Statistical properties of alternative methods of fish abundance assessment in baited, remote, underwater video

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Baited Remote Underwater Video (BRUV) is an emerging modern technique for non-destructive monitoring of fish populations for stock assessment and basic ecological research, and has been shown to have greater statistical power than commonly used destructive methods for detection of moderate changes in fish population density in time or space. However, for many fish species the variance in abundance can be volatile, making estimates of mean abundance for some economically important species uncertain, and changes in mean abundance difficult to distinguish from changes in its variance. This problem is compounded by the method for estimating abundance in BRUVs: namely finding the quantity MaxN, which is the maximum number of fish visible in the field of view in a single frame of video. This quantity may be biased downward in some species caused by the limited field of view, and is expected to have a higher sampling variance than the true number of individuals near the bait since there is an additional methodological variance caused by subsampling of those present individuals within the viewfinder of the camera. An alternative method of estimating BRUV species abundance is to model the time of arrival of any number of individuals of a given species to the camera. Time of first arrival is expected to be negatively correlated with abundance within a random-walk model of fish movement, and the variance properties of this measure can be adjusted by choice of the number of arrivals used in the calculation of arrival time. This method has the advantage of easier and faster video analysis, and potentially lower sampling variance than MaxN due to greater flexibility. Based on a sample of BRUV deployments in central Croatia using processed sardine bait and a stereo GoPro camera system, we calculate sampling variance of time of first appearance and its covariance with MaxN for common species *Chromis chromis, Coris julis, Serranus scriba, Diplodus annularis, Diplodus vulgaris, Diplodus sargus* and *Sparus aurata.* We find that sampling variance for time of first appearance (T1) can be lower than that for MaxN, resulting in higher statistical power in detecting differences in mean abundance, and T1 is significantly correlated with MaxN in the studied species, with correlation coefficients in the range of -0.2 to -0.28. Using T1 as a proxy for population density in a baited camera system can solve longstanding problems in abundance estimation with these methods.

Keywords: baited remote underwater video; statistical power; abundance estimates