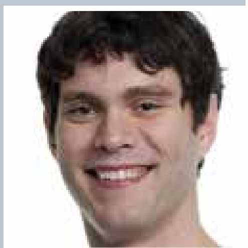
The Art of Observation



Brett Favaro

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Favaro and Duff observe the behaviour of fish using underwater cameras.

Who should read this paper?

Anyone who is interested in either underwater camera technology or life sciences, and the symbiotic relationship that can exist between the two.

Why is it important?

A fundamental element of natural science is the act – some would say the art – of observing. Most consider it to be the first step in the empirical scientific method. Technology, on the other hand, combines knowing and doing through systematic design to achieve a practical result. This paper illustrates how science and technology often go hand in hand.

In 2010, the authors conducted a research project in the waters off British Columbia, Canada, in which they used specially designed underwater video cameras to study the performance of traps designed to catch spot prawns (*Pandalus platyceros*). While their focus was on understanding the fishing gear, being good natural scientists they observed something surprising while analyzing their videos – rockfish (*Sebastes spp.*) appeared to be trying to eat prawns in and around the traps. Direct evidence regarding rockfish diet is hard to come by – when they are brought to the surface from deep water their stomach contents are mostly lost due to the effects of barotrauma. Actual field observations of feeding behaviour in deep water are rarer still.

The observations of rockfish feeding habits made by the authors based on analysis of underwater videos led the authors logically to the next two steps in the scientific method – first, they posed a number of questions about how rockfish find and consume prey and, next, they constructed a set of hypotheses to explain the behaviour of both the predator and the prey. Along the way, questions were raised about the impact of the camera itself and whether it influenced the behaviour of the predator or prey (due to the use of red light) and the validity of the observations (ability of the cameras to detect objects smaller than a certain size). The next two steps in an empirical scientific approach to understanding and explaining the feeding behaviour of rockfish (or, depending on one's perspective, the avoidance behaviour of prawns) will be to develop predictions of predator/prey behaviour, and then to test those predictions by gathering more data. At this point the technologist should work hand in hand with the scientist (and vice versa) to ensure that the technology used will best suit the scientific objectives. In other words – the science should inform the technology and the technology should enable the science.

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OBSERVATIONS OF FEEDING BEHAVIOUR OF QUILLBACK ROCKFISH (*SEBASTES MALIGER*) AROUND SPOT PRAWN (*PANDALUS PLATYCEROS*) TRAPS USING AN UNDERWATER CAMERA

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ABSTRACT

Direct observation of animal behaviour is common in terrestrial biology, but requires the use of technology to be conducted in the ocean. In this study, we present opportunistic in-situ observations of quillback rockfish (*Sebastes maliger*) attempting to feed on spot prawns (*Pandalus platyceros*) near pots deployed at depths of ~100 m. In these specific circumstances, quillback rockfish had poor foraging success, and we hypothesize that low light levels may have hampered their ability to assess prey size and position. We conclude with a call for more targeted behavioural research at depths greater than those accessible to scuba divers.

KEYWORDS

Foraging; Underwater filming; Predation; Hunting; Light

INTRODUCTION

Predation is a fundamental process that shapes ecological communities [Glasser, 1979; Welborn et al., 1996; DeWitt and Langerhans, 2003]. The process of predation has been generally described as occurring in five sequential steps: search, encounter, pursuit, capture, and handling, each of which must occur successfully for a predator to consume its prey [Juanes et al., 2002]. Understanding how fishes execute each step can be challenging, particularly when a species' range extends to deep water and in-situ observations of feeding behaviour become difficult.

Rockfish (*Sebastes* spp.) are a group of species whose ranges can span shallow water to depths of hundreds of metres [Love et al., 2002]. The quillback rockfish (*Sebastes maliger*) is of particular interest, given its wide depth range (from near the surface to 182 m [Yamanaka et al., 2006]) and assessment as a threatened species on the west coast of Canada [COSEWIC, 2009]. Observations of related species in shallow water provide few clues about the feeding ecology of *S. maliger*. For example, dwarf scorpionfish [*Scorpaena papillosa*] employ a "pause and move" search strategy and are non-visual predators, which rely on prey detection via their lateral line [Bassett et al., 2007]. By contrast, lionfish (*Pterois volitans*) are primarily stalking predators [Côté and Maljković, 2010; Green et al., 2011], which rely on visual cues to detect prey [Fishelson, 1997]. Knowledge of *S. maliger* diet could provide insights into foraging behaviour. However, such information is limited to examination of stomach contents from individuals caught in shallow water [Murie, 1995]. Less is known about deep water diets because rockfish experience stomach eversion upon retrieval to the surface, causing their stomach contents to be regurgitated and lost [Bowman, 1986; Hannah et al., 2008; Rogers et al., 2008]. Data derived from stomach contents of shallow-dwelling *S. maliger* individuals suggest that they feed most actively during the crepuscular period [Murie, 1995], suggesting that some light is required for feeding activity. The importance of vision is further supported by direct observations in shallow water of copper rockfish (*Sebastes caurinus*) and *S. maliger* that showed the presence of a nearby fibreglass predator model (i.e., a strictly visual cue) caused both species to be less likely to inspect a prey item relative to prey without an adjacent model [Frid et al., 2012]. However, neither species was likely to attack prey regardless of the presence of a model.

Here, we report in-situ observations of *S. maliger* feeding at depths of 90-100 m, using video recorded by a "TrapCam" apparatus [Favaro et al., 2012] designed to video-record commercial spot prawn (*Pandalus platyceros*) traps. We describe the interactions we observed, and produce hypotheses that could guide future investigation into this species. In addition, we outline the technological aspects that made this study possible.

METHODS

The design of our camera apparatus was outlined in Favaro et al. [2012]. This camera used red light illumination, which is thought to be invisible to many fish species, particularly in deep water [Douglas et al., 1995]. For the purposes of this paper, we define "deep" as being deeper than 40 m – a range inaccessible to the majority of scuba divers. Unlike ROVs, whose noise and illumination can affect the behaviour of nearby fishes [Popper, 2003; Ryer et al., 2009], stationary cameras can be effectively used to record behaviour in and around fishing gear. The apparatus consisted of a PVC frame attached above a prawn trap, on which we mounted a downward-facing camera [Favaro et al., 2012].

We conducted our recordings in Howe Sound, British Columbia, Canada (49°25'30"N, 123°20'00"W) in July-August 2010. The observations we describe in this paper were collected during a study designed to record behaviour of spot prawns (*Pandalus platyceros*) in and around fishing gear [Favaro et al., 2014]. We deployed camera-equipped traps at locations we knew from experience to be effective for prawn fishing, and that were recommended by local fishers. Our full field methodology is outlined in Favaro et al. [2014]. We analyzed a total of 13 eight-hour videos, and recorded every time rockfish appeared on camera (we termed an "approach"). We noted the frequency and success rate of predation attempts, as well as the relative difference between predator-prey size, and whether prawns employed any observable defensive behaviour. We visually identified species to the best of our ability.

RESULTS AND DISCUSSION

We observed 96 instances where rockfish appeared on camera across 105 hours of video (94 *S. maliger*, two greenstriped rockfish, *Sebastes elongatus*), and we recorded five separate predation attempts by quillback rockfish.

In four separate events, *S. maliger* attempted to consume spot prawns in and around the prawn traps (Video 1, A-D), and a predation attempt with no clear target occurred in a fifth event (Video 1, E). The first attempt occurred against an exposed *P. platyceros* individual walking adjacent to a prawn trap (Video 1, A; Figure 1). The rockfish approached the prawn from behind, and quickly struck at the prawn (time from initiation to conclusion of strike: 0.79 s). In this attempt, the rockfish was roughly three times the length of the prawn. The prawn responded to the rockfish's forward thrust by eliciting a series of powerful retrograde escape responses, or "tail-flicks" [Bauer, 2004], and it successfully escaped capture. In the second attempt, a larger *S. maliger* (approximately 3.5 times the length of the prawn) attempted to feed on a prawn that was sheltering under a corner of the trap (Video 1, B). In this case, the fish hovered in front of the prawn, and struck at the trap corner, attempting to pull the prawn from under the trap. As with the previous attempt, the prawn evaded capture using tail-flicks. In the third attempt (Video 1, C), a small *S. maliger* struck at a prawn that was free-swimming above the substrate (size ratio could not be determined). The approach was not visible on camera, but the strike occurred head-on, as the rockfish attempted to ingest the prawn head-first. The prawn escaped using two tail-flicks. In the fourth occurrence, a *S. maliger* entered the trap, which contained 101 *P. platyceros* (Video 1, D). The rockfish's entry into the trap triggered escape responses by many of the prawns. After a few seconds

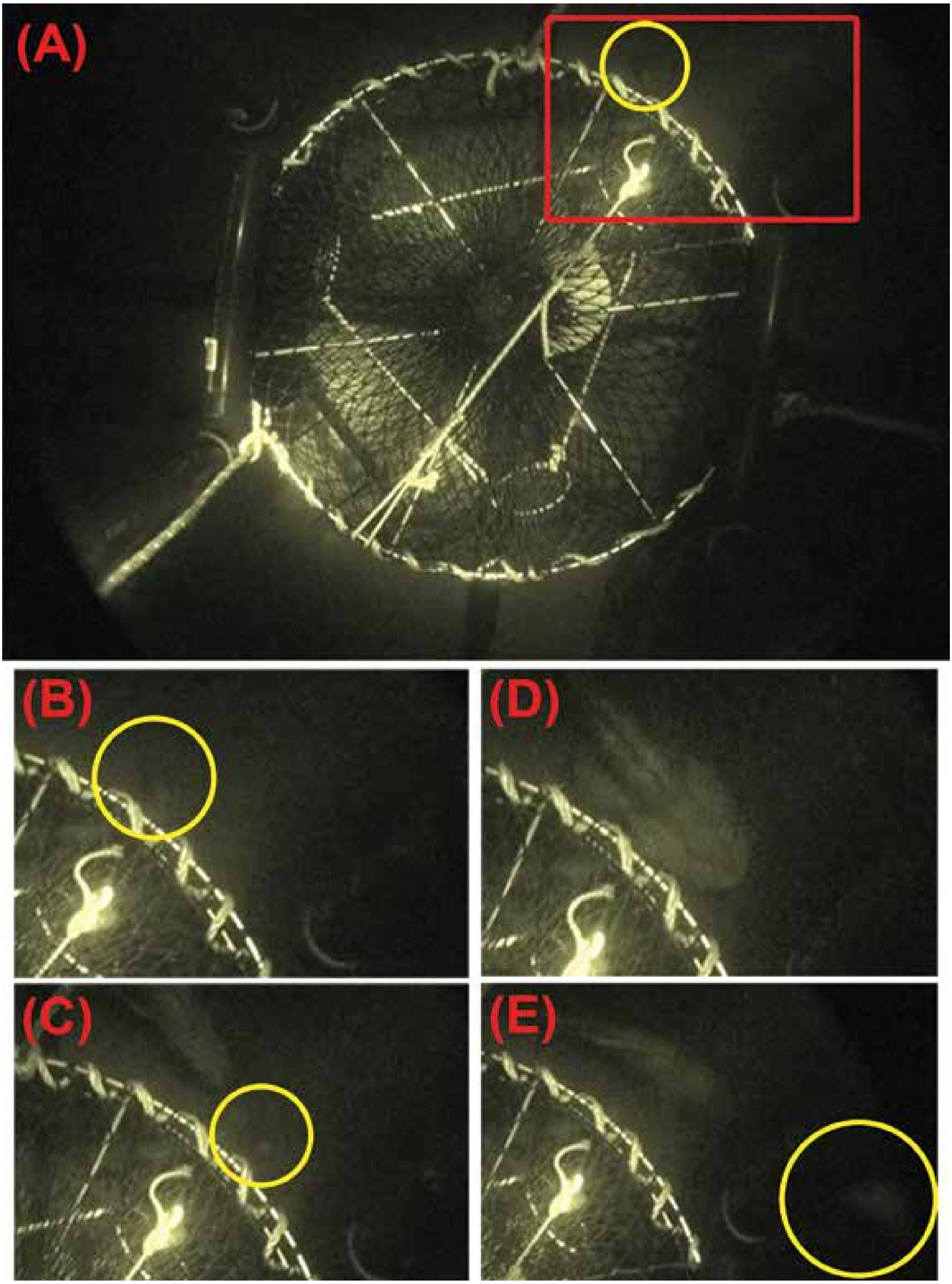

Figure 1: Predation attempt of quillback rockfish (Sebastes maliger) on spot prawns (Pandalus platyceros) in Howe Sound, British Columbia, as shown in supplementary video: (http://dx.doi.org/10.6084/m9.figshare.1497933). The scenario progresses chronologically from (A). From the top: (A) shows the field of view of videos collected in the present study. The red box indicates the zoomed-in area of the next screenshots, while yellow circles highlight the location of the spot prawn. The small white dots are reflections of the spot prawns' eyes in the red light from the camera apparatus. In (B), an expanded version of (A) is shown, while in (C) a quillback rockfish is visible approaching (top left of frame). The quillback rockfish makes its attack in (D), while in (E) the spot prawn is visible escaping via "tail-flicks."

inside the trap, the rockfish made two attempts to consume prawns, both of which failed. In a fifth attempt, the rockfish struck at what appeared to be empty water (Video 1, E), either because it captured something too small to be seen on video or because it struck in error.

There were commonalities among these predation attempts. In three of the four cases (Video 1 A, C, D), the rockfish appeared to be too small to successfully consume the targeted prey. Gape limitation commonly restricts a fish's ability to consume prey [Holmes and McCormick, 2010; Persson et al., 1996] and it appeared to be what prevented the small rockfish from successfully ingesting prawns. In the fourth case (Video 1, B), the fish was too large to fit within the tight space in which the prawn was hiding. In these cases, the rockfish did not correctly assess their own ability to consume the targeted organisms.

Camera-equipped prawn traps created a unique, albeit artificial opportunity for viewing the feeding behaviour of *S. maliger*. The presence of bait caused large aggregations of prey-sized spot prawns to occur in and around the traps, making them available to fish approaching the trap. These videos raise two main questions about feeding ecology of *S. maliger* in deep water. First, what contribution, if any, does *P. platyceros* make to the typical diets of deep-dwelling *S. maliger*? The aggregation of prawns in this confined environment provided an opportunistic target for nearby rockfish, so it is impossible to assess from this study whether prawns would make for a substantial diet item in a natural setting. Second, was the observed failure rate typical of feeding attempts by *S. maliger*, or was it influenced by biotic or abiotic factors specific to the depths at which the observations took place? While published data on the success rates of *S. maliger* feeding attempts are not available, bocaccio (*Sebastes paucispinis*), olive (*Acanthoclinus fuscus*), and yellowtail rockfish (*Sebastes flavidus*) capture prey at rates of 0.04 to 0.05 prey items per strike in shallow water [Johnson, 2006]. If strike efficiency is similar in *S. maliger*, then the present results may be typical. However, it is also possible that the low-light conditions at depth might have reduced feeding success, or the red lights might have somehow impaired visual acuity. Many species of fish rely increasingly on supplementary cues for prey detection or capture in highly turbid or poorly lit environments, and these cues affect the choice of prey items, and ultimately the ability to feed successfully [Janssen and Corcoran, 1993; Montgomery and Hamilton, 1997; Ranaker et al., 2012].

We recommend caution in interpreting these results. Our interpretation is based on only four feeding attempts in a set of circumstances that may be unlikely without the presence of fishing gear. Nevertheless, this study represents a rare, serendipitous set of in-situ observations of *S. maliger* feeding in deep water. It has raised questions about how dietary composition and feeding effectiveness may differ in deep versus shallow water, which could be addressed through a well-designed study targeting these questions. Predation by rockfish plays an important role in structuring shallow-water temperate communities [Frid and Marliave, 2010], and they might also do so in deep water. This study also demonstrates the opportunistic value of deploying cameras for underwater research – while they may be deployed for one purpose (in this case, assessing fishing gear), they can also generate surprising and interesting results that lead to further inquiry.

APPENDIX

Video 1: In-situ recordings of *S. maliger* feeding attempts in and around traps designed to catch spot prawns. Available online at http://dx.doi.org/10.6084/m9.figshare.1497933

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