Answers to the reviewer comments:

All the comments of the reviewer were exhausted in detail in corrected in the manuscript. We agree with reviewer suggestions and the paper was corrected.

Model concept.

1. p. 679: The description of the ecological model lacks explanations especially on how nutrient loadings are represented in the model and how temperature, salinity and vertical mixing is incorporated in the 1D model

Nutrients seasonal dynamics are simulated (see Dzierzbicka-Glowacka et al. 2010).
Here, the linear trend for nutrient is consider as initial condition for annual slices:
$Nutr = Nutro + Nutra \cdot Yd(Year - 2000)$ where *Nutr*o – simulated values at every time step, *Nutr*a – average annual rise of the *Nutr* (except of summer), *Yd* – time (as a fraction of the year). It means: at every time step, a fraction of an average annual rising of the *Nutr*, which dependents on given year, is added to the simulated value.
The nutrients increasing *Nutr*a include the inflow of nutrient compounds from the river and atmosphere, which is not considered in this model.

All physical components such as velocities, salinity, temperature and vertical mixing were calculated in the 3D hydrodynamic model. The output from this model as an average values for the period 1960-2000 (ECOOP IP WP 10.1.1, Osinski 2008 Ph.D. Thesis) on temporal and special vertical scale for three selected areas (Gdansk Deep, Bornholm Deep, Gotland Deep) was linear interpolated at every time and vertical step of the 1D POC model.

2. Apparently the ecological model does not contain cyano-bacteria (but only “bulk” phytoplankton). Cyano-bacteria can be abundant in the Baltic and have a quite different parameterization compared to “bulk” phytoplankton. ignoring this functional group model response during scenario runs might be incorrect.

As the model aims at capturing average POC dynamics cyano-bacteria blooms were not incorporated in the model as they occur occasionally on the bacground of common phytoplankton. However the authors recognize the need for including cyano-bacteria into the model, and work is in progress regarding this.

3. p. 680: It is not clear how the 3D flow field is used as input to the 1D model and the justification of using interpolated outputs from the 3D model as input in the 1D model is rather unclear.

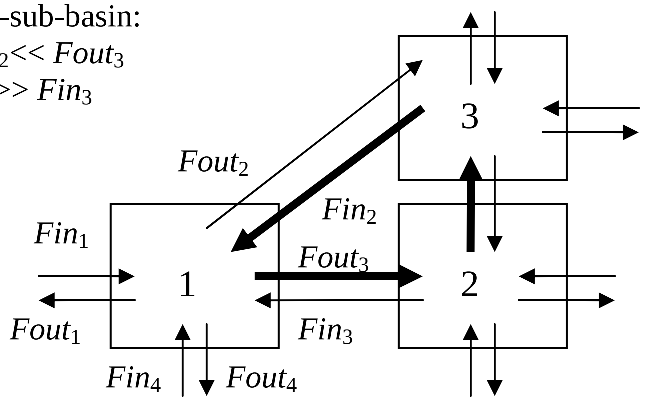
The 1D POC model is a one-dimensional biogeochemical model. The model has a high vertical resolution with a vertical grid of 1m, which is constant at the whole column water. This means that the model calculates the vertical profiles of all its variables and assumes that they are horizontally homogeneous in the studied areas (sub-basins). The dynamical characteristics remain almost unchanged in a horizontal plane in comparison to vertical changes. Hence, the magnitudes of the lateral import/export are lower, and the above assumption can be made. The horizontal velocity components (v, u) obtained in ECOOP IP project WP 10.1.1 model for the Baltic Sea (ECOOP IP project WP 10.1.1, Osinski 2008 Ph.D. Thesis) were averaged and used for calculation of different hydrodynamical variables such as: w, K_z, S and T. In order to include horizontal variations in the Southern Baltic (a larger area) it was divided into three sub-basins (1-Bornholm Deep, 2-Gdansk Deep and 3-Gotland Deep; one of the sub-basin has 64 pixels; 1 pixel = 9×9 km^2).

The main average circulation of the Baltic Sea is called *baltic haline conveyor belt* (BCB, Doos et al. 2004, Meyer 2007). If we take into account BCB, the main flow though the subbasins is assumed to be a part of BCB and other flow could be neglected.

At the scheme of those cells bold arrows represent BCB

In this paper, it was assumed, that for *i*-sub-basin: $\sum_i Fin_i = \sum_i Fout_i$.

for 1-sub-basin:
$Fout_2 << Fout_3$
$Fin_2 >> Fin_3$



In the model, we do not include the inflow of nutrient compounds from the rivers and atmosphere. Hence, in the 1D POC model the boundary conditions (from the land and atmosphere) are zero.

In this model, the bottom is raised to 70 m (it is an average depth value of the halocline).

4. Justify how a 1D model can represent a 3D system. How big is the area that the model is assumed to represent and how is the horizontal transport of nutrients and POC treated?

I think it is explained in point 3. The area is (9*8)^2 km^2 = ~5200 km^2.

Horizontal transport of nutrients is treated as typical advection process. The POC concentration was determined as the sum of phytoplankton, zooplankton and pelagic detritus concentrations:

$$\frac{\partial POC(z,t)}{\partial t} = \frac{\partial Phyt(z,t)}{\partial t} + \frac{\partial Zoop(z,t)}{\partial t} + \frac{\partial DetrP(z,t)}{\partial t}$$

Horizontal transport of *Phyt*, *Zoop* and *DetrP* is defined the same way as for nutrients.

5. Apparently the model only covers the top 10 meters (or is it 0-1 meter?) of the water column. What is the boundary condition at this depth?

No, the numerical simulations are made with a high vertical resolution with the 1 m layers for the n=70 layers, but the results are from 1st layer (1m) and average 10 layers.
The boundary condition for this depth is next layers.

6. Explain how the initial conditions was derived (were they based on measurements, guestimates?)

It was assumed that the initial conditions of the numerical simulations are average winter values of the last 4 past decades and that the final states of each year are the starting points of the next year.

For the Gdańsk Deep we assumed: as phytoplankton values for January and December were sparse, a constant value of $\{Phyt\}_0$ =10 mg C m^{-3} (Witek 1995) was applied. The model is not sensitive to the initial phytoplankton concentration owing to the long simulation period (from January) preceding the spring bloom (April/May). The initial zooplankton biomass was obtained according to data by Witek (1995) as $\{Zoop\}_0$ = 1 mg C m^{-3} . The initial values for nutrients were taken from the Institute of Meteorology and Water Management (IMGW) database as the average values for January: total inorganic nitrogen – $Nutr_N$ = 6 mmol m^{-3} and phosphate – $Nutr_P$ = 0.6 mmol m^{-3}. These values were assumed to be constant with depth. Data for the detritus content at the bottom were not available, and the instantaneous sinking of detritus is a more arbitrary model assumption. The initial detritus content in the subsurface water layer was prescribed as 100 mg C m^{-2}. However, a constant value of 50 mg C m $^{-3}$ for pelagic detritus was assumed throughout the water column.
For the Bornholm and Gotland deeps, the initial values we assumed the same as for the Gdańsk Deep except for the nutrient concentrations, it means: total inorganic nitrogen – $Nutr_N$ = 5 mmol m^{-3} and phosphate – $Nutr_P$ = 0.5 mmol m^{-3}.

Scenarios.
7. The assumption regarding future changes in temperature, PAR, wind speed and nutrients (loadings and/or concentrations?) need justification/references.
It is not clear how “nutrients” are increased when making scenarios. Is it an increase in loading (if so, how is nutrient loading represented in the model) or is it the actual nutrient concentration (if so, then nutrients are not a state variable) or is it perhaps the initial nutrient concentration that is changed between scenario runs? Explanation is needed.

The data presented in this paper are the results of the numerical simulations based on several assumptions which is one of many possible. “Scenario of future changes” was made on the basis of the changes for the 1965-1998 period, mainly in the Gulf of Gdańsk.

The most important factors, that have dominant influence on primary production are PAR, nutrients and temperature. Fourier analysis of the archived data (34 past years) provides seasonal and annual variation of the sea surface temperature and nutrient concentrations in the past and shows the main trend of increasing temperature and nutrient during over 4 past decades in the southern Baltic Sea, mainly at the Gdańsk Deep. This equation was used by Renk (2000) to analyze data collection from the Sea Fisheries Institute (Gdynia).
Based on this trend, seasonal variability were numerically calculated for the next 50 years. This main trend was used as a scaling factor for the future Baltic climate scenario.

Description of the method :
The long term variations of the examined parameters we assumed to be:
$S = So + Sa \cdot Yd\,(Year - 2000)$, where:
S – examined parameter (temperature, PAR, nutrients)

So – simulated values at every time step for nutrients;
So – mean value of each day for the years 1965-1998 for PAR
So – mean value of each day calculated in the 3D hydrodynamic model for the period 1960-2000 for temperature
Sa – average annual rise of the *S* parameter
Yd – time ($Yd = x/365$ as a fraction of the year)

Line 10, page 682, point 4: nutrients increase 1% of an average annual value per year with the exception for the summer when nutrients concentration are close to zero (it means 0.0036 mmolP m^{-3} and 0.022 mmolN m^{-3} at Gdańsk Deep for the period 1965-1998 after Renk (2000). It will give nutrients concentration in 2050 higher than in 1965-1998 of ~0.18 mmolP m^{-3} for phosphate and ~1.1 mmolN m^{-3} for total inorganic nitrogen.
The initial nutrient concentration is changed between scenarios. It means that simulated initial value for investigated year (= value at end previous year) plus average annual rise· *Yd* (*Year* – 2000).
For Bornholm Deep and Gotland Deep, we assumed the lower values: 0.0034 mmolP m^{-3} and 0.021 mmolN m^{-3}. The nutrients increasing include the inflow of nutrient compounds from the river and atmosphere. The increase of nutrient concentrations in the southern Baltic Sea over a period of many years has resulted in the increase of the average annual primary production by about 2 to 3% (Renk, 2000: eq. 39). The average increasing of daily solar energy in Gdynia was 0.2% ≅ 0.03 MJ m^{-2} d^{-1} in the spring and summer and decreasing about 0.05%≅0.0053 MJ m^{-2} d^{-1} during the winter. The calculations were made on the basis of experimental data provided by the Institute of Meteorology and Water Management in Gdynia.

Point 3 (line 9, page 682) is faulty. I am sorry for misleading sentence, this was corrected. Should be: flow field is assumed at the same level as average value from the 1960-2000 period from the hydrodynamic model (were not changed, only daily average values were calculated).

8. It appears that measured chl.a values were used in the model to calculate the primary production (P.681). How is this done and what assumptions/ methods are used?. Modelled primary production is normally parameterized based on nutrient concentrations and light availability and not modelled using measured chl.a data. Explain this. How is the initial condition for the 2020-2050 scenarios determined? Explain.

I am sorry for misleading sentence, this has been corrected.
The average chlorophyll-a concentrations in the southern Baltic Sea (average values for 1965–1998 period, Table 1) were used for the calculation of primary production after Renk (2000: eq. 32). The PP values obtained this way were subsequently compared with the simulated ones.
Modeled primary production (PP) values for the 1965-1998 period agree with experimental data for PP as average values during the 1965-1998 period. A new figure showing it will be added to the revised manuscript.
The primary production was obtained by equation ($PRP = f_{max} f_{min} F_I Phyt$), see paper (Dzierzbicka-Glowacka et al., 2010: Appendix A).

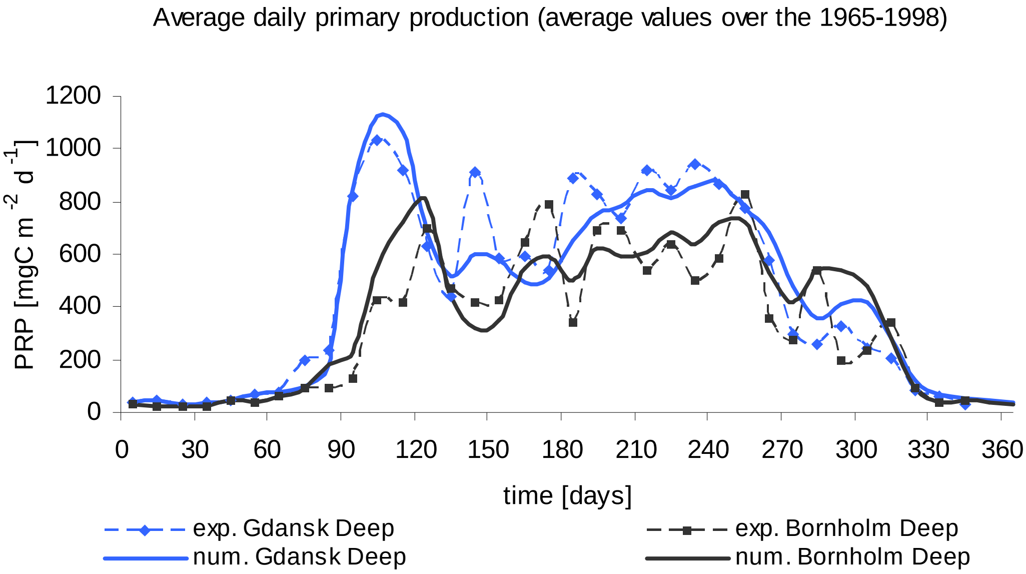


Figure 8. Average, daily primary production in the Gdansk Deep (blue) and the Bornholm Deep (black); numerical simulation (solid line) and experimental results (dashed line).

The initial conditions for the 2020-2050 scenarios are determined like for previous years. According to calculated year *Year*, average annual rise of the *S* parameters is increasing $\{Sa \cdot Yd(Year - 2000)\}$.

Expression 'Nutrients scenarios ' is replaced by 'nutrients concentrations' in the final version of the manuscript. We used past trends in the nutrients and irradiation to select a range of physical and chemical conditions that differ from the present day ones in a realistic way. Then the conditions were used to investigate how the POC dynamics changes under the selected sets of conditions.

Results.

9. It is not clear if primary production is a model result or based on measured chl.a data as indicated on p. 681 (scenario of future change).

I am sorry for misleading sentence,
The primary production on p.681 is a model result.
The measured *Chla* data were used for calculated the primary production for comparison with the simulated ones.

10. Validation of the model for the different areas is lacking and needs to be included in order to gain trust in the model results and scenario runs.

Model was validated for the Gdańsk Deep (Dzierzbicka-Głowacka et al., 2010). It was assumed that processes governing POC concentrations in other areas of the Baltic Proper are similar. Thus the POC concentration and POC dynamics in the Gotland Deep, and the Bornholm Deep differ from these in the Gdańsk Deep due to nutrients concentration and physical factors differences.

Detailed comments:
11. p. 677: Not clear how the DOM fits into the story. Either leave it out or include DOM in the model.

Although our model does not include DOC and/or DOM at this stage of the model development, the dissolved fraction of organic matter is an important component of the organic matter cycling in the Baltic Sea. This was proven by the measurements cited by the authors in the paragraph 1 (Introduction). Presently, model presented in this paper is improving with the DOC cycling and results are going to published soon.

12. p.680, l. 8-12: section needs to be rewritten

This has been corrected.

13. p.680: Apparently there are two different descriptions of Io(t)?

I am sorry for misleading sentence, this has been corrected.

14. p.681: Are the applied average values for 1965-1998 that are used as starting point (initial condition?) based on measurements and is detritus also measured during that period?. Is it yearly average or monthly average that is used as starting point?

I am sorry for misleading sentence, this has been corrected.
The starting-point of the numerical simulations was assumed to be the end of 2000 with the daily average values of the hydrodynamical variables for 1960-2000 period.
All physical components such as velocities, salinity, temperature and vertical mixing were calculated in the 3D hydrodynamic model (see point 1).
The daily solar energy for obtained the radiance at the sea surface I_o was calculated on the basis of experimental data.
The pelagic detritus was not measured.
The daily average values of physical components and solar energy were used as starting point.

We would like to express our thanks to Reviewer for his/her very instructive and profound comments.