

## 琉球列島におけるマングローブの構造と生産力から推察される緯度の効果

The effects of latitude on mangroves inferred from forest structure and productivity in the Ryukyu archipelago

\*諏訪 錬平<sup>1</sup>

\*Rempei Suwa<sup>1</sup>

1. 国立研究開発法人 森林総合研究所

1. Forestry and Forest Products Research Institute

Mangrove is one of the unique ecosystems in subtropical and tropical coastal regions. Mangroves provide various ecosystem services, such as wood production, supporting coastal food webs and nutrient cycles in adjacent coastal ecosystems, carbon accumulation, trapping sediment and tsunami reduction. On the other hand, mangroves are one of the world's most threatened tropical and subtropical ecosystems and are being degraded in most countries mainly caused by anthropogenic activities and unsustainable exploitation. Ecology in plant production can give an insight into the basic mechanism supporting the ecosystem services with a viewpoint from forest structure and function.

This presentation focuses on the structure and productivity of mangroves around the Ryukyu Archipelago where the forest structure and function change drastically along a latitude since the study region is located around the northern distribution of mangroves. The effects of latitude on mangroves in East Asia will be discussed with some results based on the field researches conducted in the Ryukyu Archipelago.

キーワード：生産生態学、バイオマス、総生産量、純生産量

Keywords: Production ecology, Biomass, GPP, NPP

人間活動の影響を受けた河口浅海域における大気中CO<sub>2</sub>の吸収に関する現地観測と生態系モデリング  
Net uptake of atmospheric CO<sub>2</sub> in human-dominated estuarine and shallow coastal systems:  
empirical studies and the ecosystem modeling

\*桑江 朝比呂<sup>1</sup>、神田 穰太<sup>2</sup>、久保 篤史<sup>2</sup>、中島 典之<sup>3</sup>、小川 浩史<sup>4</sup>、相馬 明郎<sup>5</sup>、鈴木 昌弘<sup>6</sup>

\*Tomohiro Kuwae<sup>1</sup>, Jota Kanda<sup>2</sup>, Atsushi Kubo<sup>2</sup>, Fumiyuki Nakajima<sup>3</sup>, Hiroshi Ogawa<sup>4</sup>, Akio Sohma<sup>5</sup>, Masahiro Suzumura<sup>6</sup>

1.港湾空港技術研究所、2.東京海洋大学、3.東京大学、4.東京大学大気海洋研究所、5.みずほ情報総研、6.産業技術総合研究所

1.Port and Airport Research Institute, 2.Tokyo University of Marine Science, 3.University of Tokyo, 4.Atmosphere and Ocean Research Institute, 5.Mizuho Information and Research Institute, 6.National Institute of Advanced Industrial Science and Technology

Estuarine and shallow coastal systems (ESCS) are recognized as not only significant carbon reservoirs but also net emitters of CO<sub>2</sub> to the atmosphere, posing the dilemma of how ESCS functions relate to climate change mitigation. However, some studies have shown that ESCS take up atmospheric CO<sub>2</sub>. Here we reviewed empirical studies and developed a new ecosystem model to investigate the magnitude and determinants of net uptake atmospheric CO<sub>2</sub> by ESCS. We found that the capability of ESCS to function as CO<sub>2</sub> sinks is enhanced by environmental conditions that are typical of human-dominated systems (e.g., input of high terrestrial nutrients, input of treated wastewater in which labile carbon is highly removed, and presence of hypoxia).

キーワード：ブルーカーボン、気候変動、生態系モデル

Keywords: Blue Carbon, Climate change, Ecosystem model

日本の浅海域における海水中CO<sub>2</sub>分圧に係る現地観測とパス解析

Field observations and the path analysis of CO<sub>2</sub> fugacity in shallow coastal waters of Japan

\*田多 一史<sup>1,2,4</sup>、所 立樹<sup>2</sup>、渡辺 謙太<sup>2</sup>、山本 将史<sup>3</sup>、中山 恵介<sup>4</sup>、桑江 朝比呂<sup>2</sup>

\*Kazufumi Tada<sup>1,2,4</sup>, Tatsuki Tokoro<sup>2</sup>, Kenta Watanabe<sup>2</sup>, Shoji Yamamoto<sup>3</sup>, Keisuke Nakayama<sup>4</sup>, Tomohiro Kuwae<sup>2</sup>

1.中電技術コンサルタント株式会社、2.国立研究開発法人 港湾空港技術研究所、3.東京大学、4.神戸大学

1.Chuden Engineering Consultants Co., Ltd., 2.Port and Airport Research Institute, 3.The University of Tokyo, 4.Kobe University

海洋生態系の光合成などによって固定される炭素「ブルーカーボン」は、気候変動緩和策の重要なオプションとして注目されており、特に浅海域（海草場、干潟、塩生湿地など）は炭素固定・隔離の場として重要であると考えられている。一方で、これまで国内の様々な浅海域で海水中CO<sub>2</sub>分圧が計測されているが、それらを総括した解析事例は少ない。また、海水中CO<sub>2</sub>分圧は、呼吸・分解、光合成、石灰化といった生物化学的な変化を含んでおり、非線形かつ多変量の相互作用を伴った複雑な集合体となることから、統計モデルを適用する必要がある。

そこで本研究では、2010年～2015年に実施した現地観測と統計解析（パス解析）を用いて、海水中CO<sub>2</sub>分圧に直接的または間接的に影響を及ぼす環境要因を検討し、因果関係の相対的な影響度を推定した。対象サイトは、風蓮湖、コムケ湖、走水海岸、野島水路、松輪干潟、盤洲干潟、富津干潟、吹通川河口、白保海岸、名蔵湾の計10ヶ所とし、海水中CO<sub>2</sub>分圧とその環境要因（水温、塩分、溶存無機炭素濃度（DIC）、全アルカリ度（TA）、生物過程による炭素増減量（ $\Delta$ DIC）、石灰化によるアルカリ度増減量（ $\Delta$ TA）等）の測定を行った。また、パス解析では因果関係の強さについて様々な推定・検証を行い、海水中CO<sub>2</sub>分圧に影響を及ぼすと考えられる重要な環境要因を明らかにした。

キーワード：ブルーカーボン、海水中CO<sub>2</sub>分圧、海草場、干潟、サンゴ礁、パス解析

Keywords: blue carbon, the fugacity of CO<sub>2</sub> in water, seagrass meadow, tidal flat, coral reef, path analysis

## 亜熱帯性海草藻場における有機炭素蓄積量の制御条件としての海草現存量

## Seagrass biomass as a controlling factor of organic carbon stocks in subtropical seagrass meadows

\*棚谷 灯子<sup>1</sup>、渡辺 謙太<sup>1</sup>、山本 将史<sup>2</sup>、本郷 宙軌<sup>3</sup>、茅根 創<sup>2</sup>、桑江 朝比呂<sup>1</sup>\*Toko Tanaya<sup>1</sup>, Kenta Watanabe<sup>1</sup>, Shoji Yamamoto<sup>2</sup>, Chuki Hongo<sup>3</sup>, Hajime Kayanne<sup>2</sup>, Tomohiro Kuwae<sup>1</sup>

1. 港湾空港技術研究所、2. 東京大学、3. 琉球大学

1. Port and Airport Research Institute, 2. The University of Tokyo, 3. University of the Ryukyus

Carbon sequestered in marine ecosystems has been termed “blue carbon”, and seagrass meadows are one of the most dominant blue carbon stocks. Globally, one of the major distribution sites of seagrass meadows is coral reef flat. Recent studies have revealed that the amount of sedimentary organic matter in tropical and subtropical coasts is comparable to that in temperate coasts. However, these estimations are based on a few data and have wide range. Since quantifying organic carbon in the carbonate sediment is technically difficult and costly, easier methods for estimating the amount of organic carbon in seagrass meadows are strongly needed to assess the global blue carbon stocks for mitigation of global warming. Seagrass biomass is suggested to have responsible for the variability of seagrass carbon sink capacity, but the models have not been presented yet. To identify the relationship between seagrass biomass and blue carbon stocks, we developed a new box corer which can facilitate to obtain the intact cores structured by both sediments and seagrass bodies. Using the core samples taken in subtropical seagrass meadows and adjacent unvegetated areas, located around Ishigaki Island, Japan, we measured total organic carbon mass ( $TOC_{mass}$ ) and the stable isotope ratios ( $\delta^{13}C$ ) of total sedimentary organic matter and then conducted regression analyses between organic carbon stock and seagrass biomass. The averaged  $TOC_{mass}$  of the top 15 cm sediment including live seagrass biomass was  $876 \pm 408 \text{ g C m}^{-2}$  ( $n = 28$ ). The live seagrass biomass accounted for  $17 \pm 15 \text{ wt\%}$ , whereas the dead plant structures ( $>2 \text{ mm}$ ), coarse sediments ( $>1 \text{ mm}$  except for dead plant structures  $>2 \text{ mm}$ ) and fine sediments ( $<1 \text{ mm}$ ) accounted for  $4 \pm 4 \text{ wt\%}$ ,  $21 \pm 14 \text{ wt\%}$ , and  $58 \pm 15 \text{ wt\%}$ , respectively.  $TOC_{mass}$  increased with increasing the above seagrass biomass ( $A_b [\text{g DW m}^{-2}]$ ) ( $TOC_{mass} = 5.92 A_b + 502$ ,  $R^2 = 0.72$ ,  $n = 28$ ,  $p < 0.01$ ). The above seagrass biomass was one of the controlling factors of blue carbon stocks at the sites.

Sedimentary organic carbon mass (mixture of the dead plant structures, coarse sediments and fine sediments) was also positively correlated with the above seagrass biomass ( $R^2 = 0.45$ ,  $n = 28$ ,  $p < 0.01$ ). Using a Bayesian isotopic mixing model, we estimated that the contribution of seagrass-derived carbon to total sedimentary organic carbon was about 70%. The median values of seagrass-derived carbon mass estimated by the model was positively correlated with the above seagrass biomass ( $R^2 = 0.46$ ,  $n = 28$ ,  $p < 0.01$ ), whereas those derived from terrestrial POM or suspended POM had no correlation with the above seagrass biomass. Consequently, the enrichment of sedimentary organic carbon with increasing the live seagrass biomass was mainly due to accumulation of seagrass-derived organic carbon at the sites. These results suggest that blue carbon stocks can be increased by the conservation and restoration of seagrass meadows in subtropical coasts.

キーワード：炭素蓄積、ブルーカーボン、海草藻場、同位体分析、サンゴ礁

Keywords: carbon stock, blue carbon, seagrass meadow, isotopic analyses, coral reef

渦相関法と間隙水鉛直プロファイルを用いたサンゴ礁海草帯堆積物のアルカリ度フラックスの観測  
Total alkalinity flux at seagrass meadow estimated by eddy covariance and pore water profiles in sediment

\*山本 将史<sup>1</sup>、茅根 創<sup>1</sup>、本郷 宙軌<sup>2</sup>、棚谷 灯子<sup>3</sup>、渡辺 謙太<sup>3</sup>、桑江 朝比呂<sup>3</sup>

\*Shoji Yamamoto<sup>1</sup>, Hajime Kayanne<sup>1</sup>, Chuki Hongo<sup>2</sup>, Toko Tanaya<sup>3</sup>, Kenta WATANABE<sup>3</sup>, Tomohiro Kuwae<sup>3</sup>

1.東京大学大学院理学系研究科地球惑星科学専攻、2.琉球大学、3.港湾空港技術研究所

1.The University of Tokyo, Department of Earth and Planetary Science, 2.University of the Ryukyus,  
3.Port and Airport Research Institute

海洋酸性化によって海水中のpHおよび鉱物の飽和度は低下する。そのため、炭酸塩堆積物の溶解は石灰化生物による石灰化よりも敏感に応答すると言われている (Eyre et al. 2014)。特に海草帯の炭酸塩堆積物は、多様な酸化還元環境で起こる豊富な有機物の分解によるCO<sub>2</sub>分圧増加のため溶解反応が起きやすくなり、その結果、堆積物から水柱方向のアルカリ度Fluxが大きくなると考えられる。そこで本研究では、白保サンゴ礁海草帯の堆積物中の間隙水鉛直プロファイルを観測し、堆積物—水柱でのアルカリ度FluxをD0の渦相関法を用いて求めた。調査地域の堆積物は、有孔虫由来のMg-calcite (16.4Mg mol%) が半分以上を占めていた。夜間では堆積物中深度4mm以下では酸素が枯渇して硫酸還元が起こりうる環境だった。アルカリ度と全炭酸は深くなるにつれ増加、pHは深くなるにつれ減少していたが、aragonite飽和度 ( $\Omega_{arg}$ ) は30mm以深ではおよそ2.3で一定であった。一方、渦相関法を用いたアルカリ度Fluxを計算したところ、有孔虫のMg-calciteに対して過飽和条件下でも、夜間では堆積物から水柱方向の0.9-3.2 mmol m<sup>-2</sup> hr<sup>-1</sup>のアルカリ度Fluxが観測された。今後、海洋酸性化が進むと、よりMg-calcite溶解と硫酸還元によるアルカリ度フラックスが増加すると考えられる。

キーワード：海洋酸性化、アルカリ度フラックス、マグネシウム方解石

Keywords: Ocean acidification, Total alkalinity flux, Mg-calcite

リン酸の酸素安定同位体比を含む生物地球化学的指標を用いたフィリピン・ボリナオおよびアンダ沿岸の養殖海域における継続的な富栄養化状態の原因解明

Sustained eutrophic conditions in mariculture areas of Bolinao and Anda, Philippines as seen using biogeochemical indices including oxygen isotope of phosphate

Ferrera Charissa<sup>1</sup>、宮島 利宏<sup>2</sup>、San Diego-McGlone Maria Lourdes<sup>3</sup>、森本 直子<sup>2</sup>、梅澤 有<sup>4</sup>、Herrera Eugene<sup>5</sup>、土屋 匠<sup>1</sup>、吉開 仁哉<sup>1</sup>、灘岡 和夫<sup>1</sup>、\*渡邊 敦<sup>1</sup>

Charissa M Ferrera<sup>1</sup>, Toshihiro Miyajima<sup>2</sup>, Maria Lourdes San Diego-McGlone<sup>3</sup>, Naoko Morimoto<sup>2</sup>, Yu Umezawa<sup>4</sup>, Eugene Herrera<sup>5</sup>, Takumi Tsuchiya<sup>1</sup>, Masaya Yoshikai<sup>1</sup>, Kazuo Nadaoka<sup>1</sup>, \*Atsushi Watanabe<sup>1</sup>

1.東京工業大学大学院情報理工学研究科、2.東京大学大気海洋研究所、3.フィリピン大学ディリマン校 MSI、4.長崎大学水産学部、5.フィリピン大学ディリマン校工学部

1.Tokyo Institute of Technology, 2.AORI, University of Tokyo, 3.Marine Science Institute, University of the Philippines Diliman, 4.Faculty of Fisheries, Nagasaki University, 5.Institute of Civil Engineering, University of the Philippines Diliman

フィリピン・ボリナオ沿岸における長期栄養塩観測データは、2002年に同海域でミルクフィッシュの養殖生簀数に規制が設けられたにも関わらず、富栄養化状態が継続していることを示している。この規制は、同年にボリナオで発生した養殖魚の大量斃死が契機となり、ボリナオ沿岸で課された。本研究は規制後も続く富栄養化状態と度重なる赤潮、貧酸素化、養殖魚の斃死の関連性を解明することを目的に、ボリナオおよび隣接するアンダ海域を対象に窒素 (N) およびリン (P) の動態を調べた。

水柱、堆積物中の栄養塩類に関する時空間分布、および養殖海域に対する負荷源として想定されうる各種起源物質中の栄養塩類を詳細に解析した。その結果、養殖海域は溶存態無機窒素 (DIN、特にアンモニア態窒素)、溶存態無機リン (DIP) 濃度が高いことがわかり、これは非摂餌・未消化の餌や魚の排泄物の分解が主な原因と考えられる。回帰した栄養塩はN/P比が約6.6となっており、レッドフィールド比より大幅に低くなっていた。DIPは雨季より乾季の方が高い傾向が認められ、これは回帰した栄養塩が流況により乾季に海域内にたまりやすいためと考えられる。過去の衛星画像を解析したところボリナオ海域では養殖生簀の数が規制内でほとんど変化していなかったのに対し、アンダ海域では増加傾向にあり、この海域の養殖活動に伴う有機物やPに富んだ栄養塩類が乾季の残差流の影響でボリナオ海域に輸送されたと考えられる。こうした諸要因により、ボリナオではDIPが富み、Nが制限栄養素となった状態が継続しており、雨季に河川等からNが多く供給されると散発的に植物プランクトンの増殖を引き起こす下地を作っていると考えられる。

リンの起源をより詳しく調べるために、環境試料中のリン酸の酸素安定同位体比 ( $\delta^{18}O_p$ ) を解析したところ、河川水と養殖で用いられる餌が、養殖海域に対する2つの起源物質として特徴的な値を示した

(各々、 $14.4 \pm 0.2 \%$ と $21.8 \pm 0.4 \%$ 、平均 $\pm$ 標準偏差)。堆積物の間隙水中のDIPは $21.3 \pm 0.2 \%$ と餌と同程度の値を示し、餌の分解がDIPの主な起源となっていることが示唆された。養殖場の水中のDIPも概ね餌に近い $\delta^{18}O_p$ を示したが、季節および潮汐による影響で変動することも明らかになった。

キーワード：リン、富栄養化、餌、栄養塩比、海域養殖、リン酸の酸素安定同位体比

Keywords: phosphorus, eutrophication, fish feed, nutrient ratios, mariculture, oxygen isotope ratio of inorganic phosphate

## 造礁サンゴのストレス応答

## Stress responses of reef-building corals

\*樋口 富彦<sup>1</sup>\*Tomihiko Higuchi<sup>1</sup>

1. 東京大学大気海洋研究所

1. Atmosphere and Ocean Research Institute, The University of Tokyo

Over the past several decades, coral reef ecosystems have experienced various stresses and extensive degradation due to increased anthropogenic activity. Reef-building corals respond to stress in various ways (e.g. bleaching, etc.). Corals exhibit defense mechanisms such as mycosporine-like amino acids against stresses, although many of these functions have not yet been clarified. Understanding the defense mechanisms in corals could provide important information for finding solutions to stress-related responses such as coral bleaching. In this presentation, I describe coral bleaching, oxidative stress, antioxidant activities as responses and defense mechanisms against environmental stressors including high temperature, low temperature, eutrophication, and ultraviolet radiation.

キーワード：造礁サンゴ、環境ストレス応答、白化現象

Keywords: reef-building corals, stress response, coral bleaching

## パラオ共和国におけるグローバル環境問題とサンゴ礁生態系

## Global environmental effect at Palau coral reef ecosystem

\*栗原 晴子<sup>1</sup>、本郷 宙軌<sup>1</sup>、三村 泉美<sup>1</sup>、河井 崇<sup>1</sup>、渡邊 敦<sup>2</sup>、Otto Evelyn<sup>3</sup>、Gouezo Marine<sup>3</sup>、Golbuu Yimnang<sup>3</sup>

\*Haruko Kurihara<sup>1</sup>, Chuki Hongo<sup>1</sup>, Izumi Mimura<sup>1</sup>, Takashi Kawai<sup>1</sup>, Atsushi Watanabe<sup>2</sup>, Evelyn Ikelau Otto<sup>3</sup>, Marine Gouezo<sup>3</sup>, Yimnang Golbuu<sup>3</sup>

1.琉球大学、2.東京工業大学、3.PICRC

1.University of the Ryukyus, 2.Tokyo Institute of Technology, 3.Palau International Coral Reef Center

## Introduction

Coastal ecosystem supplies a number of ecosystem services that sustain human society, however it is now threaten by multiple anthropogenic impacts. Our need to understand the degree of human impacts in coral reef ecosystem is principally essential in small reef island countries because reef health is directly linked to the sustainability of their economy. In this present study, we will focus on the Republic of Palau and evaluated the global and local environmental change on the reef ecosystem of Palau for the aim of getting information needed for better reef conservation and management.

## Methods

Twenty two sites around the coast of Palau was selected and environmental parameters including temperature, salinity, dissolved oxygen, chl<sub>a</sub>, turbidity, suspended solid, particle organic carbon (POC), particle organic nitrogen (PON), dissolved inorganic nutrient (DIN, DIP), total inorganic carbon (DIC), alkalinity, pH and aragonite saturation was measured at surface (0 m) and bottom (8 m). At the same time, the benthic coverage and coral community was evaluated by 5 transects of 10 m length for each sites. From these parameters, we evaluated the most important factors that regulate coral reef community.

Next, we focus on the two main climate change factor (temperature and pH), and evaluate the recent pH and temperature trend in Palau coast and study the possible impact on the coral community. Additionally, we focus on the sewage discharge on the reef, and evaluate the recent nutrient and Chl<sub>a</sub> trend in Palau coast and evaluate the effect on the coral community.

## Results and Discussions

From present results we found that the reef environment and coral community in Palau can be divided into three areas: north-west area, east area and lagoon and south area. The North-West area was characterized by Acropora dominant community with high pH (high aragonite saturation), the East area by Montipora and Pocillopora community with high pH (high aragonite saturation) and variable turbidity, and Lagoon and South area by Porites with low pH, and high nutrient and turbidity. From these results it is suggested that coral reef management should be focused on these 3 different areas, and pH, nutrient and turbidity are the important environmental factors that should be monitored. Additionally, we found that both pH and temperature is significantly increasing in the coast of Palau suggesting the progress of ocean acidification and global warming. Finally, we found that the continuous sewage discharge have increased the nutrient concentration by two times within these 20 years. Additionally, this environmental change is suggested to causing out break of COTS (Crown of Thorns Starfish), which might affect coral community. From these results, we suggest that local management together with the consideration of climate change, will be essential for



management of Palau coral reef ecosystem.

キーワード：サンゴ礁、気候変動、下水排出、サンゴ群集、保全

Keywords: coral reefs, climate change, sewage discharge, coral community, management

## Numerical simulation of typhoon events in Sekisei Lagoon, Okinawa, Japan

\*Lawrence Cases Bernardo<sup>1</sup>, Takashi Nakamura<sup>1</sup>, Atsushi Watanabe<sup>1</sup>, Kazuo Nadaoka<sup>1</sup>

## 1. Tokyo Institute of Technology

Typhoons of sufficient intensity have been known to cause damage to coral reef ecosystems but may also bring benefit in the form of typhoon-induced cooling, which can mitigate against thermal stress. Sekisei Lagoon is the site of Japan's largest coral reef area and is also impacted to varying degrees by typhoons which approach yearly during the summer season. To closely investigate typhoon-driven hydrodynamics in Sekisei Lagoon, selected typhoon events were modeled using a nested Regional Ocean Modeling System (ROMS) configuration with an outer coarse scale regional model at 1.5 km grid resolution, and an inner model focused on the Sekisei Lagoon domain with a grid resolution of 300 meters. Ocean boundary forcing for the regional model was derived from global 1/12° Hybrid Coordinate Modeling System analysis data (HYCOM GLBa0.08). Meteorological forcing was derived from Japan Meteorological Agency-Grid Point Value (JMA-GPV) mesoscale model results. Model performance was evaluated by comparing simulation results with in-situ observations from sensor deployments around Sekisei Lagoon conducted during the summer months of 2013, 2014, and 2015. Sensor positions and durations varied between the deployments, but typhoon event field data at specific locations was available for model comparison for parameters such as water velocity, water level, temperature, and wave height. Analyses of field observations during typhoon passages revealed various typhoon related trends, such as sudden temperature downshifts, potentially destructive wave conditions, and enhanced water flow velocity, especially through channels. The timing, magnitude, and spatial patterns of such trends varied depending on typhoon track and intensity, and the ability of the model to reproduce these observed trends was assessed. The model results were then analyzed further in terms of modeled 3-D spatiotemporal trends both within the Sekisei Lagoon domain and the surrounding ocean areas to clarify the dominant physical processes involved in each specific event, such as the effects of strong vertical mixing due to typhoon winds, wind-driven currents, and the possibility of typhoon-driven upwelling of cold, bottom waters from offshore. The results of this investigation may give further insight into the ways in which typhoons affect the hydrodynamic conditions in Sekisei Lagoon, which are related to many aspects of the coral reef ecosystem, such as coral health and susceptibility to bleaching, larval dispersal, and physical damage from waves. Such information may help guide coral reef ecosystem management and conservation efforts to more properly account for the effects of typhoons.

Keywords: hydrodynamics, typhoon, ocean model, coral reef, sensors

## ツバル フォンガファレ島のサンゴ年輪に見られる混入物について

## History of Coastal Environment Recorded in Coral from Fongafale Island, Tuvalu

\*中村 修子<sup>1</sup>、荻原 成騎<sup>2</sup>、細井 豪<sup>3</sup>、茅根 創<sup>2</sup>、山野 博哉<sup>4</sup>

\*Nobuko Nakamura<sup>1</sup>, Shigenori Ogihara<sup>2</sup>, Go Hosoi<sup>3</sup>, Hajime Kayanne<sup>2</sup>, Hiroya Yamano<sup>4</sup>

1.慶應大学 理工学部、2.東京大学大学院理学系研究科地球惑星科学専攻、3.(株)電通、4.国立環境研究所  
1.Keio University, 2.Univ.Tokyo, 3.Dentsu, 4.National Institute for Environmental Studies

Because of their low altitudes, atoll islands in Tuvalu, the South Pacific is concerned for the earliest influence of the sea level rise and resultant submergence caused by global warming. However the local environmental change such as land development and water pollution with recent increasing population also damages the ecosystem and the sustainability of coral reef islands. To examine the time series of anthropogenic impacts on the coastal reefs, we analyzed the coral annual bands obtained in 2009 from the lagoon of Fongafale Island, the capital of Tuvalu.

The coral core fg01 from living colonies of *Porites lutea* (core length; 78 cm) shows growth interruption at 20cm under the top and the characteristic black bands were observed along annual bands above that break. We introduced the age axis to fg01 using the  $\Delta^{14}\text{C}$ - annual bands correction constructed with the other continuous coral annual bands (fh11, core length; 93 cm, 1940-2009) from Funafala Island on the same atoll. The core fg01 started the growth from 1940-50s and the discontinuous period was for 1970s-1990s, after that the coral has restarted its growth but the black bands pollution is conspicuous.

To identify this pollution we performed organic/ inorganic analysis and studied a microscopic inspection. We found high dense fibers of boring microbes; some kinds of algae and fungi in the black bands of coral skeleton. The propagation of microbes into the feeble coral skeleton and the construction of the black bands started from 1990s, which was coincident with increase of living drainage caused by densely population at Fongafale Island (Yamano *et al.*, 2007, Fujita *et al.*, 2013, 2014). Further the construction of the black annual bands suggests the seasonal propagation of microbes related to coastal environment.

On the other hand, in the process of the organic analysis using GC/MS we detected the higher concentration of petroleum hydrocarbons from the bottom of the coral core corresponded to 1940-50s annual bands than the upper part. The low CPI value (Carbon Preference Index; a rate of diagenesis) suggests this hydrocarbon was used as fuel for heavy equipments introduced during the World War II. Fongafale Island has the history that the US Army built a heavy bomber-runway for one month in 1943.

70yr coral annual bands from Fongafale Island recorded both the trace of the World War II and recent human impact in that skeleton.

## サンゴ礁生態系における懸濁粒子・沈降粒子の炭素・窒素安定同位体比時空間分布

Spatiotemporal variation in carbon and nitrogen stable isotope ratios of suspended and settling particles in coral reefs

\*宮島 利宏<sup>1</sup>、森本 直子<sup>1</sup>、田中 泰章<sup>2,3</sup>、渡邊 敦<sup>4</sup>、中村 隆志<sup>4</sup>、山本 高大<sup>2,5</sup>、灘岡 和夫<sup>4</sup>

\*Toshihiro Miyajima<sup>1</sup>, Naoko Morimoto<sup>1</sup>, Yasuaki Tanaka<sup>2,3</sup>, Atsushi Watanabe<sup>4</sup>, Takashi Nakamura<sup>4</sup>, Takahiro Yamamoto<sup>2,5</sup>, Kazuo Nadaoka<sup>4</sup>

1.東京大学 大気海洋研究所、2.東京工業大学、3.Faculty of Science, Universiti Brunei Darussalam、4.東京工業大学 環境・社会理工学院、5.Environment and Life Science Center, Kuwait Institute for Scientific Research

1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Tokyo Institute of Technology, 3.Faculty of Science, Universiti Brunei Darussalam, 4.School of Environment and Society, Tokyo Institute of Technology, 5.Environment and Life Science Center, Kuwait Institute for Scientific Research

サンゴ礁生態系は、典型的には外洋側からサンゴの優占する礁斜面、サンゴと藻類の混在する礁嶺・礁原、砂地を中心とする礁池・礁湖、海草藻場などの地形的に区別できるコンパートメントから構成されている。サンゴ礁は貧栄養な海水中に成立するため、生態系と外界との物質交換、および生態系内のコンパートメント間の相互作用におけるキャリアとして、粒子状有機物（POM）の重要性が極めて高い。POMは懸濁食物者等に捕獲されてエネルギー源となるだけでなく、窒素やリン、珪素、鉄などの重要な栄養素の輸送担体ともなっている。また沈降して堆積物に移行することにより、生態系の炭素隔離機能にも貢献している。本研究では、特にサンゴ礁内のコンパートメント間の相互作用においてPOMのもつ役割を解明するため、石垣島・白保地先および吹通川河口沖（伊土名地先）の2箇所のサンゴ礁においてPOMの濃度、炭素・窒素安定同位体比（ $\delta^{13}\text{C}$ ・ $\delta^{15}\text{N}$ ）、沈降フラックスを調査し、リーフ内の異なるハビタット間で比較した。また季節変動・日周変動に関する調査を行った。サンゴ礁周辺外洋域における海水中のPOM濃度は $5 \mu\text{mol C L}^{-1}$ 未満であるが、サンゴ礁内では濃度が高まり、特に海草藻場では $50 \mu\text{mol C L}^{-1}$ に達することがあった。外洋水POMの $\delta^{13}\text{C}$ は $-24\%$ ～ $-18\%$ 、 $\delta^{15}\text{N}$ は $+3\%$ ～ $+5\%$ であるのに対して、サンゴ群落上の海水中のPOMでは $\delta^{13}\text{C}$ がやや高く、 $\delta^{15}\text{N}$ は若干低めになっていた。サンゴ群落上で夜間に採集されるPOMの $\delta^{15}\text{N}$ は $+7\%$ ～ $+9\%$ と特に高くなっていた。また海草藻場上の海水に含まれるPOMでは $\delta^{13}\text{C}$ が高く、 $-10\%$ を越える場合もあった。沈降フラックスは場所と時期による変動が大きい。概ね夏季（8月）の方が冬季（1月）より多かった。サンゴ群落で捕集される沈降粒子は、外洋性POMに比べて $\delta^{13}\text{C}$ が明瞭に高く、 $\delta^{15}\text{N}$ は低い傾向が認められ、また $\delta^{13}\text{C}$ は夏季の方が冬季より高かった。沈降粒子のPOC/PN比は6～9の範囲で、懸濁粒子とほぼ重なっていた。これとは別に、サンゴ礁内のPOMの主要な生産者となる生物（造礁サンゴ・褐虫藻・大型藻類・海草類・海草葉上付着藻類）および消費者となる動物種の $\delta^{13}\text{C}$ と $\delta^{15}\text{N}$ を調査した。本発表ではこうしたデータの比較に基づいて、特に外洋からサンゴ群落への物質流入、サンゴ群落と海草藻場との間の物質交換、ならびに底生動物群集の栄養構造における懸濁粒子と沈降粒子の役割について考察する。

キーワード：粒子状有機物、サンゴ礁、海草藻場、沈降フラックス、起源解析

Keywords: particulate organic matter, coral reefs, seagrass beds, sinking flux, provenance analysis