GLOMAR

Ph.D. Defence

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Title of the Thesis Colloquium:

Organic carbon transfer between coral reef micro- and macro-organisms under environmental change

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Organic carbon transfer between coral reef micro- and macro-organisms under environmental change

Efficient organic carbon (OC) and nutrient cycling between coral reef-associated micro- and macro- organisms is vital for coral reef functioning and supports the ecosystems' exceptional productivity. However, global and local anthropogenic stressors interfere with the transfer of OC within the reef ecosystem (i.e., through altered benthic-pelagic coupling) as well as within its keystone species, the coral holobiont (i.e., between coral host and algal endosymbiont). Excess OC inputs though wastewater and/or algal blooms can stimulate microbe-mediated hypoxia and disease, supporting coral mortality and resulting in shifts towards macroalgae or soft coral dominance on many degraded reefs. While soft corals are generally understudied, carbohydrates exuded by macroalgae may support reef degradation by stimulating bacterioplankton respiration, but the role of carbohydrates released by benthic primary producers in shaping coral reef community metabolism is still poorly understood.

This thesis aims to improve our knowledge on OC transfer between coral reef micro- and macro-organisms under environmental change by: i) assessing the effects of global and local stressors on the physiology of the increasingly widespread soft coral Xenia umbellata, ii) developing an indicator tool for the detection of OC eutrophication in reefs, and iii) investigating the carbohydrate compositions of hard coral- and macroalgae exudates and their effects on bacterioplankton communities. The experimental studies in this thesis include physiological, biogeochemical, and microbial parameters, and were carried out in aquarium facilities in Bremen and on Curaçao, Dutch Caribbean.

Findings revealed a high resistance of X. umbellata to warming, phosphate eutrophication, and acidification, while nitrate eutrophication reduced its resistance to warming. A newly developed microbial fuel cell (MFC) successfully detected OC pulses by electrically quantifying microbial degradation of OC in coral reef sediment. Compositional analyses of coral mucus carbohydrates and comparisons with previously reported data revealed a correlation with hard coral phylogeny. When comparing hard coral- with macroalgae exudates, differences in carbohydrate compositions and responses of bacterioplankton communities emerged. Coral exudates enriched opportunistic microbial taxa commonly considered as stress indicators, while macroalgae exudates were compositionally similar to ambient reef water and did not induce any shift in bacterioplankton communities.

In conclusion, the soft coral X. umbellata may replace less resistant hard corals on many reefs in the future, and may therefore sustain some ecosystem functions and services provided by reefs. However, coastal water quality management will become more important for hard- and soft corals with ongoing ocean warming. As such, the here presented MFCs could be used to detect OC eutrophication before benthic community shifts occur. Changes in hard coral assemblages may influence benthic-pelagic coupling in yet unexplored ways through their compositionally distinct mucus carbohydrates. Macroalgae exudates will likely reduce trophic transfer of OC compared to coral exudates due to their inefficient incorporation and/or resistance to microbial degradation. Results further suggest that not the origin of OC (i.e., coral- vs. macroalgae-derived) per se, but rather an alteration in OC composition relative to ambient reef water disrupts the stable bacterioplankton community and supports the increase of opportunistic microbes. Overall, results presented here can be used by coral reef managers to target conservation strategies at a soft coral species with high resistance to environmental change and monitor OC eutrophication in reefs with the here developed MFC biosensors. Finally, this thesis provides new insights for understanding how benthic macro-organisms shape microbial communities by altering the OC composition of reef water. As shifts in benthic primary producers are not exclusive to coral reefs, altered OC compositions may influence microbial communities in a wide range of coastal ecosystems under environmental change.