Response to Reviewer #1

Thank you for reviewing our manuscript and for providing supportive comments. We appreciate the effort you made to improve this manuscript and are grateful that you recognized the significant amount of data that was used to create these nitrogen budgets for the Strait of Georgia. The discussion below responds directly to the specific comments made by Reviewer #1. The reviewer's comments are in bold and italicized. The authors' comments are in normal font.

Pg 7141 L 10-15 - it is not clear whether the samples were from the surface or several samples over a depth profile.

The samples were collected over a depth profile. To ensure clarity, Line 12 (p. 7141) will be changed to: "Seawater samples were collected at 18 depths (0 m to >400 m below surface) from 20 stations…".

Pg 7144 L3 see estimates by Pawlowicz et al. that are higher than Harrison et al. 1983. C3049

The estimates of primary production made by Pawlowicz et al. (2007) include an uncertainty of 50%, therefore, within uncertainty, the estimates made by Pawlowicz are not higher than Harrison et al. 1983. Estimates from Pawlowicz, et al. 2007 for new primary production is 220 ± 110 g C m^{-2} y^{-1}. Applying an f-ratio of 0.5, as assumed by Pawlowicz et al. 2007, to Harrison et al. 1983's primary production estimate of 280 g C m^{-2} y^{-1} would yield an estimate of 140 g C m^{-2} y^{-1} new production. Therefore, the Pawlowicz et al. (2007) estimates of gross primary production fall within the range provided on lines 7-8.

We will include a reference for Pawlowicz et al. (2007) on line 8 (p.7144) because this reference was missed in the original draft of the manuscript.

Sections 2.8 to 2.10 - these inputs usually have relatively high NH4 that has not been included in your estimates of DIN.

NH_4 is included in the estimates of dissolved inorganic nitrogen since these measurements were of total dissolved nitrogen and total particulate nitrogen. The only samples that did not include a measurement of NH_4 were the seawater samples. To clarify, we will add a little text on page 7141 Line 8. The sentence at this location will be changed from:

"Seawater samples for DIN (nitrate + nitrite) analysis were collected as…"

To:

"Seawater samples for DIN (only nitrate + nitrite measured for seawater) analysis were collected as…"

Pg 7147 L19 - Your statement that the PP in the south = north is only based on Chl and nutrients. I'm surprised that they are the same since it is often assumed that the north is less than the south. You should give Chl/m2 (water column integrated). Where your Chl/m3 values for the surface or avg for the water column - for what years- seasons, etc. This is a case where this section needs to be expanded.

The statement is outlined as a constraint and is based on the only evidence available derived from the primary literature. There have been no published accounts of primary production rates being measured in the northern Strait of Georgia; therefore, there is no evidence to suggest that the primary production rates are regionally different. This section will be expanded for clarification; however, the chlorophyll data will not be described as requested by the reviewer. These data have been discussed previously by Masson and Pena (2009) and they do a very good job of describing their chlorophyll data. For reference, the Masson and Pena data were collected over 7 years (2001-2007), 4 times a year (April, June/July, September/October, and December/January), and at multiple depths. Further, Masson and Pena (2009) found that there were no seasonal or regional differences in chlorophyll concentration or depth-integrated biomass. In support of their findings, Parsons et al. (1981) also found areas of high chlorophyll in the northern SoG. New *in press* data from Gower et al. (2013) will also be presented to assert the assumption that PP rates in the northern SoG are similar to the rates measured in the south.

The text will be changed as follows:

"The rate of PP for both the northern and southern is the same. Although the rate of PP has only been measured in the southern SoG (Harrison et al., 1983), there is evidence that support the assumption that PP rates are similar for both the northern and southern SoG including: (a) the concentration of chlorophyll (mg m^{-3}) is regionally equivalent on an annual, seasonal and depth-integrated basis (Masson and Pena, 2009); (b) water column profiles for NO_3 are regionally indistinguishable both annually and seasonally (Masson, 2006); (c) chlorophyll a concentrations, derived from satellite imagery, indicate PP is active in both the southern and northern SoG (Gower et al. 2013); (d) the PP rates are constrained by total organic matter and nitrogen and carbon isotope composition of particles collected in the sediment traps and sediment samples."

Pg 7152 - there must be useful comparable data from Puget Sound. You have no reference to Puget Sound in the whole paper.

There are limited data on particulate nitrogen and $\delta^{15}N$ for the Puget Sound, but nothing for the Haro Strait. However, we will include a statement on page 7152 Line 20 to include the data from Puget Sound. In order to effectively include this statement, new detail has been added to Fig. 1 and some text will need to be modified/removed.

The text to be removed will be (page 7152 Line 20):

"Since the particulate dynamics for this region are not completely understood, and we lack [PN] and $\delta^{15}N$ data, the influence of this region is the least constrained component

of the PN budget. Based on the constraints on the PN budget (Sect. 3.1) the incoming particulate material from Haro Strait (1709 Mmol yr^{-1}) must carry a $\delta^{15}N$ composition of 5.4 ‰. Effectively, there is no loss of PN from this budget, therefore, the PN_{Terr} originating from the Fraser River (1.7‰) must mix with a an external source that carries a $\delta^{15}N$ composition that is ≥ 8.7±0.3 ‰."

The new text will be:

"Unfortunately, the influence of this region adjacent to the Haro Strait is the least constrained component of the PN budget. Based on the constraints on the PN budget (Sect. 3.1) the incoming particulate material from Haro Strait (1709 Mmol yr^{-1}) must carry a $\delta^{15}N$ composition of 5.4 ‰. Effectively, there is no loss of PN from this budget, therefore, the PN_{Terr} originating from the Fraser River (1.7‰) must mix with a an external source that carries a $\delta^{15}N$ composition that is ≥ 8.7±0.3 ‰. To date, the particulate dynamics for this region are not completely understood and there is a paucity of [PN] and $\delta^{15}N$ data along the west coast of North America. For regions adjacent to the SoG, such as Puget Sound (see Fig. 1), there is one study that examines the C:N ratio (Walsh et al., 2008) but does not provide [PN], one study (Hedges et al., 1988) that examines the [PN] of a small coastal bay, and one study (Brandenberger et al., 2011) that has both [PN] and $\delta^{15}N$ data from sediment cores sampled at two locations within Puget Sound. Based on the available data, the [PN] within Puget Sound is similar to the concentrations in the southern SoG (Fig. 2) and range from 0.1 to 0.29 wt. % (Hedges et al., 1988; Brandenberger et al., 2011). Similarly, the $\delta^{15}N$ composition of four sediment core samples (two sediment cores per sampling location) collected within the Puget Sound have analogous $\delta^{15}N$ compositions to most sediment cores evaluated for the SoG (e.g. GVRD sediment cores 1, 8, 9, 10, 11, 12. 13, 14, 17, 18, 20, 21, 22, see Fig. 2). The $\delta^{15}N$ composition of the four sediment cores from Puget Sound ranged from 6.0-6.8 ‰ at the sediment-water interface but subsequently, became isotopically heavier (6.5-7.2 ‰) at depths > 50 cm (Brandenberger et al., 2011). It would be beneficial…"

Pg 7153 L15 - while there may be no data on DON in rivers, I am sure that there are data for the SoG. Since it is likely that DON is comparable to DIN in the SoG (similar to other systems), then you should include a few key calculations assuming the DON is similar to DIN.

If we look at the global situation, we might assume that DON is about the same as DIN, but this may not be the case for the Strait of Georgia. Our manuscript includes the most recent information regarding dissolved N in the study area (SoG) but the focus was more on constructing the particulate budget and examining how the two systems interact. Dissolved nitrogen is the major term in this system by an order of magnitude and suggesting that it may be larger, by doubling riverine inputs (~1700 Mmol yr^{-1}), will do nothing to clarify how this influences the particulate budget. The only DON concentration data available in the primary literature near the SoG were presented by Wong et al. (2002). The DON data presented by Wong et al. (2002) were collected adjacent to the SoG (Saanich Inlet, Stuart Island, Swanson channel, Juan de Fuca Strait), therefore, no data are available within the SoG. Further, Wong et al. (2002) suggested that the measured DON was refractory and, therefore, did not contribute to

phytoplankton growth/particulate production. Consequently, we do not think it necessary to calculate the influence of DON.

Pg 7153 L20 - similarly, there are NH4 data for the SoG and it would be useful to convince readers (with a few calculations)that including NH4 does not change you overall general conclusions (just like you have done for denitrification on the next page).

As mentioned previously, these data have already been included in our budget.

Pg. 7155 - L5 - give a number/percent instead of the vague "small proportion".

I will include an overall proportion for the entire SoG. It should read. “Only a small proportion (12 % for entire SoG) of the PN is…”

Table 1 - expand the Table legend to include date of the data - data from –and reference to the map in Fig. 1. Make reference to the Logs and lats of the stations (in a data report). What do you mean by ’area’ for each station?

Collection date, location, station, longitude, latitude, water depth and sediment accumulation rate are provided in the supplementary table (S1). Area for each station is the “Depositional Area” as described in line 7139 L16. This was obviously unclear and the caption for the table will be changed.

It will now read “Estimates of total PN fluxes derived from dated and modeled sediment box cores from the Strait of Georgia. The sediment accumulation rate is shown as SAR and PN concentration as [PN]. The depositional portion of the surrounding area as described in Sect. 2.2.2 is denoted as Area. Collection date, location, station, longitude, latitude, water depth and sediment accumulation rate are provided in the supplementary table (S1).”

Fig. 1 - Legend says that the longs and lats are given in data tables – I could not find them. This fig should be made as big as possible so that readers can see all of the important information in it.

Collection date, location, station, longitude, latitude, water depth and sediment accumulation rate are provided in the supplementary table (S1). The inclusion of a reference to the supplementary tables S1 and S2 will be included. Supplementary table S2 was previously omitted and this was an oversight. This table has been added. The figure caption will be changed to:

“…The exact latitudes and longitudes for the sampling locations for the sediment box cores are given in the supplementary table S1 and all other sampling locations are provided in supplementary table S2…”

Fig. 2 PN is given as % (of what)? The blue color is not easily distinguishable from the black - make them a different color id you are going to use color. I could not determine that there were "open' diamonds - looked filled due to the small size. The fig shows 22 C3050 cores but the legend says 20. What years are these data for?

It is weight percent (wt. %) and has been clarified in the text. It should now read "Depth profiles for total particulate nitrogen concentration (wt. %).

Thank you for your comments on the aesthetics of the figure. The figure has been changed accordingly. As such, the figure caption needs to be changed to address these changes. The caption should now read:

"**Fig. 2.** Depth profiles for total particulate nitrogen concentration measured as weight % (wt. %) (black solid diamond) and δ15N composition of sediment (blue open square connected by solid black line) for all 20 box cores used in this study. The horizontal dashed line for each sediment profile represents the burial depth (the depth at which the [PN] becomes approximately constant). The solid red line that follows the [PN] depth profiles represents the theoretical exponential decay curve described in Sect. 2.2.4."

The figure shows 20 cores (1-22, without 19 and 4). Core 19 and 4 are not included in the figure nor are the data used to construct the budgets. The years that these samples were collected are reported in the methods section and presented in the supplementary data table.

Fig. 3 Where are these data from (Table 1?). What years?

The time frame and location from where these samples were collected are reported in the methods section and presented in the supplementary data table (S1).

Fig. 4 - This is a very visually friendly depiction of the N cycle for SoG. However, it need further explanation in the figure legend (please expand it). Why does the PN in the south split into 2 sections and what is the 980 splitting off represent? in the DIN section, the arrow for denitrification should be up - representing a loss of N (see Pg. 7154 L19).

The denitrification arrow is pointed correctly. It is a loss from the system, not an input.
We do not agree that the figure legend needs to be expanded. The PN splitting into two sections is described on page 7152, L17-19.

Additional References Need references for Puget Sound - especially northern PS. Look up recent references (about 2008-12) for Pawlowicz et al 2007 Atm Ocn 45: 173-193 (2007) and 2 other papers on Carbon flow and plankton ecology Dynamics of community production and respiration. Collins et al. 2009 CJFAS 66:1567 Classic physical oceanography refs LeBlond 1983 CJFAS 40:1033 Thomson 1981 book on physical oceanography

A reference for Pawlowicz et al. 2007 will be included as indicated above in response to the reviewer's second comment. LeBlond 1983 will be added to the references and included as a citation for line 21 (p. 7137). Thomson 1981 will be added to the references and included as a citation for line 21 (p. 7137).

Technical comments Pg. 7144 - L4 - Harrison et al. is repeated twice - remove one.

Thank you for noticing. This will be changed.

Pg. 7149 - L21 - remove this and insert is – but is not likely to be—

Thank you for noticing. This will be changed.

Pg. 7150 L10 - insert and – water column and therefore,—

Thank you for noticing. This will be changed.

Table 5 - Groundwater – in the first column–130-391 should have a superscript 1 since it comes from Mackas and Harrison (1997).

Thank you for noticing. This will be modified.

The following citations will be added:

Pawlowicz, R., Riche, O., and Halverson, M.: The circulation and residence time of the Strait of Georgia using a simple mixing-box approach, Atmosphere-Ocean, 45,173-193, 2007.

Leblond, P.H.: The Strait of Georgia: Functional anatomy of a coastal sea, Can. J. Fish. Aquat. Sci., 40, 1033-1063, 1983.

Thomson, R.E.: Oceanography of the British Columbia coast, Can. Spec. Publ. Fish. Aquat. Sci., 56, 291 pp, 1981.

Supplementary Table S1. Summary of collection details and the Sediment Accumulation Rate (SAR) for all sediment cores collected within the SoG for this study. Data not available = na.

Collection date	Location	Station	Longitude (°W)	Latitude (°N)	Water depth (m)	SAR (g cm^{-2} yr^{-1})
2003-06-19	N	GVRD 1	124.6	49.6	169	0.08
2003-06-18	S	GVRD 2	123.3	49.3	76	0.26
2002-12-19	S	GVRD 3	123.3	49.2	83	1.30
2002-12-20	S	GVRD 4	123.3	49.1	84	na
2002-12-20	S	GVRD 5	123.5	49.2	388	0.64
2003-06-18	S	GVRD 6	123.3	48.9	187	2.70
2003-12-06	S	GVRD 7	123.4	49.1	233	0.32
2007-07-08	N	GVRD 8	123.9	49.4	214	0.10
2007-07-12	N	GVRD 9	124.1	49.5	365	0.17
2007-07-09	N	GVRD 10	124.9	49.8	310	0.05
2007-07-11	N	GVRD 11	124.6	49.7	336	0.12
2007-07-11	N	GVRD 12	124.4	49.4	328	0.12
2007-07-12	N	GVRD 13	124.2	49.4	326	0.12
2007-07-13	S	GVRD 14	123.6	49.4	160	0.23
2007-07-14	S	GVRD 15	123.5	49.1	296	1.73
2007-11-06	S	GVRD 16	123.3	49.0	210	0.98
2007-11-06	N	GVRD 17	124.0	49.4	410	0.21
2007-11-29	S	GVRD 18	123.1	48.9	157	0.30
2007-11-29	S	GVRD 20	123.8	49.3	365	0.10
2007-12-01	N	GVRD 21	125.1	50.0	260	0.11
2007-12-01	N	GVRD 22	124.2	49.6	373	0.23

Supplementary Table S2. Summary of location details for all sampling locations excluding sediment core sample sites.

Sample Type	Location	Longitude (°W)	Latitude (°N)
River Station	Campbell River	125.3	50.0
River Station	Englishman River	124.3	49.3
River Station	Fraser River	123.1	49.1
River Station	Nanaimo River	123.9	49.1
River Station	Oyster River	125.1	49.9
River Station	Squamish River	123.2	49.7
Sediment Trap Mooring	SOGS	123.4	49.0
Sediment Trap Mooring	SOGN	124.9	49.8
Atmospheric	Campbell River	125.2	50.0
Atmospheric	Nanaimo	124.0	49.2
Atmospheric	Victoria	123.4	48.4
Atmospheric	Saturna	123.1	48.8
Aquaculture	AQ 137	125.2	50.2
Aquaculture	AQ 547	125.2	50.2
Aquaculture	AQ 138	125.2	50.2
Aquaculture	AQ 216	125.4	50.2
Aquaculture	AQ 1770	125.3	50.1
Aquaculture	AQ 221	123.9	49.7
Aquaculture	AQ 332	123.9	49.6
Aquaculture	AQ 408	123.8	49.6
Aquaculture	AQ 412	123.9	49.6
Aquaculture	AQ 746	123.9	49.6
Aquaculture	AQ 572	123.7	49.6
Aquaculture	AQ 304	125.0	50.3
Aquaculture	AQ 1698	124.1	49.8
Aquaculture	AQ 1697	124.1	49.8
Pulp Mill	PM1	124.5	49.9
Pulp Mill	PM2	123.2	49.4
Pulp Mill	PM3	122.9	49.2
Pulp Mill	PM4	124.0	49.2
Pulp Mill	PM5	123.1	49.8
Pulp Mill	PM6	123.7	48.9
Wastewater facility	W1	122.9	49.2
Wastewater facility	W2	123.2	49.2
Wastewater facility	W3	123.2	49.3
Wastewater facility	W4	122.8	49.2
Wastewater facility	W5	123.1	49.1

Supplementary Table S3. Nitrogen isotope composition of sediment cores both at the sediment-water (surface) and at the location determined to be where PN is buried.

Station	**Location**	**$\delta^{15}N$ (‰, surface)**	**$\delta^{15}N$ (‰, buried)**
GVRD 1	N	6.4	6.8
GVRD 2	S	4.7	4.6
GVRD 3	S	2.1	3.7
GVRD 4	S	3.7	3.4
GVRD 5	S	6.0	5.0
GVRD 6	S	5.7	5.6
GVRD 7	S	5.6	5.3
GVRD 8	N	6.2	6.5
GVRD 9	N	7.0	6.7
GVRD 10	N	7.1	7.1
GVRD 11	N	7.1	7.3
GVRD 12	N	7.2	7.5
GVRD 13	N	7.0	7.6
GVRD 14	S	6.5	6.1
GVRD 15	S	5.8	5.8
GVRD 16	S	5.7	5.7
GVRD 17	N	6.9	6.6
GVRD 18	S	6.5	5.9
GVRD 20	S	6.1	6.4
GVRD 21	N	7.0	7.3
GVRD 22	N	6.7	6.1