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Low target strength fish in mixed species assemblages: the case of orange roughy

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Abstract

Use of acoustics to estimate biomass remains problematic for mixed species assemblages, and the problem is particularly difficult where the main species of interest has low acoustic target strength, as is the case for orange roughy. Despite their size and relative abundance in mixtures, orange roughy have low acoustic backscatter due to their oil-filled swimbladder. Trawl catches and acoustic target strength—length relationships at 38 kHz were combined to estimate the species-specific area backscattering coefficients from a mixture of species on the flat areas around the North West Hills on the Chatham Rise to the east of New Zealand. Orange roughy constituted a large proportion ($\bar{x} = 48\%$) by weight in trawl catches, but their contribution to the area backscattering coefficient was very low (<1%). Robust cardinalfish (30.1%), three species of rattails (White rattail = 17.4%, Notable rattail = 13.8% and Serrulate rattail = 9.7%) and Johnson's cod (10.8%) made much larger contributions to the area backscattering coefficient (*values in brackets*) despite their relatively low catch rates (totaling an average of 7.6% of the catch by weight). We calculated the effect of changing the mean density of orange roughy on the backscattering coefficient by simulating order of magnitude increases or decreases in orange roughy densities. Increasing the density of orange roughy by a factor of 10 times would only increase the area backscattering coefficient from the fish community by 3%. We conclude that changes in orange roughy density of this order are not likely to be detectable in acoustic backscatter using echo integration data. This does not mean that orange roughy cannot be separated from mixtures, but to detect them it will be necessary to use single-target discrimination techniques such as the phase difference-⟨TS⟩ methods [Barr, R., Coombs, R.F., Macaulay, G., 2000. Can we discriminate between different deepwater fishes using a standard acoustics target strength ping? In: Proceedings of the 2000 Conference on International Society for Acoustic Remote Sensing, Sydney, Australia, pp. 77–80].

Keywords: Acoustic; Orange roughy; Target strength; Fish assemblage; Trawl; Biomass; New Zealand

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1. Introduction

Acoustic biomass estimation of orange roughy has been used to support fisheries stock assessments since 1986 in New Zealand. Surveys are spatially focussed on the spawning plumes that are often associated with seamounts, although the plumes also occur over relatively flat bathymetry in some areas. Although the spawning plumes themselves are almost (>95%) pure orange roughy, there is considerable biomass of roughy over the "flat" areas around the plumes. These areas support a mixed assemblage of fish species. To estimate the biomass of orange roughy acoustically it is necessary to develop acoustic techniques that can be applied to the "flat" areas as well as to the spawning plumes.

To estimate orange roughy biomass where a mixture of species occur, one must determine what fraction of the acoustic returns are due to roughy, as opposed to the other species in the mixture. The proportions of orange roughy and bycatch species are determined by trawling. Target strength-size relations at 38 kHz for many of the more abundant bycatch species are now known from swimbladder modelling (Macaulay and Grimes, 2000; Macaulay, 2001; Macaulay et al., 2001, 2002). Total acoustic backscatter is partitioned to species using the species. $\langle \mathrm{TS}_i \rangle$–*length* regressions and the species-specific size distributions weighted by the proportions of each species in the trawl catches in that area (where $\langle \mathrm{TS}_i \rangle$ is tilt-averaged target strength for a given sized fish of species i). This approach requires a lot of trawling that is both time-consuming and expensive. It is important to test the underlying assumptions of the method and to evaluate whether the procedures are useful for estimating the biomass of orange roughy in mixtures of species. One of the assumptions is that a change in the biomass of orange roughy will result in a detectable change in the integrated acoustic backscatter.

Orange roughy is a particularly problematic species to separate from a mixture of species because it has an unusually low ⟨TS⟩. Kloser et al. (1997) reported that a single 8.2 cm myctophid has approximately same ⟨TS⟩ as a 35 cm orange roughy (cited as −50 dB). By their calculation, a 33 cm rattail had a ⟨TS⟩ equivalent to four orange roughy, and a single morid cod was equivalent to 79 orange roughy. The effect of this disparity in ⟨TS⟩ is that backscatter from orange roughy can be lost in the backscatter from associated bycatch species in the same area. This is because the proportion of the total backscatter due to orange roughy is far smaller than the proportion of the trawl catch weight due to orange roughy (by as much as a factor of 28, according to Kloser et al. (2000)).

In this paper we test whether the acoustic backscatter due to changes in the proportions of orange roughy can be detected amongst the much larger signal from bycatch species in a mixed species assemblage. The broader question of whether changes in the mix of species in trawl catches is reflected in the integrated acoustic backscatter is of fundamental interest in fisheries surveys. The underlying multispecies model is an extension of the linearity of fisheries acoustics model (Foote, 1983). Essentially, given the densities of a known number of fish of species having measured size distributions and representative tilt angle distributions, then the total integrated acoustic backscatter is predictable if the ⟨TS⟩–*length* relationship for each species is also known. When the density of a species in the assemblage changes, the change may be reflected in the total integrated backscatter, but the magnitude of change will be greatly influenced by the ⟨TS⟩ of the species. The concern is that for orange roughy with low ⟨TS⟩, no change will be detectable. The multispecies model is seldom tested despite the application of acoustics to biomass estimation of mixed assemblages in the tropics and at locations where there are more than two easily identifiable species present. It is particularly important to test the assumptions where the mixtures of species include those with markedly differing ⟨TS⟩. This is the case for orange roughy acoustic surveys in Australia, Namibia, Chile and the North Atlantic, as well as in New Zealand. Investigation of this problem is therefore of wider relevance than its application to the New Zealand orange roughy surveys.

The problem might be approached in three ways. First, one could attempt to correlate acoustic backscatter with associated targeted trawl catches. If this were done over a range of contrasts in species composition, one could test whether differences in orange roughy catch rates were detectable as differences in echo integrals. A second approach might be theoretical, using an artificial fish community and known *TS–length* relationships to calculate the relative contributions of orange roughy versus other species to the echo