IH276: The abundance, diversity and biomass of reef herbivores across environmental gradients, Indonesia

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Coral reefs are highly dynamic ecosystems, and natural disturbance events help to maintain a mosaic of successional stages which results in high habitat heterogeneity, thus driving high biodiversity levels. However, human activity is causing disturbance events to increase in their frequency and intensity and the reefs are being degraded. Many coral reefs fail to regenerate after negative impacts, whether they are natural or anthropogenic, and in some cases instead have undergone shifts to alternative stable states (Bellwood *et al.,* 2004). This results in a phase shift, which is when corals are no longer the dominant benthic organism and alternate organisms are able to dominate. There has been relatively little work to enable us to predict phase shifts, mainly due to the instability of reefs prior to their collapse (Bellwood *et al.,* 2004). Phase shifts to algal dominated reefs have been the most common shift, particularly in the Caribbean.

Functional groups have already provided a basis for considering the specific roles of coral reef fish within the system, and their relative importance in maintaining the resilience of the reef in avoiding ecological phase shifts (Hughes *et al.,* 2003). A functional group can be defined as a collection of species that perform a similar function, irrespective of their taxonomic resemblance (Steneck and Dethier 1994; Bellwood *et al.* 2004), and identified by their roles in ecosystem processes (Bellwood *et al.* 2004). One example of a functional group is the herbivores, which are essential for maintaining ecosystem health and avoiding phase shifts. Benthic algae exhibit much faster growth rates than the corals they compete with for space, and are generally less sensitive to environmental changes such as temperature and sedimentation. For these reasons algae have the potential to out-compete corals. However, consumption of the algae by herbivores limits their growth, thus maintaining a healthy competition between the two groups.

Reefs that lack sufficient herbivory have been known to suffer greatly as a result of an overgrowth of algae. Algae are common on the reef and represent an important group of benthic competitors for space. Nevertheless, the effect of algae on coral populations is under constant mediation by the grazing pressures posed by urchins and fish (Sammarco et al. 1974), and it is important to note that the overfishing of scarids (Parrotfish) and acanthurids (Surgeonfish) has been identified as a major reason for the replacement of coral populations with algae (Hay, 1984; Hughes *et al.,* 1987). Herbivorous reef fish species within the functional group of 'herbivores' may be considered functionally redundant if other species within that group exhibit the same feeding selectivity (Mantyka & Bellwood, 2007).

The functional roles undertaken by species to contribute to the architecture of an ecosystem is termed the functional redundancy. All roles in maintaining the vital equilibrium of a system must be fulfilled, whether it is by one or one thousand species (Fonseca and Ganade, 2001), meaning that multiple species may have the same role. The more species there are to fulfil a particular functional role, the higher the functional redundancy. The Indo Pacific has very high diversity, thus functional redundancy levels may also be high. Therefore if there were to be a loss or decline of a species, the effect would not necessarily impact the entire ecosystem as a whole (Figure 1). The more specific the behaviour to fulfil a role, the more important the community composition and functional redundancy becomes (Petchey and Gaston, 2002). If there are more ways in which a role can be fulfilled, then the species richness of that function can increase, decreasing functional redundancy.

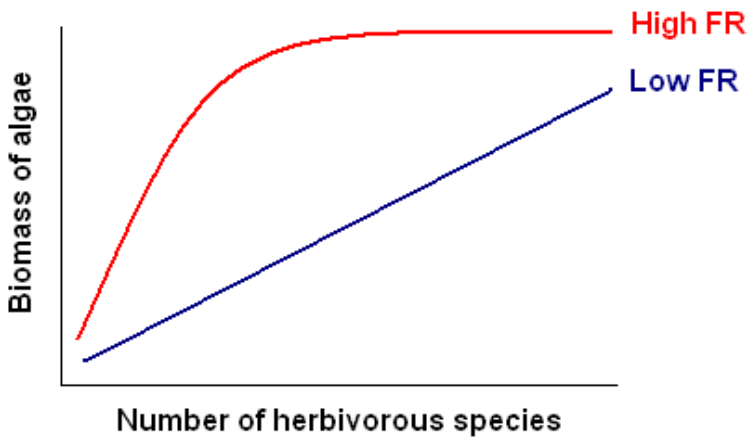

Figure 1: Theoretical schematic illustrating the concept of 'Functional Redundancy' (FR)

Herbivorous species each play their own role within the coral reef system. Through controlling the abundance of the food source, the equilibrium of benthic cover on the coral reef is maintained, ultimately preventing phase shifts to alternative stable states. However, how this roles changes across reefs of varying quality is needed to further our understanding and management of reef systems.

One project could identify the key grazers of coral reefs of the Wakatobi, and for these species determine their abundance and biomass, in order to increase understanding of feeding behaviour (e.g. rates) across sites of different habitat quality. Biomass can be very accurately estimated through the use of stereo videography, which takes footage along reef transects. This footage can then be analysed back on land to determine fish density, community structure, size distributions and, through known length:mass relationships, biomass.

Reading List

Bellwood, D.R., Hughes, T.P., Folke, C., and Nyström, M. (2004). Confronting the coral reef crisis. *Nature* **429:** 827-833

Fonseca, C.R., Ganade, G. (2001). Species functional redundancy, random extinctions and the stability of ecosystems. *Journal of Ecology* **89:** 118-125

Haapkylä, J., Seymour A.S., Trebilco, J., Smith, D. (2007). Coral disease prevalence and coral health in the Wakatobi Marine Park, south-east Sulawesi, Indonesia. *Journal of the Marine Biological Association of the United Kingdom* **87:** 403–414

Hay, M.E. (1984). Patterns of fish and urchins grazing on Caribbean coral reefs: are previous results typical? *Ecology* **65:** 446-454

Hughes, T.P. (1994). Catastrophes, phase shifts, and large-scale degradation of a Caribbean coral reef. *Science* **265(5178):** 1547-1551

Hughes, T.P., Reed, D.C., Boyle, M.J. (1987). Herbivory on coral reefs: community structure following mass mortalities of sea urchins. *Journal of Experimental Marine Biology and Ecology* **113:** 39-59

Hughes, T.P., Baird, A.H., Bellwood, D.R., Card, M. et al. (2003). Climate change, human impacts, and the resilience of coral reefs. *Science* **301:** 929-933

Hughes, T.P., Rodrigues, M.J., Bellwood, D.R., Ceccarelli, D., Hoegh-Guldberg, O., McCook, L., Moltschaniwskyj, N., Pratchett, M.S., Steneck, R.S., Willis, B. (2007). Phase shifts, herbivory, and the resilience of coral reefs to climate change. *Current Biology* **17:** 360-365

Mantyka, C.S., Bellwood, D.R. (2007). Macroalgal grazing selectivity among herbivorous coral reef fishes. *Marine Ecology Progress Series* **352:** 177-185

Pennings, S.C. (1996). Indirect interactions on coral reefs. *In:* Birkeland, C. (eds.) Life and Death of Coral Reefs. *Chapman and Hall, New York, USA pp. 249-272*

Petchey, O.L., Gaston, K.J. (2002). Functional diversity (FD), species richness and community composition. *Ecology Letters* **5:** 402-411

Randall, J.E. (1961). Overgrazing of algae by herbivorous marine fishes. *Ecology* **42:** 812

Rützler, K. (1970). Spatial competition among Porifera: solution by epizoism. *Oecologia* **5:** 85-95

Sammarco, P.W., Levinton, J.S., Ogden, J.C. (1974). Grazing and control of coral reef community structure by Diadema antillarum Phillipi (Echinodermata: Echinoidea): a preliminary study. *Journal of Marine Research* **32:** 47-53

Wellington, G.M., Trench, R.K. (1985). Persistence and coexistence of a nonsymbiotic coral in open reef environments. *Proceedings of the National Academy Science USA* **82:** 2432-2436