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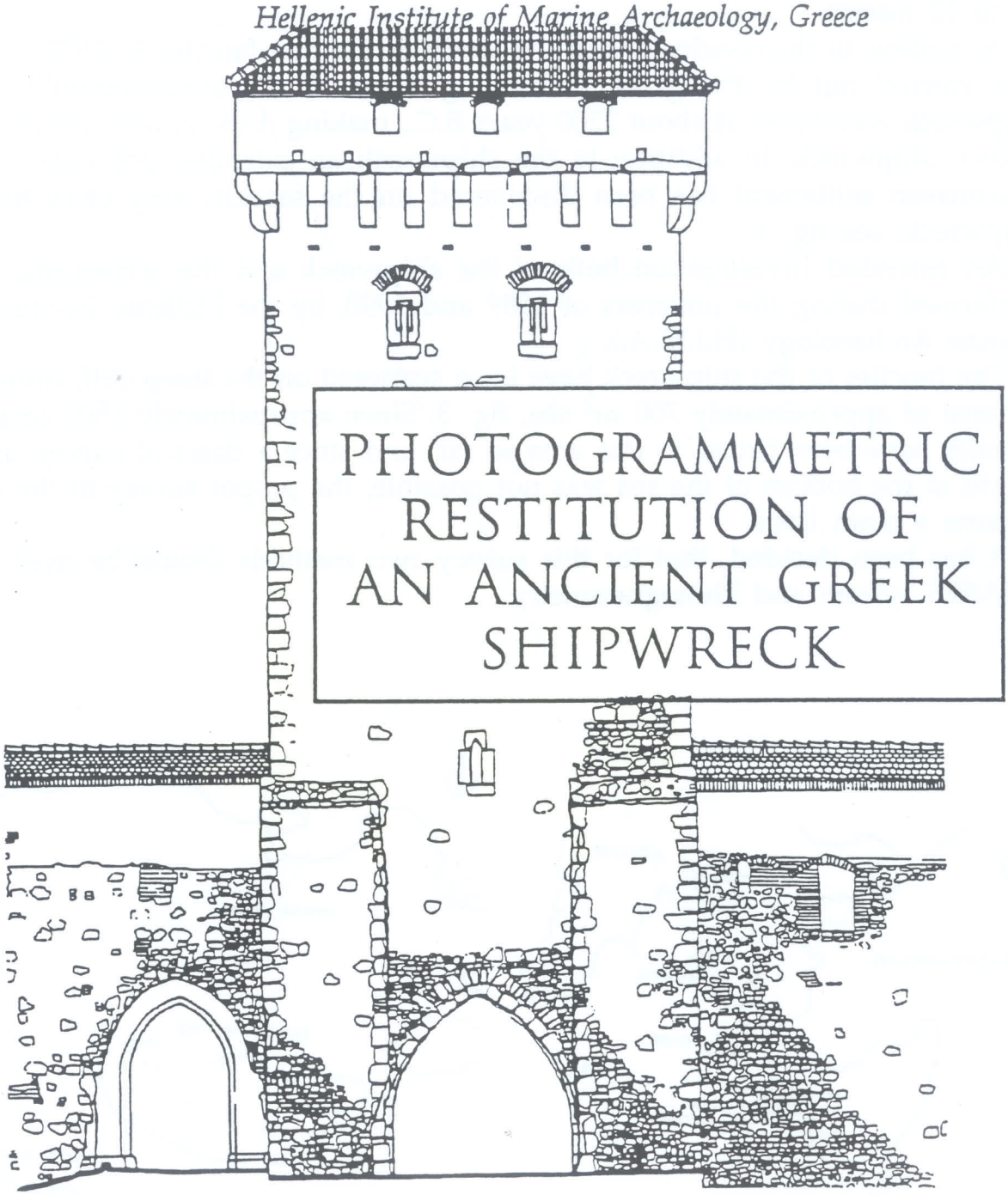

PHOTOGRAMMETRIC RESTITUTION OF AN ANCIENT GREEK SHIPWRECK

CIPA XIII INTERNATIONAL SYMPOSIUM
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1. INTRODUCTION

In 1975 American Peter Throckmorton, who was living on his boat exploring the greek sea, has located an ancient shipwreck very close to the shore of Dokos island.

Dokos is a small, almost uninhabited island, at a distance of 42 n.miles south of Piraeus, between the island of Hydra and the east coast of Peloponnesus, see fig. 1. The shipwreck is spread on a steep cliff at a depth, that varies from 15 to 32 meters.

According to the conclusions of the study of the first fauciles in 1975, which was carried out by the greek archaeologist mr. G. Papathanasopoulos, the shipwreck was dated at about 2200 years B.C., making it the oldest world-wide known shipwreck. In addition to the shipwreck an extended prehistoric and Mycenaean settlement has been discovered on the seaside, very close to the shipwreck, see fig. 2.

An extended investigation both of the shipwreck and the settlement, was performed during the summers of 1989 and 1990, by the Hellenic Institute of Marine Archaeology (H.I.M.A.).

The fauciles of the shipwreck have been scattered on the steep cliff, covering an area of approximately 700 m^2 sèe, fig. 3. Since approximately 1500 ceramic fauciles have been found in this area so far, and since a classical survey using a grid at the bottom of the sea was not possible, the proper survey of the area became a main issue.

It has been decided, that for this survey two methods should be used; the SHARPS system and Photogrammetry.

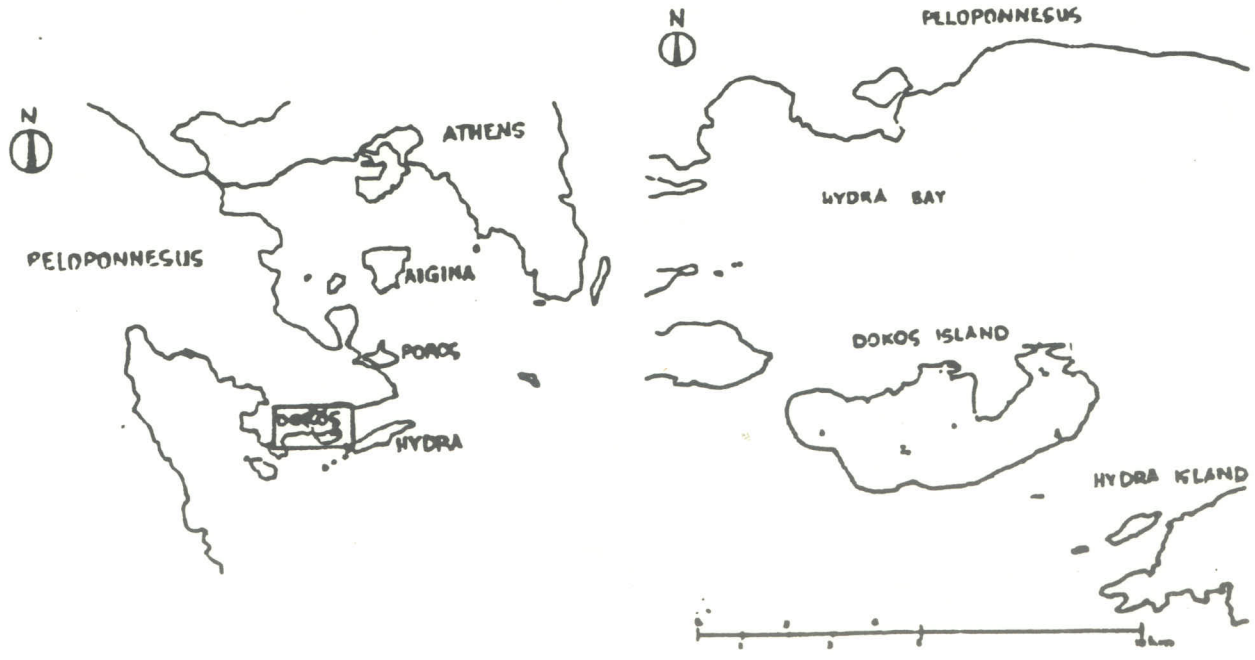

Fig. 1.

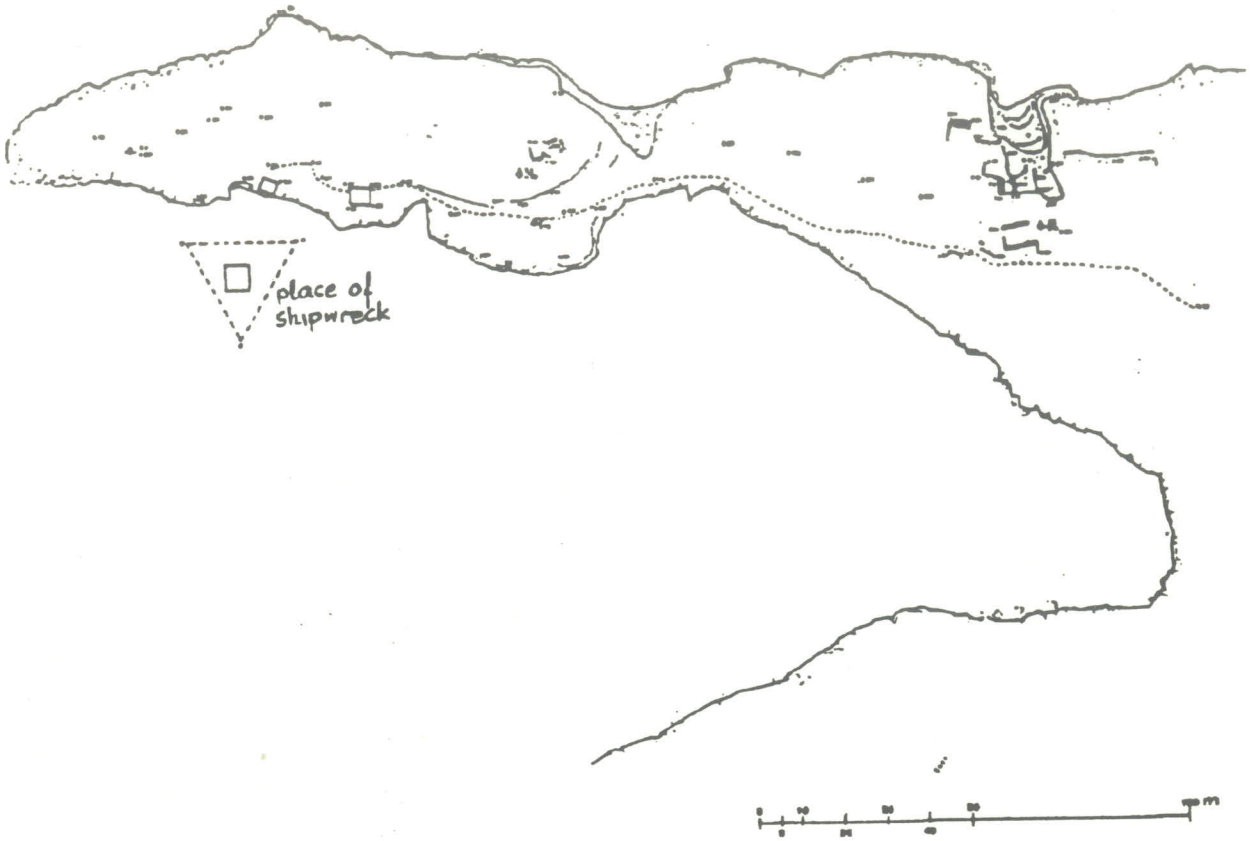

Fig. 2. Surveing map of part of the Dokos Island near the site of the shipowreck (by Kasmiakis Surveyor Eng. for H.I.M.A./Sept. 1989).

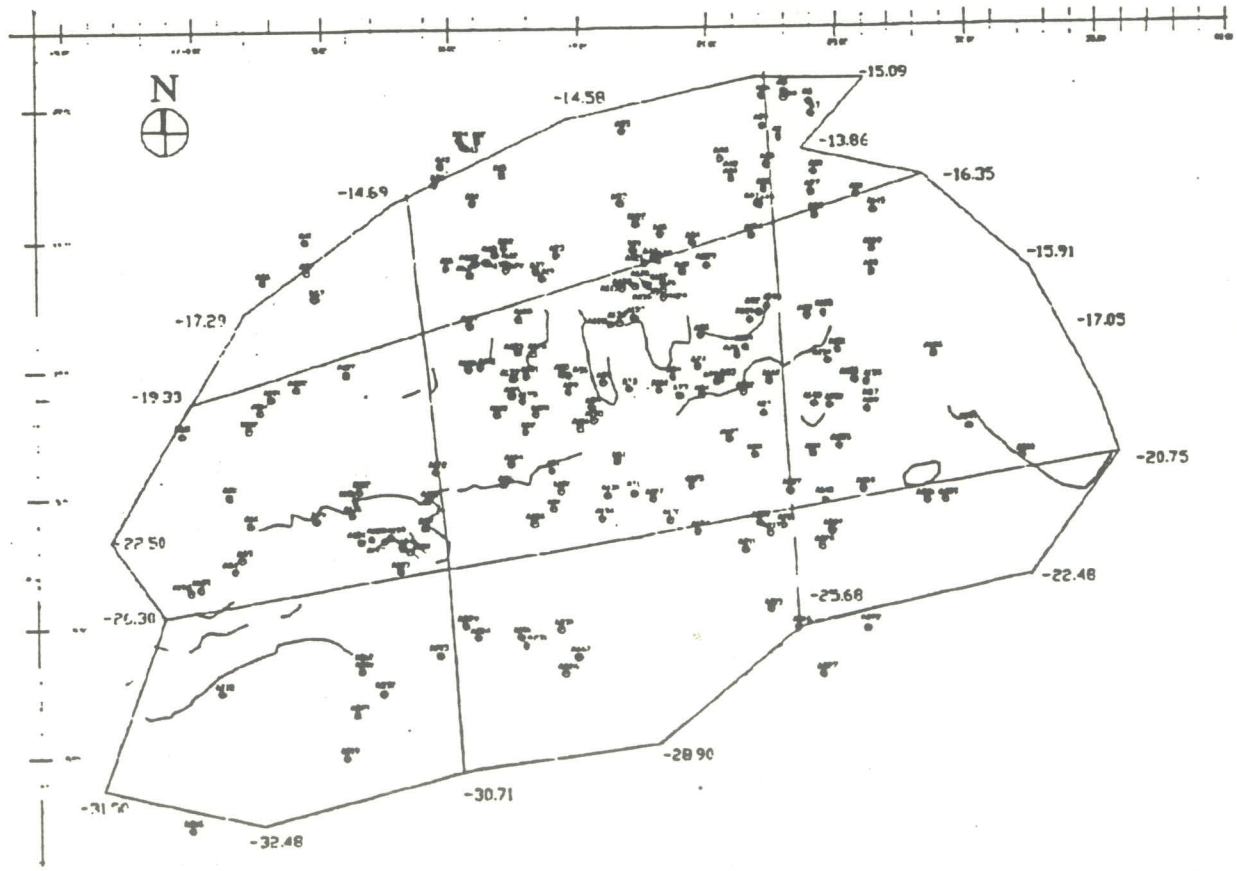

Fig. 3. Surveing of the site of the shipowreck with the groups of fauciles (by H.I.M.A./Sept. 1989).

2. THE SHARPS SYSTEM

SHARPS is the acronym for Sonic High Accuracy Ranging and Positioning System. This is a sonic system of Marine Telepresence Firm and is composed of four transmitter-receivers supported by a computer of at least 640 KB RAM, hard disk, mathematical coprocessor 8087 and graphics screen. The transmitter-receivers are connected with the control unit and through that with the computer, with wire up to three hundred meters.

Three of these are fixed on the bottom of the sea (see fig. 4) in a distance not longer than 100 meters from each other. They function as receivers of audial waves, which are sended from the fourth either automatically with a rate of 10 signals per second or manually with a special trigger. The fourth transmitter is carried and placed by the diver at the points to be measured, see fig. 5. The position of these points are calculated, in a local coordinate system, according to the time needed for the sended signal to reach the three fixed receivers. Simultaneously the diver transmittes, through underwater communication, the code number of the point to the user of the system who stays at the coast. To define the local system, the measurement (with a tape) of the distances between the three fixed receivers is needed. Also, their vertical distance from the bottom is measured.

The sharp inclination and the local relief of the surface of the bottom at the area of the shipwreck have caused special problems and restrictions to the settlement of the three receivers of SHARPS. The optical connection between

Fig. 4. Settlement of a SHARP transmitter-receiver on the bottom of the sea.

Fig. 5. Coordinate measurements of a point with SHARPS system.

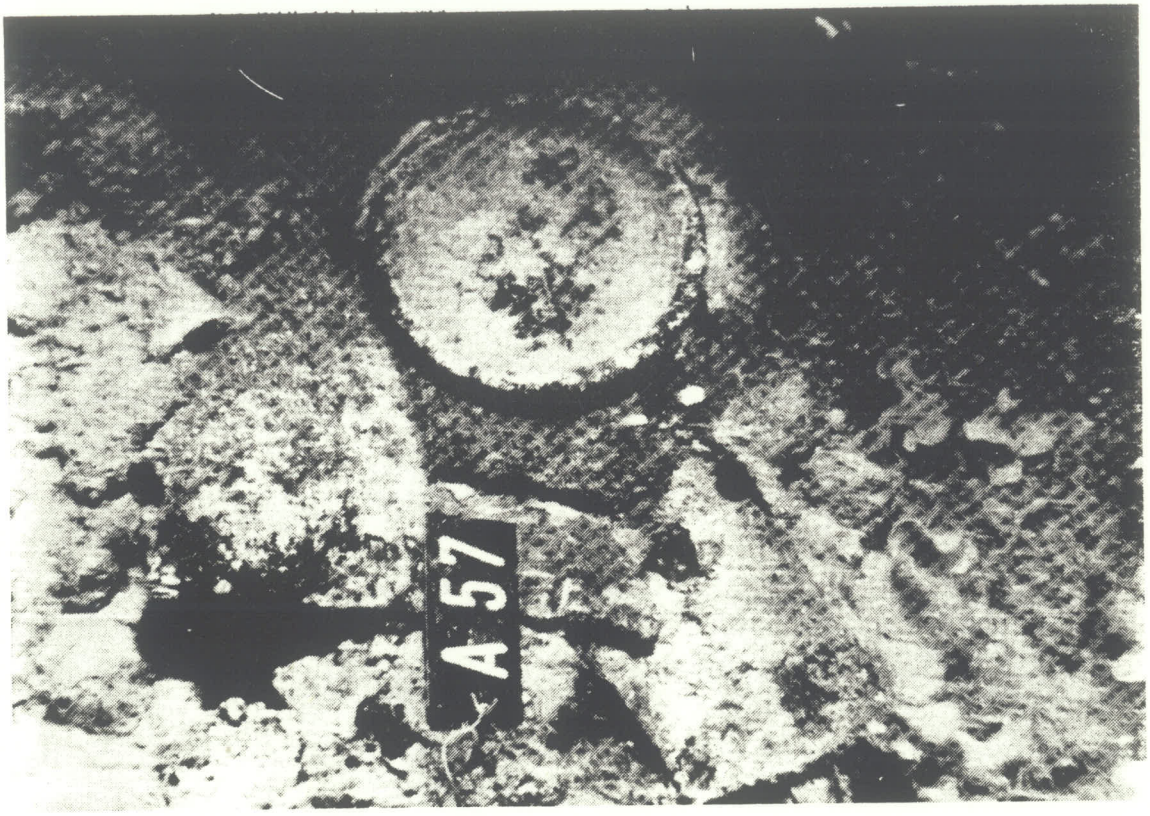

Fig. 6. Group of faucilites, with code number A57, atthe bottom of the sea.

them and the sender at each point to be measured, is necessary. It can be considered that those difficulties have been faced with success during the first period of research, summer of 1989. The products were topographic plans of the area of the shipwreck with the positions of the groups of fauciles. A general plan can be seen in fig. 3. and a particular group of fauciles in fig. 6.

3. PHOTOGRAMMETRIC SURVEY

Since SHARPS was going to be used for the first time in underwater archeology and its accuracy and reliability were unknown, a stereophotogrammetric restitution was decided to be used. For that purpose a special system for underwater photography was designed and constructed. This system consists of:

a) a special camera

b) a special camera mounting

The camera used was an ordinary 24 × 36 amateur camera SLR NIKON F3 with a 35 mm lense, in a waterproof case IKELITE with DOMEDORT, see fig. 7.

The camera was used with B/W KODAK T MAX 400 ASA film and the final results can be considered as satisfactory.

The camera mounting consists of three frames A, B, C, see fig. 8.

Frame A is an orthogonal one 5 × 2 meters lying on four poles of changeable height allowing the frame to be placed horizontally over inclined or relieved surface of the bottom of the sea. Frame B is approximately a 2 × 1 meter frame

Fig. 7. The special camera in underwater action.

and it is sliding on the A frame along its long side. It carried the C frame on it, which is of approximately 1 × 0,5 meters size and it carries the camera, which is fixed in the middle of this frame. The camera can also slide along the long axis of the C frame. With this system photography of all the area underneath the frame A can be held.

It has been decided that the photographs should be taken with natural lighting from a distance of 2 meters which gives a photograph of an average scale of 1 : 6. By defining also the forward overlap as 60% and the side overlap as 25%, which is the usual case in aerial photography, the total number of photographs that cover stereoscopically the A frame or the equivallent area of 5 × 2 meters is 15. That is, 5 sets taken along frame A; each set consists of a triplet of photographs taken along frame B (3 × 5).

This system has been proved quite successfull in practice, since only during the summer of 1989 a number of 19 frames of 285 photographs have been completed.

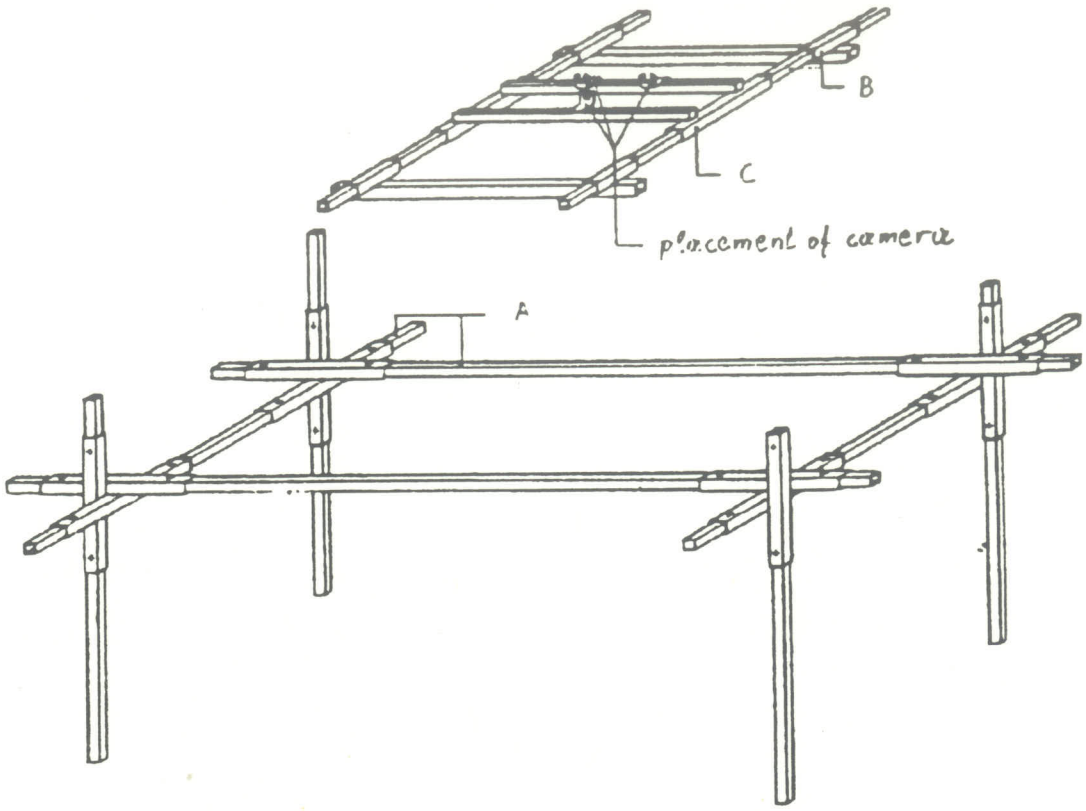

Fig. 8. The design of the special camera mounting.

4. PHOTOGRAMMETRIC PRODUCTS

The completion of the photogrammetric part comprises several problems. Besides the production of mosaics which may contain some deficiencies (see Fig. 9), the rigorous stereophotogrammetric restitutions also deserve special care. The Photogrammetric Laboratory of National Technical University of Athens has designed a procedure for:

— accurate camera calibration using a specially designed pair of metallic canvas as a test field,
— definition of known coordinates points on the bottom of the sea; two kinds of structure have been used, either wooden cubes 8 × 8 × 8 cm, which have a metallic cross of 30 cm dimension attached on their base, or 2 metallic rods of square profile 4,25 m long and 4 mm wide, with 5 targets on each one; the necessary measurements have been done with SHARPS system and a tape,
— determination of the necessary control points for the restitutions of all the photogrammetric pairs with aerotriangulation with combined adjustment of photogrammetric and tape measurements,
— simultaneous analytical photogrammetric restitution on a Zeiss Stereocord G2 connected with an AT personal computer.

Part of this work has been completed during the summer of 1990 but the whole project is expected to be ready and will be reported at the symposium in Delphi in 1991.

Fig. 9. Photomosaic of the area of 5×2 m^2 *of the bottom (source* ΕΝΑΛΙΑ 1 Γ–Δ 1989).

BIBLIOGRAPHY

[1] BASS G.F.: *Eighteen Mediterranean wrecks investigated between 1900 and 1968*, Underwater archeology: a nascent discipline, Unesco, p. 35–51, (1972).

[2] BASS G.F., KATZEV M.: *Tools for underwater archaeology*, Archaeology, vol. 21 (3), (1968).

[3] BASS G.F., ROSENCRANTZ D.: *Submersibles in underwater search and photogrammetric mapping*, Underwater archeology: a nascent discipline, Unesco, p. 271–283, (1972).

[4] FLEMMING N.: *Cities in the sea*, New English Library, Doubleday & Co. Inc., (1971).

[5] HALL E.T., GREEN J., KATZEV M.: *Survey of a Greek shipwreck off Kyrenia, Cyprus*, Archaeometry, vol. 10, (1967).

[6] I.E.N.A.E., *ΕΝΑΛΙΑ*, τομ. 1, Γ/Δ, P. 35 (in greek), (1989).

[7] REBIKOFF D.: *Photogrammetry in dirty water by mosaic and strip scanning"*, Underwater archaeology: a nascent discipline, Unesco, p. 223–230, (1972).

[8] THROCKMORTON P.: *The practical application of underwater photography"*, Underwater archaeology: a nascent discipline, Unesco, p. 205–209, (1972).