Species diversity of tropical seagrasses affect fish assemblage structures, around Santiago Island, Bolinao, northwestern Philippines

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Coastal ecosystems in southeast Asia have been deteriorating rapidly due to various types of human-induced stresses. Among them, excess nutrient and organic matter derived from fish culture has particularly affected adjacent ecosystems through the alteration of water quality and sediment conditions. Seagrass species richness are reported to decrease at sites close to aquaculture facilities. The seagrass species composition and structure are known to affect fish assemblage structures. In this study, we tried to evaluate the relationship between species diversity of tropical seagrasses and fish assemblage structures, around Santiago Island, Bolinao, northwestern Philippines, where effects of fish culture are obvious.
Around Santiago Island, 13 sites in dense seagrass beds and 13 sites from sparse seagrass beds (total 26 sites) were selected, using a satellite image. Then actual conditions of seagrasses were checked by ground truth. At the 26 sites, species compositions of seagrasses and fish assemblages were observed in Feb - Mar 2014. Shoot density of *Enhalus acoroides* was counted at 20 locations at each sites using a 0.5 x 0.5 m frame, because this species has large shoots. For other species, a 0.5 x 0.5 m frame that was divided into 25 quadrats of 0.01 m^2 was used, and shoot densities in 10 haphazardly selected quadrats in each of five frames were counted at each sites. The biomass of seagrasses were calculated based on the shoot density of this study and leaf dry weight in Vermaat et al. (1995). The fish visual censuses (FVCs) were conducted on 5–8 March 2014 at 26 stations. Six 1 ×20-m (20 m^2) belt transects were established haphazardly using a scaled rope within a 50 m radius of each station. The transects were separated by at least 5 m. The number of individuals of the target species was counted in each transect, and their sizes (total length, TL) were recorded underwater using a ruler attached to a recording slate. All FVCs were conducted during the day between 08:00 and 16:00 h, using snorkeling at depths of 0.5–4.0 m.
The highest seagrass species richness at a site was seven species. The five sites where more than six species were observed belong to the dense seagrasses. Three sites among the dense seagrasses have only two species. Usually around two species were observed at the sparse seagrass beds. Two species *Thalassia hemprichii* and *Enhalus acoroides* were recorded, and the shoot density was relatively high at the site where the largest number of commercially important fish species were observed.

Keywords: eutrophication, fish culture, seagrass , Enhalus acoroides, fish assemblage, commercially important species

Assessing organic carbon storage in seagrass-meadow sediments using grain size fractionation and isotopic analyses

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Coastal sediments play an important role as the major sink of organic carbon (OC), storing both marine biota-derived OC (i.e., blue carbon) and terrestrial-derived OC. Part of OC stored in the sediments is sequestered from atmospheric CO_2 for geological timescales. The OC burial rate is much higher in coastal ecosystems than the open ocean. The burial of biochemically recalcitrant OC and the physical protection of OC by sedimentary minerals are the suggested mechanisms of long-term OC preservation. In general, OC content is correlated with the specific surface area of sedimentary minerals in the open ocean; however, relationships between the characteristics of OC and sedimentary minerals in coastal systems are poorly understood. In this study, we sieved collected sediments to generate several size classes (>1000 μm, 250–1000 μm, 125–250 μm, 63–125 μm, 30–63 μm, and <30 μm), and analyzed mineral characteristics (specific surface area) and OC characteristics (OC content, ^{13}C, ^{14}C). Sediment cores were collected in seagrass meadows in the Furen Lagoon, the Hichirippu Lagoon (Hokkaido), and the Shiraho reef (Ishigaki Island), Japan. Silt and clay contents (<63 μm) in the sediment samples ranged from 4% to 62%. The specific surface area of the fractioned samples ranged from 0.84 to 22.90 $m^2\ g^{-1}$. We will present the results of the physical and chemical analyses to investigate relationships between the characteristics of both OC and sedimentary minerals of seagrass-meadow sediments in our poster.

Keywords: carbon storage, blue carbon, sediment, seagrass meadows, isotopic analyses, specific surface area

Dynamics of terrestrial materials in coastal areas: evaluation using multiple stable isotope signatures of H_2O, DIC and POM

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Evaluation of terrestrial loading of anthropogenic materials in coastal marine environments has become essential given the serious degradation of coastal habitats such as seagrass beds and coral reefs from human activities. Inputs of terrestrial materials change coastal water quality directly and indirectly, and local multiple organic sources such as mariculture fish feeds, resuspended sediment, and seagrass and mangrove detritus, and hydrodynamic characteristics complicate those influences. In order to assess the effect of allochthonous inputs in coastal areas, isotope signatures of water, dissolved inorganic carbon (DIC), and particulate organic matter (POM) were examined to identify sources and loading processes. Where freshwater simply mixes with seawater, $\delta^{18}O$-H_2O, a conservative tracer of freshwater input in coastal areas, linearly decreases with the decrease of salinity, hence can be used to calculate the mixing ratio as a basis. $\delta^{13}C$-DIC also linearly decreases with salinity since $\delta^{13}C$-DIC of river water is lower than that of seawater. But $\delta^{13}C$-DIC is also affected by photosynthesis and respiration in seawater through isotopic fractionation especially of CO_2 absorption. Where POM is dominated by phytoplankton, $\delta^{13}C$-POC is affected by $\delta^{13}C$-DIC which the phytoplankton used for photosynthesis, so river water inputs decrease the $\delta^{13}C$-POC. Terrestrial POM usually has lower $\delta^{13}C$ than phytoplankton. In the study sites, Bolinao (mariculture area) and Banate Bay (area affected by siltation) in the Philippines, $\delta^{18}O$-H_2O positively correlated with salinity in the wet season over the pycnocline layer, indicating freshwater inputs, and a similar pattern was also observed in $\delta^{13}C$-DIC, suggesting that large terrestrial DIC inputs overwhelmed local biological processes as the determinant of $\delta^{13}C$-DIC. On the other hand, $\delta^{13}C$-DIC correlated with the apparent oxygen utilization (AOU) in the bottom layer of the mariculture area in the wet season and all layers in the dry season in Bolinao, suggesting accumulation of CO_2 with low $\delta^{13}C$in the bottom layer in both seasons. Such CO_2 could have been generated by respiration and decomposition of sediment organic matter and excess fish feeds. In shallow seagrass beds, $\delta^{13}C$-DIC was mainly controlled by primary production. In Banate Bay, the variation of $\delta^{13}C$-DIC was small, and correlations with salinity and with AOU were not clear in the dry season, which is attributed to limited biological activity. $\delta^{13}C$-POC reflected lower $\delta^{13}C$-DIC in the wet season, but varied even when POC/Chl ratio was low. We tried to unravel underlying multiple processes by using mixing model of terrestrial water and seawater and focusing on the difference between model and measured values.

Keywords: terrestrial input, stable isotope ratio, dissolved inorganic carbon, particulate organic matter, tropical coastal area

Nitrogen cycles in the barrier reef lagoon of Palau Island

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The coral reef ecosystems at Palau Island have attracted growing attention recently. However, there are still many uncertainties about the coral reef ecosystems there because the characteristics of nutrient dynamics and primary production are expected to be largely different between shallow fringing coral reefs distributed in the Southern Japan and barrier reefs with deeper lagoon at Palau Island. Especially, how physical parameters such as light intensity, current velocity and wave strength, which vary depending on the water depth, control the primary production and material transport in the lagoon area is not yet well known. In this study, we investigated nitrogen cycles in the lagoon system combining the observations and several process studies: 1) distribution of nutrients and dissolved organic nitrogen in the water column, 2) depth-dependent characteristics of the surface sediment such as particle size, organic matter contents and nutrient profiles in the porewater, 3) flux of sinking particles, and 4) primary production in the water column and surface sediment.
The results showed that, as light intensity and current velocity decreases with an increase in the water depth, the main contributor to the primary production per unit area shifted from benthic microalgae to planktonic algae, and the material fluxes from the sediment to the water column appeared to shift from organic matters to inorganic nutrients. This finding suggests that these shifts are important factors to determine the vertical and horizontal profiles of nutrients in the water column in the lagoon of Palau Island.

Keywords: Palau Island, Barrier reef, Nitrogen Cycle

Relationship of Massive Coral Distribution with wave height, soil particle quantity and water depth in Amitori Bay, Iriomote Island, Japan

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Amitori Bay is located in the northwest region of Iriomote Island, Japan with a few km length. The bay has no access roads, and the bay perimeter is uninhabited, thus, has various natural environments without human impact. In fact, broad areas of coral have developed in the bay, and their life forms, coverages, sizes, and species vary depending on their locations, thus, the bay is considered to be one of the most suitable areas for studying the relationship between coral distribution and physical variables.
We have investigated the relation between tabular and branching coral distribution and physical variables in Amitori Bay using coral distribution investigation, oceanic-atmospheric-riverine observations and numerical simulations using ocean and wave models [e.g., Shimokawa et al., 2014]. In this study, we focused massive coral which is one of representative coral life forms in Amitori Bay other than tabular and branching corals [Shimokawa et al., 2015]. Field observations were conducted to obtain data on coral distributions, sea temperature, sea salinity, wind speed, and river flow rate. Ocean and wave model numerical simulations and soil particle tracking analysis were conducted to obtain the spatial and temporal distributions of wave height and the numbers of soil particles with the observed data.
The conclusions were the following: (i) Massive coral coverage shows an inverse relation with water depth. (ii) Massive coral coverage shows an inverse relation with other coral coverage. (iii) Massive coral coverage shows a weak relation with wave height. (iv) Genus numbers and coverage of massive coral show an inverse and a direct relation with soil particle quantities, respectively. The relation in (iii) is attributable to the strong wave tolerance of massive corals because of their form and stiff skeleton, and to the slight difference of wave height between the east and west sides of the bay. The relation in (iv) results from the fact that coral genera except for Porites with strong ability of mucus removal are hard to survive on the east side with large quantities of soil particles, although various coral genera can inhabit in the west side with small quantities of soil particles.
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Keywords: Massive coral, Wave height, Soil particle, Water depth, Iriomote Island, Amitori Bay

Property of soil perticles related to reef-building coral distribution in Amitori and Sakiyama bays, Iriomote Island.

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Amitori and Sakiyama bays are located in the northwest in Iriomote Island, Okinawa, Japan. The both bays have various natural environment and no access roads, and their bay perimeters are uninhabited. Therefore, in the bays, abundant coral reef ecosystem remains in nature. Sakiyama bay has been designated as a natural environmental protection area in 1983, and the area was also expanded to Amitori Bay in 2015.
Various reef-building corals inhabit in the bays. The reef-building coral distributions are affected by various physical factors (Shimokawa et al. 2014). Soil particles from rivers is one of the physical factors and disturb photosynthesis of zooxanthella by getting sea water muddy. Also, soil particles accumulating on coral's body surface cause damages to their molluscous parts and their respiratory failures (Yamazato, 1991).
This study aims to clarify the property of soil particles in the bays and its relationship to the coral distribution. For the purpose, we analyze behavior of soil particles by numerical simulation using the method called particle tracking analysis in which the tracers regarded as soil particles are released in flow fields of the bays calculated by an ocean model (Murakami et al. 2013). However, their observational confirmation is weak only by using this method. Therefore, to obtain the observational confirmation, we conducted SPSS (content of Suspended Particles in Sea Sediment) analysis for the bays and investigate the relationship between the SPSS values and the numbers of soil particles calculated by particle tracking analysis. SPSS is a method to estimate the amount of soil particles originated from land in ocean floor material by visibility of a mixture of the floor material and clear water (Omija, 2003), is used as an index of soil quantities influencing on coral distribution.
Field observations for SPSS were conducted in July 2013, October 2014 and August 2015. The SPSS values were high from the inner part to the middle part of east coast in Amitori Bay. In Sakiyama Bay, they were high in the northeast of the inner part of the bay, whereas they were low around the reef edge facing the open ocean. Then, the SPSS values and the numbers of soil particles calculated by particle tracking analysis show proportional relations in all periods in Amitori Bay. In the presentation, we will show the details of those results and their relationship to coral distributions in the bays.
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Keywords: Reef-building coral, Amitori-Bay, Sakiyama-Bay, Soil particles, Particle tracking analysis, SPSS

