Global Environment Research Account for National Institutes

Research on Cooperative Coral Monitoring for Environmental Impact Assessment of Ocean-Warming and –Acidification
（Abstract of the Final Report）

Contact person Masahiko Sasano
Chief Researcher, Sensing Technology Research Group,
Navigation & Logistics Engineering Department,
National Maritime Research Institute
Shinkawa 6-38-1, Mitaka, Tokyo, 181-0004 Japan
Tel:+81-422-41-3123 Fax:+81-422-41-3905
E-mail:sasano@nmri.go.jp

Total Budget for FY2008-FY2011 56,256,000Yen
（**FY2011**; 17,683,000Yen）

Key Words Ocean-Warming, Ocean-Acidification, Coral, Monitoring, Lidar (Laser Radar)

1. Introduction

According to the IPCC 4th report, the CO2 concentration in the atmosphere has been increased around 40 percent since the industrial revolution. It has been reported that, due to the greenhouse effect of the CO2 gas, air temperature at the ground has risen by around 0.7 degrees Celsius, and sea temperature between surface and 700 m depth has risen by around 0.1 degrees.[1] Additionally, it has been reported that, due to dissolution of CO2 gas into the sea, pH level of the sea surface has been decreased around 0.1.[2] In the IPCC report, it is predicted that these changes of the ocean environments will continue.[3]

Coral reefs are fragile ecosystem affected by for both of ocean-warming and ocean-acidification. The monitoring of coral for large-area and long-term is regarded as particularly important in terms of the environmental impact assessment of global climate change.

The two current typical methods for coral monitoring are the diving investigation and the satellite remote-sensing. Unfortunately, the diving investigation method needs a large number of divers to investigate coral reefs in large-area and long-term. On the other hand, satellite remote-sensing method has a potential to cover globally though it gives rough resolution images and less-accurate information of coral reefs. It is expected to develop a new method with intermediate resolution and intermediate covering area to build the framework of cooperative coral monitoring.

National Maritime Research Institute (NMRI) has a specialty of laser radar (Lidar) [4)5)], and this technology has a potential to realize boat-based optical observation for shallow ocean investigation and coral monitoring.

2. Research Objectives

The main objective of this research is to build a framework of cooperative coral monitoring by three observation methods for covering large-area and long-term monitoring of coral reefs. This framework and its observation data will support the environmental impact assessment of global ocean-warming and ocean-acidification in the future.

For that purpose, the coral monitoring technique by a boat will be developed first. The boat-based fluorescence imaging lidar system will allow observation of corals by intermediate image resolution and intermediate cover area. Additionally, live versus dead determination of corals from fluorescence images can be confirmed by verifying the coral image pattern and fluorescence intensity.

In the second stage, cooperative coral monitoring will be operated by three methods of diver investigation, boat-based observation and satellite remote-sensing. The monitoring will be operated mainly at two locations; one is Sekisei-Shoko, one of the largest coral reef sea area in Japan, and the another is Tateyama, the northern limit sea area for hermatypic corals. By the cooperative monitoring, variety of data will be achieved from high-resolution and small-area to low-resolution and large-area. The unified database will be built for the aim of storage and providing of these data

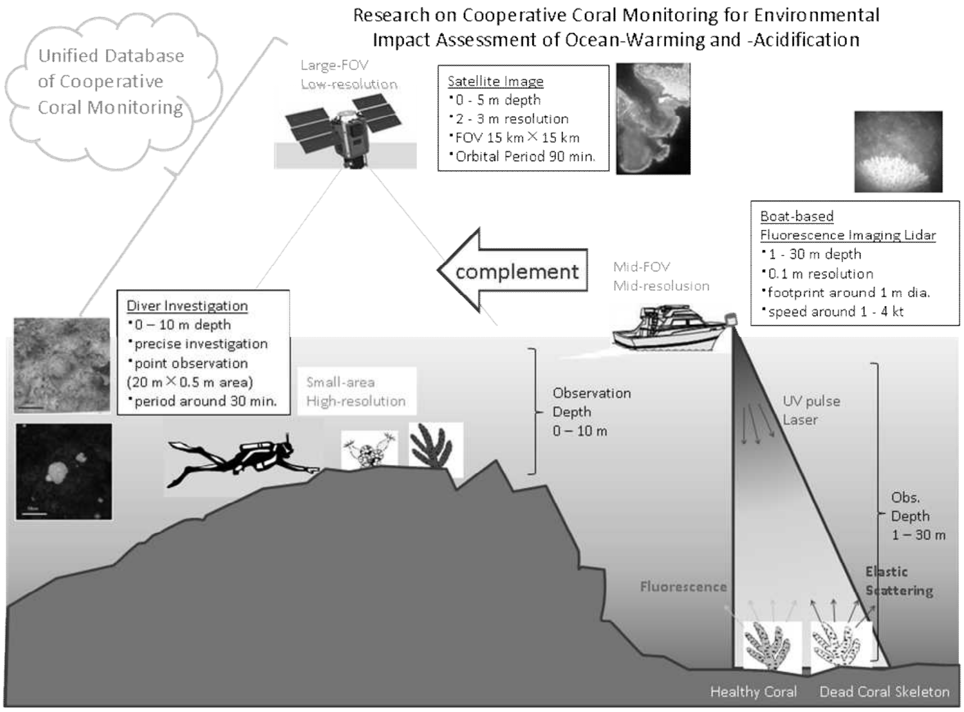

Figure1 Overview of the “Cooperative Coral Monitoring”.

3. Methods and Results

(1) Diving investigation for Coral Cover and Bleaching

① Observation points have been set up 1 place at Tateyama, Chiba, and 4 places at Sekiseishoko, Okinawa.

② Diving investigation has been carried out by both of daytime quadrat photo investigation and nighttime UV-excited fluorescence quadrat photo investigation.

③ It is confirmed that nighttime UV-excited fluorescence quadrat photo investigation is sensitive for small size coral, and is also effective for live/death determination of a coral colony.

④ Coral cover of each observation point has not changed much in 2009 to 2011, and the large-scale coral bleaching has not observed in these years.

Table1 Observation Point

Observation Point	Latitude	Longitude	depth
(Chiba) Tateyama Banda	N 34.976983°	E 124.776783°	around 5 m
(Okinawa) Taketomi North	N 24.348500°	E 124.084667°	around 10 m
(Okinawa) Taketomi North-East	N 24.335083°	E 124.103333°	around 6 m
(Okinawa) Taketomi East	N 24.328483°	E 124.108833°	around 3 m
(Okinawa) Ishigaki Harbor South	N 24.322833°	E 124.169167°	around 8 m

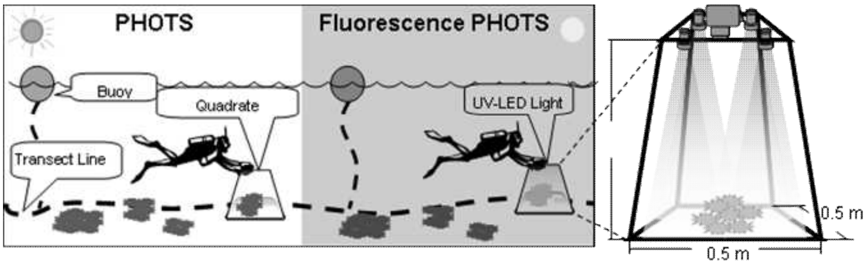

Figure2 Schematic of diving investigation by Quadrat method
and UV-Fluorescence Quadrat method

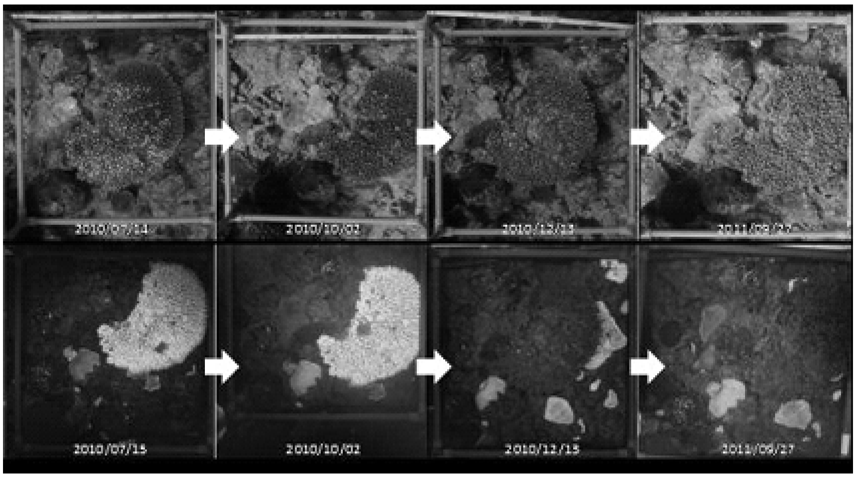

Figure3 Time transition of a coral colony (might die between Oct. and Dec. 2010)
(up: daytime quadrat photo, down: nighttime UV-fluorescence quadrat photo)

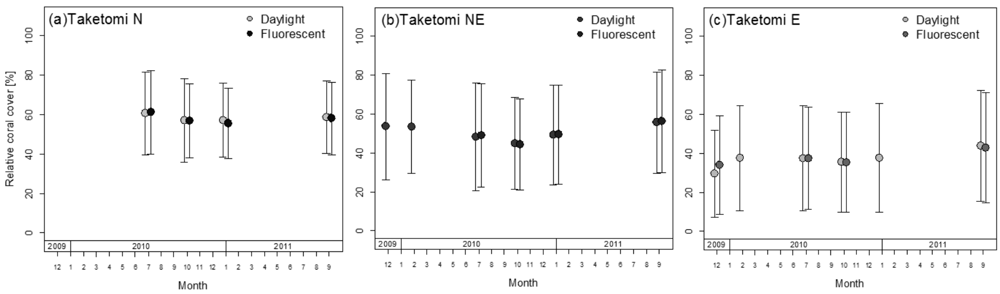

Figure4 Coral cover investigation results at the three observation points around Taketomi island
(left:Taketomi-N, center:Taketomi-NE, right:Taketomi-E)

(2) Boat-based observation for corals

① The imaging fluorescence lidar system has been developed and its performance has been evaluated at the Deep-Sea basin, NMRI (between 5.5 and 30 m depth) for both of fluorescence image observation and laser bathymetry.
② Coral monitoring by the ship investigation has been carried out by a glass-bottom-boat at Taketomi island, Okinawa, and the coral fluorescence images and depth data have been collected successfully.
③ Marine environmental data have been collected by shipboard CTD observation, such as depth, temperature, salinity, turbidity, pH level.

Figure5 The glass-bottom-boat at Taketomi island, Okinawa (left) and the overview of the imaging fluorescence lidar system installed on the glass-bottom-boat (right)

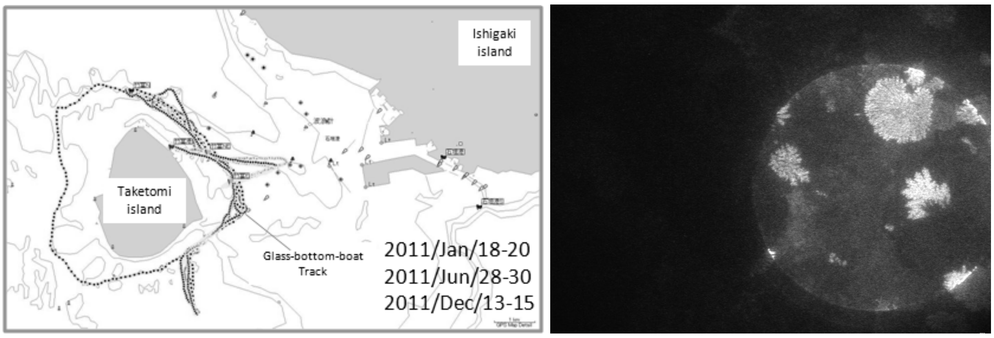

Figure6 Coral observation data by the glass-bottom-boat onboard imaging fluorescence lidar (left: plots of the lidar observation points along the glass-bottom-boat track, right: an example of the coral fluorescence image near Taketomi area)

(3) Remote-sensing of Corals using Satellite Images

① The cluster analysis procedure has been developed for both of 4-band multi-spectral satellite images (QuickBird and IKONOS) and 8-band multi-spectral satellite images (WorldView-2).
② The consideration has been carried out for estimate accuracy of bottom sediment using other method's coral monitoring data and GIS data unification.

Table2 Available high resolution satellite images for this project

Satellite	date	area	data
QuickBird	2009.06.01	Okinawa Ishigaki SW sea area	Multi-spectral image (4-band) 2.5 m resolution
QuickBird	2009.07.15	Okinawa Taketomi sea area	
IKONOS	2004.05.13	Okinawa Taketomi SE sea area	Multi-spectral image (4-band) 3.3m resolution
IKONOS	2007.07.21	Okinawa Iriomote E sea area	
IKONOS	2007.01.26	Okinawa Sesoko sea area	
WorldView-2	2010.01.16	Chiba Tateyama Sunosaki sea area	Multi-spectral image (8-band) 2.0m resolution
WorldView-2	2010.08.14	Okinawa Taketomi sea area	
WorldView-2	2010.10.02	Okinawa Taketomi sea area	
WorldView-2	2011.01.23	Okinawa Taketomi sea area	
WorldView-2	2011.08.24	Okinawa Taketomi sea area	

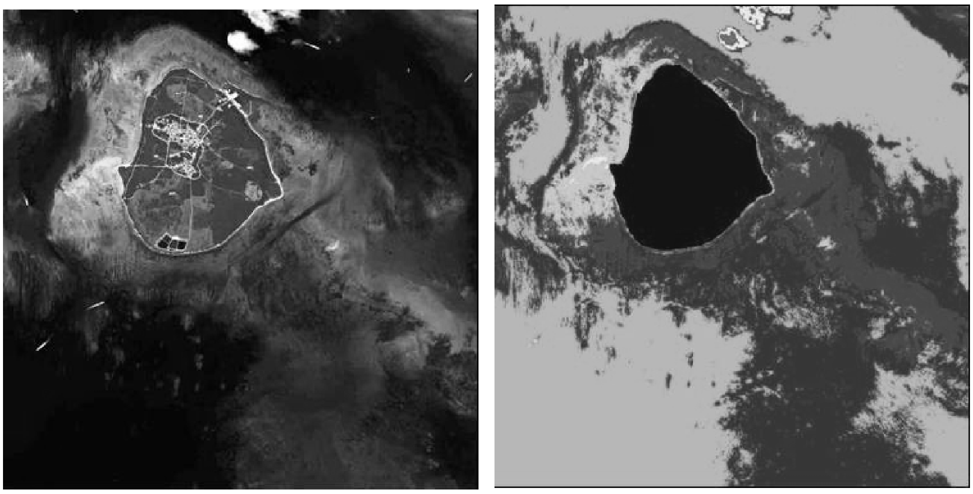

Figure7 High resolution satellite image by WorldView-2 (2010.8.14) (left), and the result of cluster analysis (right)

(4) Construction of Unified database system for Coral monitoring

① Data unification of the cooperative coral monitoring framework with diver investigation, ship-borne lidar observation and satellite remote sensing is built by the GIS database system.

② Other data are also unified to this system including GIS coral distribution data published by other institutes.

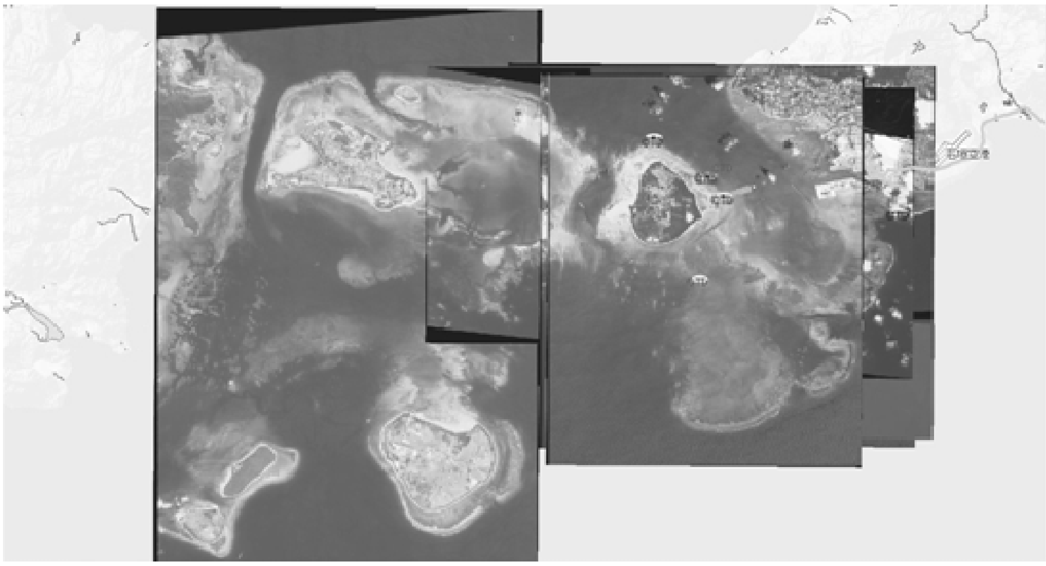

Figure8 The GIS based unified database system for corporative coral monitoring (diving investigation, boat observation, satellite remote-sensing, and others)

4. Discussion

The boat-based coral observation data can be linked to satellite GeoTiff images with comparative ease because the observing site is measured precisely by DGPS system. On the other hand, boat-based coral observation data can be linked to diving quadrat photo investigation with comparative ease because the coral colony image is recorded by the fluorescence imaging lidar system. So, the boat-based fluorescence imaging lidar system is useful for the cooperative coral monitoring network.

Reference

1) IPCC 4th assessment report (2007), working group I report http://www.ipcc.ch/publications_and_data/ar4/wg1/en/contents.html
2) Richard A. Feely,et.al, "Impact of Anthropogenic CO2 on the CaCO3 System in the Oceans", Science Vol.305. No.5682 (2004) 362-366.
3) IPCC 4th assessment report (2007), working group II report http://www.ipcc.ch/publications_and_data/ar4/wg2/en/contents.html
4) K. Hitomi et.al, "Monitoring of Oil Spill by the Helicopter-based Fluorescence Lidar", Journal of Japan Institute of Navigation, Vol.117 (2007) 143-150.
5) M. Sasano et.al, "Fluoerscence Lidar for Oil Spill Monitoring", Journal of the Visualization Society of Japan Vol.28 No.1 (2008) 9-14.