A dynamic model to assess mariculture-induced environmental impacts on seagrass beds along coasts of Bolinao and Anda, Philippines

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A dynamic model which reproduces the physical and biogeochemical environmental conditions and associated factors, can be an effective tool in determining coastal management strategies in an area influenced by intensive human activities. The outputs of the model suggest the need for proper assessment of the effectiveness of coastal management efforts which is made difficult by multiple environmental stressors such as pollutant discharge from rivers and from unregulated mariculture, the effects of which vary in space and time.

Seagrass beds are found in many coastal areas and their responses are regarded as key indicators of ecosystem health, are nursery grounds for fishes and invertebrates, and are major sources of primary production in coastal waters. However, their recent disappearance along many coastal areas in the world caused by anthropogenic stressors has become a serious global concern.

Our study site is located along the coastal towns of Bolinao and Anda in northwestern part of Luzon Island in the Philippines. Bolinao alone has at least 34 sq.km. seagrass area, an important resource for local communities as habitat of local fishes and invertebrates of economic value. However, the coastal waters of Bolinao and Anda are also a sites where mariculture has intensified. The area is known as one of the top producers of Chanos chanos (milkfish), an important food fish in the Philippines. The unregulated milkfish culture characterized by high feed input resulting in feed wastage, and proliferation of fish farm structures continue to degrade water quality in the area. Nutrient enrichment have resulted in excessive growth or blooms of phytoplankton and reduced light availability for the seagrass bed. Such environmental impacts due to excessive mariculture activities led to the decline and loss of seagrass species number and area at the site.

In order to assess the mariculture-induced environmental impacts on the seagrass bed ecosystem, a modeling system was developed to reproduce the spatial and temporal variation of water quality and associated light environment at the site, and evaluate the ecosystem responses to the environmental stressors. The modeling system is composed of a hydrodynamic-water quality model, a light attenuation model, and a seagrass bed dynamics model that computes seagrass growth using mass balance equation. This seagrass model was applied to *Thalassia hemprichii* (*Th*) and *Enhalus acoroides* (*Ea*), which are dominant seagrass species in the area. Results of the model indicate good agreement between observed and modeled values of seagrass biomass for *Th* and *Ea*, with coefficient of determination R^2=0.68 and 0.53, respectively.

To help implement proper mariculture regulation to conserve the seagrass ecosystem, the effectiveness of feed reduction was assessed by testing feed reduction scenarios for different combination of target areas. The results demonstrate that decreasing feed amount is an effective way to improve light conditions in the reef area. Results show that by reducing the feed amount in Bolinao alone, the biomass of both *Th* and *Ea* will increase (figure b, e), relative to the case of keeping present feed input amount (figure a, d), and there is recovery of seagrass in the mariculture site where seagrass has disappeared (figure e, area enclosed by

a circle). However, a remarkably greater increase in biomass and wider area of seagrass recoveries will happen if feed reduction is carried out by both Bolinao and Anda (figure c, f). These results clearly suggest the importance of mariculture management efforts through inter-municipality cooperation. The model can thus provide technical information that will be useful input to coastal management schemes for a sustainable coastal ecosystem.

Keywords: seagrass bed modeling, hydrodynamic-water quality model, eutrophication, mariculture, coastal management