Impact of projected wind and temperature changes on larval recruitment of sole in the North Sea

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Introduction

The impact of anthropogenic factors such as climate change on larval dispersal and population connectivity remains largely unknown. The case of sole (*Solea solea*) is of particular interest because sole is one of the most valuable commercial species in the North Sea. It is important to understand how the retention/dispersal of larvae would be affected by climate change in order to propose appropriate measures for the management of the North Sea stock.

Objective

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

Methodology

Our sole larval transport model coupling the 3D hydrodynamic model COHERENS with an Individual Based Model (IBM) of the sole larvae [1] was implemented in the North Sea for the period 1995-2011. In the sole larvae IBM 4 stages were considered [Fig 2]. Eggs were released within the 6 main spawning grounds of the North Sea [Fig 1] during a 3-month period (peak of spawning at 10°C). The nurseries [Fig 3] were defined as coastal area (depth < 20 m) with high proportion of sand/mud.

Algal Bloom (AB) period, used as a proxy for larval food, is computed by piecewise linear regression [2] from MERIS Chl *a* time series averaged over an area where larval abundance is > 10^7 [Fig 4].

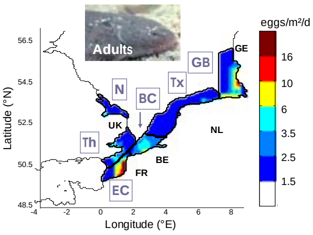


Fig. 1. Main spawning grounds in the North Sea and mean number of eggs spawned within the 3-month spawning period. Eastern Channel (EC), Belgian Coast (BC), Texel (Tx), German Bight (GB), Norfolk (N), and Thames (Th).

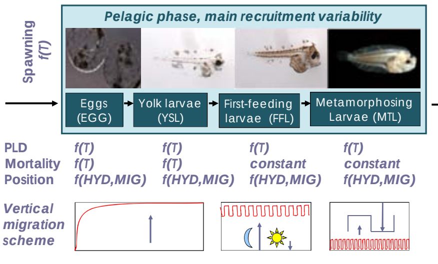


Fig. 2. Schematic representation of the sole larvae IBM. PLD: Pelagic Larval Duration, T: temperature, HYD: hydrodynamics, MIG: vertical migration, SED: type of sediments. Details on parametrisation can be found in [1].

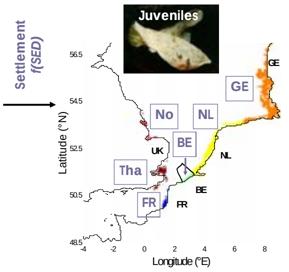


Fig. 3. Nurseries. France (FR), Belgium (BE), Netherlands (NL), Germany (GE), Norfolk (No), Thames (Tha).

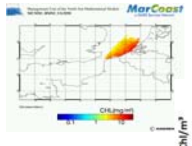
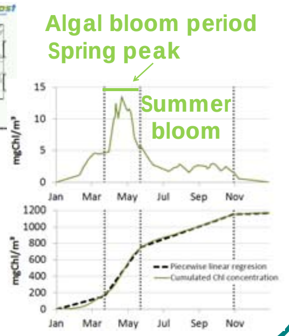


Fig. 4. Left: Mean Chl a on Belgian Coastal Larvae (BCL) area. Upper right: time series of Chl a averaged over the BCL area. Bottom right: cumulated Chl a and begin/end of AB period computed by piecewise linear regression [2]



Results & Discussion

Sensitivity of larval recruitment at nurseries [Fig 5] and connectivity [Fig 6] to climate change (CC) is assessed by estimating the impact of:

- increase of SW wind (+ 10% → East, + 20% → North)
- wind intensity + 4 %
- water temperature + 2°C & early spawning

} Inspired from 2040 IPCC scenario [3]

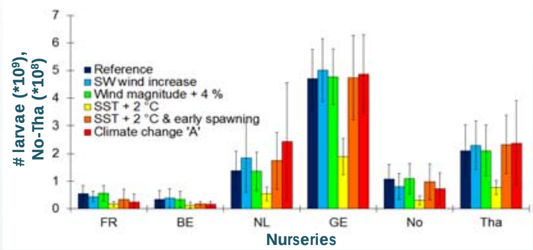


Fig. 5. Larval recruitment in the 6 nurseries (mean 2005-2010). The error bars are the stdev due to interannual variability. Scenario CC'A': all perturbations together

Left: REF run (Nurseries × Spawnig grounds)

	FR	BE	NL	GE	No	Tha
Th	7	9	9	0	0	9
N	0	0	3	0	9	6
GB	0	0	1	9	0	0
Tx	0	7	9	9	0	0
BC	2	9	9	7	0	9
EC	9	9	9	1	0	9

Right: scenario CC'A' (Nurseries × Spawnig grounds)

	FR	BE	NL	GE	No	Tha
Th	2 ↓	8 ↓	9	5 ↑	0	9
N	0	0	3	1 ↑	9	5 ↓
GB	0	0	1	9	0	0
Tx	0	4 ↓	9	9	0	0
BC	1 ↓	9	9	9 ↑	0	7 ↓
EC	9	9	9	9 ↑	0	9

Fig. 6. Connectivity matrices (2003-2011). #years where connection/retention is predicted by the model. Left: REF run, right: scenario CC'A'. Frequency of connections: never (red), sometimes (orange), often (yellow), always (green)

Larval food requirement (LFR) period (presence of first feeding larvae, FFL) computed by the model is compared with AB period for the REF run and for scenario CC'A' [Fig 7].

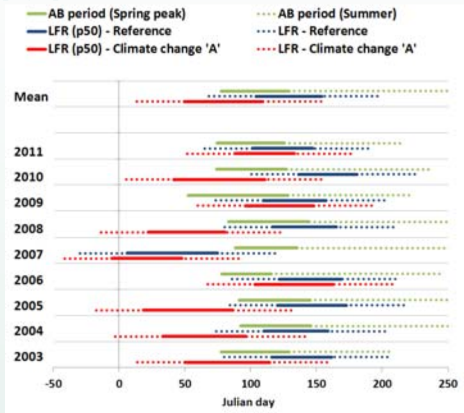


Fig. 7. AB period and LFR period for the reference run and climate change scenario 'A' (2003-2011). P50 corresponds to the upper 50%

Results show:

- Interannual variability of the overlap between AB & LFR periods.
- On average, a match between AB peak and the 1st half of LFR period (REF run).

→ Could we use the overlap between AB peak & LFR period to estimate FFL mortality?

- On average, no overlap between AB peak and the 1st half of LFR period (CC'A' run).

→ Since we expect little impact of CC scenario on AB timing (mainly triggered by light), larval mortality could be higher during the 1st half of LFR period.

Conclusions & Perspectives

Impact of CC'A'

→ Larval recruitment at nurseries

↓ FR, BE, No ↑ NL, Tha, GE

→ Connectivity

↓ FR, BE, Tha ↑ GE

→ Match-Mismatch

↓ Overlap between AB & 1st half of LFR

↑ Larval mortality?

↓ Larval recruitment?

PERSPECTIVES:

- The IBM is in still under development. We will focus on mortality by including mortality based on overlap between AB timing and LFR period. Not only the period of AB & LFR but also magnitude of the peaks must be considered.
- The dispersal pattern of larvae and recruitment must be validated.

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

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References:
[1] Lacroix G., Maes G.E., Bolle L.J., Volckaert F.A.M. 2013. Modelling dispersal dynamics of the early life stages of a marine flatfish (*Solea solea* L.). JSR 84: 13-25.
[2] Muggeo V. 2008. Segmented: an R package to fit regression models with broken-line relationships. R News, 8, 1: 20-25
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