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Uncovering the connectivity of coral reef systems via Lagrangian Coherent Structures

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There has been a staggering decline in the health of coral reef ecosystems worldwide over the past century, driven by anthropogenic influences, natural processes, and overall climate change. The future of coral reefs depends largely on their ability to recover from catastrophic events, which in turn crucially relies on the ability of reef larval populations to supply and restore damaged reefs. Improving quantitative predictions of reef larval transport and connectivity has thus emerged as a high priority research area in coral reef science. Ocean circulation models are being increasingly utilized in conjunction with particle tracking methods to provide spatially explicit predictions of larval transport within reef systems. The current major drawback of this approach is that it does not elucidate the underlying yet dynamic flow structures that drive reef connectivity. Recently, however, novel Lagrangian-based analysis approaches have been developed to identify the hidden coherent structures that govern material transport in spatiotemporally complex flow fields. Here we apply these methods to investigate the connectivity within a complex coral reef system, using the UNESCO World Heritage Ningaloo Reef in Australia as a case study. Our study demonstrates how this new approach identifies the dominant flow structures present on the reef, thereby uncovering connectivity and advocating a new practical framework for investigating and understanding how ocean processes shape the ecological transport in and around coral reefs. The technique can prove particularly valuable in supporting the design of Marine Protected Areas that are intended to safeguard the future of coral reefs and other ocean ecosystems.