Dissolved carbon dynamics in rivers and coastal areas of the Philippines: evaluation of terrestrial inputs using dissolved inorganic carbon stable isotopic composition

*Naoko Morimoto[1], Atsushi Watanabe[2], Yu Umezawa[3], Maria Lourdes San Diego-McGlone[4], Charissa M. Ferrera[4], Toshihiro Miyajima[1]

1. Department of Chemical Oceanography, Atmosphere and Ocean Research Institute, The University of Tokyo, 2. Department of Transdisciplinary Science and Engineering, School of Environment and Society, Tokyo Institute of Technology, O-okayama 2-12-1 W8-13 Meguro, Tokyo 152-8552, Japan, 3. Faculty of Fisheries, Nagasaki University, 1-14 Bunkyo, Nagasaki 852-8521, Japan, 4. Marine Science Institute, University of the Philippines, Diliman, Quezon City 1101, Philippines

River load of anthropogenic materials is one of key sources for degradation of coastal habitats as with aquacultures. They change coastal water quality directly and indirectly, and local multiple organic sources such as mariculture fish feeds/feces, resuspended sediment and coral mucus complicate those influences. To assess the effect of allochthonous inputs, isotope signatures of dissolved inorganic carbon (DIC) and particulate organic matter (POM) were examined to identify sources and their loading processes. In Bolinao, where mariculture is densely deployed in semi-closed embayment, δ^{13}C-DIC and δ^{13}C-POC values of river water were almost similar between the wet and dry seasons, and were decreased as decreasing salinity. However, the relationship between δ^{13}C-DIC and δ^{13}C-POC was unclear. In the coastal area, large decrease of salinity was observed in the wet season. The negative correlation between salinity and each parameter suggests that river inputs mainly decreased δ^{13}C-DIC (−5.8‰ ~) and δ^{13}C-POC (−28.5‰ ~) in the wet season. In the dry season, mariculture, maybe fish feeds/feces, was mainly attributed to the decrease of δ^{13}C-DIC values especially in the surface layer through their decomposition. In contrast, in Iloilo, where some rivers input to the strait among islands, the character of river δ^{13}C-DIC and δ^{13}C-POC was similar as Bolinao. In coastal area, the decrease of δ^{13}C-DIC was not so serious in the wet season (−1.4‰ ~) compared to Bolinao, however low δ^{13}C-POC value was observed in the bottom layer (−27.7‰ ~). It may be ascribed to resuspension of settled materials which was originated from river inputs. We try to unravel their underlying multiple processes and discuss the relationship between river and coastal area in terms of dissolved carbon dynamics in those areas.

Keywords: terrestrial inputs, stable isotopic composition, dissolved inorganic carbon, particulate organic matter, tropical coastal area

Photosynthesis, calcification, and organic carbon and nitrogen fluxes from coral reef primary producers measured with in-situ chamber experiments

*Atsushi Watanabe[1], Takashi Nakamura[1], Yoshikatsu Nakano[2], Kazuo Nadaoka[1]

1. School of Environment and Society, Tokyo Institute of Technology, 2. Tropical Biosphere Research Center, University of the Ryukyus

Photosynthesis, calcification, and organic carbon and nitrogen fluxes were studied with an in-situ benthic chamber using major coral reef primary producers (two reef-building corals: *Acropora pulchra* and *Porites cylindrica*, seagrasses, macroalga (*Sargassum* sp.), and bare-sand communities) on Shiraho Reef, Ishigaki Island, the southwestern part of the Ryukyu Islands, Japan. The measurements were carried out for 24 hours (2hours x 12 times) for each benthic community in Jul.-Aug. (bare sand and two coral communities) and Oct. 2012 (seagrass and macroalgal communities). The calcification and photosynthetic rates were measured through analyses of carbonate chemistry parameters (total alkalinity and dissolved inorganic carbon) and combination of DO-pH sensors. Total organic carbon (TOC), TN, and nutrients (NH_4^+, NO_3^-, NO_2^-) were also measured to calculate organic C and N fluxes.
Daytime photosynthetic rates clearly followed the PAR in all the experiments even in bare sand. Dark respiration became largest right after sunset and gradually decreased during night, and this trend was related to water temperature. Daytime calcification followed the PAR in two coral experiments, and that in bare sand and macroalgal communities were slightly positive while that in seagrass community was negative indicating dissolution of carbonate sand in seagrass meadow even in daytime. In the dark, corals calcification decreased as pH decreased during night. The dark calcification was higher for *A. pulchra* compared to *P. cylindrica*. Bare sand showed dissolution when pH became lower than 8.1, and the seagrass community showed larger dissolution rates than bare sand community, suggesting organic matters derived from seagrasses decompose and enhance carbonate dissolution.
Regarding organic matter fluxes, *A. pulchra* released more TOC during daytime compared with nighttime. Seagrass and macroalgal communities released TOC regardless of day or night, and the fluxes were greater than those of corals. Organic N flux was also the higher for seagrass and macroalgal communities compared to corals. The results suggest that seagrass and macroalgal communities are important exporters of both organic C and N to the neighboring communities.

Keywords: Coral reef, Primary producers, Productivity, Calcification, Benthic chamber

The high turbidity reduced mortality of coral bleaching in Kabira Bay, Ishigaki Island

*Kotaro Yashiro[1], Koichi Kinjo[2], Yoshiyuki Nakamura[3]

1. Department of Urban Innovation, Yokohama National Univ. / Tokyo Kyuei Co., Ltd., 2. Okinawa Prefectural Institute of Health and Environment, 3. Institute of Urban Innovation, Yokohama National Univ.

Kabira Bay have 1.5 km in length and 0.5-1.0 km wide, it is located in the northwestern part of Ishigaki Island, Okinawa. The bay mouth is almost closed by several islets, and the bay is connected to the open sea by narrow channels. The inside of the bay is calm and bottom sediment of bay inner part is much silt. Recently, transparency decrease and coral decline are indicated by local inhabitants.
We investigated the present conditions of coral community in Kabira Bay from 2012 to 2013. In the late 1970s, branch-formed and bottle wash brush-formed Acroporidae were dominant species of the east side of the bay (Horikoshi 1979), those most corals died and became coral gravels. However, those corals survived only 2-6 m depth of the bay inner part.
We considered a factor of coral death by several data sets (water temperature, aerial photograph, coral monitoring data of adjacent area, local information) and concluded that it would probably depend on coral bleaching in 2007. Then corals did not die by some kind of factor in the bay inner part.
Water temperature of the bay inner part exceeded 30˚C in July, and decreased approximately 2˚C by torrential rains, and returned to the high temperature a few days later. If there was not the torrential rain, the remarkable water temperature decline was uncommon. We observed water temperature consecutively from 27 August to 30 September in 2013 (largest amount of rainfall was 15mm/day). In 5 m depth, the bay central part and the inner part did not have difference, at 28.7±0.7˚C (mean ±SD) and 28.7±0.8˚C each. Consequently, it is thought that frequent torrential rains were the only requirement for water temperature decline in the bay inner part. During coral bleaching of 2007, the torrential rain was observed only 1 time (60 mm/day), and the possibility that a remarkable water temperature decline got up continuously in the bay inner part is very low. Therefore, coral survival was caused by a factor except the reduction of the high water temperature.
Goreau et al. (2000) reported lower bleaching mortality in very turbid waters in large-scale coral bleaching of 1998. Protection from solar radiation can often occur through scattering by suspended-sediment (SS).
We observed turbidity consecutively from 27 August to 30 September in 2013. Turbidity of bay inner part was the highest in all observed layer. About the solar radiation of 5 m depth, bay inner part was lower than central part, and the value was 2.7% of surface and 6.5%, so reducing the solar radiation by the high turbidity was seen. In addition, the turbidity of the bay inner part had tendency to increase at low tide in the daytime. It is thought that this phenomenon was resuspension of sediment caused by the wind and waves or was transportation as SS such as the red soil which deposited on tidal flats. As the low tide in the daytime is the strongest condition of solar radiation, the effect of the reducing is higher.
On the other hand, turbidity induce the inhibition like a bleaching of Acroporidae when SS reach 10-20 mg/l (Erftemeijer et al. 2012), and mean SS value of the bay inner part was 2.3 mg/l. Consequently, the turbidity condition of the bay inner part was in the range where solar radiation reducing did occur and inhibition did not occur.
Inflows such as the red soils in the bay inner part increased recently, as a result, it is thought that coral mortality was decline. Corals may be protected from bleaching if the turbidity condition was controlled as suitable for corals by the adjustment of inflows such as the red soils.

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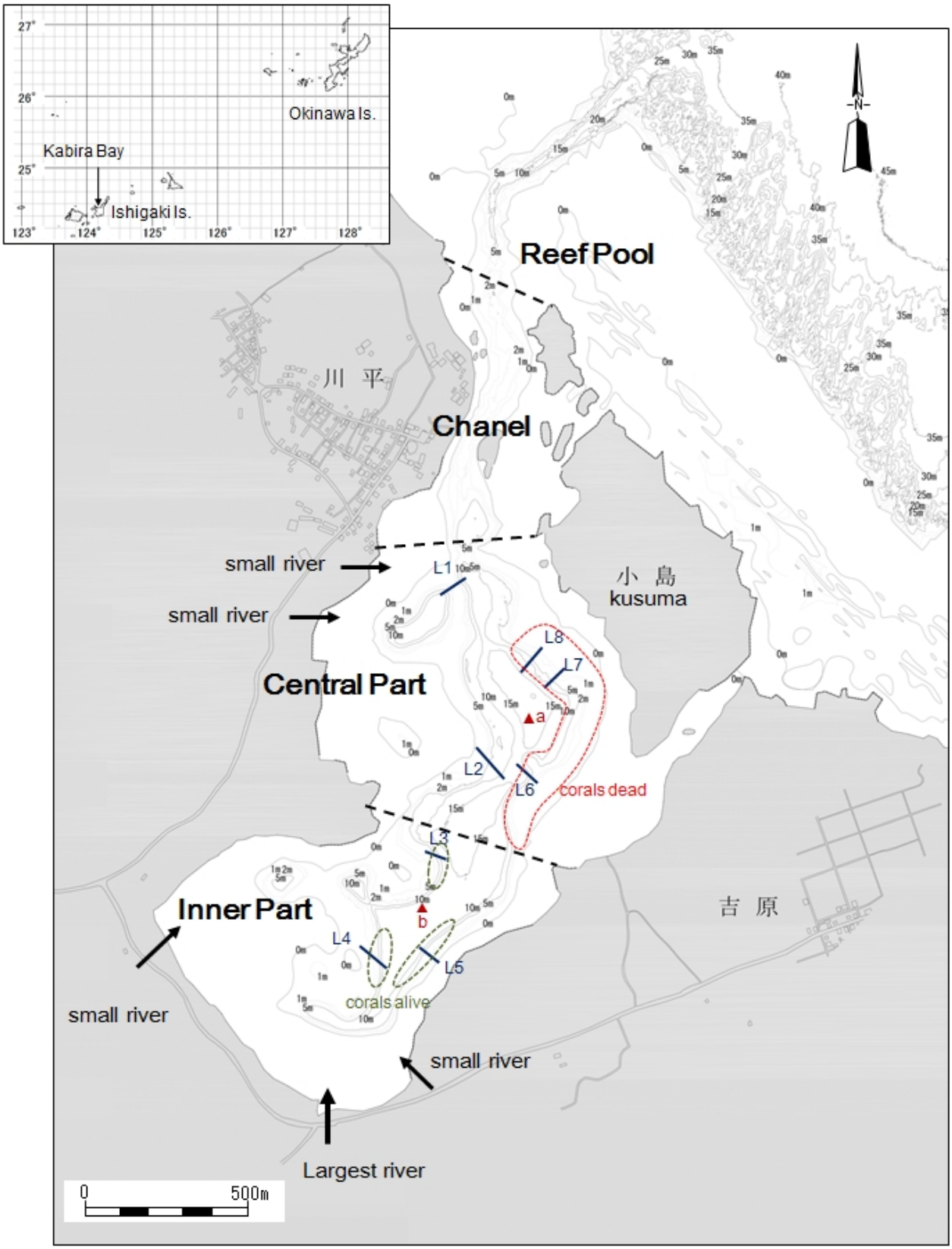
Keywords: Kabira Bay, Acroporidae, Coral bleaching, Turbidity



Verification of Seagrass Beds recovery in the inner part of Otsuchi Bay, Iwate prefecture, where the distribution decreased due to the tsunami associated with the 2011 off the Pacific coast of Tohoku Earthquake

*Yoshiyuki TANAKA[1], Hideki FUKUDA[2], Toshihiro Miyajima[3]

1. Center for Liberal Arts and Sciences, Hachinohe Institute of Technology, 2. Coastal Conservation Section, International Coastal Research Center, Atmosphere and Ocean Research Institute, The University of Tokyo, 3. Marine Biogeochemistry Group, Division of Ocean-Earth System Science, Atmosphere and Ocean Research Institute, The University of Tokyo

The Sanriku coast of Japan was struck by a massive tsunami associated with the 2011 off the Pacific coast of Tohoku Earthquake on 11 March 2011. The tsunami caused large disturbances in ecosystems along the coasts. Especially, seagrass beds located in inner part of Otsuchi Bay, Iwate prefecture, was seriously damaged.
We have been investigating seagrass beds coverage using CCD camera and have been analyzing temporal changes. We also have been analyzing water qualities such as nutrients and suspended solids.
Two *Zostera* species, *Zostara marina* and *Z. caulescens* were observed at the study sites. After the tsunami attack, seagrass beds coverage was hardly recovering for 5 years. However, recently trend of recovery was detected. We will present the possible cause of this delayed recovery of seagrass bed coverage.

Keywords: recovery, Zostera marina

Quantitative DNA assays for detecting Zostera marina DNA in coastal Sediments

*Masakazu Hori[1], Masami Hamaguchi[1], Hiromori Shimabukuro[1], Goro Yoshida[1], Toshihiro Miyajima[2]

1. National Research Institute of Fisheries and Environment of Inland Sea, Fisheries Research and Education Agency, 2. Division of Ocean-Earth System Science, Atmosphere and Ocean Research Institute, The University of Tokyo,

The sequestration of organic carbon (OC) in seagrass meadows has been attracting more attention as global actions to climate change mitigation and adaptation increase. A direct method to detect *Zostera marina* DNA in coastal sediments, which is essential to unravel long-term *Z. marina*-derived OC accumulation, was developed as an environmental DNA (eDNA) detection techniques. Quantitative real-time PCR (qPCR) and droplet digital PCR (ddPCR) were applied to quantify ancient *Z. marina* DNA in coastal sediments, using specifically-designed dual-labeled probes (DLPs) and primers for one nuclear and one chloroplast gene. Suitable pretreatments and methods for extracting *Z. marina* DNA from coastal sediments were examined and their applicability to environmental samples was determined. Surface sediments collected from *Z. marina* meadows contained about 2000 times more DNA than the adjacent unvegetated tidal-flats in the Seto Inland Sea. Moreover, both qPCR and ddPCR successfully detected *Z. marina* DNA in ancient sediments (up to 5000 calibrated years before present (yr cal BP)), evidencing that *Z. marina* DNA can be sequestrated in temperate coastal sediments for several millennia. In addition, qPCR and ddPCR results obtained in the present study were highly correlated, although the later was more accurate than qPCR, particularly at low eDNA concentrations and in PCR inhibitor-rich samples. Thus, the present study sets the basis for clarifying the process of *Z. marina*-derived OC sequestration and demonstrates that seagrass meadows have been present in the Seto Inland Sea for at least 5000 years.

Keywords: Blue carbon, Seagrass, eDNA

Application of deuterium tracer techniques to food-web analysis of seagrass meadows

*Toshihiro Miyajima[1], Masakazu Hori[2], Masaaki Sato[2], Akiko Hamaoka[2], Hideki Hamaoka[2]

1. Division of Ocean-Earth System Science, Atmosphere and Ocean Research Institute, The University of Tokyo, 2. National Research Institute of Fisheries and Environment of Inland Sea, Fisheries Research and Education Agency

Coastal benthic ecosystems are fueled by multiple basal resources of both autochthonous and allochthonous origins. For seagrass beds, major basal resources include live and dead seagrasses, attached microalgae, microphytobenthos, suspended and sinking organic matter derived from plankton, and terrestrial and mangrove-derived organic matters depending on location. The turnover rate and the conversion efficiency through trophic transfer are vastly different between different basal resources. Stability and resilience of an ecosystem have been considered to depend on the range and diversity of such dynamic properties associated with respective basal resources. However, conventional tools for trophic analysis, such as stable isotope mapping and gut content inspection, are not necessarily useful for evaluating time scales of trophic transfer. In this study, for evaluating trophic transfer and turnover rates in experimental mesocosms, a deuterium (^{2}H)-based pulse-and-chase experiment combined with carbon (C) and nitrogen (N) stable isotope mapping was developed and applied to the macrobenthic community of seagrass meadows. At first, primary producers such as seagrasses and epiphytic microalgae were labeled with ^{2}H through a short-term incubation in ^2H_2O-enriched seawater under natural light conditions. Then, the labeled primary producers were washed and transferred to a mesocosm with running or static natural seawater and incubated further with macrobenthic consumers such as crustaceans, molluscs, echinoderms, annelids, and juvenile fish for 2 –10 days. After incubation, primary producers and consumers were collected, freeze-dried, and analyzed for hydrogen, C, and N isotopic ratios. Trophic transfer rate was evaluated by comparing the ^{2}H enrichment between the primary producers and the consumers. Because ^{2}H enrichment did not disturb natural abundance of C and N isotopes, the trophic position of each consumer could be assessed by conventional C-N isotope ratio mapping. A preliminary experiment was also performed in which primary producers were labeled with multiple tracers of ^{2}H, ^{13}C, and ^{15}N, to compare uptake and translocation processes within the seagrass and trophic transfer to consumers between these elements. In this presentation, we introduce backgrounds, methodology, and some technical precautions of this method with some examples of application to the epibenthic food web in subtropical seagrass meadows (*Thalassia hemprichii* and *Syringodium isoetifolium*) and experimental acidification mesocosms of a temperate seagrass *Zostera marina* and associated macrobenthos.

Keywords: Food web analysis, Pulse-chase experiment, Stable isotope mapping, Coastal benthic ecosystem, Ecosystem functioning, mesocosms

