D-4.3.1 Studies on the Changes in the Coral Reef Environment by Archiving of Under-Water Images

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Abstract: Methods for monitoring the long-term changes in the coral reef ecosystem were developed by taking underwater images and archiving them. Image sampling was done in two ways: A. accessing to the fixed points with quadrat of 1m by 1m and B. ship survey with still and video cameras in a water proof housing for the extensive coverage over the coral reef area. The raw images from still camera, where the quadrat are not always expressed as a square, were digitized and contained in Photo-CDs. Then a geometrical correction algorithm was developed to obtained the normalized images so that the quadrat was transformed to the square. The video data were also digitized by a video capture software. Furthermore, available underwater photographs in the past were collected and processed to CD-ROM archive. The archive thus generated will contribute to the coral reef environmental managements.

1.Introduction

In recent years, the health of coral reef ecosystem has been of great concern in terms of several issues[1]: the destruction or deterioration by human impacts, the relation between the global warming and the coral reef change such as bleaching phenomena or possibility of drowning of corals due to sea level rise and the conservation of biodiversity as the oceanic version of tropical rain forest issue. Therefore, it is an urgent problem to establish an efficient method to assess the present state and the long-term variation of coral reef ecosystem. Nowadays satellite has become an efficient tool to grasp the phytoplankton distribution of wide areas. However, its spatial resolution is not sufficient to estimate the necessary information on coral reef qualities. To use the underwater images is more informative and therefore, to obtain and preserve the underwater images systematically is effective. We developed the two serieses of obtaining underwater images[2] and process the images as shown in the nest section.

2.Method

2-1 Underwater Image sampling

Fig.1 shows the flow diagram of image sampling and the data processing to generate image archives. In method A., we take photographs of the points with quadrat in the line, whose length is 50 meters and shown by the markers fixed by in-water cement in both sides.

We designed a continuous image sampling equipment composed of the still and video cameras contained in a water proof housing for Method B.(Fig.2). This housing is contained inside a small vessel, which is attached in the hull of a ship. Watching the monitor of the video, the observer sails slowly at the speed of around one knot over the coral reef area. The shutter of still photo is triggered by a key of the PC. The latitude and longitude from GPS and the depth

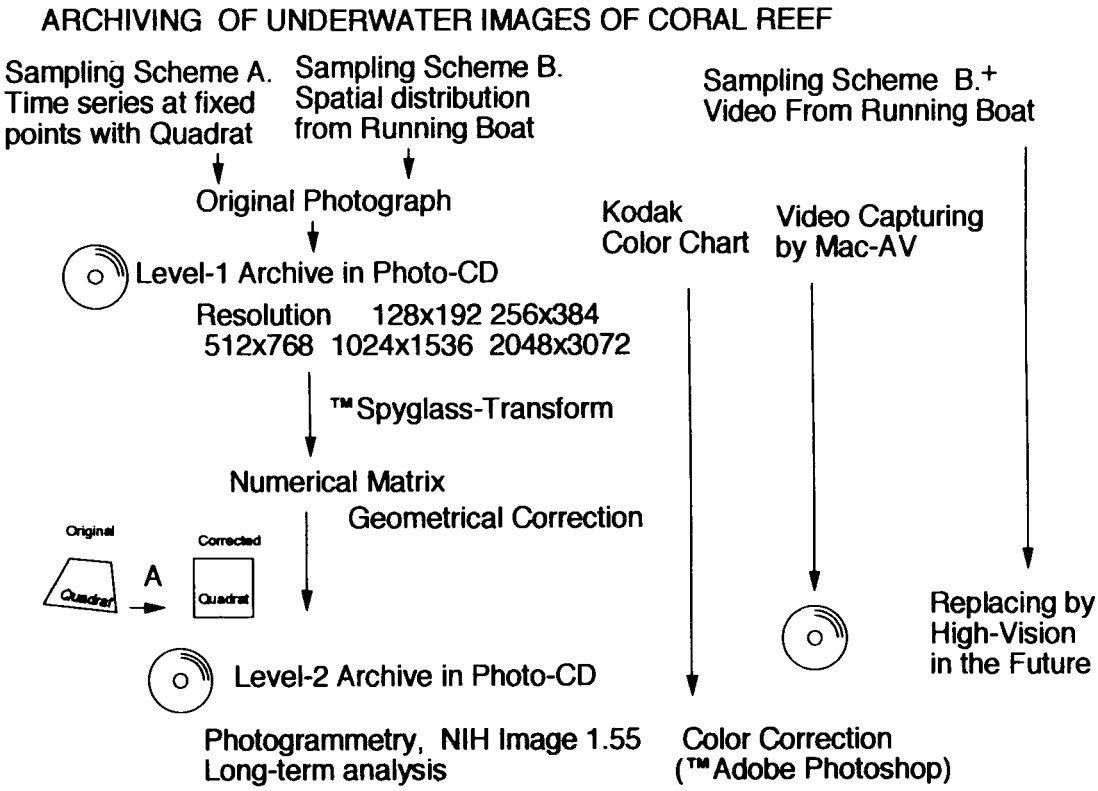

Fig.1 Flow diagram of under-water image sampling and image data processing

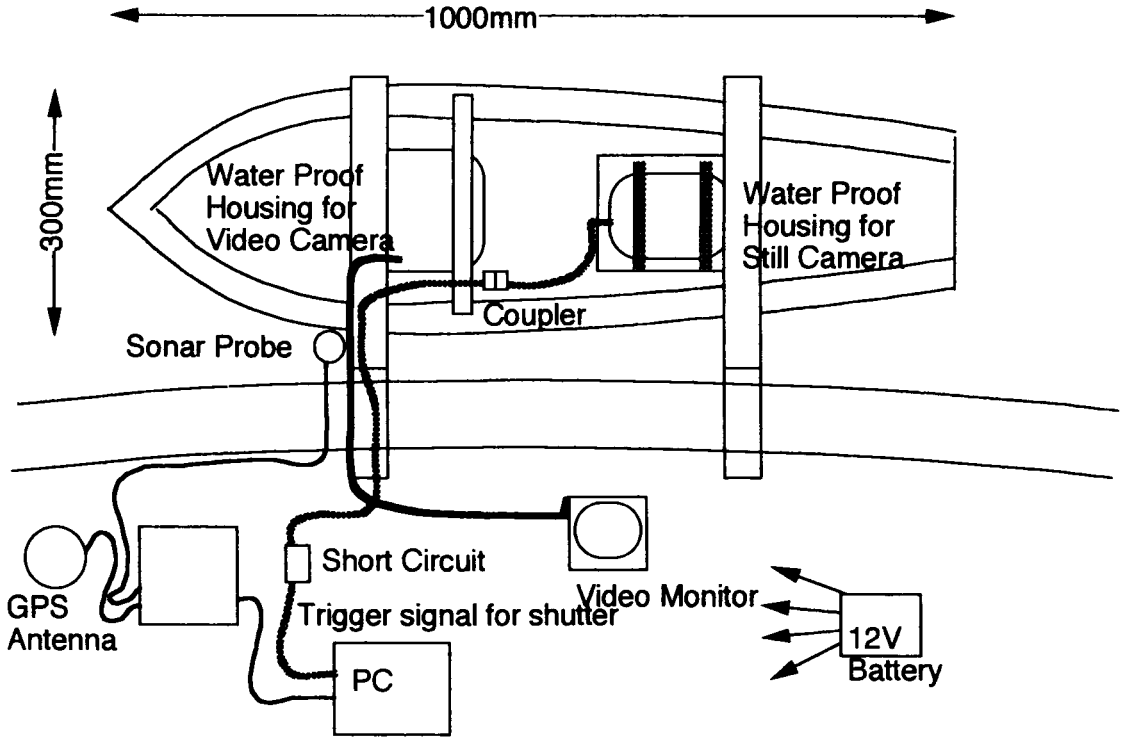

Fig.2 A schematic diagram of the equipment for method B.

signals from a sonar are recorded in the PC in the same time. It is not possible to take the course on the identical coral colonies repeatedly from the present GPS because the preciseness of latitude and longitude from the GPS that we used is 0.01min (around 20m). Therefore, the data sampling by Method B. may be regarded as random sampling. Revising the method to include the differential type GPS, whose accuracy is within 1m, will make it possible to make access to the identical coral colonies in the future.

It should be considered how to prepare in the stage of field sampling to normalize the raw images into the archive on which inter-annual comparison or the trend analysis will be based. To put the quadrat in the scene will help the geometrical correction. Strictly speaking, the radiometric correction in the satellite data managements may be required in our under water image archive. The intensity and the spectrum of under water light condition depend on the insolation condition, dissolved matters, particulate matters and the wave condition. Furthermore, the characteristics of raw pictures depend on the difference in the films and development condition. Therefore, we include the color test chart produced from Kodak in the scene at the rate in one shot per one film. To correct the color in the photo-retouching process using the software such as Adobe Photoshop® will function as a radiometric correction, although such a process is not done in the present data processing shown in the next section.

2-2 Data processing

The raw still photo from Methods A and B were digitized and contained in CDs in Kodak Photo-CD format as Level-1 data. The video data were also digitized by a video capture software (Adobe Premier®) and contained in CDs.

In Level-1 data from Method A, the quadrat is not necessarily expressed as a square because the camera was not always right above the object. We developed a Macintosh-based software in C-compiler for geometrical correction, *i.e.*, a transformation so that the quadrat is expressed as a square in the corrected image in Level-2 data. Within this data flow, the conversion from Kodak Photo-CD format to numerical matrix for the calculation was carried out by Spyglass Transform®.

In addition to the raw images taken in 1994-1996, we collected the past underwater photos taken in the investigation by Marine Parks Center (a nonprofit private organization) under contract with Environment Agency of Japan and created an archive of geometrically corrected images.

3.Results

Fig.3 shows one example from the archive: the yearly variation of identical coral colonies in the period of 1990-1992, which corresponds the stage the newly recruited coral colonies began growing after the large scale damage from crown of thorn starfish (*Acanthastrea Planci*). It was demonstrated that the planar growth of a tabletop *Acropora* sp. was relatively rapid and this colony seemed weaker in the competition with the smaller colonies in the right-bottom corner. In the other time series for the period 1994-1996, which is nearly in quasi climax stage, the planar growth of colonies seemed slower. The photogrammetric techniques can be applied to these images and the discrimination of coral colonies to the level of genus or class was possible depending the condition of the original photos.

4.Conclusion and Remarks

It was demonstrated that the flow that consists of the under water image sampling and data processing is the best possible way to generate the archive, which will be effective in analyzing the long-term trends of coral reef deterioration. However, individual processes should be constantly revised owing to the rapid developments in video and computer-aided imaging technologies. For example, it may be appropriate that the present combination of still and video cameras in Method B. is replaced by the hi-vision video system in the future. And it may be

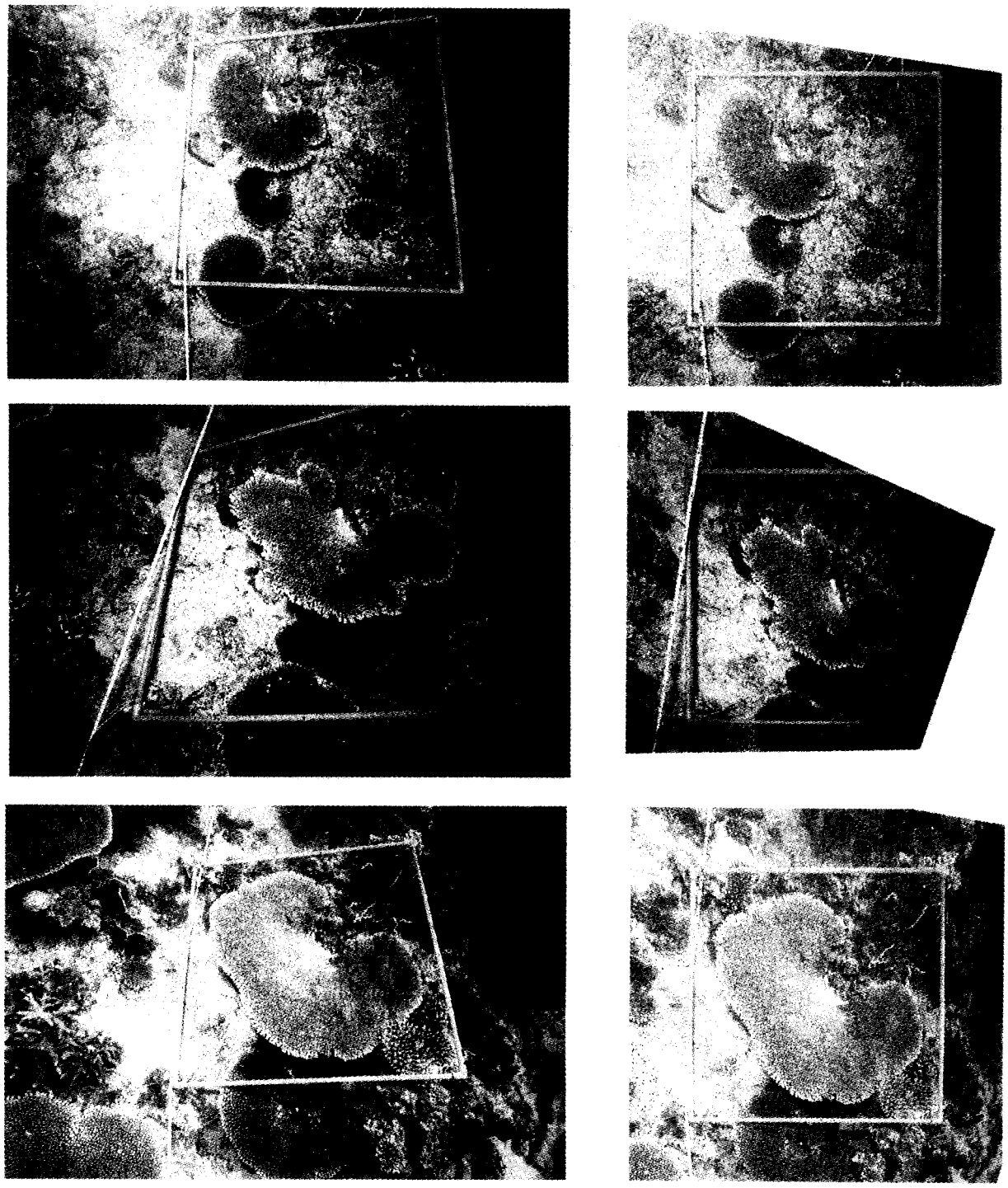

Fig.3 Time change of coral colonies in the period 1990 - 1992,. Images in the left and right hand sides are original and the geometrically corrected images, respectively.

more fruitful to introduce the stereo photo system to the Method A. Our method basically hold robustness and generality and we believe that it will fit the monitoring and archiving in organization-based coral reef environmental managements[4),5)].

Reference

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