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AN UNDERWATER TELEVISION SYSTEM

Oceanographers are often both literally and figuratively in the dark about the appearance of the ocean bottom beneath their ships. It is very useful to know whether the bottom below is soft or hard, smooth or rough, and populated by animals or barren and if the water there is in motion. A television system, properly designed and used, can give an excellent real-time moving picture of the bottom, the animals, their activities, and the currents.

It is not, easy to make effective use of television; in the past many scientists have tried and found it to be an expensive burden. To be successful it is necessary to have exactly the right kind of equipment and the proper operational techniques.

The first requirement is a recently built camera to take advantage of the great advances in electronics during the last few years that reduce the lighting requirements and improve the imagery. Then one needs an underwater light with a wavelength that is precisely peaked in a narrow part of the light spectrum called the "seawater window," where light penetration through salt water is at a maximum. The other parts of the TV system are the cable, the monitor, and the tape recorder; these are more expensive but relatively less important to the performance.

The system now being used by the Project has produced excellent results. The TV camera we use was manufactured by RCA; it produces a picture with considerable contrast at low light levels and has automatic light compensation that rapidly responds to sudden changes in the illumination of the subject. Most important, the light frequency response of this camera is peaked in the region of 5,500 angstrom units, encompassing the seawater window (we have also modified the camera to further refine operations at low light levels). Our underwater light bulb, made by Westinghouse, uses ionized thallium to produce light at 5,350 angstrom units, creating an emerald green glow that disturbs fish less than white light. The advantage of using this segment of the light spectrum is that 250 watts of power at this wavelength gives more useful light than 1,000 watts of white light produced by ordinary quartz bulbs. With this combination of light, the camera "sees" at least twice as well as a diver would when the visibility is reduced by particulate matter.

The underwater housings for both the camera and the light were designed and built by Jack Mardesich. The techniques for using this equipment at sea were devised primarily by Harold Stubbs, also of our staff.

Once equipped with these basic units, the question arises as to how they can be used effectively at sea to obtain data or answer questions relating to ecological studies. We have devised several ways.

Except in very special places there is not much to see between the sea surface and bottom, although the television does give a good idea of the relative amounts of plankton and motions of the water. The sea floor is of greater interest. To inspect a substantial area of it carefully and, on occasion, hold still and look at details, a sled is the logical answer. Our sled is a light framework of pipe, weighted at the bottom, that can be dragged along the sea floor. This arrangement has the advantage of fixing the distances between camera, light and subject so that the lighting and the focus can be optimized in advance and so that the dimensions of objects seen on the screen are known (we use a transparent overlay that shows a square meter in perspective)

The sled is usually towed along the bottom in depths to about 120 meters at a speed of about 0.5 m/sec. This permits the scientist to inspect an area about 2 meters wide and nearly a kilometer long in 30 minutes. He can quickly discern the type of bottom (mud, sand, rock), the shape of the bottom (mounds, holes, ripples)., the presence of epibenthic animals (crabs, shrimp, gastropods, sea pens, brittle stars, etc.), particles in the water (suspended bottom materials or minute animals), and the presence of fish (flatfish on soft bottom and rockfish over hard substrates). When the sled is not moving, the direction and velocity of water motion is readily apparent (the direction of the sled is the ship's direction when it stopped towing).

We can think of no other single marine instrument that produces so much information. When something unusual is observed, such as a special kind of bottom or a cluster of sea animals, appropriate samples can be taken on the spot with other gear. The principal difficulty with a television system is that the visibility is occasionally bad.

Our black and white television pictures are often supplemented with 35-mm color photos taken by a camera described in the following article. The camera can be set to take a picture automatically at, say, 1-minute intervals, or be fired on command by the person watching the television monitor. This gives a reasonable sampling of the bottom conditions and animals in subtle color (albeit with a greenish cast from the TV light). These slides can be used for illustrations, have a slightly different kind of information, and are a more convenient way of presenting our data (TV screening facilities are not always available).

The TV and photo system can be operated by technicians, who may occasionally spend as much as several days at sea to obtain an hour or two of good tape. Later, back at the laboratory, a group of biologists of varied disciplines can review the tapes, discuss the animals and the sea conditions (replaying important segments as often as necessary), and report on the biota more effectively than if they had actually been at sea. This is not only an efficient use of biologist's time but it permits quantification of the various sea animals and an estimate of their numbers in various situations.

The television system can be used in other ways. For example, the sled can be lightened by the addition of floats and "flown" a few meters above the bottom. This makes it possible to fly above an outfall pipe or over rocky areas of bottom that are difficult to examine otherwise. This also prevents damage to plants or animals on hard substrates that might be touched by the sled runners.

Alternatively the camera is mounted on a tripod with a Jaymar pan and tilt unit. In this form, it can be used to watch the activities of sea animals or the jets of outfall discharges.

Sometimes we secure the TV camera to the headline of a bottom trawl and watch the net in operation. This permits us to see the shape taken by the net and to get a much better understanding of how a trawl operates and why it catches what it does. We have watched fish swim ahead of it, dive under the foot rope, and swim in and out at will (sometimes after riding for a while). This shows clearly that under many circumstances a net is likely to miss healthy adults and capture mainly the young and the infirm.

A television system, properly designed and used at sea by an expert marine technician, is a very valuable addition to the techniques available for studying ocean ecology.

Table 1. Coastal Water Research Project Television System.

Camera
- Model: RCA TC-1000 Videcon (modified by Jay-Mar)
- Resolution: 550 scanning lines per inch; 2/3-inch tube
- Peak: 5,600 angstrom units
- Sensitivity: Scene illumination 5.3 footcandles (5.7 lumens/sq m)
- Automatic light compensation: 8,000:1
- Underwater housing: Jay-Mar 1000

Video monitor
- Model: Shibaden VM-172U (E,K)
- Resolution: 650 scanning lines per inch
- Screen size: 16-inch diagonal

Cable
- Type: Boston Insulated Wire, 1/2-inch OD, 6 conductor including video
- Length: 500 feet (152.4 meters)
- Safe load: 400 pounds (181 kg)
- Weight: About 1/4-pound/foot (372 grams/meter) in water
- Connectors: Bratner Envirlcon

Video Tape Recorder
- Model: Shibaden 510 DU 1/2 inch, portable
- Resolution: 300 scanning lines per inch
- Capacity: 1 hour continuous recording

Light
- Type: Westinghouse Electric tube, thallium-iodide vapor
- Peak: 5,350 angstrom units
- Watts: 250
- Packaging: Coastal Water Project design

Pan and Tilt Head
- Model: Jay-Mar All-Depth
- Capability: 360 degrees at 2 degrees/second, pan or tilt

The camera sled. The large black cylinder with yellow bands contains the 35-mm camera and its electronics, with strobe lights at each end. Jack Mardesich has his hand on the light for the television camera beneath.