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Deploying action cameras to observe fish in shallow, ice-covered streams

Lindsay Davis^a, Jaclyn Cockburn ^a and Paul V. Villard^b

^aDepartment of Geography, University of Guelph, Guelph, Canada; ^bGEO Morphix Ltd., Milton, Canada

ABSTRACT

Winter is a stressful season for freshwater, stream-dwelling fish because ice decreases habitat area and creates habitat fragmentation, and cooler water temperatures lower fish metabolism. Small streams regularly become completely ice-covered, and common techniques used to study fish developed for open-water conditions are not easily modified. These winter conditions make it difficult to accurately observe fish behaviour in their natural habitat. This study evaluated remote underwater video cameras used to observe minnow behaviour in overwinter conditions. Waterproof action cameras (e.g. GoPros™ and Sony™ action cameras) were lowered into the water column from the channel ice and set to record for 30-minute intervals, and with a modified antenna, Bluetooth™ connected cameras facilitated real-time observations to check and ensure camera position and function. Advances in video camera technology have allowed high quality video to be captured with inexpensive equipment (~\$500 CDN for camera, case, memory card and back-up batteries), such as small, portable action cameras that are now readily available. This technique was effective at observing fish behaviour, communities and habitat preference during the winter in small, ice-covered streams, which is important for water resource and fisheries management, conservation biology and stream restoration.

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Introduction

Winter conditions make it difficult to evaluate fish behaviour in their overwinter habitat, particularly in shallow, ice-covered streams. Due to this difficulty, there is limited information on fish overwinter habitat preferences in small streams (e.g. Brown et al. 2011). Previous work, on larger species, such as salmonids, provided valuable insight on observation techniques, but lacked specific observations for smaller species (Brown et al. 2011). Small fish (e.g. *Semotilus atromaculatus*, *Rhinichthys atratulus* and *Clinostomus elongates*), juvenile and young-of-the-year salmonids (e.g. *Salmo salar* and *Salvelinus fontinalis*) are an important food source for larger, predatory fish and contribute to overall biodiversity. Observing their behaviour during winter conditions is necessary for fishery management and informing conservation or restoration practices (e.g. Skyfield & Grossman 2008).

Most studies using remote underwater video focus on mature salmonids or marine species in open water, where camera movement or rotation is minimal and the species observed do not exhibit a fright response (e.g. Carlson & Quinn 2005; Becker et al. 2010; Burge et al. 2012). Marine studies typically employed larger, stationary underwater camera systems and recorded continuously for 20–30 minutes (Becker et al. 2010; Burge et al. 2012). Modifications to the larger camera systems by

reducing the size and adding more cameras can provide a technique to observe fish in smaller streams. The increased availability and affordability of small, high quality cameras also allows reduction of the camera system size (e.g. Struthers et al. 2015).

Small fish behaviour is different from larger, predatory species, and it is expected that during the winter season as water temperatures decrease, fish metabolic rates decrease thus reducing their ability to avoid predators and forage (Berg & Bremset 1998; Parsons & Smiley 2003). To counter reduced energy levels, juvenile salmonids utilize refuge when temperatures decrease (Cunjak et al. 1998; Stickler et al. 2008). Smaller fish likely employ this strategy in the winter. Shallow, ice-covered streams still present a challenge to observing overwinter habitat preference for small fish (e.g. juvenile salmonids, Creek Chub, Redside Dace and Blacknose Dace). This note presents an approach to monitoring and observing small fish in shallow, ice-covered channels using underwater cameras. The principle advantage of this technique is that it is easy to conduct and relatively inexpensive. Given sufficient battery capacity and memory, the design can be deployed to record video for several hours and provide information about fish activity in an otherwise difficult to observe habitat.

Camera deployment

Camera types

Optical, colour, digital cameras were used to record video simultaneously for 30-minute intervals. Three to four cameras were positioned between 150 and 300 mm above the streambed secured to a weighted, metal rod (Figure 1). Observations were recorded with two SonyTM HDR-AS100V cameras, one GoPro Hero3TM camera and one GoPro Hero3+TM camera in waterproof housings. All cameras used a CMOS sensor for video recording and resolution was 1080 p at 60 frames per second (Table 1). Each camera set-up, waterproof case, memory card and back-up battery was ~\$500 CDN when this project started in 2014. Since that time camera prices have dropped for these models, but \$500 represents the typical cost for all of the components, including a top-end action camera.

All cameras used a lithium ion battery and performance differed depending on air temperature. The SonyTM camera battery had the longest battery life as described by the manufacturer when operating at optimal conditions (e.g. ~20 °C; Table 1). But during field-testing when air temperatures were consistently below -25 °C and water temperature was below 10 °C the batteries lasted for approximately one hour of recording regardless of brand. When the air temperature was between -25 °C and 0 °C and water temperature was below 10 °C the SonyTM cameras lasted for approximately one and a half hours, whereas the GoProTM batteries only lasted for an hour. When air temperatures were above 0 °C and water temperatures were above 10 °C, the battery performance closely matched the manufacturers published expectations. Increased battery life was achieved by keeping the cameras and batteries warm between recordings (i.e. placing the cameras in an inside pocket).

Camera apparatus and positioning

A camera stand was built based on marine studies with modifications to use in small streams through ice cover (Becker et al. 2010; Burge et al. 2012). The apparatus consists of a secure base to reduce motion while recording with a hollow metal rod perpendicular to the base used to secure the cameras (Figure 1). Bait stations constructed from two wire cages were added to the metal rod above the base, but were not used during observations (Figure 1). Cameras were attached with adjustable mounts fit onto the hollow rod. Scour around the weight was not observed in our study (velocities were slow along the bed, <0.05 m/s maximum, Davis 2016); however, deployments in faster moving water may need to modify deployment to avoid scour.

At each site, two holes were drilled with a manual ice auger (diameter = 0.20 m). One hole was used to deploy the cameras, and the other was used to ensure a ruler or stadia rod was within the

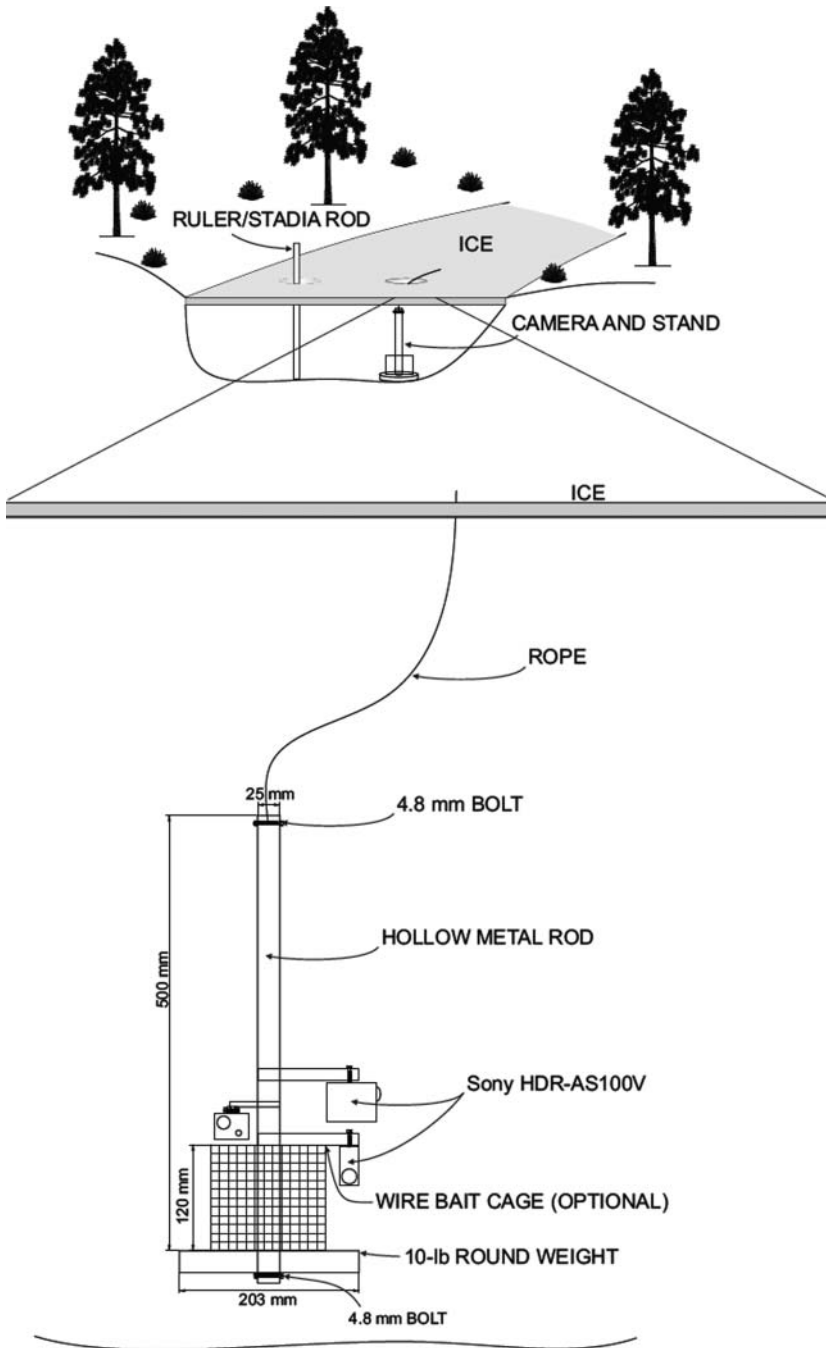


Figure 1. Camera set-up within a typical, narrow, shallow stream in Southern Ontario. The lower schematic illustrates the camera stand apparatus and individual camera positions.

line of view of at least one camera (Figure 1). Snow and ice (from the ice auger) were cleared off the surface in a 2.0 m diameter around the hole to increase the light reaching the water column. After drilling was finished, a 20-minute quiet period was imposed before the cameras were deployed to mitigate noise disturbance. A study done on salmonids suggested 20 minutes was adequate time to recover from noise disturbance (Carlson & Quinn 2005). Anecdotal observations during our work

Table 1. Specifications for cameras used in this study.

Camera	Optical sensor	Resolution	Battery type	Expected battery life (hh:mm)	Actual battery performance (hh:mm)
GoPro Hero3	CMOS	1080 p 60 fps	Lithium-ion 1050 mAh	1:45	1:00–1:45
GoPro Hero3+	CMOS	1080 p 60 fps	Lithium-ion 1080 mAh	2:00	1:00–2:00
Sony HDR-AS100V	CMOS	1080 p 60 fps	Lithium-ion 1600 mAh	4:00	1:00–4:00

suggest auguring noise travelled ~ 100 m from the location of the works and thus multiple observations at a site might be delayed due to noise disturbance. After the cameras were lowered into the water column, if fish were present, they were observed throughout the video and not just towards the end of the recording period, suggesting that the 20-minute delay was sufficient. Once the cameras were in place they were left to record for 30 minutes. Each camera was left stationary for the entire recording time to reduce any fright response caused by movement.

The inability to watch the video while it records potentially decreases the quality of results. Vegetation, leaves and other debris can obstruct the camera view and thus useful footage was not produced. Even a partial view blockage can reduce the quality of observations. One way this was mitigated was to watch the video through a live-feed either through applications provided by the manufacturer (i.e. watching from an iPhone or iPad) and/or using the wristband remote viewers that come with newer camera models. The cameras used in this study were Wi-Fi enabled but the signal was not sufficiently transferred through water without the use of an inexpensive antenna. An antenna was created using a modified, 5 m coaxial cable suitable for a Wi-Fi frequency (e.g. RG 174 u). Approximately 5 cm of the insulation around the cable was removed from each cable end, and then made water resistant with super glue and heat shrink tubing placed over edge of the insulation and small (~ 1 cm) of the exposed wire. The exposed wire was fixed to the waterproof camera housing and to the wristband remote viewer (or iPhone) with waterproof tape (e.g. electrical tape or duct tape). With a functional antenna, the remote viewer application was a useful quick check on the camera position, but during cold temperatures (air temperature -10 °C or lower) battery life was greatly reduced and thus additional back-up batteries are recommended.

Challenges

All cameras came with low light capabilities and suggested light levels above 6 LUX would be suitable for recording images. The light levels during recording sessions were at least 50 LUX (Davis 2016). External lights were not tested in this study but they might improve focal distance in light conditions below 50 LUX. In low light conditions less than 6 LUX, white light can improve the viewing capabilities of the cameras (Mueller et al. 2006). While the effects on smaller fish are unknown, laboratory experiments with larger fish (e.g. Marchesan et al. 2005) suggested that white light attracted some predatory fish.

Turbidity reduced visibility and focal distance during our study. Mueller et al. (2006) found that turbidity levels above 4 NTU significantly decreased fish detection for optical cameras; during this study, turbidity greater than 10 NTU was common during the spring observations (following ice break-up; Davis 2016). When ice cover was present on the streams, turbidity levels remained relatively low. Midwinter floods are common in small streams and may produce higher turbidity levels and thus impact observations (e.g. Harvey et al. 1999).

Conclusions

The technique presented was effective for observing fish in small, ice-covered streams and is based on previous work in larger systems (e.g. Struthers et al. 2015). Viewing a live feed from the cameras

improved observation quality and confirmed field of view. Bait can also be used to draw fish into the camera view but this will alter behaviour. Using the camera best suited for the environment will increase observation quality.

Underwater video has several advantages over traditional methods. It is suitable for recording species composition, relative abundance, behaviour and habitat use. It reduces the disturbance caused by other techniques. Electrofishing can lead to fish mortality and requires specialized training and extra personnel. There is limited risk of mortality with underwater video. This makes it particularly favourable when dealing with endangered species. It also requires minimal personnel and training to provide an affordable option to study fish communities and behaviours under ice cover.

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Disclosure statement

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Notes on contributors

L. Davis completed her Bachelor of Science, Environmental Geoscience and Geomatics, in 2014 and her Master of Science, Geography, in 2016, both at the University of Guelph. She currently works at GEO Morphix Ltd.

J. Cockburn completed her PhD at Queen's University, Kingston, Ontario, Canada, and has worked in the Department of Geography, University of Guelph since 2011.

P. Villard completed his PhD at University of Auckland, Auckland, New Zealand, and is the director of GEO Morphix Ltd. in Milton, Ontario, Canada.

ORCID

Jaclyn Cockburn  <http://orcid.org/0000-0002-1326-4457>

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