Connectivity measures in the Mediterranean sea from Lagrangian Flow Networks: patterns, sensitivity and robustness

Pedro Monroy[1], Vincent Rossi[2], Enrico Ser-Giacomi[3], Cristóbal López[1] and Emilio Hernández-García[1]

[1]IFISC (CSIC-UIB), Palma de Mallorca 07122, Spain
[2]Mediterranean Institute of Oceanography, CNRS UMR 7294, Campus de Luminy, 13288 Marseille, France
[3]Institut de Biologie de l'École Normale Supérieure (IBENS), ENS, PSL Research University, CNRS, Inserm, Paris F-75005, France

The Lagrangian Flow Network (LFN) approach to ocean transport [1] is a modeling framework in which geographical sub-areas of the sea are represented as nodes in a network and are interconnected by links representing the transport of water, substances or propagules (eggs and larvae) by currents. In this way the tools of network theory become available to address questions of fluid transport and of ecological connectivity [2, 3].

Here [4] we compute for the surface of the whole Mediterranean basin four connectivity metrics derived from LFN that measure retention and exchange processes, thus providing a systematic characterization of propagule dispersal driven by the ocean circulation. Then we assess the sensitivity and robustness of the results with respect to the most relevant parameters: the density of released particles, the node size (spatial-scales of discretization), the Pelagic Larval Duration (PLD) and the modality of spawning. We find a threshold for the number of particles per node that guarantees reliable values for most of the metrics examined, independently of node size. For our setup, this threshold is 100 particles per node. We also find that the size of network nodes has a non-trivial influence on the spatial variability of both exchange and retention metrics. Although the spatio-temporal fluctuations of the circulation affect larval transport in a complex and unpredictable manner, our analyses evidence how specific biological parametrization impact the robustness of connectivity diagnostics. Connectivity estimates for long PLDs are more robust against biological uncertainties (PLD and spawning date) than for short PLDs. Furthermore, our model suggests that for mass-spawners that release propagules over short periods (’ 2 to 10 days), daily release must be simulated to properly consider connectivity fluctuations. In contrast, average connectivity estimates for species that spawn repeatedly over longer duration (a few weeks to a few months) remain robust even using longer periodicity (5 to 10 days). Our results give a global view of the surface connectivity of the Mediterranean Sea and have implications for the design of connectivity experiments with particle-tracking models and for evaluating the reliability of their results.

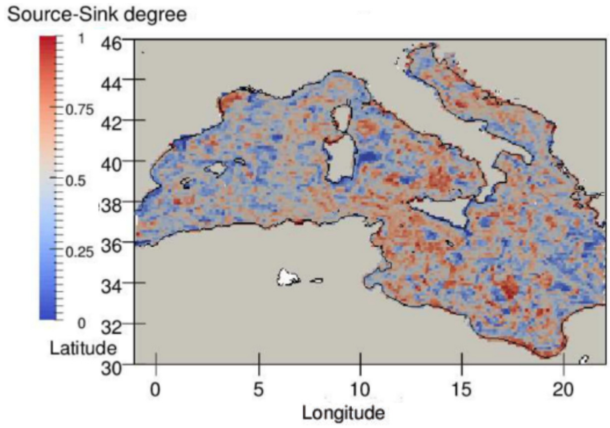

Figure 1: An example (Mediterranean surface, November 2010) of a source-sink degree map, a network measure indicating if a geographical node acts as a source of larvae (small values, blue colors) or as a sink (large values, red colors).

[1] E. Ser-Giacomi, V. Rossi, C. López and E. Hernández-García, *Flow networks: A characterization of geophysical fluid transport*, Chaos **25**, 036404 (2015).

[2] E. Ser-Giacomi, R. Vassile, E. Hernández-García and C. López, *Most probable paths in temporal weighted networks: An application to ocean transport*, Physical Review E **92**, 012818 (2015).

[3] Rossi, V.; Ser-Giacomi, E.; Lopez, C.; Hernandez-Garcia, E.; Hydrodynamic provinces and oceanic connectivity from a transport network help designing marine reserves. Geophysical Research Letters **41**, 2883–2891 (2014)

[4] P. Monroy, V. Rossi, E. Ser-Giacomi, C. López and E. Hernández-García, *Sensitivity and robustness of larval connectivity diagnostics obtained from Lagrangian Flow Networks*, ICES Journal of Marine Science, to appear (2017).