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Stream F – Invited keynote

Marine ecosystem modelling with generative AI

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Abstract: Ecosystem models are indispensable tools for understanding and managing complex ecological systems, yet their development remains a time-intensive and expertise-driven process (Holden et al. 2024). This bottleneck limits our ability to respond swiftly to pressing environmental challenges. We present two complementary frameworks that leverage large language models (LLMs) to automate and accelerate key stages of ecosystem model development – mechanistic model discovery and food web construction – while preserving ecological interpretability and scientific rigour.

The first framework, AI for Models of Ecosystems (AIME), addresses the inverse problem of inferring mechanistic ecological models directly from time-series data. AIME integrates LLMs with evolutionary optimization to generate interpretable, biologically plausible models that explain observed dynamics. We validate AIME through two marine case studies and find the resulting models are ecologically plausible and have high predictive skill. AIME thus offers a novel approach to ecosystem modelling, dramatically reducing development time while maintaining ecological validity.

The second framework tackles another critical bottleneck: the construction of species groupings and trophic networks for ecosystem models. This LLM-driven pipeline automates the process of (i) retrieving marine species lists for a given region, (ii) classifying species into functional groups, and (iii) synthesizing trophic interactions from structured databases and unstructured text. We evaluate this framework across four major Australian marine regions, assessing reproducibility and ecological accuracy. The system achieves >99.7% consistency in species grouping and 51–59% reproducibility in trophic proportions across runs. Validation against expert-derived food webs for the Great Australian Bight (Fulton et al. 2018) reveals strong ecological alignment: 92.6% of taxonomic assignments are at least partially correct, 85% of trophic interactions are correctly identified, and 80% of diet proportions are estimated within 0.2 of expert values.

Together, these two frameworks enable rapid, reproducible, and interpretable model development. This integrated approach holds significant promise for researchers and environmental managers seeking to understand and respond to ecological change in a timely and scientifically robust manner.

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