Fish monitoring in the Mediterranean Sea: Statistical power of baited, remote, underwater video is higher than traditional trammel net sampling for fish stock assessment

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Sentinel monitoring of fish populations is an indispensable component of sustainable management, yet most current methods of fish monitoring are either destructive or have questionable or unknown statistical power to detect change. Evaluating the power of alternative methods is difficult because fish population densities rarely follow anything resembling a normal distribution, and spatio-temporal variance itself is highly variable, making changes in mean abundance difficult to separate from changes in variance, regardless of sample size. It is currently unclear if there are any methods of fish stock assessment that are capable of reliably demonstrating population declines before they result in serious ecological and economic losses. We evaluated the suitability and statistical power of two alternative methods in the Mediterranean Sea: traditional but destructive trammel net sampling, and non-destructive BRUV (baited remote underwater video). Based on 20 and 90 deployments of trammel and BRUV sampling equipment near Kornati NP in Croatia in 2016 and 2017, we found that abundance of most fish species were indistinguishable from either quasi-Poisson or negative binomial distributions, often zero inflated, for which there are no simple methods for calculating statistical power. We used numerical simulation to precisely estimate power in confirmatory tests using generalized linear models that assume a quasi-Poisson distribution of residuals with a log link function for the nonzero component of abundance, and a binomial distribution with logit function for the presence/absence component of abundance. We found that the dispersion parameter varied among species from 0.1 to over 60 for BRUV sampling, and up to 300 for schooling species in the trammel method. Because of higher dispersion and lower mean abundances, the trammel method is incapable of detecting less than a 60% loss in abundance in any species at a power of 80%, while the BRUV method can detect less than a 50% loss in a total of 10 species. For 72% of species, the BRUV method can detect a loss of 50% at less than half the field effort of the trammel method. Because of high dispersions in both methods, logistic regression on presence/absence generally has greater statistical power than testing for differences in mean nonzero abundance. Presence/absence can be measured with BRUV for nearly every species (but not in trammel) based on time of its first appearance. Our results indicate that for the Mediterranean Sea, the non-destructive BRUV method has higher statistical power for detection of loss in most species. However, several species have volatile abundance distributions and there remains a great need for the further refinement of non-destructive methods for detecting moderate fluctuations in mean population density of economically/ecologically important fish species.

Keywords: stock assessment; BRUV; trammel; statistical power; generalized linear models