Tidal dynamics effect on the connectivity patterns of the blackspot seabream (*Pagellus bogaraveo*) in the Alboran Sea

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Keywords: Blackspot seabream, Early Life Stage, Hydrodynamic connectivity, Tidal dynamics, Alboran Sea

Introduction

Several researchers have reported that the blackspot seabream have been subjected to an excessive exploitation over the years (Gil Herrera, 2006). Experts in fishery ecology agree that for optimizing the fisheries as well as curbing the over-exploitation is necessary to study population dynamics and connectivity of the species according to the circulation and oceanographic variability (Cowen and Sponaugle, 2009). The objective of the present work is to analyse the blackspot seabream connectivity with a hydrodynamic numerical model, using early life stage (ELS) blackspot seabream virtual particles as passive tracers advected by dynamical tides.

The numerical model

The model used to carry out the numerical simulations is the MIT general circulation model (Marshall et al., 1997). The general configuration of the model, its advection and vertical mixing scheme is described in detail in Sammartino et al. (2014).

To assess the dynamic interaction of the ELS blackspot seabream with marine environment, a lagrangian particle tracking (LPT) algorithm was used. Lagrangian simulations are an effective way to study the general pattern of connectivity between different sub-areas as a result of observing the advection of eggs and larvae (that, numerically, are considered as passive particles) under the effect of the current. For this particular case, LPT was based on the Runge-Kutta 4th order method. Lagrangian particles were simulated under different spatial and temporal combination of conditions to investigate how different tides affect them. First, to see the particles behaviour according to the release area, three starting areas were defined within the SoG: Tanger, TangerMED and Tarifa. On the other hand, ten possible destination areas were defined: Cadiz, Estepona, Malaga, Roquetas, Carboneras, Oran, Melilla, Alhucemas, Tetuan and Arcila. Secondly, to see the particles behaviour at several vertical levels, five release depths were considered, at 1m, 12m, 25m, 52m and 81m. Third, with the aim of estimating the effect of tides on the ELS dispersal patterns, an array of LPT simulations have been started under a set of eight tide combinations of the different conditions depending on the tidal phase [(H) High, (L) Low, (F) Flood, (E) Ebb tide] and the tide strength [(S) Spring, (N) Neap tide]. Finally, with the aim of obtaining a more robust estimation of the metrics used, a total of four replicas for each of the aforementioned condition, were implemented throughout the first two months of 2005. Each single LPT simulation lasted for 60 days.

Results

Figures 1 and 2 shows maps of the averaged maximum particles of ELS reached at all the connectivity boxes from Tarifa and TangerMED, respectively.

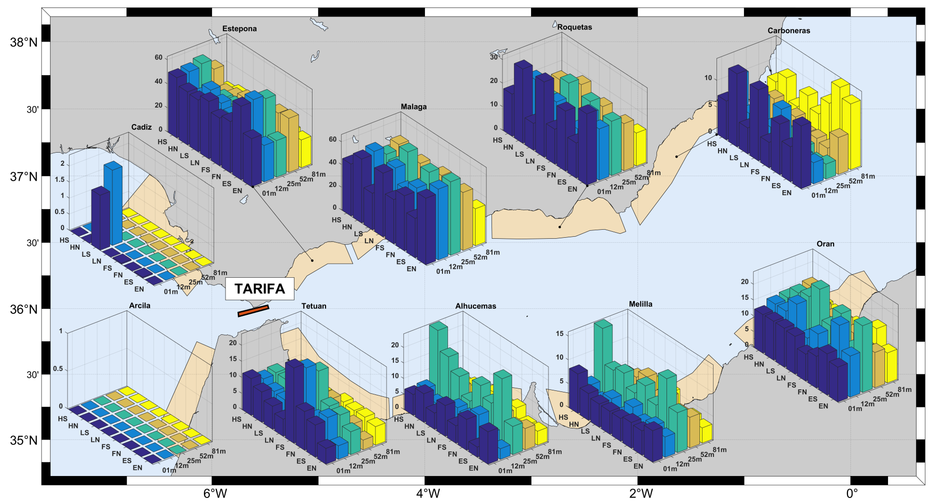

Figure 1: Map of the averaged maximum particles of ELS reached at all the connectivity boxes from the Tarifa area according to the 160 combinations and the 10 adjoining boxes.

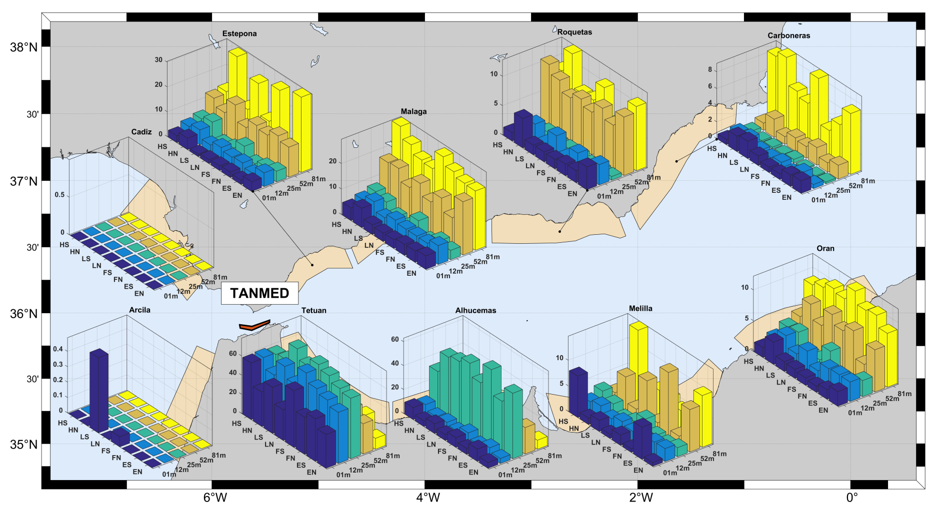

Figure 2: Map of the averaged maximum particles of ELS reached at all the connectivity boxes from the TangerMED area according to the 160 combinations and the 10 adjoining boxes.

For their location within the SoG, these areas are a good example of the latitudinal divergence of the connectivity patterns. Particles released in Tarifa are registered predominantly in the northern boundary of the Alboran sea, whilst particles released in TangerMED are registered in the southern boundary. Instead, few particles were registered at the Atlantic Ocean, demonstrating the Atlantic Jet predominance. Relative to both maps, the connectivity boxes Estepona and Tetuan, for its proximity to the Tarifa and TangerMED release areas respectively, presents the earliest maximum connectivity percentages, and a progressive drop of values from High Tide (HS) to Low Tide (LS), according to the general tidal modulation of the SoG exchange that prescribe the maximum (minimum) inflow and the corresponding minimum (maximum) outflow in ebb (flood) tide. The variability due to the tidal fortnightly modulation is also noticeable, especially in terms of time shift of the connectivity maxima, which, in turn, are not sensibly broadened. In the rest of the connectivity boxes of the northern and southern boundary, the discrepancy driven by the fortnightly modulation starts to be more evident. This, prior to other calculations suggests a faster speed of the particles under spring cycle and, thus, a higher dispersion of the eggs and larvae in this tide condition. On the other hand, there are not big differences between the different tidal phases (high, low, ebb and flood tides) along the boxes, which suggests a major influence of the tidal strength for the particles released in this area. Figure 3 provides a clear example of the effect of fortnightly modulation. The percentage of ELS registered and the corresponding elapsed time were lower under the spring cycle, whilst the percentage registered under neap cycle and its corresponding time, were significantly higher, which affirmed the lower dispersion and velocity of the eggs and larvae under this cycle.

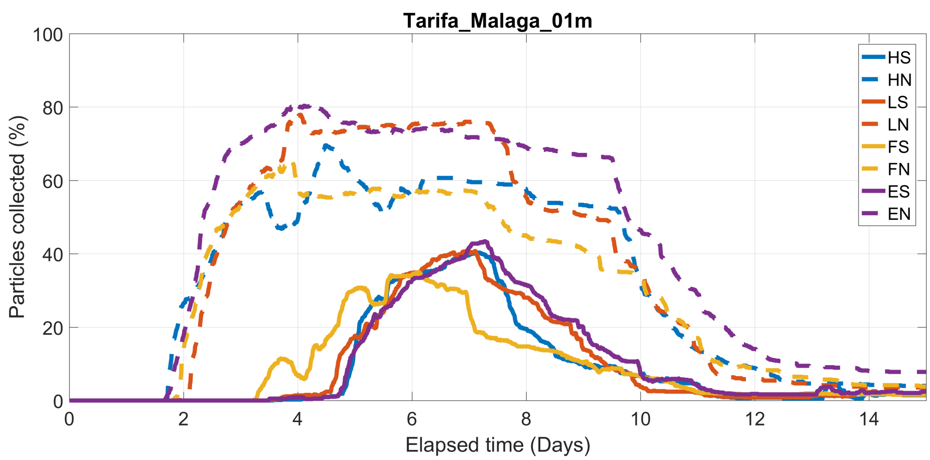

Figure 3: Percentages of ELS released at surface in Tarifa and found in Malaga box over the elapsed time under different tidal conditions. The four tidal phases combined with the spring cycle are displayed by solid lines, whilst the combined with the neap cycle are displayed by dashed lines.

Finally, the variability according to the depth level shown a higher energy and, thus, higher percentages on the most superficial levels.

Acknowledgments

Special thanks to Manuel Hidalgo and Juan Gil Herrera for sharing their expertise in fish connectivity.

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