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How is the connectivity of sole larvae affected by wind and temperature changes in the Southern North Sea? A modelling approach

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Introduction

Connectivity of flatfish remains an open question, especially at early life stages. The impact of anthropogenic factors such as climate change on larval dispersal remains unknown. It is important to understand how the retention/dispersal of sole larvae, one of the most valuable commercial species in the North Sea, would be affected by climate change.

Objective

To investigate the impact of climate change – temperature increase and wind magnitude/direction changes – on the recruitment and connectivity of sole larvae

Methodology

The sole larvae transport model couples the 3D hydrodynamic model COHERENS (Fig. 1) with an Individual Based Model (IBM) [1]. It has been implemented for the period 1995-2006.

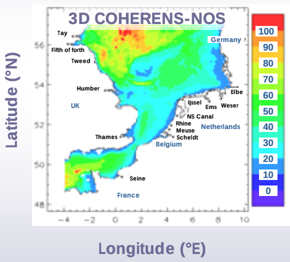


Fig. 1. Geographic implementation of the model, with bathymetry (m)

Four stages are considered (Fig. 2). Eggs are released within the 6 main spawning grounds (Fig. 3 left) during a 3-month period (peak of spawning at 10°C). Postlarvae settle in coastal areas (< 20 m) with high proportion of sand and/or mud (nurseries, Fig. 3 right).

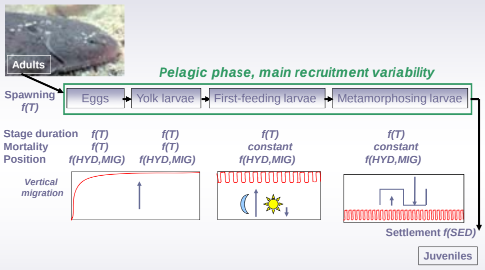


Fig. 2. Schematic representation of the sole larvae IBM. T: Temperature, HYD: hydrodynamics, MIG: vertical migration, SED: sediment type.

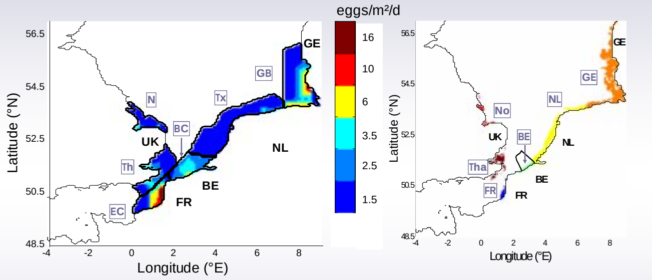


Fig. 3. Left: main spawning grounds in the North Sea and mean number of eggs spawned. Eastern Channel (EC), Belgian Coast (BC), Texel (Tx), German Bight (GB), Norfolk (N), and Thames (Th). Right: nurseries. France (FR), Belgium (BE), Netherlands (NL), Germany (GE), Norfolk (No), Thames (Tha).

The sensitivity of recruitment and connectivity to climate change is assessed by estimating the impact of a hypothetical (i) water temperature increase (+2°C) but no change of spawning period, (ii) increase of the wind intensity (+4 %) and (iii) increase of SW wind (+10 % towards East and +20 % towards North).

Results

The dispersal pattern is shown in Fig. 4.

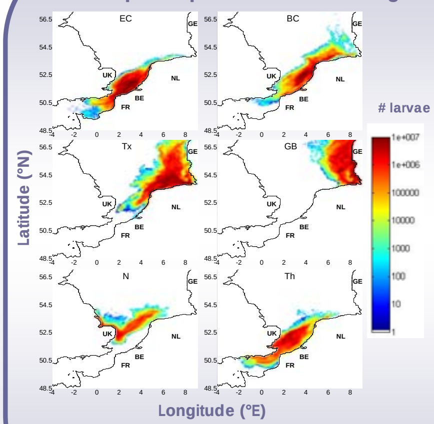


Fig. 4. Final distribution of larval abundance (# larvae) after the pelagic phase for the 6 main spawning grounds. Mean 1995-2006. STD run.

The impact of climate change scenarios is assessed by comparing the trajectories of the center of mass (fig. 5), the transport success to the nurseries (Fig. 6) and the connectivity matrices (Fig. 7) obtained with the standard run (STD) and the perturbed simulations (for 4 contrasted years in term of wind and temperature: 1997, 1998, 2005 and 2006).

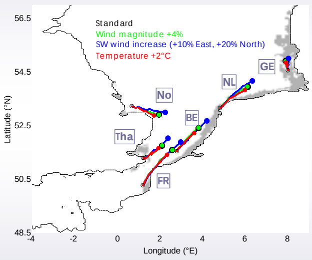
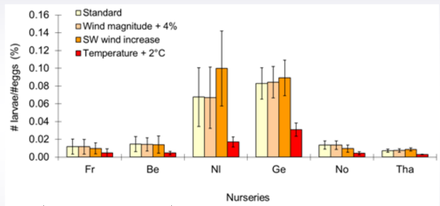


Fig. 5. Trajectories of the centre of mass (6 spawning grounds) for the 4 runs. Origin: empty circle. End of trajectories: full circles.



Relative difference (%)

	FR	BE	NL	GE	No	Tha
Wind magnitude +4%	-0.6	-2.5	-0.9	1.8	-0.7	1.2
SW wind increase	-16.3	-4.5	47.7	7.4	-28.8	18.3
Temperature +2°C	-60.5	-68.7	-74.8	-62.7	-67.1	-60.1

Fig. 6. Recruitment in the 6 nurseries (mean 4 years). The error bars are the stdev due to interannual variability. The table gives the relative difference between perturbed and standard runs.

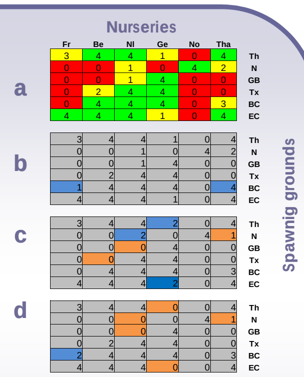


Fig. 7. Connectivity matrices. #years where connection or retention (self-recruitment) is predicted by the model. A: STD run, b: wind intensity increase, c: SW wind increase, d: temperature increase. A: Frequency of connections: never (red), sometimes or often (yellow), always (green). B-d: more connections (blue), less connections (orange).

Conclusions & Perspectives

- A T° increase (without change of spawning period)
  ⇒ Reduction of recruitment (stage duration ⇓, egg and yolk larvae mortality ⇑)
  ⇒ Reduction of the travel distance
- A modification of the wind
  ⇒ Increase/decrease of recruitment according to the nurseries (with ⇑ intensity or SW wind ⇑)
  ⇒ Increase of the travel distance (with SW wind ⇑)
- Connections appear/disappear according to the scenario
- The impact of climate change scenarios is significant (T°) and not negligible (wind) but interannual variability due to meteorological forcing is high.

PERSPECTIVES:

- The IBM is still under development (focus on mortality by including a prey/predator field).
- The dispersal pattern of larvae and recruitment must be validated.

REQUEST: We are looking for life-history data of sole to validate the model

Acknowledgements:
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Reference:
[1] Lacroix G., Maes G.E., Bolle L.J., Volckaert F.A.M. 2012. Modelling dispersal dynamics of the early life stages of a marine flatfish (*Solea solea* L.). Journal of Sea Research, in press. 10.1016/j.seares.2012.07.010