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Construction of a Junction Box for Use with an Inexpensive, Commercially Available Underwater Video Camera Suitable for Aquatic Research

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Abstract.—Underwater video camera apparatus is an important fisheries research tool. Such cameras, developed and marketed for recreational anglers, provide an opportunity for researchers to easily obtain cost-effective and waterproof video apparatus for fisheries research. We detail a series of modifications to an inexpensive, commercially available underwater video camera (about US$125) that provide flexibility for deploying the equipment in the laboratory or in the field. Specifically, we describe the design of a junction box between the camera cable and the power supply and video feed that can be constructed for about $25. We also describe different deployment configurations and detail several examples of the data we have been able to collect using this technology.

Video cameras are important tools in aquatic research, providing researchers the opportunity to obtain unobtrusive observations in field environments. Such cameras have been used for environmental monitoring (Cooke and Schreer 2002), energetics assessments (Hinch and Collins 1991), habitat studies (Dibble and Harrel 1991), reproductive ecology (Cooke et al. 2001), and fish passage monitoring (Hiebert et al. 2000). Videography is also a useful methodology for aquaculture and has been used to assess fish sizes, swimming speeds (Petrell et al. 1997), feeding rates (Ang and Petrell 1997), and reproductive activity (Salek et al. 2001). Later, video recordings can be viewed to help quantify a variety of parameters that are difficult to measure in real-time (Hinch and Collins 1991).

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Historically, the deployment of video cameras has required the purchase of customized and expensive equipment from specialty manufacturers and consultants or the time-consuming construction by the researcher of cumbersome and difficult-to-waterproof cameras. This type of customization by videography professionals is essential to provide researchers with tools for unique environments or applications. However, simple, inexpensive underwater video cameras also are available that can provide additional dimensions to most fisheries research programs. These types of cameras have become commonplace, now having been marketed for use by recreational anglers to aid in locating fish or evaluating habitat (e.g., Stout 2002), especially in environments that would be dangerous for divers (see Cooke and Schreer 2002). These cameras are easy to use without training, robust and waterproofed for field environments, and available in most outdoor retail stores. Typical packages include the camera, a length of cable, a battery, battery charger, video monitor, and carrying case. Although this configuration is useful, these packages are somewhat expensive and provide little flexibility for adapting the equipment to suit desired applications. The most valuable components are the camera and the integrated cable, which are already waterproofed, and the infrared lighting array. Maintaining waterproof conditions in underwater video equipment is a challenging, yet important, task and has resulted in some elaborate and creative designs (e.g., Collins et al. 1991); however, these systems are prone to leakage. The advantages of factory-sealed cameras include reliability and generally some form of warranty.

In this paper we detail a series of modifications we have made to an inexpensive commercially

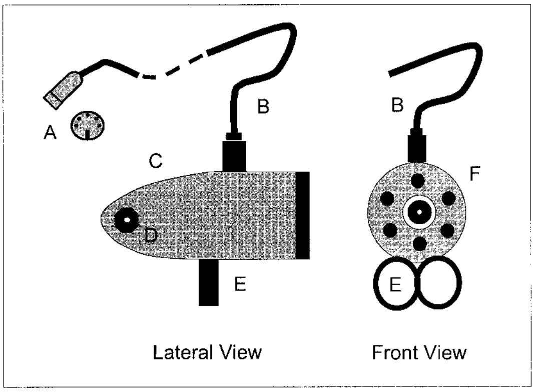

FIGURE 1.—Schematic of the camera we modified for use in fisheries research. The camera interface, a 5-pin Deutsche Industrie Normenausschuss (DIN) plug (A), is plugged into C (Figure 2). The cable (B) connects permanently to the main camera body (C). An attachment mechanism (D) provides opportunity to attach a fin or camera stand. Ballast weights are secured into (E). A frontal view of the camera (F) illustrates the six LEDs and the central location of the camera lens.

available underwater video camera to increase its utility for aquatic research. In addition to describing the equipment specifications and modifications, we briefly outline the varied applications for which we have deployed the modified video setup.

Equipment Modifications

When we were developing our videography capabilities, we investigated several different commercially available cameras. We chose to modify an underwater video camera developed by Atlantis Camera (model AUC-75, black and white 420 line, 640 × 420 analog signal, 270,000 pixels, 8 mm ccd, 0 lux, high-resolution camera, 92° angle viewing lens, six infrared light-emitting diodes [LEDs] for low light conditions, steel-mesh–reinforced cable with integrated power and video signal, 75 mm long × 35 mm diameter, 0.35 kg) because this company provides the option of purchasing only the camera and cable; many companies require the purchase of an entire package (Figure 1). This camera was also small, provided several options for mounting, included integrated infrared illumination, and was inexpensive. The cameras are factory sealed (rated to depth of 20 m) and are available with cables of various lengths (22.9, 30.5, and 60.7 m). The end of the cable is affixed with a 5-pin male Deutsche Industrie Normenausschuss (DIN) plug. We developed a small junction box that permitted us to provide the camera with appropriate power and let us to observe and record the video signal.

We used an acrylonite–butadiene–styrene (ABS) plastic enclosure with a screw-on lid that measured 130 mm × 70 mm × 40 mm for the junction box (see Table 1 for parts list). We drilled a hole sized to match the female five-pin DIN female socket panel mount with solder lugs (usually 16 mm diameter) centered in one end of the enclosure (Figure 2A). From our experience in drilling this type of ABS, we recommend using a drill press at slow speed with an appropriate bit. The five-pin DIN plug was then mounted on the outside of the box; two small holes were drilled through the fitting holes and small nuts and bolts were used to secure the DIN plug plate in place. In the opposite end of the enclosure, we drilled a hole sized to match the baby N-connector (BNC) female panel mount (Figure 2). We fixed the BNC in the hole and tightened the nut from the inside of the enclosure. We ensured that the grounding plate was placed on the inside of the enclosure and was bent out from the enclosure to facilitate soldering. To provide power to the camera, we used a 2.1-mm male panel mount power jack with solder eyelets. Generic 22-American Wire Gauge (AWG) plastic-coated multistrand wire was used to connect the

TABLE 1.—Parts list for construction of camera junction box excluding the power supply.

Parts list	Quantity	US $
ABS[a] plastic enclosure box (130 mm × 70 mm × 40 mm)	1	13.00
Female 5-pin DIN[b] panel mount	1	2.25
AWG[c] 22 gauge plastic coated wire (15-cm lengths)	3	0.50
RG 58 c/u coaxial cable (15-cm length)	1	0.50
Female BNC[d] panel mount	1	2.00
Male power jack panel mount with solder eyelets (2.1 mm)	1	1.90
5-min epoxy (3 mL)	1	0.25

[a] ABS = acrylonite–butadiene–styrene.
[b] DIN = Deutsche Industrie Normenausschuss.
[c] AWG = American Wire Gauge.
[d] BNC = Baby N-connector.

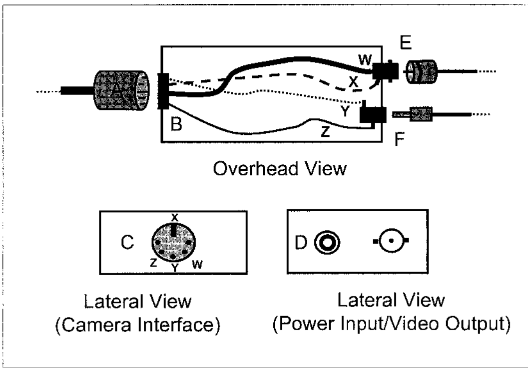

FIGURE 2.—Schematic of the junction box for underwater camera. The overhead view illustrates the location of the camera interface (C) and the power input/video output. The camera input (A) plugs into the junction box (B) camera interface (C). Power is supplied (F) to the left input (D) by way of a 12-V power supply. The video output (right fitting on D) is attached to the female baby N connector (BNC; E) that leads to a monitor or video cassette recorder or both. Wires as described in the text connect the camera interface to appropriate plugs (see B and C for wiring diagrams). The main camera signal (W) and the camera signal ground (X) connect the DIN plug to the BNC connector. The positive power source (Y) and negative power source (Z) connect the DIN plug to the power input fitting.

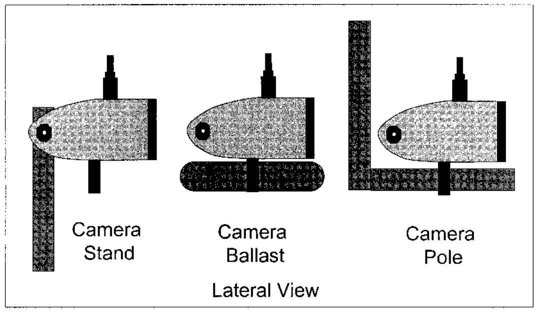

FIGURE 3.—Variety of underwater camera deployment configurations. A camera stand can be devised by using thin metal such as aluminum (described in text). Camera ballasts provided with the camera can be used for downrigging or other applications that involve towing the camera at depth. Poles can be devised to position the camera as desired for exploratory or stationary monitoring.

camera ground and the positive and negative power grounds between the DIN plug lugs and the appropriate solder tab. To reduce interference with the camera signal in the switch box, we used the core-braided wire of shielded RG58 c/u coaxial cable with Teflon insulation to connect the camera-feed DIN lug to the main solder tab of the BNC female connector. The core-braided wire was exposed by removing the plastic sheath and the woven metal shielding, leaving a length of core wire encased in the Teflon insulation. Minimal insulation was removed from the ends of the wires (~3 mm) and they were soldered to appropriate connection points (see Figure 2). A multimeter set on ohms or continuity was used to test continuity between the external DIN plug holes and the appropriate power or BNC fitting. Once satisfied that all solder points were intact and isolated from each other, 5-min epoxy was drizzled over the inner enclose location where the BNC connector nut was affixed. When cured, the epoxy secured the BNC connector and thus prevented slipping and subsequent interruption of signal from repeated use of the connector. The lid to the enclosure was then screwed into place to complete the junction box. For one camera set-up this customization required approximately 1 h and simple electronics tools (i.e., soldering iron, wire cutter, wire stripper) to complete. The total cost for parts to construct the junction box is about US$25 each, including the approximately $9 power supply, and can be combined with an AUC-75 camera for approximately $125.

The power supply for this camera required between 11.8 and 14.6 V to function properly. For field applications, the camera easily can be powered with deep-cycle 12-V batteries. Wires of at least 16 AWG gauge can be outfitted with an appropriate power jack (in this case, a 2.1 mm × 5.5 mm female plug) on one end and alligator clips or other appropriate connections for the battery terminals. For laboratory settings or other applications with 120-V power supplies, step-down transformers can be used to power the cameras. Unregulated power supplies vary widely in actual power output, potentially resulting in power surges and burning out the infrared LEDs. The safest power supply is a 12-V regulated transformer; however, any transformer that provides 12–14 V is appropriate. Voltage approaching 14 V is ideal for maximal LED output; exceeding this voltage, however, even for short periods, can render the LEDs inoperable. The video-output BNC connected from the junction box can be merged easily with a monitor, time-lapse video cassette recorder, switcher, or multiplexer.

In our initial experimentation with this camera, we experienced some failure of LEDs, in all cases because the camera received excessive voltages (i.e., >15 V). The camera, although factory sealed, can be opened, the LEDs changed, and the unit resealed. Although we do not describe this procedure in detail, we suggest changing all LEDs if a single LED becomes nonfunctional. After performing this procedure, we apply small amounts of Plastidip (Plastidip International, Minnesota), an effective medium for waterproofing the cameras, to all seals.

The extensive cable associated with the camera can be stored easily on hand-held extension cord wheels, available at most hardware retailers, to prevent kinking and cable damage.

Applications

The camera can be mounted on a stabilizing fin with two steel ballast weights for trolling behind a vessel. Other carrier devices for suspending cameras described elsewhere (Groves and Garcia 1998) should also work with these cameras. This stabilizing fin and ballast work reasonably well at low speeds ($<$5 km/h); however, for the most part we have used cameras fixed in position. For exploratory work under ice or in fishways we have mounted the camera on an aluminum pole that was bent at a 90° angle and fit inside the ballast mounts. To protect the camera face, the bottom portion of the pole should extend beyond the camera face. In addition, we have placed rubber gaskets from 35-mm (inner diameter) compression-coupling plumbing fitting that fit snugly over the end of the camera to protect it from abrasion and other damage. When mounted on a pole, the camera can easily be rotated to view different directions or stabilized and held in place with a brace.

When we planned to place the camera on firm substrates, we created a weighted stand. We mounted the camera on a thin piece of flat aluminum plate ($\sim$3 mm $\times$ 15 mm) that had a hole drilled through the stabilizing fin hole and then placed the aluminum plate (of any length) in the stand. In softer substrates, the plate was driven into the substrate without the weighted stand. We have successfully used these configurations to monitor the parental care activity of centrarchid fishes. The infrared illumination performs best when the camera lens is pointed towards a solid background at a distance of 1 m.

The cameras are also sufficiently small that they can be used in typical black perspex boxes for physiological studies held in place with shaped sponges. In one study, we used these cameras to noninvasively monitor ventilation rates and coughing in largemouth bass *Micropterus salmoides* and smallmouth bass *M. dolomieu* exposed to progressive hypoxia. To date, we have not used this camera in marine environments; however, the manufacturer submits that the camera is corrosion resistant. We have also used the cameras out of the water. When the cameras were mounted above aquaria or tanks, the set up worked best when high-contrast backgrounds were used.

To conclude, commercially available underwater video cameras are becoming commonplace, being used by recreational anglers to target fish. These cameras are also useful for a wide variety of applications in fisheries research and provide a cost-effective alternative to custom-made professional underwater video apparatus. These devices can be modified as described above to provide flexibility and maximal ease of use, on a small budget and with minimal electronics skills. This apparatus has several advantages over using a standard camcorder with a waterproof housing, including longer battery life (days to continual use), elimination of problems with waterproof seal maintenance, ability to interface multiple cameras, and small size. Fisheries managers could benefit from incorporating underwater videography into their suite of fisheries assessment tools. Indeed, many applied research and management issues will benefit from direct nonintrusive observation of fish, habitat, or other variables of interest.

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