Title

Status of research on underwater photography by artificial light

Author

Duntley, Seibert Q

Publication Date

1960-04-01

Visibility Laboratory
University of California
Scripps Institution of Oceanography

Status of Research

on

UNDERWATER PHOTOGRAPHY BY ARTIFICIAL LIGHT

S. Q. Duntley

April 1960

Index Number NS 714-100
SIO Reference No. 60-23

Bureau of Ships
Contract NObs-72092

Approved:

Seibert Q. Duntley

Seibert Q. Duntley, Director
Visibility Laboratory

Approved for Distribution:

Roger Revelle

Roger Revelle, Director
Scripps Institution of
Oceanography

SIO Ref. 60-23

Status of Research
on
UNDERWATER PHOTOGRAPHY BY ARTIFICIAL LIGHT

INTRODUCTION

It is the purpose of this status report to summarize the approach being used to produce improvements in the technique of photography by artificial light. The following topics are presently under active investigation:

1. Precision exposure control.
2. Optimization of underwater lighting.
3. Polarization techniques.
4. Optimum choice of film-filter combination.
5. Prediction of photographic range and coverage in any prevailing water.

Several other topics in underwater photography are also receiving attention (e.g., photography by natural light, lens and/or window design, etc.) but it is believed that the greatest potential for improvement is in the artificial light case, and most of the research emphasis is being placed on it. This status report will be concerned only with underwater photography by means of artificial light. Each of the five numbered topics is discussed in paragraphs which follow.

PRECISION EXPOSURE CONTROL

The optimum exposure for underwater photography by underwater artificial light depends in a complex manner upon the light-scattering properties of the water and its absorption coeficient as well as upon the geometry of the lights, the distance of the target, and the location of the camera. All of the foregoing factors are encountered even if monochromatic light is used and, of course, in ordinary practice the spectral characteristics of the lights, the water, the target, and the film must be properly allowed for. It is believed that exposure can be predicted in a straightforward, practical manner with an accuracy so great that high-contrast films and processing techniques can be used confidently, thereby producing underwater photographs of higher quality and of longer range than is possible with conventional materials.

It is believed that the greatest single improvement that can be made in underwater photography by artificial light, particulary in water of medium to low clarity, will result from the develpment of a truly valid high-precision exposure control. This can be accomplished only by an exploration of certain pertinent basic principles and the subsequent development of a practical exposure control device which measures the relevant optical properties of the water and correctly combines this information with all other important factors. On the basis of the studies conducted thus far it is strongly felt that this can be achieved. The exploratory phase of this work is the present major effort, and very rapid and encouraging progress is being made.

All of the basic experiments made thus far were performed at the Diamond Island Field Station and were performed during the summer of 1959; in that work cameras and photoelectric photometers in the research barge looked horizontally at underwater light sources of many fundamental, accurately known geometries ranging from spherical point sources through broad-beam, to very narrow-beam projectors arranged in virtually every conceivable orientation and at a very large range of distances. The purpose of all this was to study the lighting received by the barge, which was thought of as the target being illuminated. The theoretical analysis that has been made indicates that it is the contribution to the target illumination by multiply scattered light which is the principal complicating factor in making underwater exposure so difficult to predict. The multi-path effects tend to cancel in such a way as to leave a relatively simple optical situation throughout the path of sight from target to camera, but this is not true in the lamp-to-target path. So far as we are aware no other investigators have fully recognized this. The precision exposure control problem will be well toward solution as soon as the multi-path light-field at and near the target is fully understood.

The Diamond Island experiments explored the light-field problem experimentally and the results are still under study; Dr. Preisendorfer's advanced theoretical analysis (SIO Reference 59-71) produced equations which can be coded for the Datatron 220 at N.E.L. in order to provide the tables needed to make the Diamond Island results universally applicable to any kind of water. This is presently being done for the (simpler) natural light case but the coding and computation of tables for the artificial light case cannot be accomplished unless additional funding is provided. The Diamond Island data should, however, enable the development of a technique for predicting photographic range and area coverage from the measured optical properties of the water and the known characteristics of the lamps and target.

A number of underwater photographs of gray-scale test objects at various distances in accurately known lighting were made last summer in anticipation of completion of the exploratory phase. These pictures are intended to provide an over-all check on the correctness and adequacy of the combined theoretical and experimental investigation. It will probably be late in 1960 before this work is finished.

The next step will be to set up a breadboard version of the precision exposure control and test it. If it is fully successful it should be possible to use virtually any combination of lights, cameras, targets, and geometries and predict exposure so accurately that high-contrast materials and processing can be used. At this stage some very dramatic demonstrations of the new technique should be possible. The development and trials of the exposure control device should be in two stages: First, at the Diamond Island Field Station where working conditions are stable in time, where all conditions are fully known, and where laboratory-type apparatus can be used easily and at small expense; Second, at sea or in a harbor under typical operational conditions. This second step will require more rugged apparatus and should be attempted only after the system is well worked out.

The first field development trials of the breadboard exposure control equipment can probably be made at Diamond Island during the summer of 1961, and testing of the finished device can follow later in San Diego harbor or elsewhere.

OPTIMIZATION OF UNDERWATER LIGHTING

It is well recognized that the light sources used in underwater photography should illuminate the path of sight between camera and object as little as possible. Thus, separation of the source from the camera, the use of a septum or other baffles, and placement of the lights close to the object are accepted techniques for improving the range and quality of underwater photographs. The effectiveness of any given measure depends, however, upon the optical nature of the prevailing water in a none-too-simple way. Guess work would be minimized or eliminated if simple engineering procedures for optimizing the lighting for any given underwater photographic task can be evolved on the basis of measured optical properties of the prevailing water and known intensity distributions of underwater luminaires.

The experiments performed at the Diamond Island Field Station during 1959 had this concept in mind and there is every present indication that a successful and practical final result will be achieved. Additional experiments and tests of predictions should be made as the work progresses. Completion of this work before late 1960 should not be expected.

POLARIZATION TECHNIQUES

The use of polarizers on underwater light sources and underwater cameras ordinarily produce an important gain in range and contrast. No exploration of underwater exposure control, optimum lighting, and prediction of photographic range and area coverage would be complete if the polarized case were not included. The experiments at Diamond Island during 1959 included polarized light counterparts of the natural light measurements previously mentioned. There was little hope that difinitive results would be obtained, however, because long delays in the delivery of materials made it impossible to equip the research barge with sufficiently strain-free underwater windows. Examination of the photometric photographs made with polarized underwater light sources shows the data to be too contaminated by strain patterns to be useful.

The polarized light experiments must be repeated if this important technique is to be included in the practical engineering framework now being created.

Attention is called to the theoretical treatment (SIO Reference 59-60) which sets up the foundation for applying to any water the practical polarization techniques which are expected to evolve from the field experiments.

OPTIMUM CHOICE OF FILM-FILTER COMBINATION

It is inconceivable that trial-and-error methods must be used to select the optimum film-filter combination for underwater photography. Measurements of the optical properties of the water prevailing at the site where photography must be done should be made in such a manner that the optimum film-filter combination for the particular underwater photographic task at hand is indicated. With this goal in mind, a photoelectric spectroradiometer was mounted in the research barge during the 1959 experiments at Diamond Island and spectral measurements of the attenuation coefficients were made throughout the visible spectrum. Reduction of these data have been completed. This information, when combined with the underwater lighting measurements already described, should lead to the development of a method for optimizing the choice of the film-filter combination for any given underwater photographic task. Completion of this work before late 1960 should not be expected.

PREDICTION OF PHOTOGRAPHIC RANGE AND COVERAGE IN ANY PREVAILING WATER

In water of medium or low clarity it is often impossible to achieve sufficient photographic range to permit photography of a desired area in a single exposure. Advance knowledge of the range and area-coverage limitation imposed by the prevailing water should facilitate the planning of underwater photographic missions and improve the probability that an adequate technique will be used on the first attempt. Completion of the studies outlined in the preceding portions of this report should enable nomographs for predicting photographic range and area coverage to be prepared both for artificial lighting and for natural lighting. These nomographs might appear somewhat like a series of charts which have been prepared for the case of visibility by swimmers.* The preparation of such nomographs is a considerable undertaking and can be contemplated only if sufficient funds become available.

---

*IMPROVED NOMOGRAPHS FOR CALCULATING VISIBILITY BY SWIMMERS (Natural Light), S. Q. Duntley, Contract NObs-72039, Report 5-3, February 1960.