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[Crossing paths between empirical ecologists and meta-ecology modellers to advance marine functional connectivity estimation and prediction](#)

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Abstract: Anticipating the future of the oceans is an emerging challenge in the Anthropocene. The complexity, dynamic nature, and limited accessibility of the marine environment make many ecological processes harder to understand and quantify than in terrestrial ecosystems. Many of these processes depend on marine functional connectivity (MFC) across different spatial and temporal scales. MFC is defined as the movement of marine organisms transferring genes, matter or energy between habitat patches or ecosystems, thereby impacting their biodiversity, functioning, and resilience. Advances in MFC understanding and quantification are essential for the effective management and protection of marine ecosystems and their services. This Viewpoint article aims to help bridge the gap between empiricists in this field and theoretical ecology modellers. We discuss conceptual and mathematical limitations as well as data shortages for the development of meta-population, meta-community, and meta-ecosystem models. The primary challenges in applying meta-ecology theory to MFC data include accurately identifying the respective value of environmental patches for connectivity and predicting environmental variability across those patches. Limitations in empirical data mainly encompass (a) environmental variation and seascape patchiness; (b) diversity in organism life cycle and behaviour; (c) distribution and ecology of non-commercial species; and (d) fluxes of genes and matter at different spatial, temporal, and taxonomic scales. We advocate that enhancing the interaction between MFC modellers and empiricists will play a major role in overcoming these limitations and promoting the application of meta-ecology theory and models in ecological connectivity research. This will boost our capacity in providing operational solutions for current threats to marine ecosystems.

Keywords: Complex-systems modelling, Ecological modelling, Habitat patch, Marine functional connectivity, Meta-ecology, Population persistence.