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Linking basin-scale connectivity, oceanography and population dynamics for the management of marine ecosystems in the Mediterranean sea

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A major challenge in marine ecology is to describe properly larval dispersal and marine connectivity since they structure marine populations and are thus crucial criteria to design Marine Protected Areas (MPAs). Focusing on larval dispersal by ocean currents in the entire Mediterranean Sea, I present a new approach coupling Lagrangian modeling and Network Theory tools to characterize broad-scale connectivity of marine populations. The Mediterranean basin is subdivided into an ensemble of sub-regions that are interconnected through oceanic transport. Passive larvae of different pelagic durations and seasons are advected in a simulated surface flow from which a network of connected areas is constructed. First, the global analysis of the transport network using a community detection algorithm enables the extraction of hydrodynamical provinces which are delimited by frontiers matching multiscale oceanographic features. By examining the repeated occurrence of such boundaries, we identify the spatial scales and geographic structures that control larval dispersal across the entire seascape. We also analyze novel connectivity metrics for the existing marine reserves and we discussed our results in the context of ocean biogeography and MPAs design. Secondly, we studied the local properties of the network with the computation of proxies commonly used in population ecology to measure local retention, self-recruitment and larval sources/sinks. Our results confirmed that retention processes are favored along certain coastlines due to specific oceanographic conditions while they are weak in the open ocean. Moreover, we found that divergent (convergent) oceanic zones resulting from Ekman theory are systematically characterized by larval sources (sinks). Finally, although these proxies are often studied separately in the literature, we suggest they are inter-related under certain conditions. Their integrated interpretation leads to a better understanding of population dynamics and persistence, informing both genetic and demographic connectivities. Our basin-scale results have also managerial implications, especially considering the growing interests for offshore MPAs, as they are useful to evaluate existing MPAs and to implement futures ones.