F-5.3.3 A Study on the Conservation Mechanism of Biodiversity in the Coral Reef by Archiving of Under-Water Images

Contact Person Akira Harashima
Head
Marine Environment Research Team
Global Environment Research Group, National Institute for Environmental Studies, Environment Agency, Japan
16-2 Onogawa, Tsukuba, Ibaraki 305-0053, Japan
Phone: +81-298-50-2508, Fax: +81-298-50-2569
E-mail: harashim@nies.go.jp

Total Budget for FY1997-1999 17,290,000Yen (FY1999: 5,704,000Yen)

Key Words Coral Reef, Biodiveristy, Stereo Image, Archive, Photogrammetry

Abstract: Growth of coral reef generates the secondary habitats and contributes to the sustaining of the biodiversity. We developed a method to make stereoscopic image archive to record and analyze this process. The method using a pair of under-water still cameras were applied on the permanent transects around Kuroshima, Yaeyama Islands. Another method, using a stereoscopic video camera was adopted to cover an area of some extent in Urasoko Bay of Ishigaki Island. Also, the method to process the stereo-pairs on PC was developed. These stereoscopic images effectively showed the importance of 3-dimensional spatial factors acting on the growth, competition, destruction and deterioration such as bleaching of corals colonies.

1.Introduction

Growth of reef-building corals forms the secondary microhabitats for the organisms and therefore makes the basis for the formation and sustainment of biodiversity. Various environmental stresses against the corals have been working inversely and recent worldwide deterioration of coral reef has lead to the loss of biodiversity[1]. Change of the coral colonies consists of the processes such as the recruitment, reproduction[2], inter-specific competition for space, light for symbiotic microalgaes and water flow[3] required for their survival. All of them are strongly characterized by the three-dimensional spatial factors. They are, however, difficult to be seen because their time scales are as long as years or decades. Therefore, we should develop the methods to overcome these difficulties, namely, to record systematically, to visualize and to analyze effectively. This technique may be termed "archiving the under-water stereoscopic images". In the preceding research program, we developed a method of archiving underwater images[4]. Australian Institute of Marine Sciences (AIMS) has tried to take the stereoscopic images for the photogrammetry of coral colonies [5]. We further developed this method by adopting recent techniques and applied to assess the change of the coral reefs of Yaeyama Islands, Okinawa, Japan.

2.Method

2-1 Hardware

Two methods were developed. One is to take stereo-pairs of still photo images repeatedly aiming at grasping the changes of identical colonies along the permanent transects.

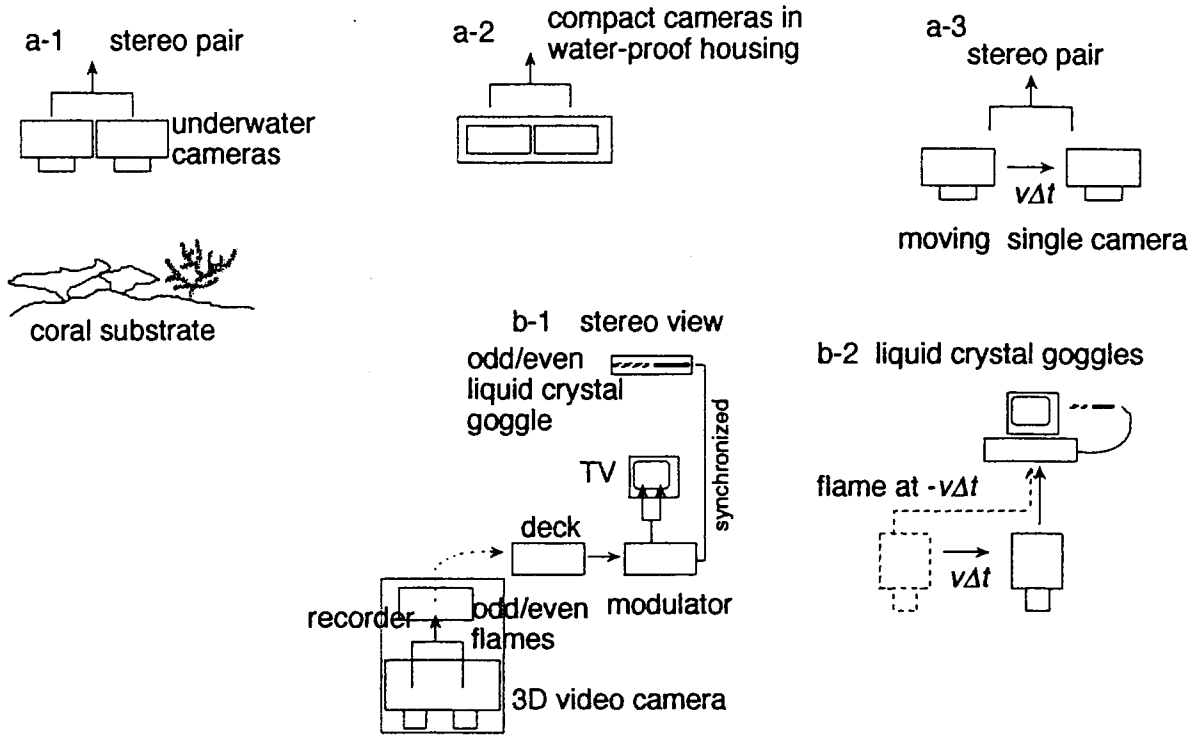


Fig.1(a) Method of taking under-water stereo images of coral reef

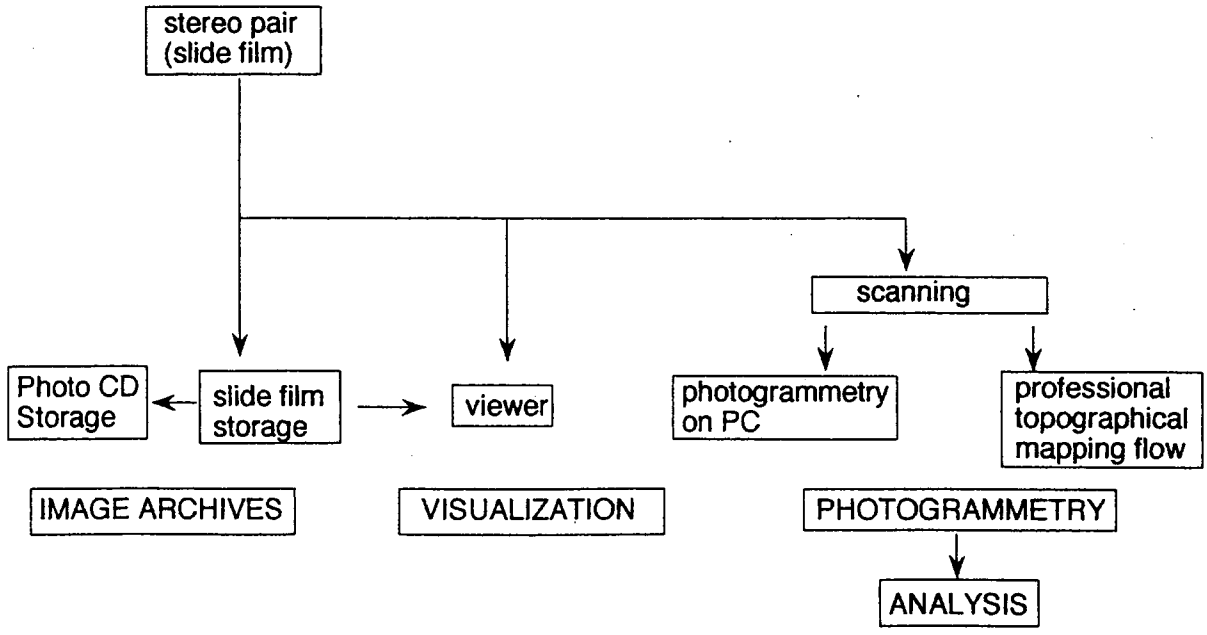


Fig.1(b) Flow diagram of archiving and processing under-water stereoscopic images of coral reef

Table 1. List of the contents contained in the under-water image archive. Images in the preceding research period (before October, 1996), images especially taken for asessing the effect of bleaching (at 03/July/1998 and at 12/Sept./1998) are not stereoscopic.

Y	M	D	Tr. North of Kuroshima Port											D	Tr. Anadomari											PCD No.
			05	10	15	20	25	30	35	40	45	50			05	10	15	20	25	30	35	40	45	50		
1994	10	10												10												0833
1995	7	5												5												0355
1996	1	22												22												4050
	4	18												18												4050
	7	4												4												4052
	10	18												18												2713
1997	2	25												25												4051
1998	1	22												22												3154
	7	1												2												4649,4650
	7													3												4650
	9													12												4650
1999	2	18												18												1292,1293
	7	7												8												3979
2000	1	24												23												0078,0079

Fig.2 Schematic diagram of a quadrat (1m x 1m x 0.5m) to be used as a reference for calculating 3-dimensional coodinates.

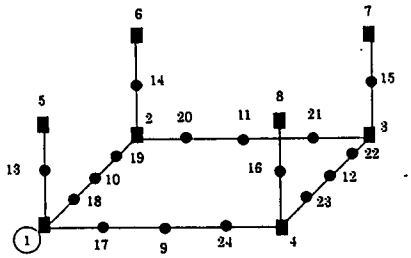


Fig.3 Location of quadrats in a transect.

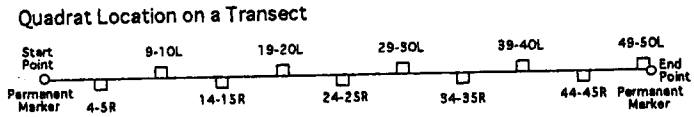
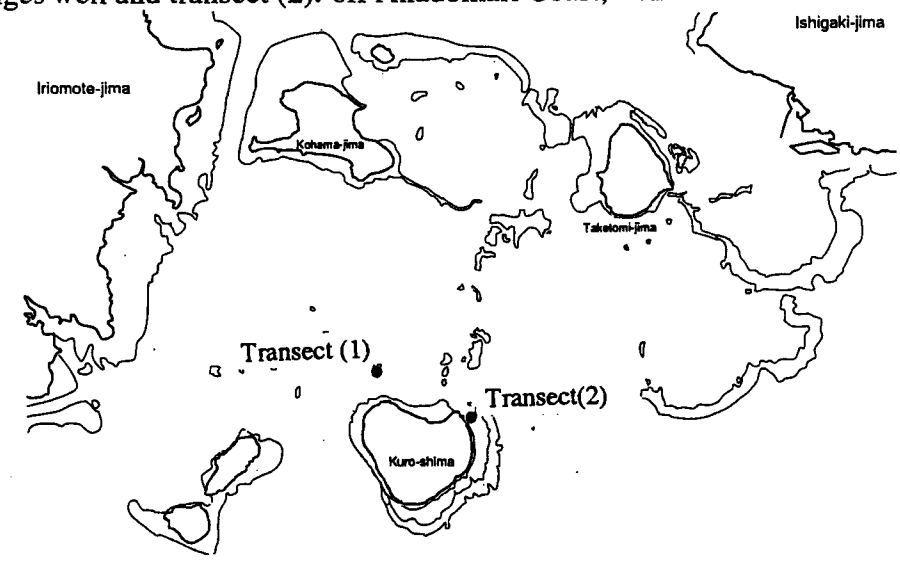


Fig.4 Location of transect (1): north of Kuroshima Port, a patch reef around which water exchanges well and transect (2): off Anadomari Coast, which is included in a fringing reef.



Among several selections (Fig.1(a)), method a-1, in which two under water still cameras (Nikonos-V, with UW-Nikkor f=20mm) are used, gave relatively good results. In case of using ordinary cameras contained in a waterproof housing (method a-2), some aberration appeared in the images because of the refraction and therefore it was found inappropriate for precise photogrammetry. However, the results of method a-2 seemed sufficient for visualization by a simplified stereo-viewer and would fit, for example, the extensive sampling by volunteer divers.

Another is to use the stereoscopic video camera (method b-1), aiming at covering an area wider than that grasped by a-1. Recently, a light-weighted stereoscopic video camera was developed and the results can be visualized by the combination of TV, a modulator and liquid-crystal goggles synchronized so that odd/even frame corresponds to left/right eye (or oppositely).

2-2 Field operations

We used a three-dimensional quadrat (Fig.2) for a reference to calculate the three dimensional coordinates from the stereo-pair obtained by a-1. Images were taken along the two 50m-long transects in the coral reef area among the Ishigaki Island, Iriomote Island, and Kuroshima Island (Fig.3). The transect (1), which is located at the north of Kuroshima Port, represents a patch reef with relatively good water exchange around it. The transect (2), off the Anadomari Coast, represents a patch reef within a fringing reef, where water exchange is relatively limited compared to (1). The date of sampling in the period (FY1997-2000) are listed in Table.1, together with those in the preceding research period (FY94-96).

Method b-1 was applied to the reef in Urazoko Bay of Ishigaki Islands by deploying the camera and GPS system on a glass-boat belonging to Ishigaki Research Station of Seikai Fisheries Research Institute. Cruising with a speed around 1 knot, an area of 1km x 100m was covered.

2-3 Archiving and processing

The stereoscopic images can be simply visualized from pairs of slide films. This makes it possible for plural investigators to discuss the diagnosis on three-dimensional structure and on long-term changes. On the other hand, original slide films were transformed to PCD files (a commercial-based Photo-CD format standardized by KODAK) and stocked as image archives for preservation.

Other than the PCDs, the slide films were scanned more precisely for photogrammetry because the four corners of the frame of the original film should be defined for this purpose, which is not sometimes fulfilled in the commercial PCDs.

The stereoscopic photogrammetry hitherto has been developed in the field of professional cartography. Recently, several PC-based softwares have become available for the general users. Among them, we tried to use ADIMS2, the results of which are shown in Fig.5 to calculate three-dimensional coordinates, values of coordinates at several points are required to be known. We use the values of the points defined by the corner of quadrat. The lower half of Fig.5 shows a stereo-pair of the under-water images including the above mentioned quadrat taken from the point slightly shifted from the right above the center of the quadrat. Defining a rectangular area in the left-handed image, autonomous stereo matching were done by the software by pattern recognition and the coordinates are calculated for each grid point (upper half). Also, the coordinates of the manually defined points can be calculated and a sample figure is illustrated in Fig.6.

3.Results

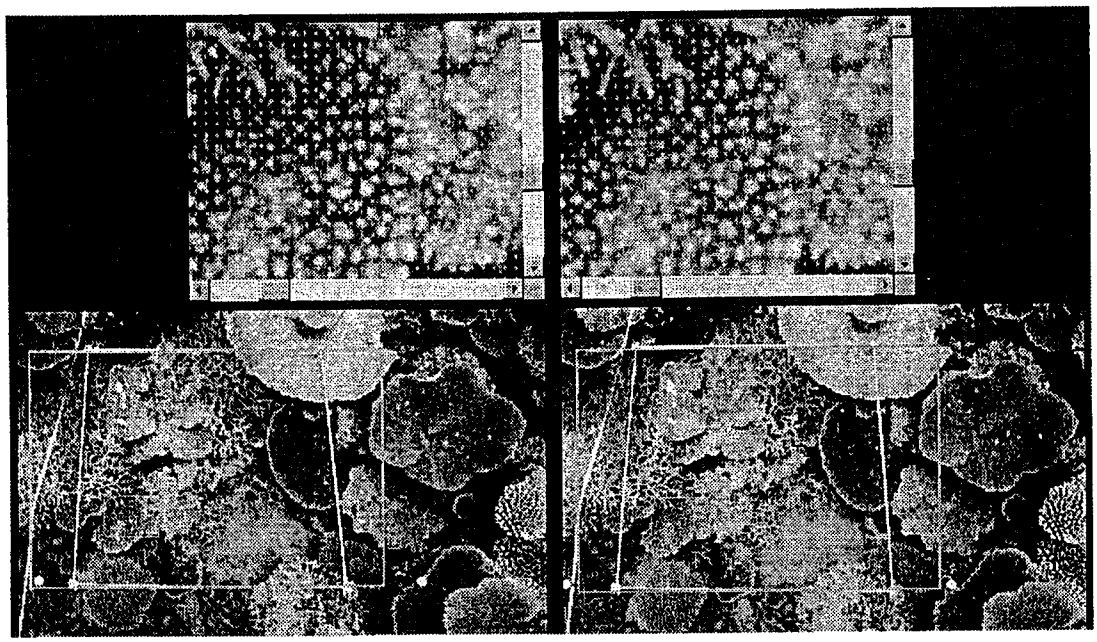


Fig.5 A stereo-matching on grid points (upper figure) defined on a rectangular area defined in a stereo-pair from under water image archive using a PC software ADIMS2.

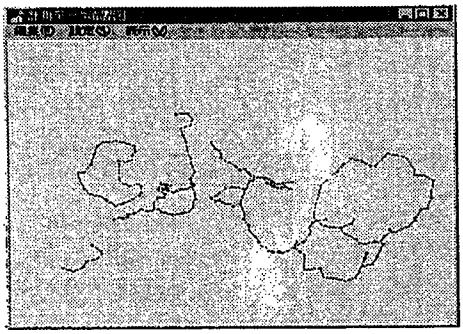


Fig.6 A point –string analysis on the identical stereo pair using a PC software ADIMS2. Points are specified manually.

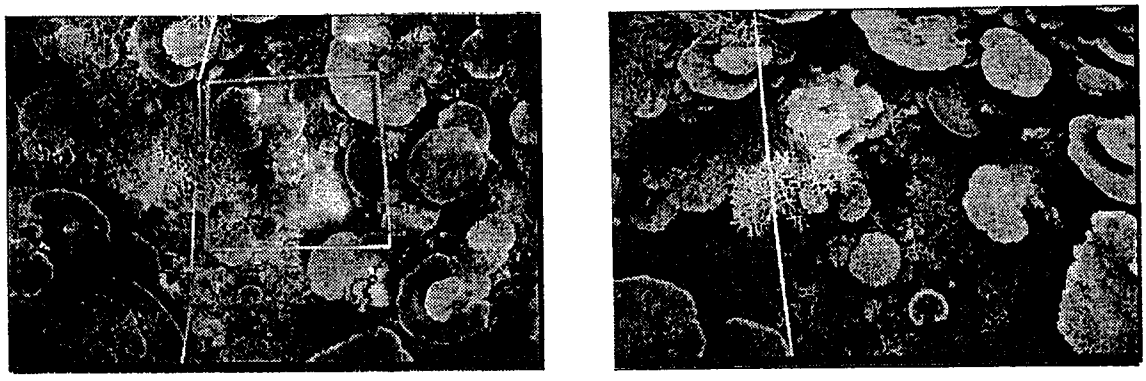


Fig.7 A sample from the image archive showing the coral reef before bleaching (left, 3/June/1998) and during the bleaching (right, 12/Sept/1998), courtesy of Yaeyama Marine Parks Research Station.

Visualizing the stereoscopic images ordered in a time-series of six years showed following diagnosis.

The growth of table-type *Acropora*, mainly *Acropora hyacinthus* (Dana), is quite fast and these species seem to make the action of shading other species such as *Favites* sp., *Porites* sp. a surviving strategy (exploitable competition).

On the other hands, table-type Acropora seems to be relatively vulnerable to the storm-induced perturbation and the inter-specific struggle (interference competition [6]).

In the summer of 1998, a large-scale bleaching and subsequent death of coral colonies occurred in because of the anomalous duration of fine days and lack wind mixing. The conditions of coral colonies before and during the bleaching are shown in Figs.7 (a) and 7(b), respectively, for a point in transect (2), which locates inside of the fringing reef. At the transect (1), where the seawater circulates relatively well, bleaching was less remarkable. This fact implies that the hydrodynamic factor is also important to the bleaching phenomena in addition to the factor of anomalous rise of water temperature. This seems also true for the deterioration of corals due possibly to some infection because it was more remarkable at the transect (2).

4.Conclusion and Remarks

It was confirmed that the three-dimensional factors in the process of recruitment, growth, competition and loss of coral colonies are crucial to the formation, sustainment or degradation of biodiversity in a time scale as long as years by developing and applying of the method of archiving of underwater stereoscopic images to the two transect in the coral reef area of Yaeyama Islands. Sampling of such images by this method should be continued to get a further long-term time series of to assess the ongoing mechanism to make the biodiversity of coral reefs increase or degradate.

Reference

1) Birkeland, C. (Ed.)(1996) Life and Death of Coral Reefs, Chapman & Hall, 536p.
2) Davies, P. J. and Hatchings, P. A. (1983): Initial colonization, erosion and accretion on coral substrate. Experimental results, Lizard Island, Great Barrier Reef, Coral Reef, 2, 27-35.
3) Denny,M. W. (1988) Biology and the Mechanics of the Wave-Swept Environment, Princeton University Press, 329p..
4) Harashima, A. and Kunugi, M. (1997) The Ocean's Role and Marine Pollution, Shokabo Publishing Co. Ltd., 181p. (In Japanese).
5) Done, T. J.: Proc. Fourth International Coral Reef Symposium, 315-320(1981) "Photogrammetry in Coral Ecology: A Technique for the Study of Change in Coral Communities"
6) Connel, J. H.(1983): On prevalence and relative importance of interspecific competition: Evidence and field experiments, American Naturalist, 122, 661-678.