Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

BBG21-01 Room:213 Time:May 1 09:00-09:15

Ocean Acidification and its effect on calcification since the late 19th century revealed by d11B of Ogasawara coral

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Boron isotopes ($d^{11}B$) of coral skeleton are known as a pH meter in the seawater. As pH of seawater is closely related to partial pressure of CO_2 (pCO_2) in the atmosphere, it is expected that $d^{11}B$ becomes pCO_2 indicator in the geological past too. However, $d^{11}B$-pH is under scrutinized since coral calcification itself probably affects the relationship. Although many studies have focused on $d^{11}B$ measurements for cultured corals under pH-controlled aquarium, those for living corals outdoors have rarely measured, which are limited to, for example, Great Barrier Reef and Guam. Here we show 125 years-records (AD1873-1998) of $d^{11}B$ and boron concentration (B/Ca ratio) for long-lived massive coral (Porites sp.) that was sampled at Chichi-jima, Ogasawara Islands, North West Pacific. They clearly reveal Ocean Acidification after the industrial revolution. We will discuss a relationship between ocean acidification and coral calcification from a slope of pH decline that is obtained from observational data. We will also discuss how B/Ca of calcium carbonate skeleton that is produced by marine calcifiers is reliable proxy for seawater pH, which is being paid a great attention mainly due to relative easiness to measure compared to isotopes.

Keywords: boron, Ogasawara, coral, calcification, Ocean Acidification

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BBG21-02 Room:213 Time:May 1 09:15-09:30

Ocean acidification influences on coral growth of temperate species

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Carbon dioxide concentration in the atmosphere has steadily increased since the industrial revolution due to burning of fossil fuel and will cause the global warming and ocean acidification. It will raise the ocean temperature around Japan and reduce the seawater pH and then it may bring serious threat to corals dwelling around Honsyu Island, Japan. Last year, our research group did temperature-controlled culture experiments of temperate coral species from the Pacific side of Honsyu Island of Japan under the present level of the partial pressure of CO_2 (pCO_2). But, synergetic effect of the global warming and ocean acidification on these corals has not been tested yet in detail. In this study, we focus on the how the different pCO_2 levels (past, present, and future) can influence skeletal growth of temperate *Acropora* coral species under the different temperature setting using a precise control system. This system was used to generate six different pCO_2 levels: (i) pre-industrial, ˜300 μatm, (ii) present-day pCO_2, ˜400 μatm, and at four near-future conditions, (iii) ˜550 μatm, (iv) ˜750 μatm, (v) ˜1000 μatm and (vi) ˜1200 μatm at three temperature conditions (17, 25, and 27 deg C). Our early results suggested a negative influence of higher pCO_2 levels on skeletal growth of temperate *Acropora* corals, but not so sensitive compared to tropical and subtropical *Acropora* corals.

Keywords: Ocean acidification, temperate coral, calcification, global warming

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BBG21-03 Room:213 Time:May 1 09:30-09:45

Projecting impacts of rising water temperature on the distribution of seaweeds around Japan

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Using monthly mean sea surface temperature (SST) from 1950 to 2035 obtained by a high-resolution climate projection model (MIROC4h) and SST-based indices of the distribution of tropical-subtropical and temperate seaweeds (*Sargassum duplicatum* and *Ecklonia cava*, respectively), we evaluated the effects of SST rises on the potential distribution of the species in seas close to Japan. Estimated distributions from the 1950s to 2000s showed that the potential southern limit of the temperate seaweed shifted to higher latitudes due to rising water temperature-induced barren ground, while there was little change in the potential northern limit of them. In contrast, the tropical-subtropical seaweed *S. duplicatum* expanded their distribution polewards during the same period. Under the global warming scenario (RCP4.5), the potential distribution of *S. duplicatum* can replace the one of *E. cava* in coastal area of Kochi Prefecture by the 2010s. This replacement of the temperate seaweed species with the tropical-subtropical one could consequently change coastal productivity and food web structure, and therefore may affect ecosystem services around Japan.

Keywords: seaweed bed, global warming, climate model, Ecklonia cava, Sargassum duplicatum

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BBG21-04 Room:213 Time:May 1 09:45-10:00

Standing genetic variation of coral populations under changing environments

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How genetic diversities affect ecosystem functions is one of key questions to understand the maintenance of genetic diversities and their roles in ecosystem. To evaluate the functional genetic diversities of corals which are main composers of coral reefs, I genotyped 20 colonies (collected in front of Sesoko Station) of *Acropora digitifera* which is one of dominant coral species around the Ryukyu Archipelago where is the northern peripheral area of coral reefs, and performed common garden experiment using five clonal fragments from each colony (to reduce accidental response in each genotype) to estimate variations of growth and photosynthetic efficiencies among colonies, namely, genotypes. Genotyping was performed with microsatellite markers for coral host and ITS2 direct sequencing for symbiotic algae, indicating that all host colonies were genetically distinct and belonging to major populations around the Ryukyu Archipelago and mainly maintaining clade C symbionts which are dominant around this region. In common garden experiment, all colonies showed different growth patterns whilst the photosynthetic efficiencies showed similar optimal peaks among colonies. The experimental approach above suggests that there are standing genetic variations in host itself of *A. digitifera*, which might guarantee the adaptive potential of coral population for future global warming in northern peripheral reef area. These genetic variations might also contribute to the change of material cycles in future coral reefs.

Japan Geoscience Union Meeting 2014
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BBG21-05 Room:213 Time:May 1 10:00-10:15

Carbon flows in estuarine and shallow waters: blue carbon study

KUWAE, Tomohiro[1*] ; TOKORO, Tatsuki[1] ; WATANABE, Kenta[1] ; MIYOSHI, Eiichi[1] ; MOKI, Hirotada[1] ; TADA, Kazufumi[2]

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Blue Carbon, which is carbon captured by marine living organisms, has recently been highlighted as a new option for climate change mitigation initiatives. In particular, coastal ecosystems have been recognized as significant carbon stocks because of their high burial rates and long-term sequestration of carbon. However, unlike sequestration in terrestrial ecosystems, coastal carbon burial does not lead directly to an uptake of atmospheric CO_2. This is because the water column separates the atmosphere from benthic systems, and buried sedimentary carbon is composed of allochthonous sources in addition to autochthonous sources. Our research project is aiming to in situ measurements of carbon flows, including air-sea CO_2 fluxes, dissolved inorganic carbon changes, net ecosystem production, and carbon burial rates in estuarine and shallow waters.

Keywords: climate change, carbon sequestration, carbon storage, blue carbon, seagrass meadows, estuarine waters

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BBG21-P01 Room:Poster Time:May 1 18:15-19:30

Field investigation and the path analysis of air-sea CO2 flux in shallow waters of Ishigaki Island

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The Blue Carbon, which is carbon captured by marine living organism, is recently focused as an important option for climate change mitigation initiatives. The Blue Carbon is equivalent to approximately 55% of carbon fixed by photosynthesis activity of the earth. In particular, vegetated shallow waters have been recognized as significant carbon stocks due to the high burial rates and long term sequestration. However, the contribution of Blue Carbon sequestration to atmospheric CO_2 in subtropical shallow waters is unclear, because the investigation and analysis technologies are unmatured.

In this study, using an approach combining field investigations and path analysis, we examined the mechanisms by which environmental factors directly and indirectly affecting air-sea CO_2 flux. Field investigations were performed to examine air-sea CO_2 flux and environmental factors (e.g., wind speed, water temperature, salinity, total alkalinity (TA), dissolved inorganic carbon (DIC)) in shallow waters (Fukido, Shiraho, Nagura, and Kabira) of Ishigaki Island, July 2013. In addition, we implemented the path analysis to infer important environmental factors and interactions affecting the air-sea CO_2 flux.

Keywords: blue carbon, coastal vegetation, air-sea CO2 flux, path analysis

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BBG21-P02 Room:Poster Time:May 1 18:15-19:30

Spatial distribution and its characteristics of stable nitrogen isotopic composition of macroalgae in Nagura Bay

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This study, focusing on Nagura Bay in the west of the Ishigaki Island, conducted a field sampling and measurement of δ^{15}N values of macroalgae, *Padina* spp. and sea grass, *Thalassia hemprichii* in order to evaluate effects of land-derived nitrogen load on the coral reef ecosystem, and to discuss the reasons for the nitrogen load distribution in the bay.

In June 2013, 55 samples for each species were collected at about 50 m intervals on 7 transect lines, and their δ^{15}N and δ^{13}C values were measured in the laboratory. At the same time, water samples at stream, spring and sea were collected and their water qualities were measured. Moreover, areas for each land use in related watershed were calculated using GIS to examine the relationship between the nitrate concentration in river water samples and land use, and to identify the source of land-derived nitrogen.

As a result, most of the δ^{15}N values of macroalgae and sea grass linearly decreased from +6 to +2 ‰ with increasing distance from the shoreline. However, the transect lines around the river mouth of Nagura River relatively showed high δ^{15}N values by about 1 km away from the shoreline comparing with the other transect lines. One of the reasons is probably water flow condition around the river mouth. Some previous studies had showed that the water flow stagnates around there due to the south monsoon wind in spring and summer. Before this field sampling, the mode of wind direction for 3 months was surely south wind. This is why the land-derived nitrogen loads through Nagura River remained around river mouth due to water stagnation and lower dilution in seawater, and the plants could have higher δ^{15}N values.

On the other hand, NO_3-N concentrations have high correlations with ratios of farm land and cultivated areas. Thus, they were perhaps the main nitrogen sources in this study area. Additionally, NO_3-N flux [mg/s], which calculated by flow rate [m3/s] and NO_3-N concentration [mg/l], estimated 81.9 mg/s at the river mouth of Nagura River, and 59.4 mg/s at the upstream. Mangrove swamps and tidal flat exist between the two locations. Thus, the nitrogen source increasing the flux 22.5 mg/s could come from the swamps or their upstream.

Keywords: Padina spp., Thalassia hemprichii, Stable nitrogen isotopic composition, land-derived nitrogen, Nagura Bay, mangrove swamps and tidal flat

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BBG21-P03 Room:Poster Time:May 1 18:15-19:30

Propagation of suspended matter from aquacultures as traced by stable C and N isotope ratios of bivalves

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Recently there is growing concern about the impact of densely-deployed aquacultures on coastal marine ecosystems in the Philippines. As suspension-feeding bivalves are expected to reflect local food sources, their effectiveness as an environmental indicator were examined by analyzing stable carbon and nitrogen isotope ratios of bivalves living in aquaculture and neighboring seagrass areas. As a whole, the δ^{13}C and δ^{15}N of bivalves collected in the seagrass areas ranged from -13.1 to -11.0 and from +4.0 to +6.6, respectively, but in seagrass area where water mass from aquaculture area passed through typically lower values (-18.9 ˜-16.1 and +2.7 ˜+5.2, respectively) were observed, and they were the lowest in the aquaculture area (-24.4 ˜-19.8 and +3.4 ˜+4.3, respectively). It suggests that bivalves mainly fed on sinking particles, and presumably also seagrass-derived particles in seagrass areas. Higher C/N ratio was observed at sites where impact of aquaculture was larger. Although the interspecies differences and food selectivity etc. may affect the variability of the bivalve δ^{13}C and δ^{15}N to some extent, these results demonstrated that stable isotope ratios of bivalves could be used as an effective indicator to evaluate propagation areas and actual effects of suspended matter resulting from anthropogenic source on ecosystems.

Keywords: suspension-feeding bivalve, seagrass, aquaculture, stable carbon and nitrogen isotope ratios

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BBG21-P04 Room:Poster Time:May 1 18:15-19:30

Organic carbon preservation in tropical seagrass-bed sediments: importance of sorptive vs. non-sorptive mechanisms

MIYAJIMA, Toshihiro[1*] ; HORI, Masakazu[2] ; SHIMABUKURO, Hiromori[2] ; ADACHI, Hiroshi[3] ; HAMAGUCHI, Masami[2] ; NAKAOKA, Masahiro[4] ; NADAOKA, Kazuo[5]

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Large benthic primary producers such as seagrasses and seaweeds often exhibit extremely high CO_2-fixing ability and are expected to have a potential to mitigate the deteriorative influence of ocean acidification on local communities. In particular, the seagrass community has also a capacity of accumulating and sequestering organic carbon (OC) in the sediment underlying it, which implies that it functions as a self-complete, long-term CO_2 sink in the biogeochemical carbon cycle. This feature has been recognized as one of the major ecosystem services of the coastal marine ecosystem. In this study, we investigated the distribution, the physical state, and the potential origins of OC stored in the sediments from tropical, subtropical, and temperate seagrass communities.

The concentration of OC per salt-corrected dry weight of sediment normally ranged between 500 and 1300 μmol C g^{-1} in both temperate and subtropical seagrass beds, although extremely high values up to 4000 μmol C g^{-1} have been found in some tropical seagrass sediments that were affected by OC inputs from adjacent mangrove forest. The carbon isotopic composition (δ^{13}C) of OC varied broadly from -28 ‰ to -12 ‰ (vs. VPDB), although the majority of seagrass bed sediments exhibited -20 $\pm$ 3 ‰. The variability in δ^{13}C could be interpreted by varying contribution of multiple OC sources to the sediment, including seagrasses (c. -10 ‰), sinking particles derived from phytoplankton (c. -22 ‰), and allochthonous OC including terrestrial plant and mangrove detritus (c. -28 ‰).

The specific surface area (SSA) of sediment grains ranged between 1 - 20 m^2 g^{-1} for seagrass bed sediments. In the case of temperate seagrass sediments, the concentration of OC was closely correlated to SSA (r = 0.9405), with the average OC/SSA ratio being 0.72 mg C m^{-2}. This trend, as well as the OC/SSA ratio, is consistent with the well-known sorptive preservation model of sediment OC originally proposed for shelf sediments (OC/SSA = 0.6 - 0.9 mg C m^{-2}; Keil et al. 1994, Mayer 1994). In contrast, no clear relationship between OC and SSA was detected for subtropical and tropical seagrass sediments. The OC/SSA ratio was generally higher for subtropical (up to 4.2) and tropical (up to 8.5) samples than temperate ones. Two clearly different trends of the δ^{13}C of OC vs. the OC/SSA ratio could be distinguished for tropical and subtropical samples. In one trend, the δ^{13}C converged to between -28 ‰ and -26 ‰ with increasing OC/SSA ratio. This trend was typically observed in mangrove-affected tropical seagrass beds and therefore could be ascribed to accumulation of mangrove-derived OC particles within seagrass sediments. The other trend, in which the δ^{13}C gradually increased up to -12 ‰ with increasing OC/SSA, was found mainly in subtropical seagrass beds. This trend indicates an accumulation of OC particles of relatively high δ^{13}C, putatively derived from the underground parts of seagrasses.

Overall, the above results demonstrated that the seagrass community actually has a large capacity to accumulate and store organic carbon of both autochthonous and allochthonous origins. However, the physical state of OC stored in the sediment seemed contrasting between temperate and tropical/subtropical seagrass communities. In the former, OC seemed to be stabilized by adsorption onto mineral particles as suggested by the consistent OC/SSA ratio. In the latter, accumulation of refractory detrital OC particles apparently played the major role in the OC storage in the sediment. The source of refractory OC particles could have been autochthonous (e.g. seagrass roots) or allochthonous (e.g. mangrove debris) depending on the environment. We are now investigating what causes such a difference in the accumulation state of OC depending on climatic and/or biological factors.

Keywords: carbon cycle, organic matter, coastal ocean, seagrass beds, sediment, specific surface area

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BBG21-P05 Room:Poster Time:May 1 18:15-19:30

Inorganic carbon cycle at the Fukido estuary in Ishigaki Island

TOKORO, Tatsuki[1*] ; WATANABE, Kenta[1] ; MIYOSHI, Eiichi[1] ; MOKI, Hirotada[1] ; TADA, Kazufumi[2] ; HOSOKAWA, Shinya[1] ; KUWAE, Tomohiro[1]

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″ Blue Carbon ″ , which is carbon captured by marine living organisms and about 55 % of biological captured carbon in the world, is an important carbon budget in the global carbon cycle. The Blue Carbon in coastal regions is recently focused as an effective option for the climate change initiatives because the part of the Blue Carbon is separated from the atmosphere for long periods as the sediment in the soil. The potential of the carbon sequestration in tropical-subtropical coastal regions is expected to be high due to the abundant vegetations such as seagrass meadows and mangroves. Meanwhile, there is the potential that the coastal regions release CO_2 to the atmosphere due to the high decomposition rate of organic matters in vegetations and from land.

The precise measurement of the carbon cycle including the air-sea CO_2 flux is necessary for the evaluation of tropical-subtropical coastal regions related to atmospheric CO_2. Because the temporal variation in tropical-subtropical regions is generally larger than that in other climate regions, the measurement should have a certain level of continuity for long periods. In this study, we analyzed the subtropical inorganic carbon flow base on the measurement of air-sea CO_2 flux by the eddy covariance method and the biomass of seagrass at an estuary in Ishigaki Island.

The measured air-sea CO_2 flux by the eddy covariance method (-1.00 $\pm$ 0.11 μmol/m^2/s; 95 % confidential limit) indicates that the estuary was atmospheric CO_2 sink during the measurement period; the value is almost the same as the flux measured by other method such as the bulk formula method or the floating chamber method. In addition, the measured flux shows different tendency before and after a typhoon approach at the site. Because the seagrass was autotrophic during the measurement period, the linkage between the Blue Carbon production and the absorption of atmospheric CO_2 was confirmed at the measurement site. The presentation will discuss about the potential of the Blue Carbon fixation at subtropical coastal regions based on the comparison of the carbon flow measurement in other climate zone.

Keywords: Carbon cycle, Blue Carbon, Air-sea CO2 flux, Seagrass, Eddy covariance method

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Skeletal records in sclerosponges from Miyako-jima, Ryukyu Islands

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Sclerosponges, living in dark environments of tropical to subtropical shallow oceans, precipitate calcium carbonate skeleton with growth bands. They grow slowly at an approximate rate of $<$1 mm/year unlike corals (about 1 cm/year) but can be so long-lived for several decades to hundred years like corals (e.g., Benavides and Druffel, 1986). Skeletal oxygen isotopic ratios (δ^{18}O) reflect variations in sea surface temperature and seawater δ^{18}O with the latter being closely related to salinity reflecting the precipitation-evaporation balance at the sea surface and changes in water mass transport (e.g., Wu and Grottoli, 2009). In contrast to zooxanthellate corals, which commonly show positive correlations between skeletal δ^{18}O and carbon isotopic ratios (δ^{13}C), there do not exist vital effects in the secretion of sclerosponge skeleton (Druffel and Benavides, 1986). Previous studies showed significant decrease trends in the δ^{13}C records toward the present, which is probably a result of $^{12}CO_2$ added into the atmosphere/ocean from fossil fuel burning (e.g., Bohm et al. 1996). Therefore, sclerosponges are shown to provide annually resolved time series of proxy records of ocean environments since the Industrial Revolution. However, longer ($>$100 year) proxy records from sclerosponges were derived only from the Atlantic Ocean.

Here we present δ^{18}O and δ^{13}C records from high-Mg calcite skeleton of two sclerosponges (*Acanthochaetetes wellsi*) collected at a water depth of about 10 m from Miyako-jima, Ryukyu Islands in the North Pacific. The samples were slabbed to a thickness of 5 mm parallel to the skeletal growth and subsamples for stable isotope measurements were taken every 1 mm. External precision of replicate measurements of interlaboratory calcite material throughout the stable isotope analysis using a continuous flow isotope ratio mass spectrometer system (Delta V Advantage and Gasbench II: Thermofisher Scientific Inc.) of Ryukyu University was $\pm$0.05 per mil for δ^{18}O and δ^{13}C. Soft X-ray images showed highly developed skeletal growth bands with $>$100 high/low density layers. The secular changes in δ^{13}C of the two sclerosponges were quite similar to previously reported δ^{13}C records from Atlantic and Pacific corals and sclerosponges. The long-term δ^{18}O trends of the two samples are characterized by slight depletions throughout their living periods, indicative of an overall trend toward warmer ocean environment around Miyako-jima. Our sclerosponge-based estimates of sea surface temperature and salinity may document thermal and hydrologic variations in the Ryukyu Islands, furthering a good understanding of northwestern tropical-subtropical Pacific climate change for the last several centuries in conjunction with coral-based long proxy records.

Keywords: sclerosponge, skeleton, oxygen isotope composition, carbon isotope composition, paleoenvironment, Ryukyu Islands

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Paleoenvironmental analysis using Tridacnidae shells from archaeological sites in Okinawa-jima, subtropical southwestern

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Symbiont-bearing Tridacnidae giant clams living in shallow waters of the Indo-Pacific tropical and subtropical regions can be a used as an archive for documenting high-resolution record of thermal and hydrologic variations in coral reef environments for the past. Their shells, composed of dense aragonitic increments, are less sensitive to diagenetic alteration than porous skeleton of corals. They have annually and daily banded shells structure, providing chronological controls (e.g., Bonham 1965). The oxygen isotope composition (δ^{18}O) of shells, which are precipitated isotopically equilibrium with seawater, can reflect the temperature and seawater δ^{18}O (e.g., Aharon & Chappell 1986). Several studies on paleoenvironmental reconstructions around the Ryukyu Islands were performed using geochemistry in fossil corals from Okinawa-jima (Mitsuguchi et al. 1998), Yonaguni-jima (Suzuki et al. 2001), Kikai-jima (Morimoto et al. 2007), and Kume-jima (Seki et al. 2012). However, only a δ^{18}O record has been published from 6.2 ka giant clams from Kume-jima (Watanabe et al. 2004).

Here we present seasonally resolved δ^{18}O time series of fossil Tridacnidae shells recovered from two archaeological sites (the Kogachibaru Shell Mound and the Second Aragusuku-Shichabaru Ruin) in Okinawa-jima, southwestern Japan to reconstruct subtropical coral reef environments of the past. The samples, mainly composed of aragonite shells with limited amounts of calcite cements, were selected for geochemical analyses. The radiocarbon dating results indicated that they lived during the early and middle Shell Mound periods in Okinawa-jima, corresponding to the middle-to-late Holocene, which is in good agreement with ages inferred from excavation (Okinawa Prefectural Board of Education 1987; Okinawa Prefectural Archaeological Center 2006). The shell δ^{18}O values roughly showed seasonal variations, coincident with the occurrence of annual growth bands. The averages of annual, summer, and winter δ^{18}O values of fossil shells were significantly lower than aragonite theoretically precipitated in present-day coral reef water of Okinawa-jima. These results demonstrate that the seawater temperature was higher and/or salinity was lower at the sites than today. It is likely that the giant clams lived in relatively small and/or closed coral-reef lagoons with less water circulation where seawater is highly susceptible to insolation-induced temperature increase and input of fresh water; the effect could be enhanced by the fisheries lifestyle that stonewalling would be constructed at shallow waters through the use of tidal variation during the Shell Mound period in Okinawa-jima.

Although it is extremely difficult to find well-preserved fossil Tridacnidae shells from carbonate sediments that are not fragmented, archaeological ruins and shell mounds can yield many fossils. Results of our study suggest that the use of fossil shells from archaeological sites can enable the reconstruction of temporal and spatial variations in coral reef environments and of the history of lifestyles and culture during prehistoric and protohistoric ages.

Keywords: coral reef, Tridacnidae, shells, fossil, oxygen isotopic composition, archaeological site

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BBG21-P08 Room:Poster Time:May 1 18:15-19:30

Evaluation of natural break water of coral reefs affected by typhoons in the near future

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Tropical cyclones are one of the most extreme natural catastrophic events over the world and devastate coastal areas affected by floods and coastal erosions. Ryukyu Islands in the northwest Pacific is especially prone to many typhoons every year (Emanuel et al. 2008 Bull Amer Meteor Soc). However, the region is moderately protected from storm surge and wave during typhoons because coral reefs play a role in natural break water. For the last several decades, coral cover and species diversity on coral reef have shown dramatic declines in the region, influenced by global and local stresses (e.g., Hongo and Yamano 2013 PLoS ONE). According to the numerical modeling of global warming at the end of 21 st century, moreover, the mean intensity of tropical cyclones will probably increase significantly in the near future (Meehl et al. 2007 IPCC 4th Report). It is thus of some interest to understand the impact of tropical cyclones on the coastal areas in the region and the evaluation of coral reefs as natural break water.

To calculate a hydraulic force on a natural break water, we measured 9 transects using the echo sounder system (HFD-1000; Hongo et al. 2013 The Quat Res) on from the coast to the reef crest at Ishigaki Island in Ryukyu Islands during November 2013. To evaluate a contribution to reef formation by corals, moreover, we observed species abundance (cover) of tabular corals at the island. We shows that a change of role in natural break water of coral reefs in the island from present to end of 21 st century. Furthermore, we suggest necessary information of corals (e.g., cover and species) for maintenance of natural break water in the near future. The information are like to be one of basic criterion for determination of species in terms of direct transplantation of juvenile or adult corals, if the coral reefs will decline in the near future.

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Keywords: typhoon, coral reef, Ishigaki Island, Ryukyu Islands, natural break water