Mapping the structure and function of Caribbean mangrove forests, and their role in coastal connectivity in the Yucatan Peninsula

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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 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.

The mangrove forests in the Yucatan Peninsula, Mexico have been under considerable anthropogenic impact: mangrove forests are cut down and the coastal land is used for building holiday resorts. The losses of key ecosystem-processes to local and adjacent ecosystems can be catastrophic and huge. This will reduce important habitat and biodiversity, reduce carbon sequestration, and nutrient export to adjacent sea grass and coral reef ecosystems. Thus, it is important to understand how and why the Caribbean mangrove forests benefit coastal habitats – in order to initiate conservation initiatives to preserve the mangroves across the Yucatan Peninsula.

Typically, mangrove forests are found accreting on coastal shorelines and bays, where wave energy is low. However, due to the geomorphology of the Yucatan, many mangrove forests grow from cenotes, sinkholes in limestone bedrock exposing groundwater. Mangrove-cenote research is novel. This project aims to investigate the structure and function of these mangrove ecosystems in Akumal, comparing various sites of interest along the coast, Casa Cenote, Xcacel, Yal Kul and Soliman Bay. Comparisons will be made between mangroves growing on accreting shorelines with those growing from cenotes. Students will also investigate differences of animal community structure, and animal behaviours – and then compare with coastal mangrove forests. The majority of mangrove animals exploit the available hard substrata within mangrove ecosystems. Areas such as mangrove prop roots and in particular large woody detritus are prime real-estate for most mangrove fauna. Such studies may highlight new and unreported information ranging from the forest structure and function, to animal behaviour. In addition, due to the geomorphology of the mangrove-cenote ecosystem, carbon sequestration and export may differ from mangrove forests accreting on coasts and bays. These differences may be due to unusual geo-hydrology processes.

Students collecting data for their dissertations wishing to conduct one of the many mangrove projects in Mexico, will be answering one of many questions needed to help towards a larger connectivity project across the Yucatan Peninsula. 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. In addition, other projects will involve diving and snorkelling, using estimates of coral and sea grass health by collecting percent cover of scleractinian (hard) corals, percent cover of macro algae, numbers of reef-health indicator species, sea grass area and density. These data will be used to compare impacted and pristine sites.

ME54: A comparison of pristine and degraded mangroves in Akumal and the impact of mangrove degradation on adjacent seagrasses and coral reefs

Rationale:

Mangrove forests are highly productive marine ecosystems that are essential for the health of adjacent ecosystems e.g. sea grass beds and coral reefs. Mangroves drawdown atmospheric CO_2, sequester and trap fine sediments, facilitate vital biodiversity mechanisms (nurseries) and improve fishery productivity. The mangrove forests in the Yucatan Peninsula have been under considerable anthropogenic impact from harvesting. This will reduce important habitat and biodiversity, impact carbon sequestration, and the productivity of adjacent sea grass and coral reef ecosystems. Thus, it is important to understand how and why the Caribbean mangrove forests benefit coastal habitats.

Brief experimental design:

Belt transects and permanent plots will be used to record tree composition, basal areas and tree densities. Biodiversity assessments will be conducted by investigation of the available mangrove substrata. These methods will be used in pristine and impacted sites, then compared. Adjacent sea grass and coral reefs will be assessed. Using transects, and quadrats, sea grass composition and density will be quantified. Hard coral cover, algae and water quality will also be investigated.

ME55: Understanding the non-conventional cenote-mangrove forest system

Rationale:

Mangrove forests associated with cenotes are not new, but research of them is. This novel project aims to investigate the driving forces behind the structure and function of these unusual mangrove ecosystems. We will investigate differences of animal community structure, and animal behaviours – and then compare with coastal mangrove forests. The majority of mangrove animals exploit the available hard substrata within mangrove ecosystems. Areas such as mangrove prop roots and in particular large wood detritus are favourable for most mangrove fauna. Such studies may highlight new and unreported information ranging from the forest structure and function to animal behaviour.

Brief experimental design:

Continuous belt transects, and plots will be used to establish the tree structure, composition and basal areas with the cenote mangrove forests. Biodiversity assessments of the fauna upon mangrove roots, substratum and LWD will be made, and animal observations will be employed. Degradation processes of LWD will be recorded in the forests and compared with those from conventional mangrove forests.

ME56: How do mangrove trees reduce thermal stress and provide environmental buffering for fish in Caribbean mangrove forest?

Rationale:

Mangrove forests have many functional traits, particularly the nursery function enhanced by the complexity of *Rhizophora* prop roots. Functional traits reflect the mechanisms that underpin species-habitat relationships and may provide insights into the responses of a community. A less understood functional trait is how mangrove trees may benefit biodiversity through environmental buffering. The Soliman Bay mangrove forest maintains extreme water temperatures in excess of 45˚C. Dense fish populations in the super-heated mangroves thrive in such stressful environments. This novel project aims to investigate how mangrove trees, *Rhizophora mangle* reduce environmental stress for the large populations of fish, *Gambusia affinis*. We will investigate diurnal patterns of fish distribution during the morning and afternoon, and also measure temperature, dissolved O_2 and determine the availability of food to the fish. Animals will avoid extreme environmental conditions in order to reduce metabolic stress, and mortalities. This study will demonstrate a new and little understood functional trait of environmental buffering provided by mangrove trees.

Brief experimental design:

Quadrats, and plots will be used to determine fish numbers in open channels and fish numbers in the shade of mangrove trees. Temperature and dissolved O_2 will be measured in the morning and in the afternoons. Plankton tows will be used to determine food availability for the fish in the mornings and afternoons. Using a seine net, fish will be caught and measured to determine the size range of the populations. Using designated 'stations' in the open channels temperature and fish numbers will be monitored from the morning to the afternoon.

Reading List

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