

平成 30 年 6 月 22 日現在

機関番号：13901

研究種目：若手研究(B)

研究期間：2016～2017

課題番号：16K17819

研究課題名(和文) AUV exploration of the mesophotic reef zone in the South Ryukyu Islands

研究課題名(英文) AUV exploration of the mesophotic reef zone in the South Ryukyu Islands

研究代表者

HUMBLET Marc (Humblet, Marc)

名古屋大学・環境学研究科・特任准教授

研究者番号：40623616

交付決定額(研究期間全体)：(直接経費) 3,100,000円

研究成果の概要(和文)：ロボット潜水艇で石西礁湖周辺の中深度海底の2箇所で調査しました：KT(深度30-110m)とTN(深度30-45m)。この研究のために、新しいautonomous underwater vehicle(AUV HATTORI)が開発されました。

サイトKTとTNの深度30-40mで観察されるサンゴ群集は非常に異なります。サイトKTではサンゴの被覆が低く、サンゴ群集にはPoritesとmerulinidsが含まれています。サイトTNではサンゴの被覆が高く、LeptoserisとAcroporaが豊富です。さらに、サイトKTではマクロベントスの明確な深度関連帯状分布が見られます。

研究成果の概要(英文)：The mesophotic seafloor around the Sekisei Lagoon was surveyed at two sites: site KT (lat. 24.27°, long. 124.08°; 30-110 m), site TN (lat. 24.35°, long. 124.08°; 30-45 m), using robotic submersibles. A new autonomous underwater vehicle (AUV HATTORI) was developed to acquire high-resolution video images of the seafloor. The AUV was equipped with sensors measuring temperature, salinity, and light intensity down to 45 m at both sites. Additional video images were acquired using remotely operated vehicles.

There are differences in coral communities occurring at upper mesophotic depths (30-40 m) between site KT and site TN: low coral cover and taxa comprising Porites and merulinids at site KT, and high coral cover with abundant Leptoseris and Acropora at site TN. In addition, a clear depth zonation was observed at site KT with a transition from coralgall communities to a mixed community at around 60 m. This study also highlights the patchiness of benthic communities at mesophotic depths.

研究分野：地球科学

キーワード：Coral reef Mesophotic habitats Benthic communities Seafloor topography AUV ROV Scleractinian corals Ryukyu Islands

1. 研究開始当初の背景

(1) The main shallow tropical reef-builders are scleractinian corals and coralline algae. The species distribution of these organisms on coral reefs is not random. There is a species zonation reflecting gradients in wave energy and light (i.e., depth). Because of their non-random species distribution, reef organisms are useful paleo-environmental and sea-level indicators.

(2) Reef-building scleractinian corals live within the photic zone, and their distribution may extend to depths of over 100 m. However, the lack of data on deep reef communities limits the accuracy of paleo-environmental interpretations of fossil reef deposits. The deep reef habitat, or mesophotic reef zone (MRZ), extends from 30 m to the bottom of the photic zone (~150 m in clear water). The seafloor in the MRZ has been shaped by repeated glacio-eustatic sea-level changes controlling sedimentation, erosion, reef growth and reef demise. Therefore, the study of reef biota and sediments, and of seafloor geomorphology at mesophotic depths is essential to understand reef growth history and reconstruct paleo-environmental and sea-level changes during the Quaternary.

2. 研究の目的

The present research is a study of the distribution and taxonomic composition of benthic organisms at mesophotic depths (30-120 m) around the Sekisei lagoon in the South Ryukyus, Japan. The goal is to establish new robust paleo-environmental and sea-level indicators based on a detailed analysis of the taxonomic composition and distribution of macrobenthic organisms in the MRZ.

3. 研究の方法

(1) Video images of the seafloor were acquired by robotic submersibles provided by Prof. Toshihiro Maki's lab (The University of Tokyo). One remotely operated vehicle (ROV *QI*, Co.Ltd.) and one autonomous underwater vehicle (AUV *HATTORI*) were used to investigate the seafloor at two mesophotic sites, one south and one north of the Sekisei Lagoon, at depths of 30-110 m (Kataguwa, site KT; lat. 24.27°, long. 124.08°) and 30-40 m (Taketomi North, site TN; lat. 24.35°, long. 124.08°), respectively (Fig. 1). Additional images were acquired at site TN by the ROV *Kukanchi* (Ambient Intelligence Technologies Lab., Co.Ltd.).

(2) The AUV *HATTORI* (Highly Agile Terrain

Tracker for Ocean Investigation) is a new lightweight robotic submersible developed and tested during this study. The AUV was equipped with sensors to obtain temperature, salinity, and light intensity profiles down to 45 m at sites KT and TN (Fig. 2). A super short baseline acoustic system (SSBL) was used to determine the position of the AUV *HATTORI* and ROV *QI* during each dive.

4. 研究成果

(1) Initial testing of the new AUV was successfully carried out in the Tonoshiro port at Ishigaki-jima in November 2016. At the same time, the ROV *QI* was used to explore the seafloor at site KT along two transects at depths ranging from 30 to 100 m.

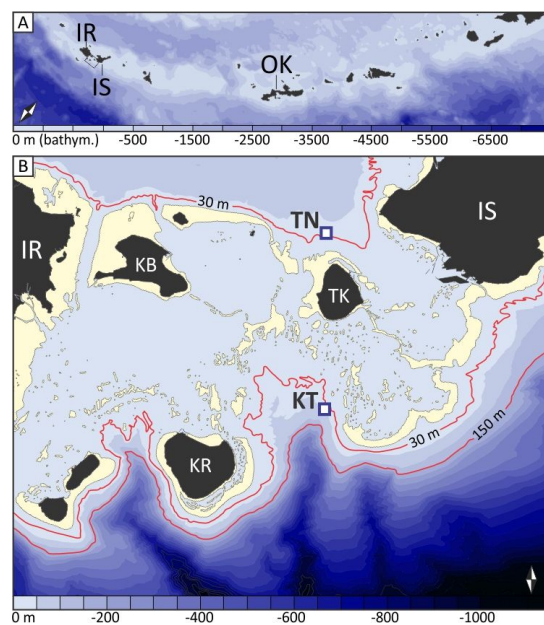


Fig. 1: Location of the two surveyed sites. (A) map of the Ryukyu Islands, southwestern Japan. (B) map of the Sekisei Lagoon. IR, Iriomote-jima, IS., Ishigaki-jima, KB, Kobama-shima, KR, Kuro-shima, OK, Okinawa-jima, TK, Taketomi-jima.

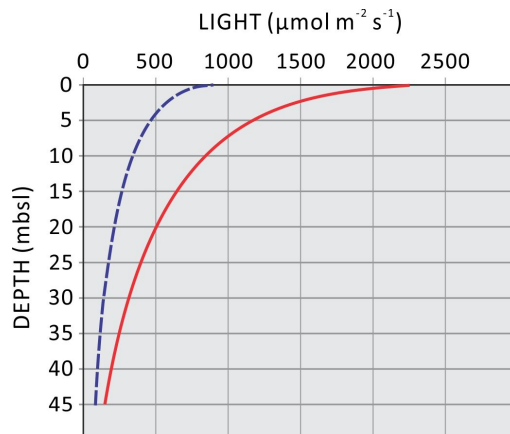


Fig. 2: Light intensity vs. depth at site KT (red plain line; May 15, partly cloudy) and site TN (blue dashed line; May 16, cloudy).

(2) During the second survey in May 2017, the AUV *HATTORI* was first deployed inside the lagoon at shallow depth (20 m or less). Several dives were conducted at these sites to fine-tune navigation parameters, such as speed and elevation. After these trials, the AUV was deployed at mesophotic depths, first at site KT (11 dives), then at site TN (2 dives), at water depths of 40-45 m, along transects up to 40 m in length. The AUV *HATTORI* successfully mapped the seafloor (Fig. 3). Additional video images were acquired by the ROV *QI* and ROV *Kukanchi*.

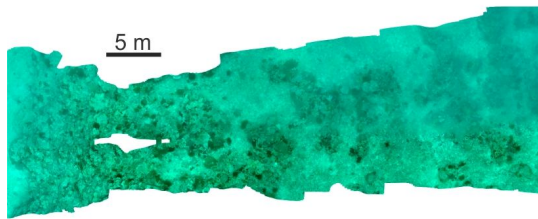


Fig. 3: Photomosaic of the seafloor performed by AUV *HATTORI*

(3) Results show a marked zonation of benthic organisms along a depth gradient at site KT, as well as a clear difference in composition of mesophotic coral communities between site KT (exposed) and site TN (protected) (Figs. 4 and 5). The discovery of a dense coral community at 30-40 m depth at site TN is particularly remarkable (Fig. 5).

(4) The depth zonation at **site KT** can be summarized as follows:

30-40 m: benthic community occurring on the fore-reef slope of the barrier reef on hard substrate composed primarily of scleractinian corals and crustose coralline algae (i.e., coralgal community) with low coral cover, and comprising coral taxa such as *Porites* and merulinids (Fig. 4a-b).

40-60 m: a coralgal community occurring on flat rocky bottom and on pinnacles with low coral cover (although cover up to 35% was reported close to site KT on pinnacles), with common occurrences of the scleractinian coral species *Acropora granulosa* (Fig. 4c-d).

60-70 m: mixed benthic community composed of scleractinian corals, calcareous and fleshy algae, sponges, sea fans, and large foraminifers, with overall high live cover and high taxonomic diversity (Fig. 4e-f).

(5) The coral community at **site TN** between 30 and 40 m water depth is characterized by up to 100% coral cover. Coral species identified from video still images include *Leptoseris gardineri*, *Leptoseris amitoriensis?*,

Acropora tenella and *Acropora echinata* (Fig. 5a-b).

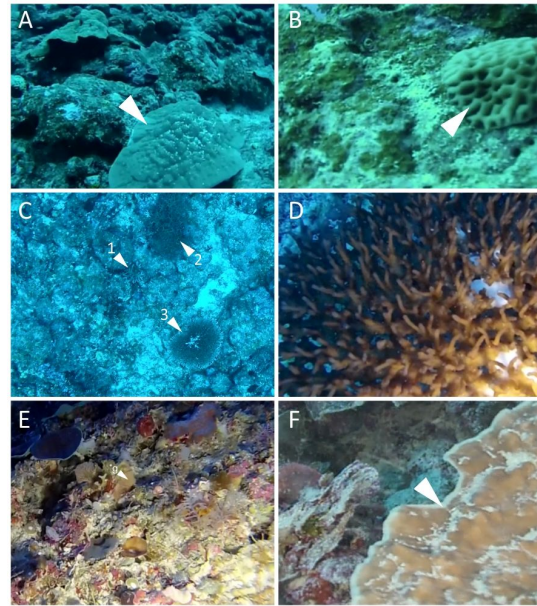


Fig. 4: Images of the seafloor acquired at site KT. (A) *Porites* sp. (33 m). (B) *Favites* sp.? (34 m). (C) *Acropora tenella* (1), *Seriatopora hystrix?* (2), *Acropora granulosa* (3) (42 m). (D) Close-up image of *Acropora granulosa* (52 m). (E) mixed community (69 m). (F) Close-up image of *Leptoseris* sp. (63 m).

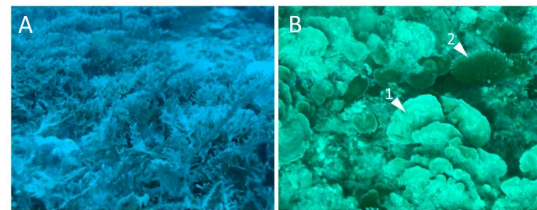


Fig. 5: Images of the seafloor acquired at site TN. (A) Dense community of *Leptoseris gardineri* (33 m). (B) *Leptoseris amitoriensis?* (1), *Acropora granulosa* (2) (40 m).

(6) In conclusion, there significant differences in coral communities occurring at upper mesophotic depths (30-40 m) between site KT and site TN. Oceanographic conditions differ markedly at the two sites. Site KT is exposed to the open ocean whereas site TN is located in a more protected environment. Fine carbonate mud is widespread at site TN and suggests a higher turbidity. Results show a clear zonation of benthic organisms along a depth gradient at site KT, characterized by marked changes in benthic community structure, and a sharp decline in coral abundance below 70 m. In addition, this study also highlights the patchiness of benthic communities at mesophotic depths, with pronounced variations in live cover within each surveyed site.

5 . 主な発表論文等

〔学会発表〕(計2件)

(1) Humblet Marc, Maki Toshihiro, Furushima Yasuo, Noguchi Yukiyasu, Kuranaga Keisoku, Sakamaki Takashi, Ito Shohei, and Yoshiga. ROV and AUV exploration of the mesophotic reef zone around the Sekisei Lagoon, South Ryukyus, Japan. The Japanese Coral Reef Society 20th Annual Conference, 23-26 Nov. 2017, Tokyo Institute of Technology, Tokyo, Japan.

(2) Maki Toshihiro, Kuranaga Yoshinori, Noguchi Yukiyasu, Sakamaki Takashi, Masuda Kotohiro, Humblet Marc, and Furushima Yasuo. AUV Hattori: a lightweight platform for high-speed low-altitude survey of rough terrain, Oceans 17 MTS/IEEE Conference, 18-21 Sept. 2017, Anchorage, Alaska, USA.

6 . 研究組織

(1)研究代表者

Marc Humblet

Nagoya University, Department of Earth and Planetary Sciences, Associate Professor

研究者番号 : 40623616

(2)研究協力者

巻 俊宏 (Maki Toshihiro)

古島 靖夫 (Furushima Yasuo)

井龍 康文 (Iryu Yasufumi)

坂巻 隆 (Sakamaki Takashi)

Frédéric Sinniger