E-ISSN: 2073-3720
https://doi.org/10.33997/j.afs.2022.35.3.006

SHORT COMMUNICATION

New Techniques for Underwater Video Photography of Line Fishing and Their Application in Shark Depredation Studies

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Abstract

There is an increasing need to understand the interaction of marine fauna with line fishing, both recreational and commercial, particularly in regions where shark depredation has become an increasing issue. The dynamic nature of the fishing requires underwater filming techniques that can move with the fishing activity and capture high-resolution footage enabling the identification of fauna species. In the case of shark depredation, the development of deterrent devices specifically designed for use while line fishing will require underwater footage to determine the effectiveness of those devices designed to invoke avoidance behaviours in sharks that approach hooked fish. Two new and inexpensive mounting systems were developed, enabling a range of "action" cameras to be attached to fishing lines to capture underwater footage while line fishing. Using these mounting systems with GoPro™ cameras, high-resolution video was obtained during line fishing trials in which the effectiveness of shark deterrents was investigated. The video footage enabled the identification of fish and shark species and recorded any avoidance behaviours of sharks, in response to the presence of deterrents.

Keywords: recreational, commercial, charter, depredation, shark deterrent

Introduction

Underwater footage can provide valuable information on the abundance and distribution of a range of marine taxa. The most frequent way this footage is captured is by using a baited remote underwater video (BRUV) system (Harvey and Shortis, 1998; Whitmarsh et al., 2017; Langlois et al., 2020). BRUVs are a common tool for examining marine fish communities and are historically designed to rest on the seafloor at a wide range of depths, although they have recently been adapted for use in sampling pelagic environments (Bouchet et al., 2018; Mitchell et al., 2020). The limited mobility of these bulky systems restricts their ability to sample marine faunal interaction and competition, particularly in a fishing setting.

The behaviour of fish and other marine fauna, such as sharks and dolphins, around fishing gear has been studied successfully. In these situations, the fishing method involves large, robust gears (i.e., trawl nets, traps) that enable small action cameras, such as GoPro™, to be kept and attached in large, attached, strong waterproof housings (e.g., Renchen et al., 2012; Bryan et al., 2014; Santana-Garcon et al., 2018). Video footage has also been obtained during trolling, although this has involved using a ~3.5 kg camera that provides live video back to the boat via an optical cable (Robbins et al., 2011). In both instances, the camera equipment is too large and heavy to incorporate into a recreational or commercial line fishing setting. O'Shea et al. (2015) and Drymon et al. (2020) have previously attached GoPro™ cameras, which have a greater resolution and a larger field of view than the previously mentioned cameras, to fishing lines, however, there are no details as to how these were attached. Some underwater cameras are specifically designed to be attached to fishing lines (e.g., GoFish Cam™, Spydro®), either by tying them directly to the line or using snap swivels to attach them via the metal wire connection points that extend in front and behind the camera. However, the cylindrical shape of these cameras tends to make them spin readily when the fishing line is retrieved, thus reducing the resolution and field of view and affecting the video quality. Mitchell et al. (2019) used a similar system to investigate shark depredation in a recreational line fishery. Features of GoPro™ cameras, such as their image stabilisation, higher resolution and a wider field of view, not available on specifically designed fishing line cameras, make them a suitable option for recreational line fishing scenarios. However, they require an innovative way to attach them to the fishing lines.

The increasing occurrence of shark depredation in the commercial, charter, and recreational fisheries (Labinjoh, 2014; Mitchell et al., 2018; Casselberry et al., 2021) has led to a call for greater baseline information quantifying the extent of the issue, including identifying the shark and fish species involved in depredation events (Mitchell et al., 2018). While depredation can occur when the hooked fish has reached the surface, depredation often happens below the surface, precluding the ability to identify the fish and shark species involved (Coulson et al., 2022), which will require the use of underwater video cameras. However, unlike other underwater camera setups, fishing line-mounted cameras need to be compact to be practical in a fishing scenario (e.g., Mitchell et al., 2019) and provide high-resolution, unobstructed footage. Furthermore, the video footage from such cameras will be crucial when determining the effectiveness of shark deterrent devices, such as the magnetic Sharkbanz zeppelin device (https://www.sharkbanz.com/products/zeppelin) and Ocean Guardian's electronic Fish01 device (https://ocean-guardian.com/products/fish01), that are designed specifically for use while line fishing. Such magnetic and electronic shark deterrent devices are designed to interfere with the shark's highly sensitive sensory system (i.e., ampullae of Lorenzini), thereby altering the behaviour of sharks that approach hooked fish. Video cameras connected to fishing lines will be essential to capture footage of the shark and fish species involved in depredation and any behavioural changes of the sharks in response to the presence of a deterrent.

A recent study (DPIRD, unpublished data) investigated the effectiveness of three shark deterrent devices (electronic, magnetic and acoustic) in preventing depredation of fish in a recreational line fishery in waters off north-western Australia. Clear, unobstructed, high-resolution video footage for multiple fishing lines is needed for the following: i) to identify fish species depredated, ii) responsible shark species, iii) time taken for sharks to depredate fish after they are hooked, iv) behavioural changes, and v) the deterrents evoked in sharks. Thus, this study aims to develop two new mounting systems that enable small, underwater, action video cameras to be attached to fishing lines.

Materials and Methods

Field tests

Rod and line fishing for demersal species, such as snappers (Lutjanidae), emperors (Lethrinidae) and serranids (Serranidae), was conducted from a recreational charter fishing vessel and a research vessel in August 2020 and April 2021, respectively, in waters <50 m deep near the Montebello Islands (~20.5°S, 115.5°E), off north-western Australia. Further sampling was conducted from a research vessel in waters around Exmouth (~21.9°S, 114.1°E), including the northern extent of the Ningaloo Reef (~21.9°S, 113.9°E) and Muiron Islands (~21.7°S, 114.3°E) in March 2021. The boat was anchored while fishing. A paternoster fishing rig with a single hook (size 10) was used exclusively during field tests. GoPro™ 3 and 4 underwater cameras in waterproof housings were used throughout the tests.

Option 1: Wire cradle

The first camera-mount design was a wire "cradle" that consisted of two lengths (190 and 210 mm) of nylon-coated (80 or 100 lb) wire fishing trace. The shorter length of wire was passed through the buckle mount joint of the GoPro™ housing, and one end of a size 2/0 swivel (swivel 1, Fig. 1a), was placed in the gap between the two sides of the buckle mount. The wire then passed through the circular end of a size 5/0 ball bearing snap swivel (swivel 2, Fig. 1a) before the two ends were crimped together. The longer length of wire also passed through the circular end of the snap swivel (swivel 2) before the two ends were crimped together. After the camera was placed into the housing, the loop created by a longer length wire was placed under the card buckle. As the buckle was shut, the camera was secured in the housing (Fig. 1a). It is crucial to ensure that the wire under the card buckle is not placed in the rubber seal between the back plate and the front of the housing. This is to prevent the housing from sealing incorrectly and allow water to enter the housing. To attach this wire cradle to fishing line, a safety line consisting of 200 mm long nylon-coated (80 or 100 lb) wire fishing trace with a regular size 2/0 swivel (swivel 3, Fig. 1a) and a size 5/0 ball bearing snap swivel (swivel 4, Fig. 1a) was crimped onto opposite ends of the trace. Swivel 3 was then connected to swivel 2, which was connected to the two lengths of wire trace making up the cradle. The swivel 4 on the safety line was connected to a size 2/0 swivel (swivel 5, Fig. 1b) tied to the main line or leader. The fishing line (200 lb monofilament) that leads to the hook and sinker was tied to swivel 5 and then passed through swivel 1 before the hook(s) and sinker were tied on using 80 lb monofilament.

Option 2: Pole mount

The second camera-mount design consists of a 250

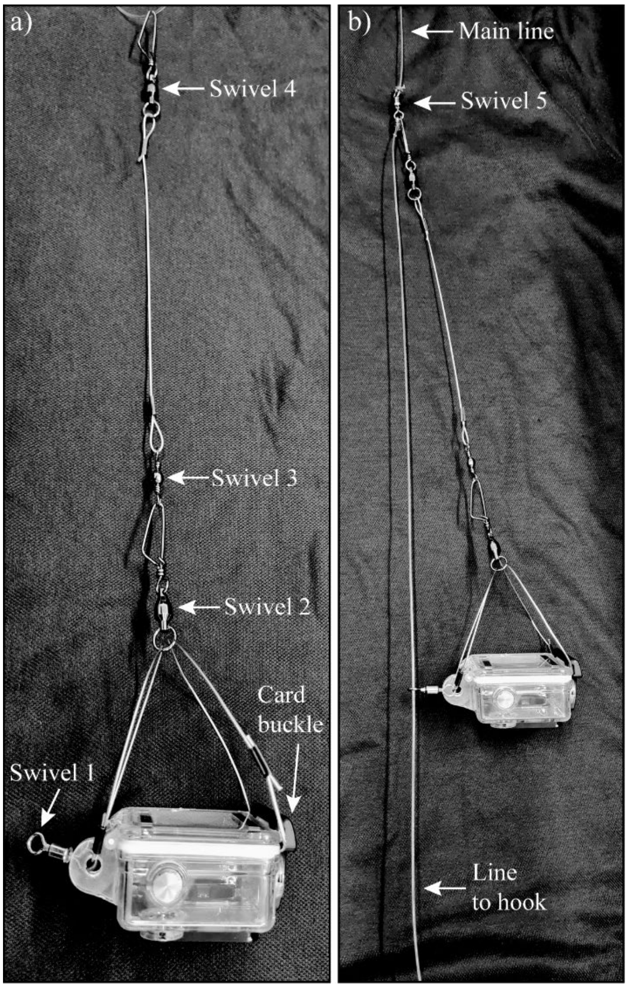

Fig. 1. (a) Picture of the wire cradle camera mount fitted to a GoPro™ underwater camera housing and attached to wire safety line, and (b) in situ attached to the main fishing line. The different swivel numbers are referred in the text.

mm long, 6 mm diameter aluminium tubing weighing only 19 g (Fig. 2a). A small tab of 3 mm thick aluminium plate was welded onto the outside of the aluminium tube ~40 mm from one end of the tube. The width of the tab was 25 mm at one end and 15 mm at the other end, with the narrower end at the top of the tubing (Fig. 2a). The tab with had two holes, and the hole in the broader end was used to mount the GoPro™ housing, using 1/18th screw and nut. The hole in the narrower end was used for attaching a safety line (Fig. 2b). The difference in the widths of the tab enabled the back plate of the underwater housing to be opened when the housing is screwed tightly in place, perpendicular to the aluminium tube. The camera could be removed to change the battery and memory card (Fig. 2c). The same safety line used in the wire cradle mount design was also used to connect the aluminium tube camera mount to the main line or leader (Fig. 2d). The fishing line (200 lb monofilament) that led to the hook and sinker was tied to the swivel, which was attached to the main line or leader. This then passes through the tubing before attaching to the hook(s) and sinker using 80lb monofilament (Fig. 2d).

Fishing line rigging considerations

The cameras used in these two camera-mount designs were deployed to capture underwater video footage of fish and sharks in regions where shark depredation was known to be high. To prevent the cameras from being accidentally bitten and increase the field of view, the cameras were positioned 1.5–2.0 m above the hook. In addition, the lighter (80 lb) "dropper" lines that attached the hook and sinker to the heavier (200 lb) mainline, ensured that if a shark depredated a fish and became hooked, or the hook/sinker became snagged on the sea floor, the lighter line would break easily allowing the camera to be retrieved. During testing, a single 6-ounce sinker was attached to the bottom of the fishing line, not only to get the fishing line to the sea floor but also to ensure that the fishing line below the camera remained relatively taught and thus in the field of view. When fishing with either of these cameras' mounts attached to fishing lines, the angler must keep the fishing line taught when he feels the sinker reach the bottom so that the camera remains suspended above the hook. This will ensure that the camera captures footage of fish and sharks interacting with the bait and prevents the camera from becoming snagged on reefs or algae.

Current and Future Application(s)

Both camera mounts are relatively inexpensive, with the wire cradle camera mount being constructed in the field with only a few tools that most anglers will have in their tackle boxes. The wire cradle's flexibility could cause the attached camera to move, not always looking down the fishing line towards the bait. This was particularly evident when the fishing line was descending and hanging static in the water once the sinker had reached the seafloor and when the line was reeled in (Video 1). In contrast, the aluminium tube mounting system maintains the camera looking down the line more consistently as the fishing line runs through the tube (Video 2). While the square shape GoPro™ camera and its housing increased pressure on the line when reeled in, both camera mounts did not spin much as observed in other cylindrical fishing line cameras (e.g., GoFish Cam™, Spydro®). These tests were conducted while fishing for demersal species using both camera-mount designs. However, the aluminium tube mounting system could be modified to include vales when trolling for pelagic fishing species susceptible to depredation, such as Spanish mackerel *Scomberomorus commerson* (Lacepède, 1800) (Carmody et al., 2021).

The video footage captured using GoPro™ cameras attached to either camera mounts were of high quality and allowed a range of measures to be recorded. These measurements included the time between a fish becoming hooked and depredated, the time when sharks were first observed, the identification of fish and shark species, number of sharks following the

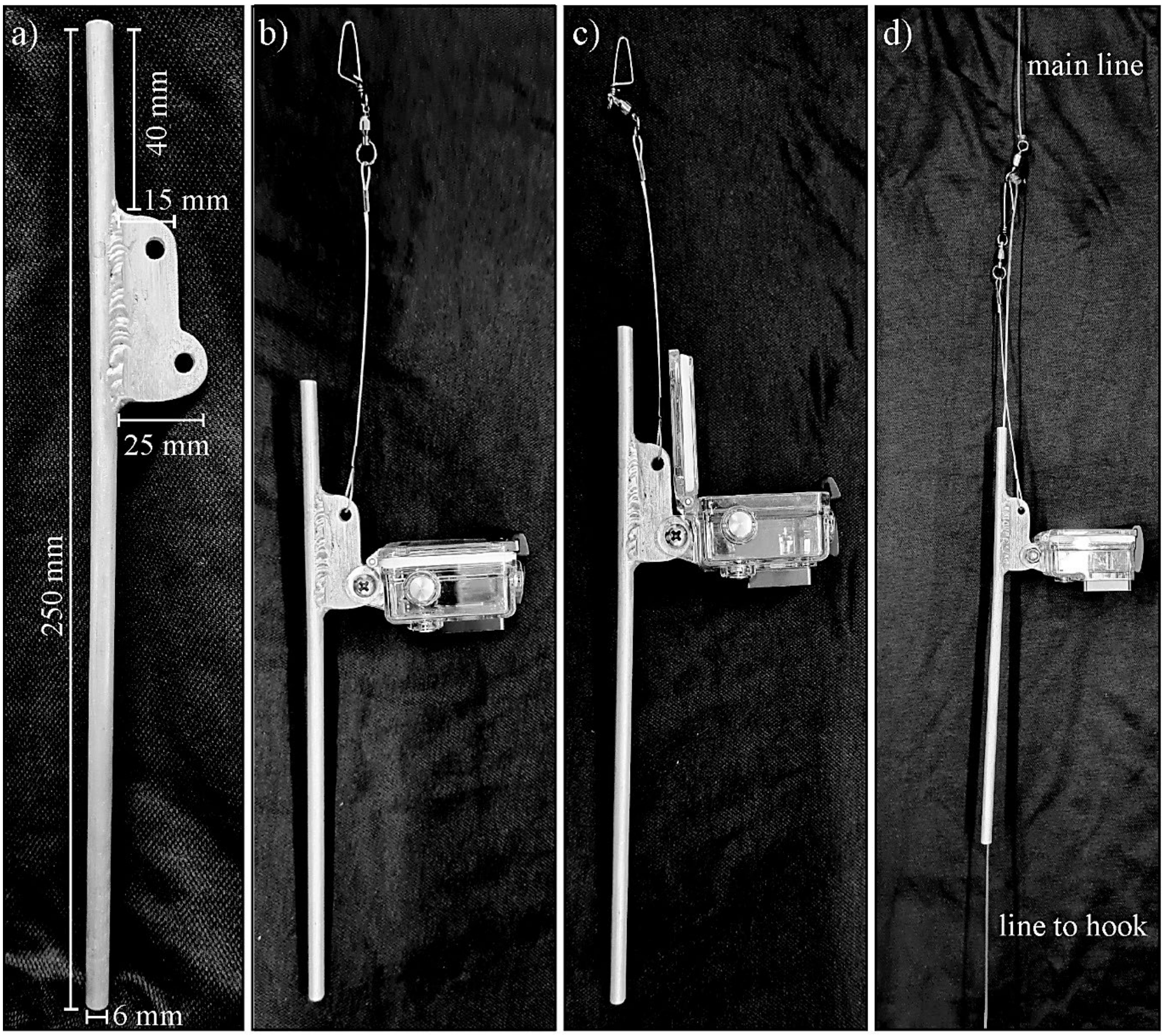

Fig. 2. Pictures of the aluminium tube camera mount with, a) the associated measurements, (b, c) fitted with the wire safety line and a GoPro^{TM} underwater camera housing and with the back plate shut and open, respectively, and (d) showing how the camera mount is attached to the main fishing line.

hooked fish (Fig. 3). The similarity of anatomical features of sharks in the *Carcharhinus* genus made it extremely difficult to identify them to species level (Figs. 4a, b). This was due to movement of cameras and the fact sharks generally approached bait straight-on and were rarely seen from the side. In addition, as we were fishing in a region where depredation was high when sharks approached hooked fish and, in many instances, were competing against other sharks, their bodies often bent, compounding the ability to identify the shark species. The field testing was to determine the effectiveness of shark deterrent devices when line fishing (DPIRD, unpublished data). In addition, it was also to determine whether shark depredates fish and their behavioural changes invoked in the presence of a deterrent. Importantly, the video footage captured by the cameras attached to these mounts has allowed a range of behaviours, such as rushing in toward a hooked fish before rapidly turning away, to be documented (Figs. 4c, d).

Depredation in recreational fisheries is prevalent in many locations globally. It requires in-situ mitigation methods and behavioural changes by the fishers, some of which are already being employed, such as regularly moving fishing locations (Coulson et al., 2022). The development of shark deterrents for use specifically in a recreational fishing setting may alleviate some depredation but are unlikely to be completely successful, as has been found for personal protection shark deterrents (Huveneers et al., 2018). Independent, rigorous scientific testing of these devices will be important to enabling consumers (i.e., commercial, recreational and charter fishers) to make informed choices regarding their effectiveness. As magnetic and electronic deterrents aim to disrupt the electrosensory system of sharks, the ability to observe subtle behaviour changes in sharks is a crucial aspect of testing deterrents. As the electrosensory system varies between shark species (Kempster et al., 2012), such deterrent devices may have variable inter-specific efficacy. Understanding which shark species are responsible for depredation, as well as the teleost species that are depredated, will be essential components for determining mitigation strategies (Mitchell et al., 2018). The increasing occurrence of

Fig. 3. Frame grabs from underwater video footage captured using GoPro™ 3 or 4 underwater cameras showing identifiable fish and shark species, (a) two large Malabar groupers *Epinephelus malabaricus* and two red emperors *Lutjanus sebae*, (b) a lemon shark *Negaprion acutidens* depredating a hooked fish, (c) a whitetip reef shark *Triaenodon obesus* investigating a baited hook, and (d,e,f) examples of footage enabling a count of the number of sharks following hooked fish.

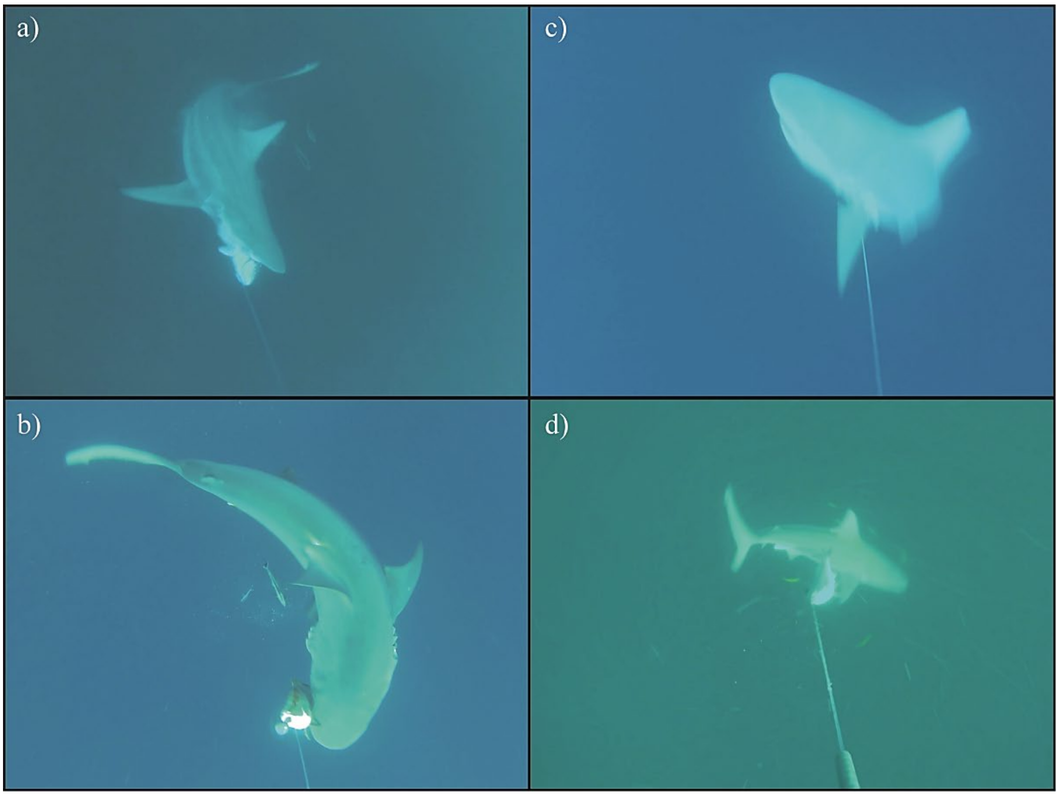

Fig. 4. Frame grabs from underwater video footage captured using GoPro™ 3 or 4 underwater cameras, (a, b) highlighting the difficulties in identifying sharks from some footage, and (c, d) examples of sharks exhibiting avoidance behaviours (i.e., turning away abruptly) in the presence of shark deterrent devices.

depredation continues to be a severe issue for fisheries worldwide, and continued effort must be made to use camera technology and to improve it further to understand the issue better and contribute to guiding future management.

Acknowledgements

Thanks to Kim Wight and Joshua Smith from Montebello Island Safaris and the skipper and crew of DPIRD's RV Naturaliste for their hospitality and field assistance and to D. Boddington, P. Lewis and D. Yeoh (DPIRD) for their help in the field. Thank you to the two reviewers whose comments helped refine this manuscript. Funding for this project was provided through the Recreational Fishing Initiatives Fund facilitated by Recfishwest and the Western Australian Department of Primary Industries and Regional Development (DPRID).

Conflict of interest: The authors declare that they have no conflict of interest.

Author contributions: P.G. Coulson: Carried out fieldwork, developed the designs of the two camera mounts, undertook the analysis of video footage and wrote the first draft of the manuscript. N.D.C. Jarvis: Carried out fieldwork and developed the designs of the two camera mounts. G. Jackson: Obtained funding for this project. All the authors edited and revised the manuscript.

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