Physical and biological controls on larval dispersal and connectivity in a highly energetic shelf sea

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ABSTRACT: Connectivity within marine species plays a fundamental role in population dynamics, genetic diversity, spread of disease, and resilience to human exploitation. However, for shellfish species that are sessile as adults, the larval-dispersal stage remains largely unresolved. Appreciation of larval connectivity is therefore crucial to population genetics and marine management. We describe a coupled three-dimensional hydrodynamic and Lagrangian particle tracking model used to simulate larval transport and show how temporal and spatial hydrodynamic changes, together with larval behavior, are likely to affect dispersal. A case study of Irish Sea (United Kingdom) shellfish populations incorporates a wide range of hydrodynamic environments that are prevalent in other marine systems around the world. Our simulations tested two main processes that control larval dispersal: hydrodynamics and vertical migration. Simulated larval cohorts were released from estuaries and soft sediment locations in regions that were oceanographically distinct. Larvae originating from exposed areas could migrate offshore (low retention and high connectivity) and disperse farther than larvae that remained in flood-dominant estuaries, which promote retention. Simulated self-recruitment and connectivity with neighboring populations (~ 50 km apart) were generally high, although well-developed mesoscale residual currents were important, controlling dispersal pathways offshore. Vertical migration strategies, synchronized either with the tide (tidal stream transport) or with the Earth's rotation (diel transport), enabled more larvae to remain close to the coast, and simulations indicated higher retention than for passive larvae. However, the probability of connectivity with other populations and potential survivorship was greater for tidal strategies than for passive (although passive transport populated more distinct areas albeit in smaller proportions, as more larvae remained stranded offshore), or diel, where larvae remained close to their release location.