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Interactive comment on "Ecosystem model-based approach for modelling the dynamics of ^{137}Cs transfer to marine plankton populations: application to the western North Pacific Ocean after the Fukushima nuclear power plant accident" *by* M. Belharet et al.

M. Belharet et al.

mokrane.belharet@gmail.com

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We thank Dr Tateda for his review and greatly appreciate the thoughtful and constructive comments and helpful suggestions. We have fully considered his comments in the revision and improved the manuscript accordingly.

General comments:

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Question: The output from the simulated result is regulated by the contamination source input to the model. Thus it is necessary to show the information of what kind/amount of the radiocesium source (e.g. atmospheric: 2.0?? PBq within radius of ??km, initial liquid release 3.5?? PBq) was introduced into the model as the source input for this study analysis. At the same time, it should be stated what other possible sources (e.g. redistributed by river discharge, late continuous release etc.) were not considered in this study. Otherwise, the reader cannot identify limits of the authors result, the applicability of which is regulated by the source used in this modeling study.

Answer: The 137Cs concentration dispersion in seawater was simulated using the regional ocean circulation model SYMPHONIE and source terms described in Estournel et al., (2012). As explained in this paper, the amount of atmospheric deposition included in this simulation is 0.26 PBq within a radius of 80 km. The direct leakage was about 4.5 PBq released between 12 march and 30 June 2011. The simulation was extended until 31 December 2012. The inverse method described in Estournel et al., (2012) and used to calculate the source term in the first three months after the accident was applied to the whole period. After June 2011, the concentrations at the two outlets of the nuclear power plant were simplified to a linear decrease from 40 and 20 Bq/L on 1st July 2011 to 8 Bq/L for both outlets at the end of 2011 and then remained constant at this value for 2012. The source term obtained by the inverse method was 70 TBq for the 1.5 year period. This value is about 4 times higher than the value given by Kanda (2013) from an estimation of the water exchange rate in the harbour of the nuclear power plant. This relatively high difference could be partly due to the oversimplification of the concentration time variation used in our approach. Nevertheless, it should be considered that the release during this period is considerably lower than during the first three months after the accident leading also to low concentration in the seawater. No additional source was considered (sediment, rivers). This point should be improved in the future especially as these contributions cannot be anymore neglected (1) when the direct leakages of the power plant were strongly reduced for example after the first year and (2) in front of the rivers mouth. This is particularly true during extreme events.

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Nagao et al. (2013) and Yamashiki et al. (2014) studying the effect of Typhoon Roke in September 2011 on the Cesium load in two small rivers (Natsui and Same) and one large river (Abukuma), pointed the role of this typhoon responsible of 30-60% of the total Cesium flux determined for a 10-month period, a large part attached to suspended sediment.

Nagao S., Kanamori M. ,Ochiai S. , Tomihara S., Fukushi K., and Yamamoto M. (2013). Export of 134Cs and 137Cs in the Fukushima river systems at heavy rains by Typhoon Roke in September 2011. Biogeosciences, 10, 6215–6223

Yamashiki, Y., Onda Y., Smith H.G., Blake W.H., Wakahara T., Igarashi Y., Matsuura Y. and Yoshimura K. (2014). Initial flux of sediment-associated radiocesium to the ocean from the largest river impacted by Fukushima Daiichi Nuclear Power Plant. Sci. Rep. 4, 3714; DOI:10.1038/srep03714.

Kanda, J. (2013). Continuing 137 Cs release to the sea from the Fukushima Dai-ichi Nuclear Power Plant through 2012. Biogeosciences, 10, 6107 – 6113

2)

Question:

Bio-kinetic parameters in the model are calibrated by the measured concentrations in zooplankton collected from Sendai Bay (MEXT?). As Kaeriyama et al., (2015) discussed about the biota data from these coastal waters, the analyzed values of zooplankton samples collected by Bongo/sledge nets were higher variable, probably because they contained suspended particles with or within the zooplankton. A similar tendency for higher variability in concentrations in collected plankton samples has been pointed out in the conference presentations by Aono (NIRS) and Ishimaru (Tokyo Univ MST)(unpublished data). The effect of this kind of variability in the data on model calibration is more or less significant for the final calculated output. One may use a bias-based calibrated parameter as an apparent (calibrated) value, especially in the model simulation carried in an area of similar conditions such as the coastal waters around Fukushima. However, in contrast, the application of bias-based calibrated parameters will generate overestimations in the case when applied to the North Pacific Ocean where the contribution of contaminated suspended particles is negligible. Thus, in this paper the authors should mention that their result of the Ocean simulation may be overestimated. Or if possible, they should consider deriving a correction factor (see. Tateda et al., 2015). If this cannot be done, mention of the extent of the assumed error would be helpful to avoid the reader's misunderstanding about the result being a maximum value or bias-based estimation.

Answer:

The bio-kinetic model parameters are calibrated using the data reported by Kaeriyama et al. (2015) for the zooplankton collected at Sendai Bay. We think that, in Kaeriyama et al. (2015), it is reported that the species composition of the samples might be variable and the concentrations can vary greatly between the various groups of zooplankton. And indeed, an oral presentation by Nishikawa and Fisher (STAR meeting in Aix en Provence-June 2015, France) underlines the possibility that different degree of bioaccumulation with different taxonomic/trophic composition of zooplankton as being one factor for highly variable concentration in zooplankton. The simulated data used in this calibration correspond to the weighted average of the three zooplankton groups (ZS, ZL, ZP). So, though certainly not perfect, our approach takes into account in some way these differences in taxonomic composition. On the other hand, according to Kaeriyama et al. (2015), it is probably possible that zooplankton samples contain particles in coastal areas, which can affect the calibrated values. Consequently, overestimations in Cs concentrations in these populations can be generated especially in the open ocean where the particles contribution is generally negligible. However, the discussion related to the possible effect of a biases introduced by the presence of particles has been added in the text.

3)

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Question:

The significant findings in this paper are that the time-dependent radiocesium concentration in zooplankton is theoretically explainable by temporal changes of plankton biomass and the food ingestion/composition rates reconstructed from the ecosystem model. In addition, it is worth reporting that limited oceanic winter food condition reduces the radiocesium concentration in zooplankton, though it should be evaluated by multi-year simulation by validation with filed observations (Kitamura, Nishikawa unpublished data). On the other hand, the sensitivity of the model output affected by parameter deviation (Fig. 5), ratio of concentration in phytoplankton and zooplankton (Fig. 7), and seasonal dynamics of concentration in a non-accident situation (Fig. 10), etc. are understood as just the calculated results defined by model characteristics. Without any validation data to compare with, they are just functions of the given input, and not the proven findings. It is therefore recommended to consider including some discussion of the above-mentioned points in this paper.

Answer:

In the winter conditions the food availability for the zooplankton populations is limited (essentially due to the phytoplankton biomasses decrease in the area), resulting in decrease in species food ingestion rates, and by consequence, the decrease of the radiocesium quantity accumulated from food, which induces a decrease of radiocesium concentrations in these zooplankton populations. Although this finding seems to be logical, validation with field observations is necessary, but at this time these field data are not available yet.

4)

Question:

The order of appearance of some tables and figures do not correspond to the order they are discussed in the text. Since tables and Fig. 2 are not necessary to shown in the main text, it is suggested to put them in an Appendix at the end of the paper, or in Supplementary Material.

Answer:

The order of appearance of different tables and figures has been corrected. Figure 2 is replaced in appendix

Specific comments:

Question:

“assess the radionuclide concentration in marine biota” -> “assess the radionuclide distribution between marine biota and the environment”? or “reconstruct the radionuclide concentration in marine biota”?

Answer:

the two propositions are correct but in this paragraph I mean “ the most commonly used to reconstruct the radionuclide concentration in marine biota”.

9502 5 :

Question: missing (ZP) in ”predatory zooplankton (ZP) such as krill and/or jellyfish”

Answer: (ZP) is added to the “predatory zooplankton”.

9505 6 :

Question: The source information used for the simulation has to be shown, such as atmospheric, initial effluent and continuous release (if included in this paper).

Answer: Information related to the source term and atmospheric deposits used in the simulations carried out by Estournel et al. (2012) are added at the end of the section 2.4.

9505 13:

Question: If the radionuclide contribution from terrestrial runoff is not estimated and included in this simulation, this should be mentioned in the text. (See Nagao, S., Kanamori, M., Ochiai, S., Tomihara, S., Fukushi, K., Yamamoto, M., 2013. Export of 134Cs and 137Cs in the Fukushima river systems at heavy rains by Typhoon Roke in September 2011. Biogeosciences 10, 2767-2790.; Tateda, Y., Tsumune, D., Tsubono, T., Aono, T., Kanda, J., Ishimaru, T., 2015. Radiocesium biokinetics in olive flounder inhabiting the Fukushima accidentaffected Pacific coastal waters of eastern Japan. J. Environ. Rad. 147, 130-141)

Answer: Terrestrial runoff contribution is not included in this simulation, I added this information at the end of the section 2.4 as follows: “ No other additional source has been considered in this simulation”

9505 17:

Question: Instead MEXT (2014), Kaeriyama et al., (2015) should be cited. See “Kaeriyama, H., Fujimoto, K., Ambe, D., Shigenobu, Y., Ono, T., Tadokoro, K., Okazaki, Y., Kakehi, S., Ito, S., Narimatsu Y., Nakata K., Morita, T., Watanabe T., Fukushima-derived radionuclides 134Cs and 137Cs in zooplankton and seawater samples collected off the Joban-Sanriku coast, in Sendai Bay, and in the Oyashio region. Fish Sci (2015) 81, 139–153”

Answer: MEXT (2014) reference is replaced by Kaeriyama et al.(2015) in all the text and in the references list.

9505 20:

Question: For the geographical positions, see the above paper.

Answer: The paragraph “However, there was no indication on the relative . . . .140-142°W ” is replaced by: “However, there was no indication on the relative composition of these field data, therefore for the purpose of the modelling we used the weighted mean of the 137Cs concentrations in the three zooplankton groups”.

9507 25:

Question: Corresponding wet weight should be shown in the text, to compare with those of zooplankton (approximately, 200–600 ? mg w.w.m-3). In that case, please cite the reference for the Organic matter/Chl ratio used for the wet weight calculation

Answer: please see the supplement

9509 13 :

Question: Calibrated elimination rate 0.03 – 0.11 d-1 for zooplankton is likely to be lower than the experimentally derived elimination rate 0.8 d-1 in zooplankton (the rotifer, Brachionus plicatilis) in Japan (Aomori Prefecture. 1990. Heisei-gannen Marine Environmental Radioactivity, General Review Report. Aomori Prefecture, Aomori, 91pp. (in Japanese) The calibrated accumulation rate of 5 x 10-4 L g-1 d-1 (being approximately equivalent to 1.0 d-1 if assuming 500mg w.w.m-3) for zooplankton is also likely to be smaller than the experimentally derived elimination rate of 50 d-1 in zooplankton (Brachionus plicatilis) in Japan (Aomori Prefecture. 1990).

Answer: We were not aware of this document published in japanese and we would like to know under what conditions this rate was determined since the rotifer Brachionus plicatilis is quite an euryhaline species. However we can add this reference to the paper if necessary.

9509 10 :

Question: If the calibrated transfer rates in Table 1 are derived by fitting the simulated result to the observed result, they should be described as “apparent”.

Answer: the term “apparent” is added in the text and in the table caption to the calibrated parameters

9509 26 :

Question: Unify the term to “accumulation rate” instead of “uptake rate”.

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Answer: the term Âń uptake rate Âż in the text is replaced by Âń accumulation rate Âż .

9512 7, 10 :

Question: “the simulated zooplankton” -> “simulated large ? zooplankton”. Are these discussion points for “large” or weight averaged ZS, ZL and ZP?

Answer: The concentrations shown in Fig.2 are related to the weighted average of 137Cs concentrations in the three size classes of zooplankton (ZS, ZL, and ZP) . So . this discussion concerns these weighted average concentrations. Therefore, the legend of the Fig.6 is modified.

9512 22 :

Question: Missing (R) in “calculated a ratio (R) of the 137Cs concentration Answer: (R) is added

9513 23 :

Question: The vertical removal and transport of radionuclides to bottom layers is an important process in the open ocean as discussed in this paper. However, at present there is no quantitative proof for a significant contribution of this process around 1FNPP. Other processes are suggested as being critical in the Fukushima coastal waters, e.g. continuous releases, river discharged particles from highly contaminated land areas, etc.

Answer: Even if there is no quantitative estimate about the contribution of this process around 1FNPP it exists and we feel it is worth mentioning it. Though, of course, we are aware that continuous releases and run off processes are critical for the contamination of coastal areas close to 1-FNPP.

9514 24 :

Question: “poor” ->”oligotrophic”? Answer: Âń poor Âż is replaced by Âń less productive Âż

9515 8 :

Question: “The time needed for . . .”-> “The time derived from the modeling analyses for these . . .

Answer: the term Âń estimated Âż is added to the sentence → Âń the estimated time needed for . . .. Âż

9516 3.8 :

Question: Is the term “TTF” is worth discussing? Discussed here is the apparent TTF (aTTF) under transition conditions. In addition, the TTF for Hg has completely different characteristics. The transfer time constant of Hg is extremely long or infinite. Thus TTF is appropriate concept for Hg transfer in the marine ecosystem, while the TTF concept is not useful for Cs.

Answer: The trophic transfer factor (TTF) is an important parameter allowing us to compare the radionuclide concentrations in predator and its corresponding preys, and to see if it has any tendency for biomagnification along the trophic chain or not. For the radiocesium, this paper is not the first to use this concept, previous studies (Wang et al., 2000; Zhao et al., 2001; Mathews and Fisher, 2008 . . .) have already calculated this parameter (TTF) and used it to discuss the possibilities of biomagnification in different marine trophic chains. Indeed, it is certainly not our intention to say that the biomagnification of 137Cs is comparable to Hg that shows the greatest biomagnification factor.

9522 17:

Question: Add JODC data archive location in the web. Answer: JODC data archive location in the web is added.

9523 23:

Question: The MEXT reference should be replaced by Kaeriyama et al., 2015.

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Answer: MEXT(2014) is replaced by Kaeriyama et al., 2015 .

Fig.3 :

Question: Unify the case of letters in fig (A – F) and in figure caption (a - f). Add to the legend a mention of the three different taxonomic compositions (ZS,ZL, ZP?) in sub-fig B, D, F.

Answer: the letters : “a,b,c,d,e,f “ in the caption are replaced by “A,B,C,D,E,F” to unify them with the letters showed in the subfigures. A legend is added for the taxonomic composition.

Fig.4 :

Question: Reference Kaeriyama et al., (2015) should be cited in the legend as a data source.

Answer: Kaeriyama et al.(2015) is added at the end of the figure caption.

Fig.5 :

Question: The parameters on the X-axes are small and are unreadable. Add planton composition PS, PL, ZS, ZL, ZP to the legend.

Answer: the X-axis font size is enlarged. Titles are added to the subfigures.

Fig6. :

Question: Unify the case of letters in fig (A – D) and in figure caption (a - d). Show the unit (Bq kg d.w.-1) for the contour legend. For sub-figures B and C, are they not Buesseler et al. (2012) and C, Kitamura et al., (2013), respectively ?

Answer: the letters are unified. The unity “Bq kg-1 dw” is added to the colorbar. “The coloured rounds in (A) and (B) represent . . .” is replaced by “The coloured rounds in (B) and (C) represent . . .”.

Fig. 8 :

Question: Missing (PS)(ZL)(ZP) in “... small phytoplankton (PS), large zooplankton (ZL) and predatory zooplankton (ZP) in the ....”. The scale of the Y-axis in subfigure ZP is different from the others. Unify the Y-scales of all subfigures.

Answer: (PS), (ZS) and (ZP) are added to their corresponding names in the caption text. “large zooplankton” is replaced by “small zooplankton” in the caption. The subfigures Y-scales are unified.

Fig. 11:

Question: Y-scales in subfigure ZP are different. Unify the whole study area and 0-30km from FNPP.

Answer: the Y-scales are unified for all sub-figures.

Fig.12 :

Question: What do the red bars and marks on the two figures represent? Answer: On each box, the central mark is the median, the edges of the box are the 25th and 75th percentiles, the whiskers extend to the most extreme data points not considered outliers, and outliers are plotted individually (the red marks). This has been added in the figure caption

Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/12/C6708/2015/bgd-12-C6708-2015-supplement.pdf

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Interactive comment on Biogeosciences Discuss., 12, 9497, 2015.