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Biogeosciences Discussions

Interactive comment on "Impacts of UV radiation on plankton community metabolism along the Humboldt Current System" *by* N. Godoy et al.

Anonymous Referee #3

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Review Impacts of UV radiation on plankton community metabolism along the Humboldt Current System by N. Godoy, A. Canepa, S. Lasternas, E. Mayol, S. RuÄśz-Halpern, S. AgustÄś, J. C. Castilla, and C. M. Duarte. Biogeosciences Discuss., 8, 5827–5848, 2011

General Comment

This article reports experimental estimates of community metabolism assessed at 8 stations in the eastern south Pacific conducted during the Humboldt-2009 cruise on board RV Hesperides from 5 to 15 March 2009. An experimental evaluation of the effect of UVB radiation on community metabolism is conducted. From few experiments the authors claim that UVB radiation suppressed net community production, resulting in a dominance of heterotrophic communities in surface waters, compared to the

prevalence of autotrophic communities inferred when materials, excluding UVB radiation, are used for incubation. They also claim that their results show that UVB radiation, which has increased greatly in the study area, may have suppressed net community production of the plankton communities, possibly driving plankton communities in the Southwest Pacific towards CO2 sources.

The evidence provided in the manuscript is not sufficient to support the conclusions. The sampling is clearly too limited, both spatially and temporally, to extrapolate their results to the Humboldt Current System. The interpretations of the results, in terms of extrapolating them to the natural system, is very simplistic and does not take into account crucial variables for these ecosystems such as the dynamics of the mixed layer, the oxygen minimum zone, freshwater input and the repair capacity of phytoplankton and prokaryotes to UV radiation.

A major weakness of the manuscript is that no information is available regarding the oxygen distribution in the water column of the sampling stations. Oxygen content is a key variable in the Humboldt Current System and the oxycline could have affected the measurement especially those located in northern Chile.

Crucial published information on several critical aspects of the manuscript is not incorporated. The paper is written in a way that, for a reader not familiar with the literature from the south eastern Pacific, it would seem as the first piece of research on several topics such as: plankton respiration, plankton metabolism, primary production, CO2 fluxes, and most importantly UV measurements and its effect on the biota of the eastern south Pacific. This is a major weakness of the paper since, due to its extremely limited temporal (15 days) and vertical (in most relevant cases only one depth) coverage, tries to extrapolate few results to very large spatial and temporal scales without referring to many other important studies previously conducted in the study zone which could eventually provide support (or not) to some of their reckless extrapolations.

The Introduction section needs to be completely rewritten using a conceptual frame-

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work proper to upwelling and fjord ecosystems and not to extremely oligotrophic systems.

The Discussion needs also to be rewritten interpreting their results with the existing body of knowledge from the Humboldt Current System and the Patagonian fjords on: net planktonic metabolism, UV measurements, experimental determination of UV impacts on microbial communities of the water column, physical factors influencing primary production and community respiration.

A major issue of the paper is the effect of the use of glass bottles in previous estimates worldwide of net primary production. In fact this issue is not totally new and has been previously studied (e.g. Smith and Baker 1980, Kim and Watanabe 1993). Once again the authors do not mention the previous body of knowledge on this issue and they do not interpret their result in comparison to previous publications.

This manuscript is clearly not suitable for publication in Biogeosciences.

Specific comments.-

1.- System definition. The Humboldt Current System extends from $\sim$42°S up to about the equator (e.g. Carr 2002, Montecino et al. 2005, Thiel 2007, Quiñones et al. 2010). The southern border of the Humboldt Current System is related to the WestWind Drift Current (WWDC), which corresponds to the meridional edge of the subtropical gyre. In fact the WWDC constitutes the origin of the northward Chile–Peru Current and the southward Cape Horn Current (Reid 1965, Wyrtki 1965, 1975, Silva and Neshyba 1977, 1979). In other words, in strict sense, this paper is not only about the Humboldt Current System but also the Cape Horn Current (Patagonia). Five of the eight sampling stations are located in the Humboldt Current System and three stations on the southern Patagonian fjords. In consequence the title of the paper should be modified, not referring to the Humboldt Current System but to the eastern South Pacific off Chile.

2.- Introduction. The authors focus a major part of the introduction in justifying the

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importance of conducting their research based on examples about the penetration of UV in the oligotrophic ocean: “For instance, UVB levels sufficient to cause mortality of photosynthetic plankton have been reported to penetrate as deep as 150m in the “clearest” natural waters on the south pacific gyre (Morel et al., 2007), 60m in the subtropical Atlantic (Llabres and Agusti, 2006) and to 26m in the Mediterranean Sea (Llabres et al., 2010)”. The Humboldt Current System is the most productive ocean system of the world and their sampling stations are coastal, therefore it does not make any sense to provide examples from some of the most oligotrophic waters of the world. They should use examples from Chile and from other upwelling and fjord systems of the world. For instance, they should refer to: Cabrera et al 1995, Cabrera & Fuenzalida 1999, Lovengreen et al. 2000, Montecino et al. 2004, Lovengreen et al 2005, Huovinen et al. 2006, Hernandez et al. 2006, 2007, 2011).

3.- Introduction. Taking into account the subject and location of this paper, the previous work conducted by Hernandez et al on the effect of UV on prokaryotes in the Humboldt Current System must be cited (Hernandez et al. 2006, 2007, 2011). Science advances generating knowledge in a synergic manner based on the knowledge produced by other present and past scientists. Recognizing other scientists work is a need and ethical imperative.

4.- Introduction. The author stated “. . . where the presence of a shallow oxygen minimum zone limits the capacity of marine biota to find refuge from UV at depth. . .”. Although this is true for many organisms there are many species in the Humboldt Current System very well adapted to low oxygen conditions (e.g. Judkins 1980, Ulloa et al. 2000, Gonzalez et al 2000, Gonzalez and Quiñones 2002, Sellanes et al 2007). The evolution of many species in the Humboldt Current System have been strongly influenced by the presence of the oxygen minimum zone.

5.- Methods. The definition of the study zone should be re-defined. Only a portion of the track (5 stations) is located in the Humboldt Current System (i.e northern than 42°S).

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6.- Methods. Â£What is the number of replicates for the seston samples?.

7.- Methods. It is a major weakness of the paper that no information is available regarding the oxygen distribution in the water column of the sampling stations. Oxygen content is a key variable in the Humboldt Current System and the oxycline could have affected the measurement especially those located in northern Chile. For instance Eissler and Quiñones (1999) found a positive significant correlation between respiration and dissolved oxygen concentration off northern Chile (Antofagasta, 23°S). Therefore caution should be exerted in interpreting and extrapolating the results because the authors do not have (or report) information on one of the most crucial variables that could have affected their results.

8.- Methods. The bottles for "light" were incubated on deck at in situ temperature. What is the range of variation in temperature during the incubation process? How were the dark bottles incubated? Was the temperature controlled? It is well know that temperature is a critical factor in determining metabolic rates.

9.- Methods. The standard error of the in situ respiration and primary production rates should be reported.

10.- Methods. The authors stated "In contrast, the quartz bottles allow the entire light spectrum to reach the sample. Hence, the difference in oxygen evolution between the quartz and borosilicate bottles represents the effect of UV radiation on NCP (i.e. the net result of impacts on both GPP and R)". This statement is not totally correct. It has been proven that some quartz bottles absorbed about 10% of UV-B and about 50% of radiation at 200 nm (e.g. Bühlmann et al. 1987, Köhler et al 2001). Did you measure the UV-B and UV-A absorption by your quartz bottles? How your measurements or estimate of UV absorption by the Quartz bottles affected your results? The authors should include a graph with the transmission spectra (in %) of the quartz and glass bottles used.

11.- Methods. Clarify if all your stations are on the continental shelf. Provide total depth

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of the water column.

12.- Results. Salinity measurements should be provided especially in the case of the experiments conducted in the fjords. It is known that at 5 m depth the influence of freshwater and dissolved organic matter can be substantial and, obviously, influence the results and how representative of the whole fjord area they could be.

13.- Results. It is necessary to include the quartz and borosilicate transparence spectrum of the bottles used

14.- Results. Data on cloudiness, wind speed and ozone concentration for each experiment should be reported.

15.- Results. The authors claim that exposure to UVB gives lower rates of NCP than in its absence based on their results of 4 out of 5 cases. What is the statistical significance of this result? Can it support one of the key "findings" of the manuscript?

16.- Discussion. The authors stated: "The waters sampled were not particularly transparent to UVB compared to the ultraoligotrophic waters in the South Pacific Gyre, where UVB was reported to penetrate down to 150m (Morel et al., 2007)." It does not make any sense to compare their results with oligotrophic waters. They should compare their results with previous estimates from the Patagonian fjords and from the Humboldt Current System (e.g Hernandez et al. 2006, 1007, 2011, Montecino et al. 2004) and from other fjords and upwelling ecosystems worldwide.

17.- Discussion. "The metabolic rates observed were within average values reported for the ocean (Robinson and Williams, 2005), and indicated that the area sampled was not exceptionally productive at the time of the study". This is a careless use of the information available for the Humboldt Current System regarding net community metabolism with several papers published after Robinson and Williams (2005). The authors should compare, at least, their quite restrictive temporal experimental coverage with the results of the following papers: Gonzalez et al. (1998), Eissler and Quiñones

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(1999), Daneri et al. (2000), Montecino et al. (2004), Montero et al. (2007), Jacob et al. (2011), Daneri et al. (2011), Iriarte et al. (2011).

18.- Discussion. There are several factors, in addition to UV radiation, that could affect the balance between primary production and respiration in the Humboldt Current System. The microbial community inhabiting the mixed layer of the coastal zone off northern Chile is subjected to marked trophic gradients triggered by synoptic-scale shifts in the upwelling driven by wind stress. Drastic changes in the wind-stress direction and hydrographical and chemical characteristics of the mixed layer influenced the phytoplankton size structure, primary production rates and net ecosystem metabolism. I strongly recommend the authors to read and incorporate in the discussion the findings of the paper by Jacob et al. (2011) entitled: "Community metabolism, phytoplankton size structure and heterotrophic prokaryote production in a highly productive upwelling zone off northern Chile" (Marine Ecology Progress Series 430: 23–34). They should also analyze deeply the paper by Daneri et al. (2011).

19.- Discussion. The possible effect of different types of radiation on organic matter and/or other compounds should be incorporated in the analysis. For instance, there is a significant relationship between wavelength band and the production of H2O2, which is a potential toxicant and it can affect the distribution and redox-chemistry of biologically active metals such as iron, copper and manganese. The photochemical production of H2O2, has been demonstrated in other upwelling systems such as the Benguela (e.g. Gerringa et al. 2004). Moreover, it has been shown that phototransformation of DOM significantly alters both bacterial metabolism and community structure in surface water for a variety of coastal ecosystems (e.g. Abboudi et al. 2008).

20.- Discussion. The authors stated: "...the communities in surface waters resulted to be, in general, strongly heterotrophic, thereby acting as a CO2 source, consistent with the supersaturation in pCO2 in surface waters driving a CO2 efflux to the atmosphere" and " The use of quartz bottles to allow the UVB component of the irradiance field yields net heterotrophic communities in surface waters, consistent with the supersatu-

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ration in pCO2 in surface waters observed along the cruise. Whereas UVB radiation is expected to impact only on the surface waters, it is the metabolism of the communities therein that most directly affects surface pCO2". Their interpretation is a clear overstatement (not only for their extremely low sample size and temporal coverage) and it does not take into account all possible variables affecting surface pCO2. It is known the Humboldt Current System tends to be a source of CO2 to the atmosphere due not only to the biology but also due to the effect of upwelling. I strongly recommend the authors to read the following papers on previous pCO2 measurements in the Humboldt Current System and use them to provide a proper and complete interpretation of their results regarding pCO2 and its possible relation to metabolism: Torres et al. (1999, 2003, 2009, in press), Lefevre et al. (2002), Placencia et al. (2010).

Furthermore, upwelling itself is important in determining heterotrophic or autotrophic community metabolism in the Humboldt Current System (Jacob et al. 2011).

21.- Discussion. There is a word missing in the following sentence: "Indeed incubation in glass material removes the incidence of in the water column. . ."

22.- Discussion. A key "conclusion" of this manuscript is: "Exposure of surface (5 m) communities to UVB radiation, greatly reduced NCP in all but one community and rendered all, except one of the communities investigated heterotrophic. . ." and " "Our results show, therefore, that the penetration of UVB radiation . . . affects the communities located in the upper layers of the water column. In experimental evaluation of the effect of UVB radiation in surface waters, those most strongly affected by UVB, showed that UVB radiation strongly suppressed net community production in most communities, resulting in a dominance of heterotrophic communities in surface waters, compared to the prevalence of autotrophic communities inferred when materials excluding UVB radiation are used for the incubation"

It is well known that microbial communities can be negatively affected by regular solar radiation. In fact, Hernandez et al. (2006) have already demonstrated that in the

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Humboldt Current System there was significant inhibition of prokaryote secondary production by PAR, followed by UV-A and UV-B, especially for surface waters as compared with deeper waters from the Equatorial Subsurface Waters.

In addition, Li et al. (2011) showed that from coastal to pelagic surface seawaters, UV-B (280–315 nm) caused similar inhibition, while UV-A (315–400 nm) induced photosynthetic inhibition and increased from coastal to offshore waters. In other words, the species assemblages as well as the DOM content of the specific sites could be very important. In the case of the manuscript of Godoy et al., this should be a clear warning to be extremely cautious in interpreting their results due to the very low sample size.

23.- Discussion. It is necessary to incorporate in the Discussion section the fact that UV radiation could also have positive effects on primary productivity. UV-A enhances carbon ïňĄxation by phytoplankton under reduced (Nilawati et al., 1997; Barbieri et al., 2002) or rapid fluctuation of solar irradiance (Helbling et al., 2003) and allows photo repair of UV-B-induced DNA damage (Buma et al., 2003). Furthermore, the presence of UV-A could result in higher biomass production (Wu et al., 2005).

24.- Discussion. It is stated: “Our results show, therefore, that the penetration of UVB radiation increases towards the Equator along the Humboldt Current System. . .”. The number of stations (5 stations) and the temporal cover (less than 12 days) in the Humboldt Current System do not allow any generalization regarding trends in the penetration of the UVB in the water column.

25. Discussion. The authors state: “These results show that UVB radiation, which has been increased greatly in the study area due to trophosperic ozone destruction, may have suppressed net community production of the plankton communities in the study area, possibly driving plankton communities in the Southwest Pacific toward CO2 sources.” This is pure speculation. The temporal and spatial coverage (8 stations, mostly 1 depth) is absolutely inadequate to support this generalization. This speculation gets even worse by the fact that the authors do not review any of the relevant

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available literature on the Humboldt Current System and the Patagonian Fjords.

26.- Discussion. Regarding the production and metabolism of the Patagonian fjord key information should be incorporated such as Gonzalez et al. (2010). Regarding UV in southern Chile, the paper by Huovinen and Gómez. (2011) should be incorporated.

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