**Introduction**

Using remote underwater video to estimate freshwater fish species richness

Remote underwater video is used to monitor fish population size, structure and abundance and the composition of fish assemblages to observe fish behaviour without any problems observed with netting techniques.

This they made use of BRUVs and UBRUVS

BRUVS – effective because it can reach different depths than scuba diving.

Sampled inland fish in remote areas of central and northern Australia. They sampled here because due to dynamic rivers and waterhole dimensions from one extreme of high velocity flow channels to another extreme of small puddles of water.

Different netting techniques are used to sample fish – beach seines, fyke nets, gill nets, dip nets, net tows or trawls and angling with hook and line. Other capturing techniques include drop nets.

Permanently turbid or sporadically turbid waterholes are characteristic of most

catchments within central and northern Australia thwarting the widespread application of visual-based survey techniques.

High visibility- visual techniques are highly informative.

Netting pose a threat to a variety of species – fish crocidiles and turtles are caught up in the nets.

BRUVs and UBRUVS – provide a versitile, non extractive tool for surveying fish.

In a pristine river system in the undeveloped tropics of north-western Australia as a case study, the aim of this study was to (1) test different video deployment techniques, (2) compare species richness estimates based on remote underwater video (with and without bait) and conventional netting techniques and (3) explore strategies for combining different survey techniques in

surveys of tropical fish communities.

**Study Area Method and material**

Fishes were surveyed in three large waterholes (Table I) in the lower western Fortescue

River catchment in the Pilbara region of Western Australia (Fig. 1) on 15–18 June 2010

during the dry season. The Fortescue River catchment is coastal but is situated in the

Australian semi-arid zone and receives wet-season rainfall most typically from December to

March; however, annual rainfall is highly variable.

**Camera deployment and retrieval**

Survey methods were applied during daylight between 0800 and 1700 hours this was done to avoid nocturnal effects of fish behaviour.

At each of the three waterholes, three UBRUVSs were set in wadeable depths

(shallow water; <1 m depth) and three UBRUVSs were set in deep water (>1 m and up to

4·5 m) for a minimum of 1 h (and essentially all six cameras filmed simultaneously).

UBRUVSs were placed essentially randomly to encounter a range of habitat

types, and cameras were placed at least 50 m apart.

UBRUVSs comprised a Sony HandiCam (HDRXR550; [www.sony.com](http://www.sony.com/)). Fixed to a focal length off infinity- this was done to avoid autofocus of objects or bubbles near the lens. Each camera was placed upright in a housing strapped to a half-hollowed concrete block 200 mm × 200 mm × 200 mm). The housing comprised two PVC pipes chemicallyfused in the middle and having threaded caps at either end. A rope and buoy was used to lower the UBRUVS to the substratum and

for shallow-water deployments cameras were faced away from direct sunlight to minimize

glare. UBRUVSs were retrieved by grabbing the float line and hoisting the camera onboard or

occasionally by wading from shore if less disturbance would be caused by the latter approach

(e.g. where the propeller would probably have churned up macrophyte beds). Following

retrieval, each UBRUVS was converted into a BRUVS. BRUVSs were deployed at essentially the same position where each UBRUVS hadbeen positioned in the waterhole. The operating time of each technique was recorded. Footagewas downloaded each night to external hard-drives in the field.

**Conventional netting**

Beach seining (26 m long with a 10 m pocket of 3 mm woven knotless mesh and two 8

m wings of 6 mm mesh and fished to a depth of 1·5 m) was conducted in shallow water at 3locatins. Similar spacing was used for three fyke nets (11·2 m in width, with two 5 mwings and a 1·2 m wide mouth, depth of 0·8 m, all comprising 2 mm woven mesh). A multi-panel gillnet (50 m in length comprised equally of 50and 100 mm monofilament mesh) (Fig. 2) was set (floating) perpendicular to shore for 15 min n each of the three locations during daylight hours.

Those fish caught in nets were counted and measured.

**Video processing**

no attempt to measure fish lengths in camera based techniques. Video was viewed in VLC Media Player. Video was only viewed for the first 10mins of each deployment.

The following 50 min was then viewed in a mixture of real time or fast forward (×1·5 or

×2 real time speed) depending on a number of factors (e.g. how diverse the fish assemblage

was on a particular camera and underwater visibility). Record was made of the first arrival

of each species in view on each deployment.

Multiple viewing of film was required n certain cases (e.g. high species richness, high densities of fish, presence of small fishor difficult to identify fish; Fig. 3).

**Data Anlysis**

Presence or absence of each species across the waterhole was used to compare effectiveness of each technique in measuring species richness.

Average catch was calculated in relation to each sampling technique to determine if the video technique provided comparable count data. speciesaccumulation curves were plotted based on arrival time (first detection) of each specieson a camera according to technique. To

compare the species captured with each different sampling method and in the different

habitat types, the presence or absence data for each individual

replicate for each method was used to construct a similarity matrix using the Bray–Curtis

similarity coefficient in the PRIMER package. Statistical differences were generated by subjecting the matrix to one-way ANOSIM. ANOSIM generates an R-statistic which is an estimate of the similarityof the replicates within these predetermined methods

**Results**

**Fish Assemblages**

In total, 2377 fish observations were made (including video-based observations and

net captures) comprising 14 species.

**Survey techniques and species richness estimates**

The camera-based techniques outperformed the conventional netting approaches with the camera-based techniques yielding 13 species and conventional netting approaches yielding 11 species. Within each of the three waterholes, each of the netting techniques detected fewer species (five to seven species) than each of the camera-based techniques (10–11 species). Three species were recorded from video filming in all three waterholes that were not detected by conventional netting techniques.

**Comparison of video-based techniques**

If camera techniques were combined, then (1) sBRUVSs and dBRUVSs marginally outperformed (2) sBRUVSs and sUBRUVSs and (3) dBRUVSs and dUBRUVSs, in terms of species richness estimation at the within-waterhole scale. The combination of sUBRUVSs and sBRUVSs yielded relatively low estimates of species richness by waterhole, despite achieving a high among-waterhole species richness estimate. The majority of species captured on video were detected within 10 min of deployment, regardless of the camera technique used.

**Species-specific detection**

ANOSIM suggested that there were significant differences between all pair-wise comparisons amongst the species recorded by the different methods with the exception of sUBRUVSs compared with both sBRUV and seines, and dUBRUV compared with both sBRUV and dBRUVSs. The relative probability of detecting each species was a function of survey technique.

The three Terapontidae species [barred grunter Amniataba percoides (Gunther 1864), Fortescue grunter Leiopotherapon aheneus (Mees 1963) and spangled perch Leiopotherapon unicolor (Gunther 1859)] were frequently recorded by camera-based techniques. Conventional netting also caught terapontids. For example, fyke nets regularly captured L. aheneus and to a lesser extent L. unicolor, but were poor at detecting A. percoides. Beach seining detected all of these grunter species, but inconsistently detected L. unicolor and L. unicolor was not detected by any of the three beach seining replicates in waterhole A. Terapontids, however, were not collected in gillnets. Western rainbowfish Melanotaenia australis (Castelnau 1875) was detected most successfully by shallow-water camera techniques, beach seine and fyke net, indicating that this species does not inhabit deep water.

**Discussion**

This study found that application of remote underwater video techniques enhances capabilities for surveying a freshwater fish community relative to exclusively using conventional netting techniques. In terms of maximizing species richness estimates, applications of BRUVSs and UBRUVSs outperformed conventional netting techniques in the Fortescue River. Similarly, Ellender et al. (2012) found that unbaited cameras more effectively detected two threatened freshwater fishes in headland streams than electrofishing.

**Comparing survey techniques**

This study demonstrates, as have numerous others (Watson et al., 2005), that no single sampling technique is adequate for detecting all fishes, and indeed most techniques were different in the species that they detected. Certain techniques were better all-rounders, maximizing species richness estimates (e.g. camera-based techniques), whereas others were specialised in effectively detecting a sub-set of species (e.g. fyke nets detected nocturnal N. hyrtlii far better than any other technique). The major limitation of conventional netting, however, was the failure to detect three of the 14 species encountered in this study whereas the remote video strategy detected these three species in all three waterholes.

Conventional netting detected one species (C. chanos) that remote video did not , but this was based on few data (just two individuals collected in a single waterhole) and therefore has questionable relevance in a comparison of survey techniques. One of the more useful attributes of underwater video in terms of assessing freshwater fish assemblages is its flexibility with regard to the range of habitat types in which it can function. Cameras can be placed in deep (including to abyssal depths) and shallow water and in open water within or adjacent to relatively dense or complex structure which is advantageous relative to many conventional netting techniques. For instance, beach seines are generally restricted to shallow water and smooth substrata and applications can be compromised by large woody structure and complex benthic topography, fyke nets are generally restricted to shallow water or require exclusion devices to prevent mortality of air-breathing species which in turn excludes large-bodied fishes and gillnets fair poorly in structurally complex habitat and in fast-flowing environments.

This study demonstrates that UBRUVSs can be used to survey moderately species-rich fish communities in large waterholes. Baited cameras may prove useful for detecting highly mobile, low-density predators.

**Video and species richness estimation**

The underwater cameras provided a useful means of identifying depth-related structuring of the fish assemblages. A sub-set of species (e.g. terapontids and G. filamentosus) were frequently detected in both shallow and deep water, whereas others were more likely to be found in either shallow (e.g. M. australis) or deep water (e.g. N. graeffei). One drawback of the cameras is their reliance on good visibility. Surprisingly, BRUVSs did not attract fishes into view more rapidly than UBRUVSs in this study, indicating that bait may be unnecessary for fish surveys at least in the context of the Fortescue River.

Baited and unbaited cameras did, however, yield subtly different types of information with regard to species richness. Unbaited cameras performed better than baited cameras in detecting the presence of some species in a waterhole (G. filamentosus and G. giuris) or the number of cameras that a species was detected on (e.g. L. argentimaculatus). Underwater video-based methods have the potential to record additional information relating to natural behaviour, biology or ecology of fishes.

**Survey strategies**

In terms of calculating alpha diversity (species richness in each waterhole), netting strategies performed relatively poorly, whereas camera strategies or a mixed camera and netting strategy produced estimates closer to those from all techniques combined. It is also possible, however, that species remained undetected in waterholes that were surveyed in this study, implying that further effort or inclusion of additional survey techniques may represent an even better strategy.

**Conclusion**

In conclusion, camera-based techniques provided versatile tools for surveying fishes in large waterholes with heterogeneous habitat under high visibility conditions. Subtle differences in species richness estimates resulted from employing of baited and unbaited cameras in this study; however, the depth that cameras were deployed to was a more important driver of species richness estimates.

No single survey technique consistently outperformed all of the other techniques in the comparison and a combination of netting and camera-based techniques maximized species richness estimation in each waterhole.

Cameras warrant application in aquatic areas of high conservation value including those where threatened species are the focus of monitoring. It is foreseeable that in particularly sensitive cases cameras will provide an invaluable means of studying fishes by informative and non-destructive means.

Thank you