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Linking the mesopelagic components of ecosystem models to acoustic vertical echosounder observations

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Mesopelagic (200 – 1,000 m) organisms (including fish and zooplankton) are a major component of Southern Ocean foodwebs and play an important role in the biological carbon pump. Mesopelagic fish could also become a major source of protein for the growing global human population. The mesopelagic can be observed using echosounders, and mesopelagic ecosystem processes have been modelled, but observations and modelling have seldom been linked. The ability to move between observations and models would be beneficial for a) model validation, b.) understanding the likely community composition of the mesopelagic, and c) predicting ecosystem change in the face of climate change. In this paper we review both the sound scattering mechanisms that dominate acoustic observations of the mesopelagic community and the varying taxonomic, vertical and spatial resolution of mesopelagic model groups across a range of ecosystem models. We then explore the reliability with which mesopelagic components of ecosystem models can be used to predict mean areal acoustic backscatter. We find that model groups that contain fish and/or siphonophores likely produce the majority of mesopelagic backscatter and that uncertainty in the conversion of these groups to acoustic signal is very sensitive to ecosystem model structure and derived outputs e.g. uncertainty is low when the model provides group depth and size distributions and fish swimbladder presence/absence (as a proportion). We also evaluate if additional observations and model variables can be indirectly used to improve the conversion, e.g. by using a model output condition variable to reduce uncertainty in swimbladder size and fish weight estimation, or net data to ascertain relationships between fish length and swimbladder volume. We conclude that to most effectively link the mesopelagic component of ecosystem models to acoustic observations, models need to be designed in such a way as to provide the necessary information required to predict acoustic backscatter with reasonable uncertainty.

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