UNDERWATER CINEMATOGRAPHY AND STILL PHOTOGRAPHY IN FISHERIES RESEARCH AND VISUAL EDUCATION

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Underwater photography has in the last few years moved up into second place importance where marine investigations are concerned. It is unfortunate that a delay appears to exist in the use of underwater photography for fisheries research and studies in fresh water although there are many limiting factors. I am confident that in a short time many biologists will be making wide use of the newer, less expensive cameras and cases to support their studies in fisheries management programs.

There are several types of underwater cameras designed to take motion pictures, stills or both. Remote operation is possible with some, where depths or other conditions make it impractical for a diver or observer to use them. Other automatic underwater cameras are used as counting devices; others for periodic or interval recording and for many specialized uses. Television cameras are quite similar to the underwater cine camera except that a permanent record becomes a secondary step. Also, they have definite limitations when used by a diver in that a connecting coaxial cable to the surface restricts their operation to more or less fixed locations. Successful experiments, however, have been carried out while the cameras were being towed or while fixed to ship hulls and new tests are underway by scientists of many nations to discover additional applications. All of these devices are highly specialized and a separate paper would be required for each to fully explain their uses and adaptions. The portable underwater camera and its use if most applicable to general research and study.

Underwater photographic work creates many problems because of the unusual physical and mechanical limitations. First is diving gear, which, now vastly improved, allows the diver greater freedom to concentrate on seeing and making effective use of the camera. Secondly, the camera, while essentially unchanged except for the adaption to an underwater case, doesn't work as easily or follow all of the rules we have already learned. The refractive index of water combined with lenses ground for use in air changes the effective focal distance and at the same time restricts the field of view. As pressures increase, the dangers of leaks, condensation and malfunction likewise become greater. In a process where visible light is the key to success, we are faced with the gradual absorbtion of part or most of the spectrum depending on whether we are working two feet or 100 feet below the surface. In the use of color film particularly this is very restrictive, and while filters may be of some practical use in shallow water, the only solution in deep water is to furnish artificial illumination. New, recently released, emulsions of extreme speed have increased the potential of black and white photography greatly. Most of the problems will be solved. Constant improvements are making available better cameras, films and diving gear, remarkably simple compared to those in use no more than a few years ago. I am about as cognizant of the engineering problems concerned with underwater cameras as most users of this equipment. I built my first operational camera in the early thirties . . . my last in 1941, an underwater housing for a 16 mm cine special.

History is not too important at this point, but I think that the year 1893 should be remembered as the beginning of underwater photography. A French biologist, Dr. L. Boutan, in that year, constructed a large, cumbersome and heavy copper box to house a simple, fixed-focus camera. It worked, after a fashion. At least Dr. Boutan did take and was able to show recognizable underwater photographs. Encouraged, he set about making improvements and tests until seven years later he was able to produce the first underwater photography at night . . . among his improvements were included simple arc lamps in watertight jackets.

Dr. William H. Longley and several other scientists, encouraged by Boutan's success, continued their experimenting. No doubt, the first World War was a big factor in the delayed development of underwater photography. In 1917 Dr. Longley did use an underwater case of advanced design which included outside adjustment of focus and shutter speeds. His case housed a 4 × 5 Auto-graflex and being made of brass was quite heavy even underwater. One of his greatest problems was condensation. Regardless of the handicaps, Dr. Longley did produce usable underwater photographs while working at the Carnegie Institute Station at Dry Tortugas. In this respect, he is considered the first, or father of underwater photography in the United States. By 1923 Dr. Longley had made the first successful color plates underwater, and by 1926 had devised a dangerous but successful manner of firing large quantities of flash powder at the surface to expose his color underwater photographs. His photography was limited to depths not to exceed 15 feet and exposures were usually a twentieth of a second.

The *National Geographic* magazine in January, 1927, published the first color photographs from the ocean bottom in an article prepared and illustrated by Dr. Longley.

The exact date when the first underwater cine camera came into being is not definitely known. Nevertheless, in 1927 a successful 35 mm camera had been produced and used by Dr. Paul Bartsch of the Smithsonian Institute. It could be focused underwater.

From the mid-twenties on, progress was sporadic in the underwater field. Such well-known names as Pillsbury, William Beebe, Mark Barr, John Tee-Van, E. R. F. Johnson, manufacturer of underwater photographic gear, Roy Waldo Miner, Capt. John Craig, Dr. Maurice Ewing and a number of other imaginative men contributed greatly to marine investigation and photography. Surprisingly, most were content to make little improvement in the diving gear then available. And, finally, men of our post war era . . . Costeau, Hass, and others, with or without background in the wartime underwater teams, contributed greatly to current progress in marine investigations and gear development. Their outstanding underwater motion pictures in color and black and white have advanced public interest as well.

Self-contained diving equipment as we know it is new . . . even of more recent development than the cameras which are used with it. However, Williamson used self-contained equipment in the production of his 20,000 LEAGUES UNDER THE SEA 30-odd years ago. Disney camouflaged Aqua-Lungs to simulate recirculating types in his production by the same name, which has been publicized recently, and is now ready for release.

In some respects the development of underwater exploratory equipment has not kept up with other scientific and mechanical advances; man's natural curiosity alone should have pushed it ahead of many other things. As early as the beginning of written history, divers were attempting to break through the water barrier and extract secrets from the seas. Fears and superstitions unquestionably were a retarding factor . . . and yet . . . Egyptian divers caught fish and fowl by grabbing them from underwater . . . possibly the first of the frogmen. During the seige of Tyre in 300 B.C., divers were ordered to destroy underwater obstructions surrounding the approaches to the City, placed there to tear open hulls of the invading fleets. Treasures, too, were being salvaged in sufficient quantities to cause salvage laws to be enacted prior to the time of Alexander the Great. It is also recorded that Alexander made a descent into the sea in a type of bell . . . a far cry from the complex underseas vehicles of our time such as the F.M.R.S. 3 which descended to a record depth of 13,300 feet recently.

Underwater photography is dependent upon diving gear, and it is essential to mention the available types other than conventional commercial gear. Least expensive and most simple is the hood type helmet which slips over the head and shoulders. Weights are attached to the breast plate to offset buoyancy and air is supplied by a hose extending up to a hand-operated pump. This type is fast becoming obsolete.

Wartime surplus equipment such as Teco, Desco and other adjustable masks are still serviceable and consist of a connecting hose, non-return valve, an infantry cartridge belt upon which is mounted an air control valve and in the pockets of which the diver carries sufficient weights to control buoyance. Air is supplied from a hand pump, compressor or tank of air. There is considerable waste of air with this type of equipment and practically no storage space in the mask. Several suppliers have stocks of this type of gear and the prices are low. This type of diving gear is only slightly more versatile than the hoods . . . you can swim with it on but it is difficult. Many commercial salvage operators use these shallow water rigs because their air equipment will serve for these as well as the commercial suit type.

Most versatile are systems such as the Aqua-lung, Hydro-pak and similar types. These are self-contained, are worn with a harness and are relatively safe. They use a bottle, or bottles of air which are compressed to over 2,000 psi. Each tank has about 35 cu. ft. of air compressed into 400 cu. in. or thereabouts, and one tank under normal expenditure of air down to 30 feet would last from 30 minutes to an hour depending on individual use. As a rule, deeper prolonged dives require multiple tank assemblies to furnish greater quantities of air and permit a safety factor for emergencies. A separate face mask is used with some models which have mouthpieces . . . others have the breather moulded into the mask.

The heart of the aqua-lung, for instance, is a dependable but sensitive regulator consisting of separate high and low pressure stages which adjust the pressure of the breathed air to that of the surrounding water and also adjust the flow so that breathing is practically effortless . . . once the user overcomes the initial breathing differences. Adjustments are automatic, exhaled air is exhausted through the outlet valve. One can swim in any position, move back and forth, up and down, without discomfort. After several initiating dives, the user can devote full time to observation and photography as they become acclimated to mouth breathing.

There is another type of self-contained diving unit known as the closed circuit type. In this type no air bubbles escape into the water since it is of the recirculation type. Developed for military use, it undoubtedly serves a very useful purpose, but is quite dangerous if out of adjustment or operation becomes faulty. In this system, oxygen is carried on the back instead of compressed air and exhaled gasses are absorbed by a purifying device containing caustic soda or other chemicals. Oxygen is then replaced in the cycle. Hans Hass used this type equipment in his earlier work with considerable success, nevertheless, it is less than safe to use.

Professional training should be undertaken if at all possible, then the new diver will not be faced with having to experience all of the mistakes that frequently haunt self-trained men. Excellent books are now in print on the fine details of diving and photography in which whole chapters are devoted to a subject that can no more than be mentioned here. Masks and flippers are manufactured to many specifications, and several types should be tried for the most satisfactory fitting and use. A weight belt is essential to establishing proper equilibrium in water. An add-a-weight belt is best . . . adding more weights until the fully outfitted diver becomes practically weightless, or until he finds it effortless to swim down and to return to the surface.

Underwater camera equipment is reaching a high stage of development also . . . while a number of inexpensive cases made of plastic serve for shallow water use, other medium-priced cases are safer. They can be used down to a hundred feet if properly sealed, and fit many popular small cameras. Naturally, cameras designed to serve one purpose, underwater photography, are compact, well-designed instruments, and have few limitations as underwater cameras go.

The Fish and Wildlife Service is doing a limited amount of underwater photography both in fresh and salt water. Our equipment consists of commercially engineered cameras and diving gear. Naturally, we have made modification in some instances to fit equipment to special purposes and we will also engineer certain photographic devices to facilitate carrying out experiments in gear development and other work.

Primary requirements in an underwater camera are, first of all, extreme simplicity of operation. The camera should be easy to handle in water, have fingertip controls and be of such shape and buoyancy that the user can make the most of photographic opportunities. I would like to tell you something of the equipment we use because it does embody many desirable features. Unquestionably, there are other pieces of good equipment and, while my personal preference may be for a certain product, it in no way indicates that other types or styles are inefficient or poorly designed.

Our cine camera has been trouble free even under quite trying conditions. The lens speed of f 1.4 is fast while the covering power and wide field is excellent. Large handholds are located on each sie of the camera and it is quite easy to operate the shutter bar, set camera speeds, diaphram, focus and change filters without releasing hold of the camera. The viewfinder is exceptionally good and is of the optical type. In the dark area adjacent to the brilliant field of view a well-engineered set of disks permit reading all of the settings mentioned, and in addition, to see how many feet of film remains in the camera. The final feature that has intrigued me is a glowlamp which flashes its dim orange color during the period of operation. It is often difficult to feel the vibration of the camera motor and this tiny indicator assures you that batteries and motor are functional. The camera opens easily and quickly with the release of two catches. It may be opened, the exposed film replaced with new film, the camera closed and back underwater in a minute. The case is self-sealing although we do carry a few pounds of air in it at times. Battery operation is possible by using small Size D flashlight batteries, 18 of which are installed in the base of the camera and supply 24 volts of DC current. We have made a modification in this respect. Replacing the dry batteries with Silvercels, permits recharging and also permits operation for long periods of time even at low temperatures when the dry cells would cease to function. These small batteries are of the non-spillable, silver-zinc type used in critical defense devices where dependable nonvarying output is essential. The weight to capacity ratio is extremely high . . . about six times that of the ordinary zinc battery. There is also little or no variation in output during the discharge period, adding considerably to the efficiency of operation. We built a charger-voltmeter tailored to the particular characteristics of these batteries and which may be plugged into any convenient AC outlet to recharge the batteries in six to seven hours or overnight.

Use of 16 mm magazine film is convenient and in this particular camera adds greatly to its ease of operation. Under some conditions, it would definitely be advantageous to have available 100 or more feet of film provided electrical operation was possible or the camera design included an easy means of winding the power spring.

Still cameras are important for documenting underwater stories and activities. Especially, where reproduction is concerned, cine film is not sufficient in most cases. Some blow-up may be made, but generally speaking, the quality and sharpness of such photographs is poor.

Underwater color photography in daylight is limited to about four or five hours; black and white allows longer operations. For that reason, good camera equipment and dependable diving gear insures better results when a day is shortened by the added restrictions imposed by underwater work. An interesting device is reported on in the August, 1954, *Journal of SMPTE.* Dimitri Rebikoff describes a torpedo which he has perfected in Europe and which contains a light source, camera and propulsion unit. It has many unique features, and will extend the work day of an underwater photographer.

This has been an extremely general treatment, and if it does stimulate further underwater projects, then it has been worthwhile. A few projects of the many which have been started recently in the United States includes an oyster research project in Chesapeake Bay. Turbidity had to be overcome to successfully carry out the project in waters of low visibility. This was done, and remarkably good stereophotography was carried out. . . . I have a few samples with me.

The Fish and Wildlife Service in cooperation with the Navy's Bureau of Ships, Geological Survey, the Woods Hole Oceanographic Laboratory and University of Miami's Laboratory began new tests November 1 in the waters lying between Miami and the Bahamas. Men from our gear development and research section are carrying out tests of commercial types of trawls including modifications to improve their utility in the hands of commercial fishermen. Television and other types of advanced electronic equipment are being tested at the same time. Motion pictures and still photographs are being made of all phases of the test for study, publication and eventually, the motion pictures most suitable for public information will be used for television and regular motion picture release.

In Puget Sound, extensive underwater work is progressing as part of a study prior to laying power cables across the Bay. Several inland universities, Woods Hole Laboratory, Scripps Institute, the University of Miami, the Chesapeake Bay Institute and others have new projects planned and underway to a fuller utilization of this medium. Inland rivers and streams, in many instances, can be surveyed more accurately with underwater cameras . . . the same applies to lakes, ponds and reservoirs. Toward that end, biologists in several states are using diving gear and underwater cameras in a limited fashion to carry out studies. Sufficient money has not been available because underwater photography as a research tool had not been accepted. This is not true any longer. New, honest appraisals of thousands of fisheries projects and studies will point out the advantages of underwater photography. In addition to use in study and research, administrators, and the public in general, will derive educational benefits from much of the photographic effort. Let's be ready. The most outstanding discoveries of this century may well be made in the Sea . . . the greatest area for exploration and the source of life itself.