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Deterioration of tropical coastal ecosystems by multiple human impacts: the effects through seascape connectivity

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Coastal ecosystems in tropical regions consist of major seascapes such as coral reefs, seagrass beds and mangrove, which occur in mosaic patterns. Diversity and connectivity of these seascapes have great effects on ecosystem functions and services of coastal area. The present paper aims to review some important effects of seascape connectivity in tropical coastal areas, based on our recent studies conducted in Okinawa, Thailand and the Philippines. I also preview how climate changes and other types of human-induced threats affect coastal ecosystems via changes in connectivity among different components of seascapes, and finally consider effective conservation and adaptation strategies against degradation of coastal ecosystems.

Interrelationships among different seascape/landscape components have been most investigated on the aspects of material and nutrient flows among these habitats using biogeochemical techniques such as stable isotope analyses. For example, it has been pointed out that major carbon and nitrogen sources for organisms in seagrass beds and coral reefs often come from mangrove and/or upper basins. Furthermore, the broad-scale studies comparing several seagrass beds facing different areas of watershed revealed that biodiversity and ecosystem functions of seagrass beds are highly affected by the amount and patterns of terrestrial input from river basins.

Another important aspect of seascape connectivity has been highlighted by the studies investigating multiple habitat uses by animals in coastal areas, especially by large-sized animals such as fish, birds and mammals which are highly mobile. Fish census survey revealed that major reef fish species which are commercially important generally change their habitats ontogenetically from mangrove, seagrass beds to coral reefs. In addition, acoustic telemetry studies which continuously monitor behavior of large-sized fish showed that they migrate frequently between seagrass beds and coral reefs on a daily basis. Although these higher-level consumer contribute relatively low in terms of energy and material flows in coastal ecosystems, they sometimes changes abundance and diversity of seascape-forming organisms by strong top-down effects. Its quantitative evaluation, however, remain to be conducted in future studies.

Global climate changes and other local human-induced stresses negatively affect ecosystem functions derived by such seascape connectivity. The most serious, but less studies problems are the interacting effects of multiple stressors which operate in a synergistic way and cause nonlinear, unpredictable changes in coastal ecosystems. For example, shallow coastal seascapes such as mangrove and intertidal seagrass beds are heavily affected by the interacting effects of sea level rise and coastal development (constructions of dikes, ports, resort hotels, etc.). Similarly, sea use conversion from mangrove to shrimp ponds leads to loss of disaster prevention functions of coastal areas, which become more vulnerable to severe disturbance by typhoons intensified with climate changes.

To solve these problems on multiple, non-linear impacts of human-induced threats, it is primarily important to carry out conservation of coastal areas with healthy combination of seascape components. For example, to set a marine protected area (MPA), it becomes more effective to place one to include mangrove, seagrass beds and coral reefs in conjugation rather than separately. For the restoration of lost habitats, arrangement and interactions of different seascape components should also be taken into account. Poor restoration practices, such as planting mangroves in healthy seagrass beds, should be avoided through consultant with stakeholders and scientists.

Keywords: coastal ecosystem, seascape, ecosystem connecivity, biodiversity, climate change, human impact