using other procedures, such as biochemical markers (e.g. fish oils) or changes in benthic faunal assemblages.