

Biogeosciences Discuss., referee comment RC1  
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## Comment on bg-2021-55

Anonymous Referee #1

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Referee comment on "Enhanced chlorophyll-*a* concentration in the wake of Sable Island, eastern Canada, revealed by two decades of satellite observations: a response to grey seal population dynamics?" by Emmanuel Devred et al., Biogeosciences Discuss., <https://doi.org/10.5194/bg-2021-55-RC1>, 2021

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The present paper investigates the decadal increase of Chl around Sable Island (on the Scotian Shelf in eastern Canada) related with an increase in the island grey seal population. It addresses interactions between biological, chemical, and physical processes associated to an island mass effect and fits perfectly well within the scope of BG. The increase in grey seal population to explain the positive trend in phytoplankton biomass is a particularly interesting way to investigate. The inclusion of additional optical parameters is also very valuable, as well as the seal haul modeling and evaluation of Chl standing stock which allow an in-depth investigation of the hypothesis that this island fertilization and Chl trends are induced by the seal populations. This study deserves to be published after the consideration of the following points. The major point is that the result section needs to be restructured as there are many back and forth in the writing. The hypothesis and informations provided by using *adg* and *bbp*, and how their change can be interpreted regarding *chl<sub>a</sub>*, clearly need to be stated in the introduction. I would also strongly suggest the authors to moderate their statement about the fact that the increase in Seal population is THE explanation for the increase in Chl as 1) figure 8 and 9 are not convincing and rather suggest the strong influence of complementary forcing and 2) few/no other dynamic processes specifically related to the IME have been studied in depth in this region. Although the increase in seal populations is a very plausible and convincing part of the explanation, other processes with a significant impact in the decadal Chl increase seem to be at stake. These statements need to be mitigated.

In the abstract (Line 14, 24...) and later along the draft there is a confusion when using the terminology "island mass effect (IME)". Here it sounds as the processes inducing the Chl increase. However according to literature (Doty and Ogury, 1956 for instance), IME refers as the biological enhancement itself, induced by the presence of islands. So, please correct that point along the draft.

Lines 63,81, 225, 238, 268 and after: use "chl-a"

Check the intermittent use of present vs past tense

Figure 2, B1 and B2: please modify the x-axis from week number to the corresponding month. A) it will be easier for the reader to follow (especially as it is not usual weeks but 8-days values) B) it will be consistent with the time axes of the other figures.

### **Abstract:**

Line 3: remove "a detailed". Only part of the processes likely involved in the Chl increase is investigated here.

Line 4-5: Please, shortly explain the interest of using bbp and adg.

Line 5: replace "the possible mechanisms" by "some possible..."

Line 6: Please precise "8-day climatology" (and hereafter in the manuscript)

Line 23: I wouldn't mentioned "a top-down control" as it is about nutrient supply (so a bottom up process) even though it originates from seal.

Line 24-25 and in the conclusion: the authors can't assert "Our findings challenge the idea that the IME is restricted to islands with strong bathymetric slope located in oligotrophic waters of mid-latitudes and tropics, and demonstrate that enhanced marine production can occur in other oceanic regions " as there is an extensive literature of IME taking place in mesotrophic environment such as in the Kerguelen /Crozet islands, the Marquesas islands, the Galapagos, the Gilbert Islands .

### **Introduction:**

Line 30: cf above about the def of IME

Line 31-2: please change "results from .... Or land drainage" to "results from a large range of processes among which...". There are other processes such as atmospheric deposition, human activity inputs....

Line 36-37: and in mesotrophic environment ...

Line 52: how marine mammals can supply nutrients through atmospheric deposition?

Line 58: same comment as Line 6 in the abstract

Line 61 : "to examine SOME of the possible mechanisms".

Line 63-65: the explanation about why using bbp and adg (and how interpret their change according to chl-a) should be provided earlier after the first<sup>t</sup> sentence of this paragraph, when DOM and backscattering are mentioned (and should be added in the abstract)

Line 64: define DOM.

## 2.2 Satellite and environmental datasets:

L 113: "large cocollithophore blooms occasionnaly.. " Is there any reference to this? Please, shortly explain why you want to remove it from your analyze. Also, the sentence after is not clear.

## 2.3 Climatology...

Section title: add "8day "climatology

Line 129: "SI"

Figure 2: In the legend: correct "SB" with "SI"

Overall, it is extremely difficult to make the link between the figure and the text. See complementary comments below in section 3.1

Line 148: What do you mean by "to obtain detailed maps of the chl-a in the SOM5"? do you mean THE SOM5 chla map (not a plural) in Figure 3?

Line 156-8: Is the 2011 unusual bloom removed from all the manuscript analysis or just for the 5-year trends analysis? If it is only removed for the trend analysis, how does it influence the interpretation with/from the other analysis?

## 2.4 Chlorophyll-a concentrations....

Line 185: add ")" after Figure 3

While maps in (a) and histogram in (b) are clearly presented and can be easily understood as their interpretation is close to those of the usual clustering or EOF, this is not the case of the grey path. Thus, please further explain how to understand/interpret the path and the location of the numbers along it.

### 2.5.1 Decadal change in grey seal abundance...

I went through the publication of Hammill et al 2017 and den Heyer et al. 2020. Finally, it is unclear what numbers in the present paper in Table A1 come from observations or are derived from modeling. Please clarify.

If the seal trend is derived from modelling and follows a "regular " curve as in Hammill et al 2017 , I guess it explains why there was no interest in showing a trend derived from annual average instead of the 5 year mean. It may deserve to be mentioned.

Line 213-Equation 1: why illustrating the equation with P4 instead of P1 which would be more logical?

### 2.5.2 From seal population...

Line 233-234: "The release of N..." What does this sentence provide? Rather move in the discussion section if relevant (for instance line 459)

Line 238-239: "chl-a multiply by the SOM5 area" : you mean the surface plume around the island delimited by the 1 mg.m<sup>-3</sup> isocontour? please clarify

Line 241: what is "HL2"?

### 3.1 Evidence of enhanced chl-a...

The first paragraph should be moved to the introduction. It does not present ongoing results.

Overall, this section is very hard to follow, because a) showing the time series of all the boxes makes impossible to distinguish the results from each other (except if you can spend 20 minutes on it). This figure needs to be rethought, perhaps by averaging some boxes together showing the std around them, b) the text back and forth from average pattern in optical properties to boxes patterns, then average patterns again. It is the same for the hydrodynamic section. It is about the Labrador current Line 299 to 301, then KE (by the way, why talking about KE as you don't use this information later), then back to the Labrador current Line 303. The main patterns then the boxes again.

At the end of this section it is extremely hard to remember/understand what are the take-home messages. This section needs to be rewritten and clarified.

Added comments:

Line 272-275: it is written that the NE box exhibits the highest chl-a while Figure 2 shows equivalent or stronger bloom in 5 boxes around Sable island.

Line 283: it is stated ". Backscattering magnitude is related to abundance and inversely related to particle size (Slade and Boss, 2015) and here the timing of maximum backscattering is consistent with the time of year when large phytoplankton such as diatoms and dinoflagellates reach their minimum abundance, while small flagellates are most abundant." In the abstract Line 64 you mention bbb to "indicates the presence of mineral particles due to resuspension", as in section 3.2.1. Therefore, what is the causal link here with the dinoflagellates?

Line 295: “. without obvious enhanced chl-a” I didn’t understand this part of the sentence as Fig 2 shows chl-a is enhanced compared to SW box, and even to NE box for boxes 8-12. What did you mean?

Line 299-301: the depth-averaged Labrador current is provided and this value is used to say that there is a decrease close to SI, but it is compared with surface value. Why don’t you use the same consistent data set (ie OSCAR) to illustrate the current weakening? Also, as it would be useful at least in the appendix to illustrate that point with a seasonal map.

Line 308-9: “However ...” you can’t completely discard this hypothesis, as finer scale dynamics than those modeled in Zhai et al 2011 could be at stake, especially considering the small size of SI and the complicated bathymetry and induced dynamics on the shelf.

Lines 310-14: the cause and effect links between the different sentences are unclear.

### 3.2 Timing of biomass.

Title and Line 331: this is chl-a, not biomass

Line 317 to 321: “ Self-organizing .... 1999)” should be removed/moved to the SOM methodological section.

Line 324: be more explicit about the fact that “The largest extent of the plume when defined with a 1 mg.m<sup>-3</sup> contour occurred ....” It need to be state asap as with a higher magnitude contour the plume would have been highlighted by node 7, corresponding to the spring bloom

Line 332: “the hypothesis of the IME” see above about the def of the IME

Line 335: not clear

Table 1&2: should appear after being cited in the text. Also, in the legend, it is stated that it is a linear regression of annual chl-a. Therefore, what does it mean “vs time in years”?

Line 336: “the annual seasonal trend” is it annual or seasonal? Unclear

Line 336: “calculated for the SW and NE and SOM5” what do you mean by SOM5? Average within the area delimited by the isocontour= 1 mg.m<sup>-3</sup> on SOM5 map? Please clarify

In this paragraph, please gather results about adg first, then bbp. It goes back and forth and it is hard to follow.

Line 344: You propose an explanation of the adg increase, and what about for bbp?

What is also unclear is why a significant positive trend in adg while chl-a doesn’t show a trend suggests that chl is not contaminated by adg? I would have rather expected that showing the same trend (or no trend) between the 2 parameters would mean no contamination.

Is the section related to Table 1 and the annual trend really noteworthy? It may be more

impacting to directly present the seasonal trend after the SOM section which also provides seasonal information's to simplify the take-home message.

Line 345 "in winter" (no THE between)

Line 348-50: what does the adg high increase for both NE and SOM5 region suggest?

Lines 351-53: is it necessary to describe everything from the figure. Rather focus on the take home message which is diluted. What do we need to remember in winter from the chl<sub>a</sub>, adg and bbp relationships, and what do we learn from the SOM5 vs control boxes.

Figure 5 should be shown in this section rather than section 3.2.1. By the way there is a misfit between the text which relates to chl standing stock (defined in section 2.5.2), while Fig 5 is chl-a purely.

### 3.2.1 Simultaneous increase in ...

Explanations/hypothesis from lines 364 to 381 should be provided adequately before, in sections 3.1 and 3.2. It would again avoid the need to go back and forth which would fluidify the reading and help understand earlier the relationships/hypothesis between chl<sub>a</sub> vs adg and bbp

Line 376-78: hyp 2 is discarded, but then to what the adg increase is related to?

Line 370: "shoaling" of what? Of the mixed layer depth? Of nutrients? Unclear

Line 376: what is "slope waters"? you mean uplift of isopycnets when the flow encounters the island? Vertical mixing from what? Seasonal convection? Horizontal mixing or advection (from where)? Please clarify

Trying to synthesize: the winter time Chl increase can be related to biomass increase thanks to nutrient supply a) from the ocean (induced by the ocean dynamics or seals), and/or b) from land (which can be detected by adg), and/or c) related to particle resuspension (related to bbp).

You can't definitely discard potential impact of changes in ocean dynamics as they are never explicitly investigated (and this is not the topic of the paper). First, regional dynamics can be partly responsible for SI Chl-a increase as an increase is also observed in the control boxes. Local processes could even enhance nutrient uplift (for instance stronger currents could uplift more nutrient from the bottom), stronger EKE could have the same impact. What about nutrient advection from the Gully MPA? Please, be less affirmative. Investigating the seal population is very interesting, you do not need to overconclude about the physical processes.

Line 382-4: if there is a continuous decrease in nitrate since 2012 how is the Chl increase in the control boxes can be explained?

Line 388-396, and last sentence: move/adapt to the introduction section. Here, directly present your own results and gather with section 3.2.2 (finally, section 3.2.1 as presented here would be removed)

### 3.2.2 Seal abundance...

Line 403-420: in the text it is referred to as "normalized chl<sub>a</sub>" while in Fig 7 legend it is Chl<sub>a</sub>, which can even be interpreted as standing stock. Please homogenize.

Here again there are back and forth: you start with changes in P1 and P4, then compare with NE box, then go back to results in SOM5 in agreement with decadal trend, talk about seal and go back into SOM5 results.

Figure 8 should be in the text and not at the end (ditto later for Fig 9)

Part of the text at the beginning of page 19 should be moved/combined to the methodological section. He would help to focus on the main results. This paragraph (more than a page is far too long).

Line 433: what are the significance associated with the pearson coef?

Line 435: I don't understand how it can be concluded that half of the Chl standing stock increase between P1 and P4 comes from the seal N-release according to Figure 8 where the model is far far below the satellite derived Chl standing stock.

Line 438: "could support PART (OR HALF) OF the observed plume

Line 450: go to line after "necessary"

### 3.2.3 Synchronized decadal...

This section is not very convincing. Fig 9 shows a far stronger trend of climate forcing than seal fertilization while in the text it is highlighted: "This is another striking finding that advocates for the impact of seal fertilization of the nearby ocean as no other mechanisms have supported the strong increase of chl-a in this region ». Not finding the explanation (as once again physical processes haven't been investigated in depth) does mean that seal fertilization is the main cause. Figure 8 and 9 rather suggest that seal abundance is part of the explanation, not THE explanation

What about the significance of the correlation coefficient Line 491, calculated with 4 points (if related to Fig 9).

### Conclusion

Line 502 and 525: see one of my first remarks about mesotrophic IME in literature

Line 505-506: provide the causal link when you state that there is also a winter increase in adg and bbp as in chl.

First paragraph: do not repeat the factual results on chl<sub>a</sub>, adg and bbp trends. Rather report the take home message about seasonal increase over the last decades and to what it can be (or not) related to by investigating adg and bbp in parallel

Paragraph 2: here again, this is not because adg and bbp didn't explained the chl increase that "the only drastic change that has occurred is the increase in seal population"

Last paragraph: you state line 529 that the N release can support the chl<sub>a</sub> standing stock of 254 tonnes in winter. Not convincing from Fig 8 and 9. This statement need to be

mitigated. It is a convincing PART of the explanation