A PHOTOGRAMETRIC APPARATUS FOR RAPID AREAL BENTHIC SURVEYS

Done (1981) described a transect line and diver-operated photographic device for rapid data acquisition in coral reef habitats. The design was modified and used to sample Florida reef coral populations. The apparatus consists of two Nikonos cameras with 28 mm focal length lenses, two electronic strobes with connectors and wiring, a bubble spirit level, and a tubular aluminum frame to mount the cameras and strobes. During deployment, a fiberglass tape measure is extended across the sea floor for reference. Photographs are taken at 50 cm to 70.5 cm intervals along the tape to create a series of overlapping photographs. Cameras are maintained in near perpendicular reference to the sea floor by the bubble level. The tape image in each photograph aids in determining object size and ordering the photographs.

INTRODUCTION

Quantitative studies of marine benthos have progressed from early descriptive accounts by scientist-naturalists to very precise detailed studies utilizing esoteric equipment expressly designed to accomplish the task. Some important advances that provided scientists new tools or methods to evaluate benthic communities include a multitude of studies, a few of which are summarized in the following account. Wahlenberg (1812) described algal community zonation patterns along the northern coast of Norway. Henri Milne Edwards (1845) used a commercial diving suit to investigate the coast of Sicily to depths of 25 ft. Lorenz (1863) described the physical relationships of wave energy, salinity, temperature, tide, light, and substrate to organism distribution in the Gulf of Quarnero, Adriatic Sea. Algae of the Gulf of Naples were studied by diving (Berthold 1882). Dahl (1893) was the first marine scientist to quantitatively census a bottom community. Ekman (1911) and Petersen (1912) developed sampling devices of a standard volume size to sample soft bottom habitats. A light weight diving helmet system was developed and used to investigate shallow areas: quantitative evaluation of octocoral contribution to reef building (Cary 1918); investigation of coral reefs in the Galapagos Islands and Haiti (Beebe 1926, 1928). Mayne (1918) advanced the use of quadrat frames for density censusing in rock bottom communities. Mayor (1918) introduced the method of measuring 50 x 50 ft quadrats, subdividing the area, and counting the individual corals, gorgonians, algae, and holothurians in coral reefs. Torsten Gislen (1930) is recognized as one of the pioneers of undersea quantitative benthic investigations. Gislen conducted a remarkable study of Gullmar Fjord, including diving quantitative biomass collections. He also developed a wooden camera case to photograph the sea floor. The camera was
lowered from a boat and triggered by wire from the surface; it could be deployed to 25 m depths. Diver operated cameras were deployed to photograph fish in coral reef habitats at Dry Tortugas (Longly and Hildebrant 1941). Quantitative non-area sampling methods utilizing a transect with continuous, point intercept, or nearest neighbor data acquisition were introduced to coral reef studies by Loya (1972, 1978). Photographic sampling of coral reef habitats includes work by Laxton and Stablum 1974, Ott 1975, Done 1981, Jaap 1983 and 1985).

In an evaluation of various methods (quadrats, transects, and photography) used to sample reef corals, Weinberg (1981) reported that the photographic transect was an accurate and efficient method to sample this reef component. Done (1981) developed a device that permits rapid photography of transects. Done reported that the two principal advantages to his device were rapid data acquisition and creation of an accurate record. The method was developed for stereophotography or photogrammetry which creates matched pairs of photographs. These provide improved detail resolution, three-dimensional perspective, and a means of determining shape and dimension of objects at different distances from the camera focal plane.

**METHODS**

Using Done's design as a model, we fabricated a stereo photographic apparatus from the following components. Two Nikonos cameras with 28 mm lenses (Nikonos III), an underwater light meter (Sekonic II), two electronic underwater strobes (Ikelite Substrobe M), wiring and connectors (Ikelite Nikonos adapters and sync cords), aluminum frame, and a spirit bubble level. The camera frame consists of a side directed "U" with a long vertical axis and shorter upper and lower horizontal members (Figure 1). The frame is constructed of one inch (25.4 mm) square tubing with 1/8 inch (3.1 mm) wall thickness, joined by heliarc welding. The vertical element is 127 cm high, the upper horizontal arm is 49.5 cm long, and the lower horizontal arm is 33 cm long. The upper horizontal arm has a Nikonos camera bracket welded in a "T" configuration on its end. The camera bracket is constructed of 1.6 mm thick aluminum sheet metal. The bracket is 47 cm long and 35 mm wide; edges of the stock are bent 90 degrees for added rigidity. Nineteen mm diameter holes are drilled in the bracket for mounting cameras and attaching strobe connectors.

Figure 1. Stereo underwater photographic apparatus. Nikonos cameras are attached to horizontal plate with strobe connectors and a 0.25 in. stainless steel bolt. Inset at upper right details the bubble level attached to the lower leg.
An 11 mm diameter bar 47 cm long is welded 8.9 cm behind the camera bracket; the bar is welded to the horizontal frame member and to the camera bracket ends with connector plates similar to the bracket material. Two rods, each 12.1 cm long, are attached to the long bar with 90 degree apparatus bar connectors. The two rods have 3.1 mm flat stock welded on one end with a 15.9 mm hole for mounting the strobes. A 3/8 inch diameter stainless steel bolt 27.3 cm behind the camera bracket is used to mount the light meter bracket to the apparatus. The lower horizontal element is constructed of 15.9 mm solid aluminum bar stock with a 90 degree bend. The bar fits inside the vertical aluminum tube component and is held fast with a thumb screw. An aluminum plate 10.2 x 5.1 cm is bolted to the other end of the lower horizontal member. A spirit bubble level is attached to the plate with epoxy cement.

The apparatus can mount two Nikonos cameras for stereo photography or a single camera with 15, 20, 28, or 35 mm focal length lenses. In shallow water with high transparency, it is possible to photograph with available light.

During deployment, a fiberglass tape measure is extended between two or more reference posts driven into the sea floor. The tape is kept as close to the bottom as conditions permit. A slate with specific data identifying the site is placed at the beginning of the tape and photographed for reference. The photographer sets the lens at 3.5 ft (1.1 m) focal distance, with the strobe illumination, the speed is 1/60 of a second, and the f / stop is set according to the film ISO-ASA number.

Photographs are taken at 0.5 to 0.75 m intervals along the tape. Closer distances create greater photograph overlap which is often useful in creating a mosaic from the photographs. Aligning the apparatus is governed by the spirit bubble level. When the bubble is within the target circle a near perpendicular film frame in reference to the bottom is assured. The photographer exposes both photographs simultaneously to create the stereo pair. The system produces photographs (with 28 mm lens) which include approximately 1 m by 0.75 m of sea floor.

The tape and a proof sheet are used in placing the photographs in their correct order. Data are processed with a digitizer to determine the surface area and relationships of the benthic components.

**DISCUSSION**

The system works well in calm to moderate wave surge and currents. In heavy wave surge and currents it is difficult to position the apparatus in a perpendicular plane to the sea floor. In areas where there is a canopy and understory community, it is virtually impossible to obtain photographs of the understory components. For example, in patch reef communities with dense octocoral populations, the benthos close to the seafloor is masked by octocoral colonies. In cases where the canopy and understory problem exists it is best to photograph and ground truth map the site with a quadrat frame. In areas with complex surface heterogeneity and numerous vertical aligned formations, photographs do not provide an adequate sample of vertically attached benthos. The use of maps or alternative photographic angles are solutions to sampling these habitats.

**LITERATURE CITED**


