IN36 Role of mangroves in marine ecosystems

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Mangrove forests are unusual, extreme and highly productive coastal marine ecosystems. They are unusual because the mangrove halophytes (flowering plants) thrive in coastal fully marine habitats, in areas where all non-mangrove plants would die. They are extreme ecosystems, because the resident flora and fauna are exposed to daily environmental fluctuations of salinity, temperature and inundation. Mangrove forests draw down atmospheric CO_2 and fix the carbon in to above and below-ground woody biomass. Mangrove forests maintain a disproportionate contribution to the global carbon cycle, accounting for 10-14% of ocean carbon sequestration while occupying only 0.5% of the global coastal area. This equates to 24 million tons of carbon burial per year. Yet mangrove forests cover only 138,000 Km^2, of the vast 361,000,000 Km^2 marine biome. Mangrove forests then are extremely productive, and recent estimates show that these coastal forests may be twice as productive when compared to their tropical terrestrial counterparts. However, 1-2% of the total global mangrove forest area is lost each year to harvesting. This then must place mangrove forests as 'high priority' for conservation initiatives. Crucially, mangrove forests are essential for fishery biomass, and sea grass and coral reef health as they facilitate vital biodiversity mechanisms (nurseries function), because of their habitat complexity. Areas of high habitat complexity typically provide a greater niche availability, increasing the number of species and individuals – partly due to reduced predator-prey interactions.

Indonesia has the largest area of mangrove forests of any country, covering 45, 421 km^2; almost one quarter of the World's mangrove forests. Such forests are important along Indonesian coastal areas as they play a vital role in the ecological, economic and social development of coastal Indonesian communities. Indonesian mangrove forests also provide habitat for many transient animals between adjacent ecosystems such as seagrass beds and coral reefs. Many juvenile and vulnerable fish species enter the mangrove forests at hightide – seeking the refuge of mangrove roots. Those fish will then follow the ebbing tide to seek refuge with adjacent reefs. Mangrove forests also support biodiversity within adjacent coral reefs as they deliver organic nutrients derived from inorganic and organic carbon to reef organisms. Thus, the connectivity between mangrove ecosystems and coral reefs enhances the survival of the fauna from both habitats. Such connectivity has rarely been studied in Indonesia even though the Indo-Pacific bioregion is considered to be a biodiversity hotspot, containing the world's richest diversity of marine life.

Mangrove forests are a sink for carbon and supports food webs. The recycling of fallen wood in mangrove forests is much less well understood than that of leaf litter, even though the majority of mangrove biomass is wood. However, wood has been shown to have a similar carbon flux as leaf litter. To add, the diversity of animals within the mangrove forests are centred on the available hard substrata as the sediments are generally anoxic and therefore unsuitable for many organisms. Animals found are similar to those commonly found in tropical terrestrial forests and marine ecosystems such as the giant centipede, *Scolopendra*, hunting spiders (Lycosidae), moray eels *Gymnothorax richardsoni* and octopus. Such animals are dependent upon fallen logs within the mangrove environment which offer protection for particularly vulnerable animals including juveniles. Fallen wood serves as a predation refuge for many aquatic communities, therefore fallen wood is an ecologically important resource for increasing biodiversity within mangrove habitats and also facilitating carbon out-welling.

Many large mangrove forests within Indonesia grow on muddy fluvial sediments though there are forests associated with coarse, sandy sediments such as the mangrove forests located in Jakarta Bay and Berau Islands. In areas of this study, Sulawesi has a much smaller area of mangrove forests due to the mountainous and rocky topography and unsuitable substratum. However, there are islands within Sulawesi where mangrove forests thrive, such as the islands of Kaledupa. Much of the coastlines from these islands have calcareous mud or sandy sediments that cover areas of fissured raised fossil coral. The forests from these islands are small and some have a close proximity with large areas of seagrass beds and fringing reefs. Such connectivity has rarely been studied along the coasts of Indonesia.

This project aims to investigate the structure and function of these mangrove ecosystems. Students will also investigate differences of animal community structure, and animal behaviours found in areas of different mangrove substrata e.g. roots and fallen wood. Another key aim of this investigation is to determine whether the trees within each mangrove forest are a source of nutrients to food webs via fallen wood. This study also aims to determine if fallen wood from mangrove trees provides a refuge from predation for mangrove fauna.

Students collecting data for their dissertations wishing to conduct one of the mangrove projects in Indonesia, will be answering one of many questions needed to help towards a larger connectivity project in the Wakatobi Marine Park. The data collected will range from the mapping of mangrove tree structure and composition, and recording basal areas as a proxy for biomass. The consortia of biodegrading organisms of fallen wood will be identified, to help understand some of processes of the carbon cycle. Motile and sessile fauna will be quantified and compared within and between mangrove forests, and animal behaviour will be identified from fallen wood and root substrata. In addition, other projects will involve diving and snorkelling, collecting data ranging from dissolved organic matter deposition upon adjacent reefs, coral and sea grass health, percent cover of macro algae and sea grass area and density.

Impacts upon mangrove biodiversity and community structure: facilitated by wood harvesting

Rationale:

The majority of mangrove animals exploit the available hard substrata within these extreme environments. Areas such as mangrove prop roots and in particular large wood detritus (LWD) is favourable for most mangrove fauna. Mangrove harvesting – the felling of trees used for construction, fishing and cooking is very common within the Wakatobi. As a consequence, the removal of LWD may reduce ecosystem-level biodiversity and reduce habitat complexity – and many mangrove fauna may directly depend upon on LWD for their survival.

Brief experimental design:

In transects and plots, wood samples from items of fallen wood will be collected and the infauna diversity will be counted and identified, and the epifauna diversity upon the prop-roots will be counted and identified. The faunal community data base generated from these data can then be tested to determine the patterns of biodiversity, and if any vulnerable animals require LWD or roots for their survival. This research will demonstrate the ecological value towards mangrove biodiversity.

Mangrove deforestation: the effects of sedimentation

Rationale:

Close association between mangrove-sea grass-coral reefs is often a unique environmental feature. However, the Wakatobi Marine Park does have this special 'close connectivity', which lends itself to some very interesting ecological research.

The Langira mangrove forest, situated on Kaledupa is harvested for wood. Immediately adjacent to the mangrove are extensive sea grass beds that extend out 500 metres directly on to a pristine coral reef. Research has highlighted that impacted mangrove forests increase sedimentation rates upon coral reefs. The sea grass beds immediately adjacent the impacted Langira site may be the vital link towards the healthy reef site, acting as natural filters.

Brief experimental design:

Using belt transects, map and monitor the forest structure and frequency of harvested flora in Langira. Using a standardised volume, sample the sediments from within the root systems of mangrove trees of various levels of damage, and the sediments from the open channels. Dry the sediment samples, sieve the samples to obtain the dry weight of grain sizes. Repeat the methodology for the sea grass beds. Using a one meter quadrat, clear areas of sea grass, and repeat the sediment sampling and monitor over time. In addition, place sediment traps on to the pristine reef flat for further analysis.

The biodegradation of fallen wood in mangrove forests:

Rationale:

Research addressing the essential role of large woody detritus (LWD) within mangrove forests is limited. Plant-animal interactions are integral for mangrove carbon sequestration and the carbon cycle. Different guilds of biodegrading organisms e.g. bracket fungi, beetle larvae, termites and shipworms process wood at different tidal heights. Do each of the biodegrading guilds have a different role in the production of particulate (POM) and dissolved organic matter (DOM)? At what rates are fallen woody items processed at different tidal heights? What environmental factors facilitate the distribution of biodegrading guilds?

Brief experimental design:

In the Sombano, Langira, Laulua and Galua mangrove forests, using belt transects from the strandline and ending at the fringing edge, measure all LWD items, identify the biodegrading organisms and record environmental variables (tidal height, salinity, and distance from the strandline). From these data, you will be able to calculate the immersion time, mean salinity and distances from the strandline. From these data we will be able to determine what environmental factors determine the different biodegrading guilds from the high to low intertidal areas of the mangrove forests in the Wakatobi.

Reading List

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