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# Detection of spatial variability in relative density of fishes: comparison of visual census, angling, and baited underwater video

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ABSTRACT: The ability to make accurate estimates of fish relative abundance is the basis of both ecological and environmental effects studies, and flawed sampling methods may give misleading results even in otherwise well-designed surveys. This paper compares surveys of snapper *Pagrus auratus* (Sparidae) and blue cod *Parapercis colias* (Pinguipedidae) conducted using 3 methods (underwater visual census, experimental angling, and baited underwater video) inside and outside the Cape Rodney-Okakari Point marine reserve in northeastern New Zealand. Angling and baited video consistently detected adult *P. auratus* at protected and fished sites, providing estimates of 36.7 and 39.2 times greater density of fishable *P. auratus* within the reserve, respectively. Visual surveys provided the least reliable measure of density of *P. auratus*, with adults only detected at the reserve centre where fish have been habituated to divers by hand-feeding. Measures of the size structure of *P. auratus* were consistent between angling and video, but mean size was significantly smaller using visual census methods. Relative density of *P. colias* was similar for all 3 methods, but angling estimated larger mean size, probably due to hook selectivity against smaller fish. The study indicates that methodological standardisation across all species is not always appropriate for environmental effects studies, and that different survey methods should be considered according to the biology and behaviour of the species of interest.

KEY WORDS: Angling · Baited underwater video · Exploited fishes · Behaviour · Log-linear model · Marine reserves · Recovery · Survey bias · Visual census

## INTRODUCTION

There is an increasing global trend, instigated by the frequent failure of traditional single species fishery management practices (e.g. Myers et al. 1997, Pauly et al. 1998), to approach sustainability of the marine environment in a more holistic fashion (Dayton et al. 1995, Roberts 1997, Allison et al. 1998). The concept of marine reserves (the complete closure of an area of seabed to all forms of fishing or disturbance) was originally regarded as a tool for conservationists, but is now slowly gaining credence with fisheries biologists as a useful hedge against '... the limitations of science in comprehending and controlling... the marine environment' (Lauck et al. 1998).

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The potential for marine reserves to act as both conservation and fishery management tools is often discussed (Roberts & Polunin 1991, Dugan & Davis 1993, Allison et al. 1998) but seldom substantiated by rigorously collected data (Roberts & Polunin 1991, Jones et al. 1993, Edgar & Barrett 1997). The enumeration of commercially and recreationally exploited fish species (which are those most expected to benefit from reserve protection) has been problematic in many cases. Difficulties in effectively demonstrating reserve effects and predicting outcomes of reserve implementation have been attributable to 3 factors: inadequate sampling methodology, inadequate survey design, and failure to obtain a suitable time series of data (both before and after reserve closure) using consistent methods.

Survey design problems have generally been caused by deficiencies in both spatial and temporal replica-