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Interactive comment on “Numerical modelling of physical processes governing larval transport in the Southern North Sea” by M. C. H. Tiessen et al.

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Numerical modelling of physical processes governing larval transport in the Southern North Sea M. C. H. Tiessen, L. Fernard, T. Gerkema, J. van der Molen, P. Ruardij, and H. W. van der Veer

General comments. The recruitment dynamics of flatfish remains an open question, especially at the early life stages. It is crucial to understand how the spawning grounds and nurseries are connected and what are the processes influencing larval retention and dispersal in order to propose appropriate management measures in the future. Especially, dispersal during the larval stage is still poorly known. Larval transport models are more and more commonly used to study the role of hydrodynamics, environmental and/or biological processes on the larval dispersal. The aim of the study is to inves-

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tigate to what extent variability in the hydrodynamic conditions alone contributes to interannual variability in transport of eggs and larvae of plaice in the North Sea and the English Channel. In such, the present study addresses an important research issue and suits within the scope of OS. The case of plaice is of particular interest because it is one of the most valuable commercial species in the North Sea. The paper doesn't present new concepts. The impact of hydrodynamics on larval dispersal and settlement in nurseries has already been shown for several fish species in the North Sea (see specific comments). What is new is the coupling between a particle tracking module for plaice (van der Molen et al., 2007) and the 3D hydrodynamic GETM implemented in the North Sea and the English Channel. The comparison of larval trajectories with drift buoy paths is interesting and useful because it is a first step towards the particle tracking model validation. This part of the study should be further developed (see specific comments). The scientific approach is correct but I think that the study lack a bit of 'realism' (in particular spawning ground and period, see specific comments). The authors consider properly related larval transport modelling work for plaice in the North Sea. The discussion would be further improved by including comparison with outcomes from other studies for the same region even if for another species (ex. Savina et al., 2010, Lacroix et al. 2013, Rochette et al., 2012). On the overall, the manuscript is clear and well presented but is it not always easy to follow the different model setups (see specific comments). It would be better explained in the M&M. The figures are clear. I am not a native speaker and I cannot judge the correctness of the language. I just found some typographic errors (see technical comments).

Specific comments. The strong impact of hydrodynamics on interannual variability of fish larval dispersal in the North Sea and the English Channel has already been demonstrated for instance for plaice (e.g Bolle et al. 2009 for 1996-2003) and sole (e.g Lacroix et al., 2013 for 1995-2006, Rochette et al., 2012 for 1991-2004). What is missing is a better quantification and understanding of the relative impact of wind/current/temperature/river discharges. What are the particular conditions that enhance/reduce larval settlement? Also, in this study it is not possible to disentangle

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the role of ‘pure’ transport (wind/current) and the temperature effect on the drift duration. In Discussion “The aim of this research was to investigate whether changes in hydrodynamic conditions alone can potentially cause significant interannual settlement variability of North Sea plaice juvenile. . .”. What do you mean by significant? It is not quantified. The authors should make a distinction between ‘purely’ hydrodynamic conditions (current) and the effect of temperature. In conclusion “The present study serves therefore to give an indication of the extent of variability that can be attributed to physical factors”. The extension of variability is not quantified. The discussion would be further improved by including comparison with outcomes from other studies for the same region even if for other species. For instance, in this study, the authors have chosen the years 1996 and 1998 as contrasted years. They compared distances drifted in both years (p. 1775, l2-4). The distances drifted by sole larval for different years are presented in Lacroix et al., 2013. The results could be compared.

Generally, larval transport models lack of validation. In such, the comparison between larval trajectories and drift buoy paths presented in the study is really useful. But the statement “the model reproduces the general trend of the drifters reasonably well” or “the accuracy of the model predictions is fairly reasonable” or “the model reproduces the hydrodynamic conditions reasonably well” is a little bit too vague. What are the criteria used to assess the accuracy? I would expect more detailed comparison and probably further sensitivity analysis to better understand the origin of divergence. Only the effect of time-step increase (from 45min to 24h) has been tested. What would be the effect of a decrease of the time-step? In section 2.1 and section 4.2 “. . . , the hydrodynamic conditions were stored at 45 min intervals to provide a high enough temporal resolution to describe the M2 tidal cycle”. What is the evidence that a shorter temporal resolution would not give more realistic results? What would be the effect of an increase/decrease of the number of vertical layers? Is there any wind driven effect on the drift buoy?

The model lacks a bit of realism, especially regarding the spawning distribution and

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period. Larval supply to nurseries is strongly impacted by both. I am not a specialist of plaice but it is the flatfish that has been the most studied in the North Sea. I wonder if it is not possible to increase a bit the realism of spawning area/period on the basis of existing literature and data? In the study, the larval duration is temperature-dependent but the spawning period not. Why not? Some examples: - “For plaice, the location of the spawning grounds is well documented” (Bolle et al., 2009). - Loots, C., Vaz, S., Planque, B., Koubbi, P., 2010. Spawning distribution of North Sea plaice and whiting from 1980 to 2007. *Journal of Oceanography, Research and Data.* 3, 77-95. - C. Loots, S. Vaz, P. Koubbi, B. Planque, F. Coppin, Y. Verin. 2010. Inter-annual variability of North Sea plaice spawning habitat. *JSR* 64:427-435. - “Profusion of studies for spawning period of plaice in the North Sea (e.g.Simpson, 1959a; Harding et al., 1978; Coombs et al., 1990)”. In Ellis, T., and Nash, R. D. M. 1997. Spawning of plaice *Pleuronectes platessa* L. around the Isle of Man, Irish Sea. – *ICES Journal of Marine Science*, 54: 84–92. - “Plaice spawns between late December and April in the southern North Sea” (review in Hufnagl et al. 2013).

On the overall, the manuscript is clear and well presented but is it not always easy to follow the different model setups. For instance, some results are based on simulations where only 100000 particles are released. For some simulations the period of release is between 1 Dec and 31 March, for others it is from 25 Dec to 6 Jan. It is not clear in the text why and for which simulations? This should be better explained in the M&M.

I wonder how are the results sensitive to the choice of 120 days as a maximum life span? What is the reason to truncate the simulations to 120 days? This must lead to bias in conclusions. P. 1783 l. 26-28 “This limit was chosen based on ... and a small change (on order of 10 days) would not result in massive increase in particle settlement”. Did you test?

The results of the sensitivity analysis to the size of settlement areas on the settlement success (section 4.2) are expected. By increasing the size of a nursery, it seems obvious that more larvae can settle. It is possible to improve the realism of the definition

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of the nurseries from the literature? For instance on the basis of sediment type? It is not mentioned in the discussion (section 5.5).

In section 2.2. The random walk model used is not clearly explained. It is well known that 'naïve' random walk formulation gives erroneous particle accumulation in low-diffusivity areas (Visser, 1977). Which formulation has been used in the study?

In section 2.2. "The internal time-step of 10 s is chosen to ensure accuracy of the tracer model". What is the criterion to ensure accuracy?

"After the final development stage, particles went into a settlement stage lasting up to 30 days. During this stage, a particle would settle if it would encounter favourable conditions" (p.1770). The sensitivity of the results to such a delay must be strongly significant. It should be discussed.

In section 5.4 "However, a change in the relation between sea water temperature and the development rate of plaice larvae might result in accelerating the particle development, and therefore result in more realistic settlement figures in 1996". If I correctly understood the parameterization of larval duration in function of temperature is the one of Bolle et al. (2009). It has been based on experimental studies. Why this parameterisation could be 'bad' just for the year 1996?

Technical corrections - P. 1768 I.23 Burchard and Bolding (2002) instead of (Burchard and Bolding, 2002). - P. 1768 I. 25 and p. 1769 I.3 van Leeuwen et al instead of Leeuwen, van - P. 1769 I.5 nautical miles instead of nautical mile - P. 1773 I.11-13. The position of the Dover Straits or the Doggerbank is not known by everybody. It should be added on the map. The same remark for the Wadden Sea (p. 1774 I. 10) and for Marsdiep-Vlie (p.1777 I.16). - P. 1775 I.23 interannual instead of intern-annual - P. 1776 I. 9 "The total number of settling particles showed only limited variability (Fig. 11)". Seems obvious because it represents the number of particles released (106). - P. 1777 I.13 The characteristics - P. 1777 I.14 replace is presented by are presented - P. 1778 I. 25 "the right conditions". Which conditions? - P. 1779 I.1 "visible for instance

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in” instead of “visible for for instance” - P. 1779 I.4-6 Sentence “The arch . . . c and d)” not clear. Needs more explanation. - P. 1784 I.9 “Similarly to the addition of a velocity threshold discussed in section 3.5”. There is no section 3.5. I suppose that you mean a depth threshold and not a velocity threshold. - P. 1784 I.14 good instead of goed - P. 1787 I.26 van Leeuwen instead of Leeuwen, van - P. 1791. Fig. 2. Add the label for latitude - P. 1792. In the legend “during the drifter-buoy” instead of “during the dirfter-buoy” - P. 1792. In the legend “around the drifter” instead of “around the the drifter” - P. 1792. In the legend “circle around the central” instead of “circle around the the central” - P. 1794. In the legend “particles that eventually settle”. Do they settle or not? - p. 1803. The figures a, b, c, d, e and f should be identified

REFERENCES - Lacroix G, Maes GE, Bolle LJ, Volckaert FAM (2013) Modelling dispersal dynamics of the early life stages of a marine flatfish (*Solea solea* L.). *Journal of Sea Research* 84:13-25 - Rochette S, Huret M, Rivot E, Le Pape O (2012) Coupling hydrodynamic and individual-based models to simulate long-term larval supply to coastal nursery areas. *Fisheries Oceanography* 21:229-242 - Visser A (1997) Using random walk models to simulate the vertical distribution of particles in a turbulent water column. *Marine Ecology Progress Series* 158:275-281

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