Larval transport in the upwelling ecosystem of central Chile : The effects of vertical migration, developmental time and coastal topography on recruitment

Ospina-Alvarez, A., Weidberg, N., Aiken, C. M., & Navarrete, S. A. (2018). Larval transport in the upwelling ecosystem of central Chile: The effects of vertical migration, developmental time and coastal topography on recruitment. Progress in Oceanography, 168, 82-99.

Abstract

Several empirical plankton studies and realistic numerical models of the coastal ocean have clearly shown the dramatic effects that larval behaviour and coastal topography can have on effective alongshore dispersal, population connectivity, successful recruitment and cross-shore distribution of the larval stages of benthic coastal invertebrates and fish. All these are essentially distinct and ecologically important aspects of the dispersal process, but which are correlated to a greater or lesser extent through the interaction of larval attributes (e.g., behaviour, pelagic larval duration, PLD) and specific velocity fields of a region of the ocean. Vertical positioning in the water column and ontogenetic and diel vertical migration (DVM) have been identified as the most efficient behavioural mechanisms that can modulate larval transport in the ocean, especially in stratified, baroclinic water columns such as those typically found in upwelling ecosystems. The large seasonal variability in circulation within most upwelling ecosystems is therefore expected to deeply influence all aspects of the larval dispersal process, but it has been less researched. Here, we use a realistic representation of velocity fields across a section of the Humboldt Current Upwelling Ecosystem (HCUE) to evaluate the relative effects of variation in PLD, geographic position, DVM and the timing of larval release on successful onshore recruitment, alongshore dispersal distances, cross-shore retention and persistence of recruitment spatial patterns. Our results show that an increase in pelagic larval duration exponentially increase larval waste, consequently reducing onshore recruitment, regardless of whether larvae perform DVM or not during their development. For any given larval duration, season of the year and location along the shore (topography) had the largest effects on recruitment variability, explaining over 8.49% and over 11.47% of the temporal and spatial variation, respectively. In contrast, while DVM had a highly consistent positive effect on recruitment along the shore, PLD's and seasons, it only explained about 3% of recruitment variability. Thus, while performing DVM appears to be a safe strategy to increase recruitment, selective forces for such behaviour maybe weak when only oceanic transport is considered. Neither season of the year, nor larval behaviour altered the broad spatial pattern of recruitment across the study region. Pelagic larval durations of over 20 days did not significantly alter this spatial pattern either, suggesting the existence of persistent sources and sinks for benthic populations across the region, although the connectivity matrices must be examined in more detail. Interestingly, in the section of the HCUE, the DVM behaviour led to significantly higher mean dispersal distances along the shore during the upwelling season, as compared to passively advected particles. Such a behavioural effect on dispersal distances have all but disappeared when larvae were released in winter time. These results demonstrate that onshore recruitment, dispersal and connectivity among populations are not correlated across the different larval behaviours, as it has often been implied in the literature and that timing of peak larval release must receive more attention within the HCUE. Results also illustrate the importance of examining fundamental questions of the dispersal process, distance, recruitment, retention, connectivity, in different regions of the world's costal ocean.

Keywords

Larval transport, Larval dispersal, DVM, IBM, Hydrodynamic model, Zooplankton, Biophysical model, Upwelling system.