BAITED UNDERWATER VIDEO FOR ASSESSING REEF FISH POPULATIONS IN MARINE RESERVES

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To study how fish are affected by fishing and other disturbances, we need to collect information on the length, density and diversity of their populations. For such studies, observational, non-destructive methods are preferred, particularly when studying fish inside highly-protected marine reserves or in ecologically sensitive areas. However, observational techniques often introduce biases, and it is important to understand these.

The most common observational method for studying shallow (< 20 m) reef fish is an underwater visual survey (UVS) made by scuba divers. Studies have summarized the advantages and disadvantages of this method (e.g. Harmelin et al. 1985; Samoilys 1997; Bortone et al. 2000) and it has been noted that certain commonly fished species are not recorded well by divers. This is because fished species tend to be behaviourally adaptable, which means they may rapidly alter their response to divers (Kulbicki 1998). Such problems can cause severe bias in studies using diver surveys. To counter the biases introduced by changes in fish behaviour, remote (surface-based) observational methods such as baited remote underwater video (BRUV) can be useful. Two main types of remote video technique have been used to describe reef fish populations; both of these techniques can be left free standing on the seafloor without the need of an operator. The first system generally uses one downward looking camera (Willis et al. 2000; Ellis and Demartini 1995) and the other uses either one (Cappo et al. 2004) or two horizontally facing cameras (Harvey and Shortis 1996; Watson et al. 2005).

Our study investigated the suitability of baited remote underwater video (BRUV) techniques for describing the distribution of coral reef fish in highly-protected marine reserves in the lagoon of New Caledonia. We wanted to compare downward view baited underwater video (D-BRUV), horizontal view baited underwater video (H-BRUV) and underwater visual surveys (UVS) made by scuba divers. This was achieved by sampling along a suspected gradient in fish density and possible gradients in fish behaviour at sites across and outside a highly-protected marine reserve. It was expected that in the centre of the reserve, a greater number of fish would be observed compared with the outside of the reserve.

Methods

New Caledonia is surrounded by a barrier reef, which borders one of the largest lagoons in the world (24 000 km^2). This lagoon supports diverse populations of fish associated with a variety of habitats, and subject to a wide variety of possible impacts, including fishing and terrestrial run-off. In May 2006, an in situ experiment was conducted on the southwest lagoon, in the highly-protected reserve at Ilot Signal (22º17.73'S, 166º17.41'E) and fished area of Récif Larégnère (22º19.71'S, 166º17.68'E). Surveys were conducted at three sites inside the reserve (A, B and C) and site D outside (Fig. 1). These sites were chosen to have comparable habitat of fringing coral reef with adjacent soft-sediment areas. At each site, replicate samples (n = 4) were collected using the three techniques to be compared. These were UVS, D-BRUV and H-BRUV.

For UVS, sampling was carried out along a 50 x 10 m belt transect (after Samoilys 1997). Commercial fish populations were recorded at species level, including abundance and size of each individual observed. For D-BRUV, we used a system that employs one camera pointed downward towards a bait pot centred on the base of a tripod (Willis et al. 2000, Fig. 2a). The base of the tripod forms a 1.6 m^2 quadrat and calibration marks can be used to measure fish seen within the quadrat. This system has been used successfully to monitor populations of commercially important fish inside and outside highly-protected marine reserves in warm and cool temperate areas of New Zealand (Willis and Millar 2005). For H-BRUV, Harvey and Shortis (1996) developed a stereo-video technique using two horizontally mounted video cameras (Fig. 2b) that uses a three dimensional calibration to estimate the size of fish. This system has been used successfully to study reef fish populations in temperate and tropical Western Australia (Watson et al. 2005). In this study,

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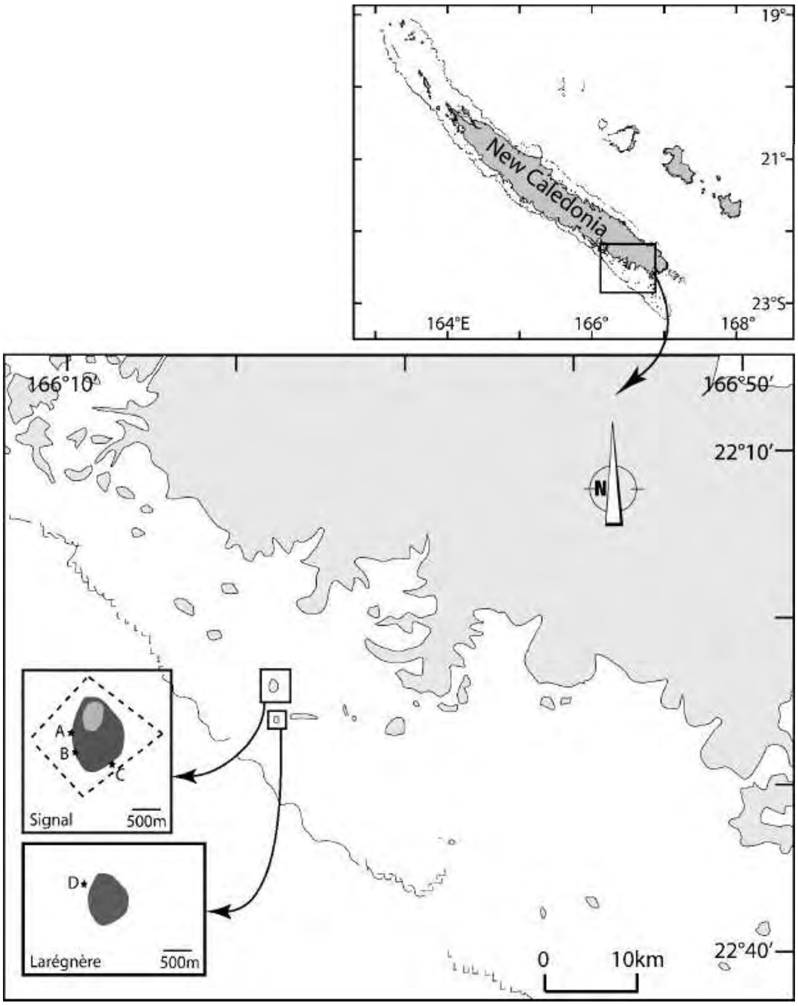

Figure 1: Map showing the location of Ilot Signal and Larégnère Reef, New Caledonia; and the position of the four sites. Three of these sites were inside the highly-protected marine reserve (A-B, in the centre; C, at the edge) and one outside (D).

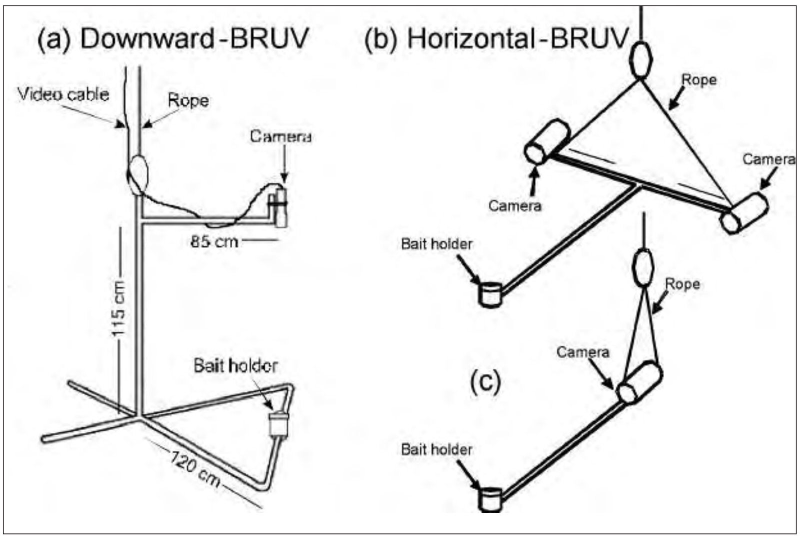

Figure 2: Different remote baited video system: (a) D-BRUV, H-BRUV using (b) two cameras in a stereo-video system or (c) one camera.

we used only one horizontal camera (Fig. 2c). This system simulates the field of view for the stereo-video system, but was not capable of estimating the size of fish. Each of the remote video techniques (D-BRUV and H-BRUV) was deployed for 30 minutes from a boat along the edge of the fringing reef, at the same sites where UVS transects were conducted. The remote video drops and UVS were not conducted at the same site

Baited stations contained 500 g of Sardinops sagax (sardines) in a plastic bait container. To avoid the repeated counting and measurement of fish attracted to a baited video, special care must be taken. Only the species present and the maximum number of individuals belonging to each species at one time are recorded, which gives a conservative estimate of relative density (MaxN, Willis et al. 2000). Only fish species considered to be targets of fisheries were recorded and their total number presented in the results. Density and biomass of fish populations recorded by UVS were used to compare with remote video techniques. Additional observations were made using different baits and bait holders.

Results

During the study, 132 species belonging to 16 families were recorded by UVS. Fourteen species belonging to four families were observed using H-BRUV. The fish belonged to Serranidae or groupers (*Plectropomus laevis*, *P. leopardus*, *Epinephelus merra*, *E. polyphekadion*, *Cephalopolis argus*), Lethrinidae or emperors (*Lethrinus atkinsoni*, *L. genivittatus*, *L. nebulosus*, *L. obsoletus*), Carcharhinidae or sharks (*Carcharhinus leucas*, *Triaenodon obesus*) and Acanthuridae or surgeonfishes (*Acanthurus xanthopterus*, *Ctenochaetus cyanocheilus*, *Naso unicornis*). The first three families recorded included carnivorous fish while the last one, the acanthurids, is mostly

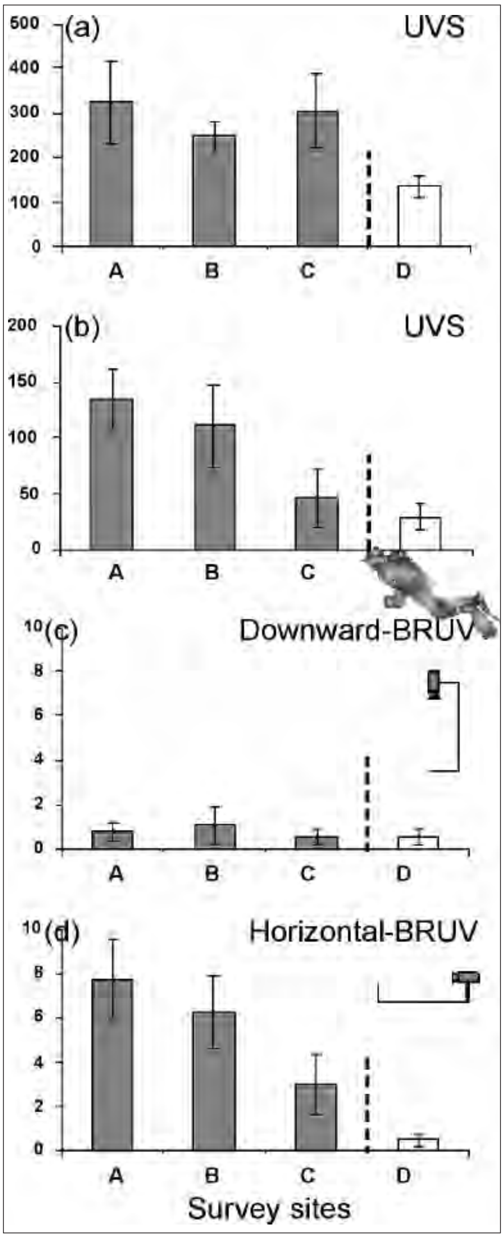

Figure 3: Commercial target fish recorded at sites at the centre (A-B), edge (C) and outside (D) the marine reserve at Ilot Signal. (a) Mean (±SE) abundance and (b) biomass recorded by underwater visual survey (UVS). Mean (±SE) abundance observed using (c) D-BRUV and H-BRUV. Closed bars are within the reserve and the open bar is the comparable fished area.

herbivorous. Only three species were recorded with the D-BRUV (*Plectropomus laevis*, *P. leopardus*, *Epinephelus polyphekadion*). Density and biomass observed by UVS was found to be highest in the reserve (sites A, B and C) compared with the fished area (site D) (density: 0.21±0.13 vs 0.06±0.05 ind./m², biomass: 575.6±0.30 vs 271.6±0.10 g/m²). Inside the reserve, no gradient was observed in density between sites (Fig. 3a), however the biomass of all commercial species was found to decrease from sites A and B in the centre of the reserve to site C at the boundary and site D outside (Fig. 3b). D-BRUV found no difference between reserve and fished areas and observed far fewer fish than horizontally viewing video. The H-BRUV system found a distribution of abundance of commercial fish similar to the biomass recorded by the UVS, despite the fact that fewer fish were recorded by this video technique.

Concerning fish behaviour, additional observations suggested that certain species, such as the ones belonging to Lethrinidae and Serranidae, would rarely approach the remote video system with the camera positioned vertically above the bait (downward video system), but they would approach when the camera was positioned at the side (H-BRUV, Fig. 4a). Bait trials using sardine, mackerel, mullet and prawn suggested that sardine and mackerel were better baits to attract serranids and lethrinids. Bait holder trials suggested that heavy mesh bait bags were preferable to bait pots. The bait bags allowed small fish to feed and the activity of these fish appeared to attract larger target fish. The presence of sharks was also observed to increase the activity of target fish. However, sharks were responsible for the loss of two bait pots during these trials (Fig. 4b).

Discussion

Our investigation found underwater visual surveys (UVS) by divers to be the most comprehensive, non-destructive method to describe fish populations at our study sites. UVS recorded the greatest abundance and diversity of fish and found a gradient in their density and biomass from inside to outside the marine reserve. H-BRUV recorded a representative sample of the reef fish populations recorded by UVS, in particular groupers and emperors. H-BRUV recorded less than 10% of the species seen by UVS, but described a similar gradient in the density of these species inside and outside the reserve. D-BRUV did not perform well, which suggests differences in feeding behaviour between tropical and temperate reef fishes, particularly given the success of D-BRUV in temperate regions of New Zealand (Willis et al. 2000).

It is interesting to note that across the sites inside and outside the marine reserve, UVS found a strong gradient in fish biomass but not abundance, with greatest biomass in the centre of the reserve. H-BRUV also found a strong gradient in abundance, which was greatest in the centre of the reserve. This difference between the two methods suggests that UVS was better at detecting small fish than H-BRUV. It has been noted before that large fish can dominate the bait stations of BRUV systems resulting in reduced observation of smaller fish.

Our study found that H-BRUV was a useful method to describe populations of commonly fished predatory species living close to the benthos such as groupers (Serranidae) and emperors (Lethrinidae). This method was not useful for more pelagic predators such as jacks (Carangidae), barracudas (Sphyraenidae) and tunas (Scombridae), or herbivorous species that are also targeted by fishers such as parrotfish (Scaridae) or rabbitfish (Siganidae). The presence of sharks can be a problem as they can quickly remove the bait used to attract fish.

Watson et al. (2005) compared baited, unbaited and diver operated video methods. They recommended that for studies wishing to examine a particular impact (e.g. fishing) on fish assemblages, BRUV can be very useful. They also suggested that multiple BRUV systems can result in a vast reduction in field time and the number of staff required. This means that even with the costs of video equipment and time associated with analysing video images, use of BRUV techniques for repetitive studies of an area can be more efficient than methods involving divers such as UVS. Another benefit is that with remote systems survey depths are not limited by diver depth profiles.

This pilot study suggests that H-BRUV systems can be used to study reef fish populations in the lagoon and reef habitats of New Caledonia. The improvement of this system will require stereo-video techniques using two video cameras (Harvey and Shortis 1996, Fig. 2b) and three-dimensional calibration software to obtain accurate length estimates of fish (see www.gemsoft.com for information on the software). The cameras of these systems are inwardly converged to allow the length of oblique objects to be estimated (i.e. fish not swimming parallel to the cameras).

For future studies of marine reserves around New Caledonia, we recommend the use of H-BRUV's with stereo-video systems. We believe this will provide an efficient tool for gathering information on the density and biomass of fish populations, and to study their rates recovery from fishing. Furthermore, video surveys can be valuable where UVS surveys are limited by particular conditions (such as high sedimentation) and during regular monitoring for commercial species such as groupers and emperors. A combination of survey techniques, including remote baited video and UVS, would be advisable to include both behaviourally adaptable predatory species and fished species that do not respond to bait.

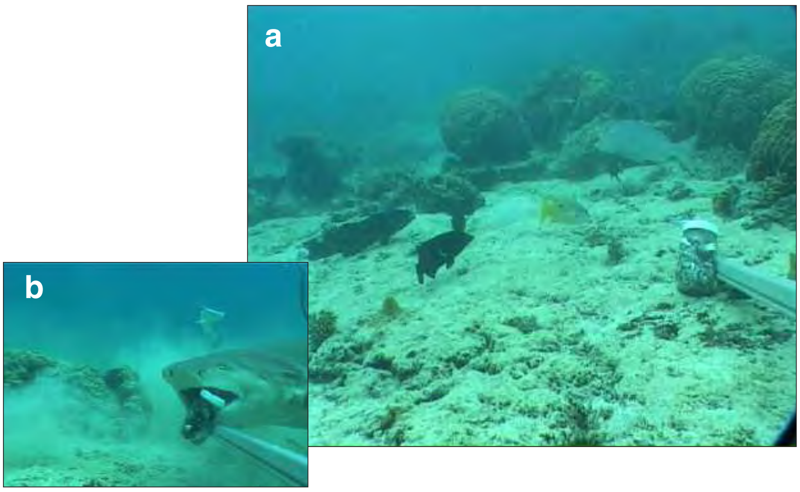

Figure 4: Images from the H-BRUV showing: (a) three *Plectropomus leopardus*, one *Lethrinus nebulosus* and one *Cephalopholis argus* approaching the bait pot; (b) one *Carcharhinus leucas* about to eat the bait pot.

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