International Hydrographic Review, Monaco, LVI (2), July 1979.

COST BENEFITS OF PHOTOBATHYMETRY

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Paper presented at the Coastal Mapping Symposium held 14–16 August 1978 in Rockville, Maryland, and reproduced here by kind permission of the organisers, the American Society of Photogrammetry.

ABSTRACT

The National Ocean Survey has recently completed photographing approximately 60 square nautical miles of underwater area surrounding St. Croix Island, Virgin Islands. Analysis of the field, data acquisition, and processing costs for this underwater mapping project show that photobathymetry is a cost-effective surveying technique. A comparison between photogrammetric underwater mapping and conventional launch hydrography gives a cost benefit ratio of 6 : 1 in favor of bathymetry.

INTRODUCTION

In the practical world of operations, a new system must either be more accurate or more cost effective if it is to replace the older, established methods. What started out as a new and rather interesting application of photogrammetry has actually achieved both of these criteria. Photobathymetry can achieve higher accuracy than the conventional techniques (by using large scale photography) and can be significantly more cost effective.

This paper summarizes the studies leading to the present photobathymetric system's capabilities and compares the cost of both the conventional technique of underwater mapping and photobathymetry.

PAST STUDIES

In a recent report (KELLER, 1977) the average cost of surveying 10 specific coastal sites by photobathymetry was given as $ 438 per square mile. Based upon this average cost, a preliminary analysis of the cost of launch hydrography was made, showing a cost benefit of 4 : 1 in favour of photobathymetry (COLLINS, 1978).

Subsequent to this cost benefit determination, the Systems Analysis Division (SAD) of NOS' Office of Marine Technology completed an in-depth study (GATZOULIS, 1978) of a number of alternative hydrographic surveying systems, including the Airborne Laser System, Airborne Photobathymetry System, Airborne Acoustic System, Landsat Multi-spectral Scanner, Hysurch (Navy), and Airship Platform Based Systems (Blimp mounted). The SAD report, which analyzed the effectiveness of these various systems, concluded that the Airborne Laser System was the best single system and that photobathymetry was the next best. This conclusion was reached despite the fact that the Airborne Laser System is currently in the development stage and is not yet operational. Until an operational Airborne Laser System is fabricated, no actual cost data will be available for analysis and comparison with launch hydrographic costs. The SAD study also included cost data for the NOS hydrographic vessels and production data (square nautical miles of hydrography) for the various hydrographic units, including both ships and launches. For example, the cost of operating one five-man shore-based launch unit was $ 124,404 per financial year (FY 1977), and the cost of operating a Class III vessel was $ 618,945 and $ 720,466 (FY 1972) per year for the two east coast vessels.

While accurate cost data are available for vessel operations, production statistics are confounded because reported production rates include both deep and shallow water launch hydrography. For example, in a given month most launch units will survey shallow water, running at speeds of 2 to 4 knots, and deep water at speeds up to 15 knots. In an earlier paper on cost benefits of photobathymetry (COLLINS, 1978) it was estimated that a launch could survey approximately 6.5 square nautical miles per month. This estimate was based upon the personal experience of the author and the experience of other personnel familiar with inshore launch operations. The SAD report (GATZOULIS, 1978) showed production rates for various projects ranging from 2 to 17 square nautical miles per month.

COST OF LAUNCH HYDROGRAPHY

The determination of a truly accurate, universally acceptable production rate for launch hydrography will probably never be realized due to the high variability of the working environment. In the interest of simplicity a production rate of 10 square nautical miles per month will be used in this paper for comparative purposes. Although this rate is biased on the high side, its use will tend to make comparisons more conservative.

The cost of shore-based launch hydrography is $ 1,037 per square nautical mile, based upon the 1977 cost data for the Hydrographic Field Party ($ 124,404 annually). The average annual cost of operating a Class III ship in FY 1972 was $ 669,705. This cost, increased by a 5 %

inflation rate per year, converts to $ 837,132 in FY 1977 dollars. Based upon this converted average value, the cost of conducting two-launch vessel-based inshore hydrography is $ 3,488 per square nautical mile.

COST OF PHOTOBATHYMETRY

The estimate which placed the cost of photobathymetry at $ 581 per square nautical mile (KELLER, 1977) was based upon analysis of 10 sites along the Gulf of Mexico and U.S. East Coast. These costs are divided into three phases: field survey, photography, and processing costs. The field survey and photography costs are available for a recently completed project in the Virgin Islands. Approximately 60 square nautical miles of underwater area surrounding the Island of St. Croix were surveyed this past winter. Aerotriangulation of the control for the project is in progress, and test models of the underwater area have been compiled.

Field survey costs accrued to photobathymetry include the cost of operating tide gages, paneling and leveling to vertical control points. These costs for the St. Croix project amounted to approximately $ 19,000 or $ 316 per square nautical mile. This figure does not include all field costs for the project since some of the field costs accrue to the shoreline mapping portion of the project. The cost of $ 316 per square nautical mile is considerably higher than the cost of field work estimated by KELLER (1977) and can be attributed to the higher cost per diem and to related costs in the Virgin Islands.

Photography and related processing costs for the project were $ 75 per square nautical mile, which compares favourably with the normal operational costs for data acquisition. Costly stand-by time and dead-head time for the aircraft are not included in the photobathymetry cost since the aircraft was required on site to complete the coastal mapping photography.

Aerotriangulation for this project consists of the block adjustment of six strips of photography. Work on the adjustment has been delayed pending resolution of a malfunction with the Wild RC-10's 88 mm lens assembly. The block adjustment is being performed to satisfy vertical control requirements for the photobathymetry. If this procedure had not been followed, many additional vertical points would have had to have been established by field surveys. The additional aerotriangulation costs for providing vertical and horizontal control for photobathymetry total $ 100 per square nautical mile. These costs represent about one-half of the total aerotriangulation cost of $ 12,000; this total cost would have been reduced by $ 6,000 if the underwater mapping had not been done.

Photobathymetry is being compiled both manually and digitally. A portion of the project will be compiled on a standard Wild B-8, with the majority of the project being compiled on a digital B-8S. Manual compilation will be accomplished in the usual manner by tracing depth contours in the underwater model, with spot elevations used to check and adjust the contours. The refraction correction will be applied to these manually compiled depths by reference to a correction template placed on the hydrographic sheet.

Digital processing accomplished on the Wild B-8S uses an off-line computer to transform the digitized plotter coordinates to latitude, longitude, and true depth. The large computer generates a magnetic tape that can be used to generate a flatbed plotter (CALCOMP) tape which in

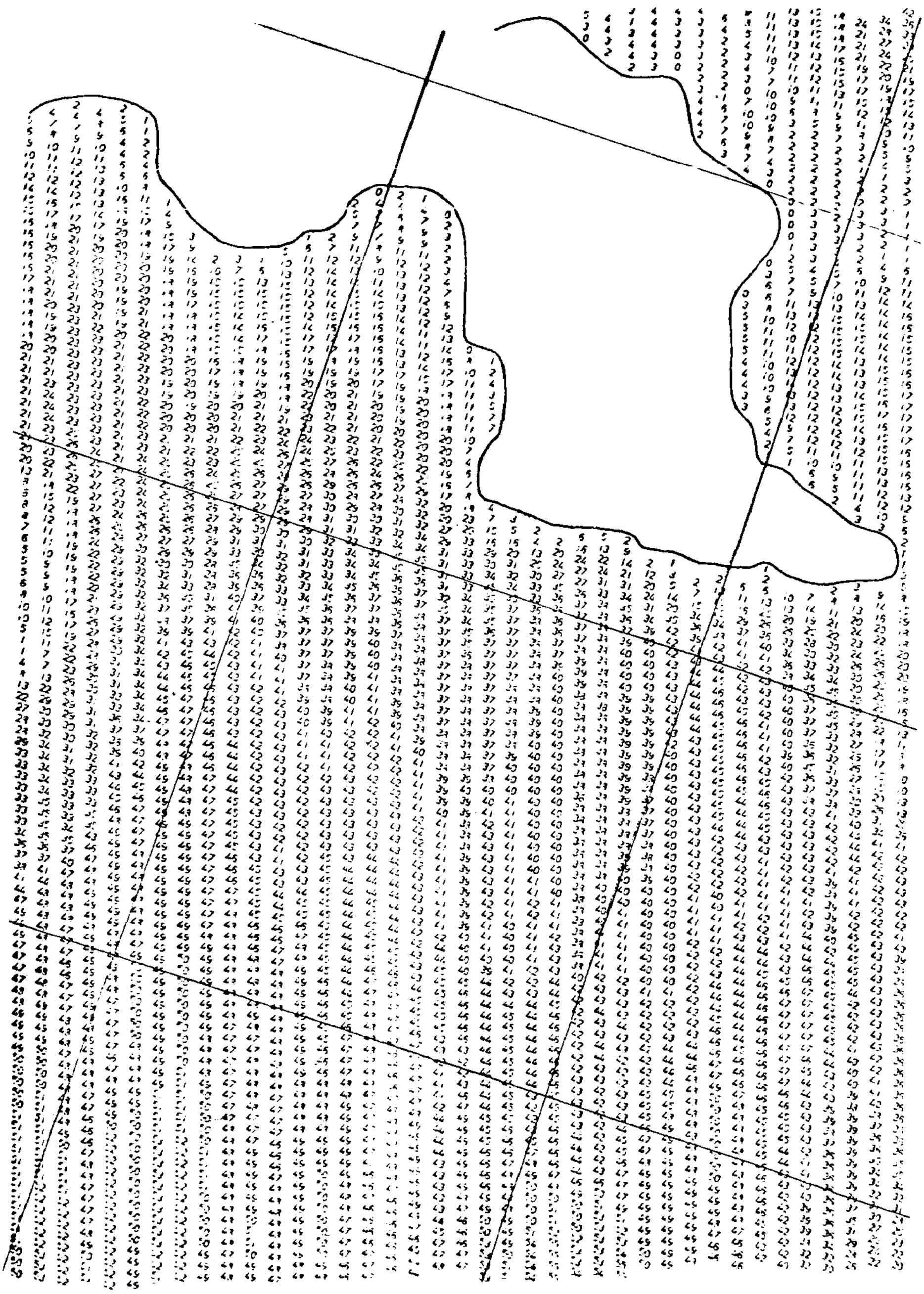

FIG. 1.

turn is used to plot the smooth hydrographic sheet. Figure 1 shows a portion of such a sheet.

The cost of producing a smooth sheet, such as the one shown in Figure 1, using a photogrammetric stereoplotter is approximately $ 100 per square nautical mile. This cost includes the time necessary to orient the model in the stereoplotter, make the necessary profile and crossline readings, compute the true depths, and plot the smooth sheet. Actual times necessary to measure water depth data only amount to 1 or 2 hours per model. This cost is a function of water clarity, bottom character, and shoreline configuration, as well as a number of other variables. Computer and flatbed plotter costs are a fairly constant portion of this total cost and are a function of the number of data points (depths) measured.

In summary the total cost per square nautical mile of photobathymetry is:

Field operations	$ 316
Photographic costs	75
Aerotriangulation	100
Compilation	100
TOTAL	$ 591

This cost of $ 591 per square nautical mile compares quite closely with the estimated cost of $ 581 per square nautical mile given in a previous paper (COLLINS, 1978). Note: the unit of measure used in the previous paper was square statute miles so that computed areas are 30 per cent smaller than areas given in this paper.

COST COMPARISON

The cost per square nautical mile for launch hydrographic operations was previously shown to be $ 1,037 for shore-based and $ 3,488 for ship-based units. The only practical scheme for surveying the waters of St. Croix would be to use ship-based launch units. The cost of shipping shore-based launches to the Virgin Islands and the logistics cost of maintaining the units would be too great to warrant using a shore-based launch party. This is borne out by the fact that NOS has traditionally used ships to survey areas like the Virgin Islands.

The cost benefit ratio for comparing the photogrammetric and conventional methods of surveying inshore waters is $ 591 to $ 3,488, or 6 : 1. This cost benefit ratio is totally realistic in that actual project costs of the two methods were used.

Considerable improvements are being made in the speed and effectiveness of processing photobathymetry. Planned projects along the Gulf of Mexico and the U.S. East Coast should cost less than the $ 400 per square nautical mile for photobathymetry, resulting in at least a 3 : 1 cost benefit over shore-based launch hydrography. Along with this lower ratio, photobathymetry has many other advantages over conventional methods.

The time a survey party spends at the site is greatly reduced when the photogrammetric method is used. The aerial photographer acquires several square miles of hydrographic data every minute and is only very briefly over the project area. The time consuming task of measuring water depths is accomplished in the comfort of an office rather than under field conditions. Furthermore, if a mistake is made in measuring a depth, the stereomodel is easily reset and a redetermination can be made.

CONCLUSION

Remote mapping of inshore water areas will probably never completely replace conventional launch hydrography. However, photobathymetry is a cost-effective alternative method of surveying many inshore areas. By using photobathymetry to map shallow areas, the hydrographer can concentrate his vessel resources on surveying deeper water areas and thus increase overall productivity.

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