PAPER

A Comparison of the Accuracy and Precision of Measurements from Single and Stereo-Video Systems

Euan Harvey
Department of Botany, University of Western Australia
Crawley, Western Australia

Mark Shortis
Department of Geomatics, University of Melbourne
Melbourne, Australia

Mathew Stadler
Department of Botany, University of Western Australia
Crawley, Western Australia

Mike Cappo
Australian Institute of Marine Science
Townsville, Australia

ABSTRACT

Underwater tests using plastic silhouettes of fish were used to compare the accuracy and precision of measurements made with a single video camera system to those made from two stereo-video systems (one using digital camcorders, the other using Hi8 camcorders). Test measurements made across a variety of ranges and angles of silhouette orientation in the fields of view showed the length estimates from both the digital and Hi8 stereo-video systems were substantially more accurate and precise than those obtained by the single video camera system, and had the great advantage that the position (range and bearing) and orientation of a fish target could be measured directly. Measurements made with stereo-video were much less restricted by range and subject orientation than those made with single video. The data resulting from these trials are used to propose a set of guidelines to optimize the accuracy and precision of underwater measurements of fish length using single and stereo-video systems.

INTRODUCTION

Conventional still photography and video imagery have been widely adapted in the aquatic sciences for non-invasively counting and measuring organisms underwater (Boland and Lewbel, 1986; Hamner *et al.*, 1987, 1988; Vrana and Schwartz, 1989; Naiberg *et al.*, 1993; Petrell *et al.*, 1997). For example stereo-photography has been used *in situ* to measure the recruitment, growth and mortality of coral colonies (Done, 1981), the length of free-swimming sharks (Klimley and Brown, 1983) and dolphins (Brager and Chong, 1999). Stereo-videography has been used for measuring aquacultured salmon (Petrell *et al.*, 1997) and reef fish (Harvey *et al.*, 2001, a, b). Recent, rapid technological improvements in video cameras have improved the utility and accuracy of measurements with such systems (Harvey and Shortis, 1996, 1998), complementing the advantages of predictable precision of measurements, opportunity for motion sequence capture, and the enhancement and archival storage of digital images. Video techniques can be readily adapted for use by SCUBA divers (Harvey *et al*, 2001 a, b; Shortis *et al.*, 2000) or mounted on remotely operated vehicles and submersible platforms (Baldwin and Newton, 1982; Li *et al.*, 1996; Pitcher *et al.*, 1999) to capture images at depths beyond those accessible by SCUBA divers.

Accurate and precise information on the length frequency or biomass of wild and cultured fish populations is fundamental to the management of harvesting. Monitoring of length and age permit estimates of recruitment to fished populations, fishing intensity and rates of recovery from fishing or other disturbances (eg. McCormick and Choat, 1987). Accurate morphometric measurements of cultured fin-fish can be used to determine fish condition, size variations and growth rates (Petrell *et al.*, 1997).

Single video camera systems have been used to measure the length frequency distribution of fish assemblages in shallow (Willis *et al.*, 2000; Willis and Babcock, 2000) and deepwater (Love *et al.*, 2000; Yoklavich *et al.*, 2000). The advantages of stereo-videography for surveys of fish length frequency and density have been demonstrated by Harvey *et al.* (2001 a, b) for reef fish assemblages. The use of stereo-video technology was superior to conventional underwater visual surveys, which have relied on the experience and subjective choices by SCUBA divers to count and estimate the range, bearing and lengths of fish within strip transects or circular point counts. Stereo-videography has also successfully been used *in situ* to measure the length of cultured fin fishes (Naiberg *et al.*, 1993; Savage *et al.*, 1994; Steeves *et al.*, 1998), to predict the weight of individual fish and the mean biomass of the fish in a sea cage or pond (Petrell *et al.*, 1997).

Harvey and Shortis (1998) and Shortis and Harvey (1998) reported the geometric stability of a stereo-video system constructed from two 3 CCD (Charged Coupled Device) Hi8 camcorders while Harvey and Shortis (1996) reported the accuracy and precision of measurements from the same system. The image quality of readily available digital video cameras has superseded both Super8 and Hi8 video cameras, but the cost of digital video is almost twice that of current Hi8 cameras. Consequently, it is important to determine whether the extra cost of using digital video cameras produces improvements in the accuracy and precision in stereo-video measurements. Stereo-videography, with the additional costs of a second camcorder and housing, and specialist stereo-photo comparator software, needs to be justified, given the recent uses of single video camera systems for the measurement of fish length (Love *et al.*, 2000; Willis *et al.*, 2000; Willis and Babcock, 2000).

Consequently, this paper aims to:

1. Compare the accuracy and precision of *in situ* measurements of fish length