First of all, we would like to thank reviewers for their valuable comments on our manuscript. We revised our manuscript carefully by taking these comments into account.

General comments:

The Arctic Ocean is a rapidly changing system that has a highly dynamic CO2 system both seasonally and with the changing physical conditions and climate change scenarios. The authors presented CO2 system data during an autumn of 2013 cruise which will enrich the available CO2 data in the Arctic Ocean and benefit the scientific community

(however the dataset is still available via the link). Their results largely support other recent observations that pCO2 is low in ocean margin but high (approaching to the atmospheric pCO2) in the Canada Basin. The explanations they provide are also consistent with other recent publications. Most interesting, the authors observed a subsurface minimal pCO2 structure in the Canada basin. They demonstrated this feature in fig. 5 and discussed the causes for low pCO2 water by analysis the water types, TA-S and pCO2-AOU relationships. Finally, they discussed the possible fate of this "hidden CO2 sink" and its influence in the future Arctic Ocean (they basically rejected this possibility, which I also agree). I agree with most of their views. Their finding is worthy to be published. However, the main conclusion in this paper is undermined because of not enough data, i.e. low pCO2 in the subsurface of Canada Basin. It is also not clear to me whether pCO2 minimum at 30-50m is due to in situ biological production as they have suggested or subduction of surface water from the highly productive shelf. I think more complete depth profiles from the Niskin bottle samples down to 150-200 m rather than 50m alone from a CTD pumping system will help to elucidate this issue.

Sections were expanded down to 180 m in order to cover PSW and PWW. Please see Figure 5 (revised) attached.

Another issue I have with this manuscript is writing. In general they have done a good job in writing except the text around Fig. 5. I don't think the authors put enough thinking into organizing the paper the best they can. One indication is they presented air-sea CO2 flux calculation method in the methods section but never presented air-sea CO2. Did they initially prepared a longer paper and then deleted the flux part?

As you mentioned, calculation of air-sea CO_2 flux is not the main theme of this paper. However, we have to mention how to calculate half-life of ΔpCO_2. We divided "Data and Methods" into two new sections, "Measurements and Data" and "Calculations". How to calculate the half-life and data used for calculation was described in "Calculations" section.

Another indication is in Fig. 5. While it is nice to see the pCO2 minimum with a high frequency depth profile, the depths of such profiles are limited to 50m. However the Pacific winter water and Pacific summer water are all deeper than 50m (if not in this region, they should say it). Thus the entire discussion is not clear. Most important, it is not clear to me whether pCO2 minimum at 30-50m is due to in situ biological production or subduction of surface water from the highly productive shelf. Again, I feel using the depth profile from the Niskin bottle based profiles will help to elucidate this issue. Such depth profiles will also present nutrient profiles to support the argument on nutrient availability (rather than just citing melting pond information). In summary I'd support the eventual publication of this paper but not at this stage. More data are needed to support their arguments.

In order to compare water properties, we calculated preformed $nDIC_{32}$ using the following equation.

$$\text{preformed nDIC}_{32} = \frac{DIC - AOU * r_{C:O}}{S} \cdot 32$$

Stoichiometric respiration ratio of $\Delta CO_2/-\Delta O_2$ ($r_{C:O}$) was set to 117/170 (Anderson and Sarminento, 1994). Also concentrations of nutrients measured onboard were used for the analysis. Figure 6c and 6d were added and attached at the end of this reply. Preformed DIC_{32} and dissolved nitrate changed abruptly around S = 29.3. Above this layer, dissolved nitrate was almost depleted and preformed DIC_{32} was relatively high (~2200 μmol kg^{-1}). Significant nitrates remained and preformed DIC_{32} was low (~2100 μmol kg^{-1}) between S = 29.3 and S = 33.1. S = 29.3 corresponds to temperature minimum in the Canada Basin, i.e., rWML (Figure 4c). The layers rWML and above have been formed in the Canada Basin. PSW and PWW which were distributed between rWML and another temperature minimum around S = 33.1 were formed in the Chukchi Sea and subducted to the Canada Basin. Low pCO_2 (< 300 matm) was mostly limited to the layer just below rWML. This layer corresponds to PSW. Therefore, low pCO_2 under the halocline in the Canada Basin was attributable to the subduction of highly productive water from the Chukchi Sea rather than in situ production in the Canada Basin.

Specific comments

Page 1 Line 23 it is unnecessary to add "e.g." before the citation.

We removed "e.g.".

Page 2 Line 14 changing "reduces" to "limits"

We changed "reduces" to "limits".

Page3 The pCO2 data set presented in this paper is still not available to readers though the link: (http://www.godac.jamstec.go.jp/darwin/cruise/mirai/mr13-06_leg1/e).

We have submitted the data to data center of JAMSTEC. However, it has not been uploaded yet. We inquired the data center about it.

Equation 1 is totally unnecessary. Just cite Takahashi would be enough.

If the authors didn't do any calculation of CO2 flux in this paper, it is totally unnecessary to have the description of air-sea CO2 flux calculation (page 3, line 17- line 25).

Calculating regional air-sea CO_2 flux was not a goal of our paper. However, it is essential to mention about air-sea CO_2 flux since we calculated half-life of ΔpCO_2. Please see subsequent comment about the calculation of half-life.

Line 22, equation (4). I don't recall W92 has a non-zero term. Please check if you cited a more recent Wanninkhof paper and equation.

$k = 0.251 \cdot U_{10}^2 \cdot (Sc/660)^{-0.5}$ was suggested in the most recent Wanninkhof's paper (Wanninkhof 2014). Also Scmidt number was updated to the latest value in Wannikhof (2014).

Line 24-25 The wind speed at 24 m height is measured by an anemometer and is extrapolated to 10m. Using an instantaneous wind speed is probably not the best choice for CO2 flux calculation with underway data. The average wind speed from satellite data may make more sense due to equilibrium time for CO2 is pretty long. For example, at 1 pm, if a vessel is at point A where pCO2 is 350 uatm and wind speed is 4 m/s. When the ship arrives at point B at 11 pm the same day where pCO2 is 350 uatm and wind speed increases to 7 m/s. It doesn't make any sense to believe that CO2 uptake flux is much greater at point B than A. If you will use satellite wind, then the fluxes in these two locations are likely the same (that is winds are same for A and B but only changes over a day). However, I must say since calculating flux is not the goal of this paper, this is not a serious problem. Then, of course, there would be no need for the authors to even present the flux calculation equation.

We used monthly averaged wind speed derived from climate reanalysis JRA-55 (Kobayashi et al., 2015). Wind speed in the Canada Basin in September 2013 ranged 4-5 m sec^{-1}. We divided "Data and Methods" into two new sections, "Measurements and Data" and "Calculations". Usage of JRA-55 was added to "Measurement and Data" section. Description about the correction from wind speed at 24 m to that at 10 m was removed.

Page 4 Line 17 What software or package was used for calculation of carbonate chemistry?

We used for macro package of CO2SYS program for Microsoft Excel. Usage and reference (Pierrot et al., 2006) were added.

Page5 Line 7 TARRO should be TARRO

"TARRO" was changed to "TA_{RRO}" according to your comment.

Line 22-24 The description of "(1) Barrow Coastal Water (BCW) was relatively warm and fresh

(SST > 2 , SSS < 30.5). (2) Canada Basin Water (CBW) was cold and fresh (SST < 2 C, SSS < 28). (3) Chukchi Sea Water (CSW) was saline (SSS > 28)" is a little confusing. BCW was fresh SSS<30.5 while CSW was saline (SSS>28). What is the reference for fresh and saline? As I see it (Fig. 3), most of BCW had SSS<28.5 except the very nearshore part while most CSW had SSS>30.5. Only minor clarification is needed here.

Difference in water properties between BCW and CBW was remarkable in temperature. On the other hand, that between CBW and CSW was remarkable in salinity. Therefore, we changed Line 21-25 to "We defined three subregions; (1) Barrow Coastal Water (BCW), (2) Canada Basin Water (CBW) and (3) Chukchi Sea Water (3). The boundary between BCW and CBW was 2°C isotherm at 72.5°N, 154.8°E. CBW and CSW was separated 28 psu isohaline at 73.3°N 168.3°E (Fig 3c)."

Page 6 Line 3 removing "the resulting" as low DIC/TA and low pCO2 are the same thing or same result of physical and biogeochemical processes (biological uptake here, but in the basin CO2 evasion from the atmosphere plus strong stratification and low PP in surface water). There is no magic low DIC/TA that leads to low pCO2.

Admittedly, "the resulting" was removed.

Line 9 regarding "half-life of CO2 gas exchange", while I can guess how did you estimate this, it is better to tell readers.

At first, initial condition of temperature, salinity, DIC, TA and mixed layer depth was set.

Initial pCO_2 (pCO_2^0) was calculated. Initial ΔpCO_2 (ΔpCO_2^0) was the difference between pCO_2^0 and atmospheric pCO_2 (pCO_2^{air}).

$$pCO_2^0 = f(T, S, DIC, TA)$$

$$\Delta pCO_2^0 = pCO_2^0 - pCO_2^{air}$$

All parameter except DIC were fixed during the calculation, i.e. evaporation, precipitation and lateral/vertical advection were assumed unchanged. Flux of CO_2 (F_{CO2}) was calculated from wind speed and gas transfer coefficient. Time step was set to one day. Here, k and K_0 denote the solubility of CO_2 by Weiss (1974) and gas transfer coefficient by Wanninkhof (2014) respectively.

$$F_{CO2} = kK_0 \Delta pCO_2$$

$$k = 0.251 \cdot U_{10}^2 \cdot (Sc/660)^{-0.5}$$

Increase in DIC in each time step was calculated from F_{CO2}.

$$\Delta DIC = \frac{F_{CO2}}{MLD * \rho(T, S)}$$

$$DIC_{t+1} = DIC_t + \Delta DIC$$

Here, MLD and $\rho(T, S)$ mean mixed layer depth [m] and density of seawater in mixed layer [kg m^{-3}] respectively. After each time step, pCO_2^t and ΔpCO_2^t were calculated from DIC at the time.

$$pCO_{2,t} = f(T, S, DIC_t, TA)$$
$$\Delta pCO_2^t = pCO_2^t - pCO_2^{air}$$

Half-life means the time required to reduce $\Delta p CO_2^t$ to half of $\Delta p CO_2^0$. Description of these processes for calculation of half-life was added to "Calculation" section.

Line 17 Font is different from other context Nutrient in melting pond cannot be a sufficient evidence for limitation of nitrate in surface water. Report directly the nutrient data in water would be better.

We used nutrients data measured on the ship to prepare Figure 6d. In this figure, nutrients depletion (nitrates < 0.2 μmol kg^{-1}) above S = 29.3 (i.e., Canada Basin origin water) and presence of nutrients (about 1 μmol kg^{-1} at S = 31) in Pacific origin water are presented.

Line 24 change "pCO2sea" to "pCO2sea "

We changed "pCO_2sea" to "pCO_2^{sea}".

Line 29-30 "Reduction in CO2 absorption capacity by riverine discharge was not as large as that by sea-ice melt." This conclusion is not solid. Need more explicit verification.

Difference in pCO_2 between BCW and CBW was attributable to DIC rather than fraction of fresh water. Please see newly drawn Figure AC1. Relation between F_{RRO} and $nDIC_{32}$ was almost linear in BCW and CSW. However, CBW indicated positive anomaly of $nDIC_{32}$ from linear relation. Additional DIC was imposed on only CBW by possibly air-sea CO_2 flux. As a result, "Reduction in CO_2 absorption capacity by riverine discharge was not as large as that by sea-ice melt." was partly incorrect. It was replaced by "At the time of the observation, BCW still could absorb more atmospheric CO_2 than offshore CBW".

Page 7 Line 4 changing "with depth" to "as depth increases"

We changed "with depth" to "as depth increases".

Line 17-18 "In CSW, the halocline, although not as clear as in the other two subregions, was at almost the same depth." But thermocline is very obvious in CSW (Figure 5a).

In CSW, the halocline, although not as clear as in the other two subregions, was at almost the same depth." was changed to "Unlike the other two subregions, thermocline was more prominent than halocline in CSW."

Line 21 Should "In contrast" be "Likewise"? not clear what is the undertone by this.

"In contrast" was changed to "Likewise".

Page 7 line 19, what is "column variation"? must be water column? Same in lines 26, 29 and 31, all change to "water" column profiles.

All "column profile" were changed to "water column profile".

p.7 Line 26- Page 8 Line 12 The biggest problem here is pCO2 data in CBW is too limited. (only three water column data shown in Figure 5e). Considering the mixing layer structure is complicated in this subregion, it is difficult to see the real pattern. With only 3 station, how to distinguish the real reasons for low pCO2 in subsurface CBW, either due to the local net primary production in CBW or just the water with low pCO2 subducted and advected into the Canada Basin? If the authors could plot the entire water column data (deeper than 50 m in Figure 5), that would provide more information and be helpful to interpret their finding. Also, the Discussion of various waters does not related to Fig. 5 very well, thus causing confusion in reading as the deepest depth is only 50m while the winter water (rWML) is about 120m and summer water (PSW) is even deeper. I am somewhat confused in reading lines 5-13 in p. 8. Since this part is the new point that the authors want to present. It absolutely should be explained very clearly.

Temperature minimum layer around S = 29.3 in Figure 5 was rWML. PSW was relatively warm water just below rWML to temperature maximum around S = 31. As shown in Figure 6a, $p\text{CO}_2^{sea}$ showed small variability ranging 300-350 μatm in the layers shallower than S = 29.3. The lowest $p\text{CO}_2^{sea}$ was seen in the water of $29 < S < 31$. This layer was PSW which was formed in the Chukchi Sea and advected to the Canada Basin. Subsurface minimum in $p\text{CO}_2^{sea}$ in the Canada Basin was formed due to biological production in subducted PSW rather than in Canada Basin origin water. This was supported by low preformed nDIC_{32} (Figure 6c) and existence of nutrients (Figure 6d) in Pacific origin water between S = 29.3 and S = 33.1.

p.8, line 30, replace "think" with "believe" or "suggest".

We changed "think" to "suggest".

Table 1 It is not clear whether the average of all the samples were within mixing layer or including the entire water columns. It is probably better to separate the data into mixing layer and below mixing layer for discussion. And please add standard deviation.

All data in Table 1 was for surface water pumped from ship's bottom. This information was added to the caption of Table 1. Standard deviation was added to Table 1 (please see below).

Reference

Anderson, L. A. and J. L. Sarmiento, (1994), Redfield ratios of remineralization determined by nutrient data analysis, Global Biogeochemical Cycles, 8, 65-80.

Kobayashi, S., Y. Ota, Y. Harada, A. Ebita, M. Moriya, H. Onoda, K. Onogi, H. Kamahori, C. Kobayashi, H. Endo, K. Miyaoka, and K. Takahashi, (2015), The JRA-55 Reanalysis: General specifications and basic characteristics. J. Meteor. Soc. Japan, 93, 5-48, doi:10.2151/jmsj.2015-001.

Pierrot, D. E. Lewis, and D. W. R. Wallace. (2006), MS Excel Program Developed for CO2 System Calculations. ORNL/CDIAC-105a. Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tennessee. doi: 10.3334/CDIAC/otg.CO2SYS_XLS_CDIAC105a

Wanninkhof, R., (2014), Relationship between wind speed and gas exchange over the ocean revisited, Limnology and Oceanography: Methods, 12, 351-362, doi: 10.4319/lom.2014.12.351.

Table 1 (revised)

Summary of three water types (BCW; Barrow Coastal Water, CBW; Canada Basin Water and CSW; Chukchi SeaWater) at the surface. All sample waters were pumped up underway from an intake at ship's bottom. Values are averages for samples collected from 4 to 11 September 2013. N denotes the number of samples. $nDIC_{32}$ and nTA_{32} are DIC and TA normalized to S =32 respectively ($nDIC_{32}$ = DIC / S · 32; nTA_{32} = TA / S · 32). Standard deviation (SD) was listed below each value.

Water Type	N	T [°C]	S	DIC [μmol kg^{-1}]	$nDIC_{32}$ [μmol kg^{-1}]	pCO_2 [μatm]	TA [μmol kg^{-1}]	nTA_{32} [μmol kg^{-1}]	DIC/TA	f_{RRO}	f_{SIM}
BCW	109	2.88	27.01	1827	2166	274	1948	2309	0.938	0.11	0.08
(SD)		0.30	1.37	72	34	13	85	25	0.006	0.02	0.04
CBW	118	0.66	26.19	1803	2203	332	1882	2299	0.958	0.10	0.12
(SD)		0.58	0.24	19	16	19	16	9	0.004	0.01	0.01
CSW	54	3.03	31.06	1923	1982	198	2131	2196	0.903	-0.01	0.08
(SD)		0.23	0.19	13	6	19	12	3	0.002	0.00	0.01

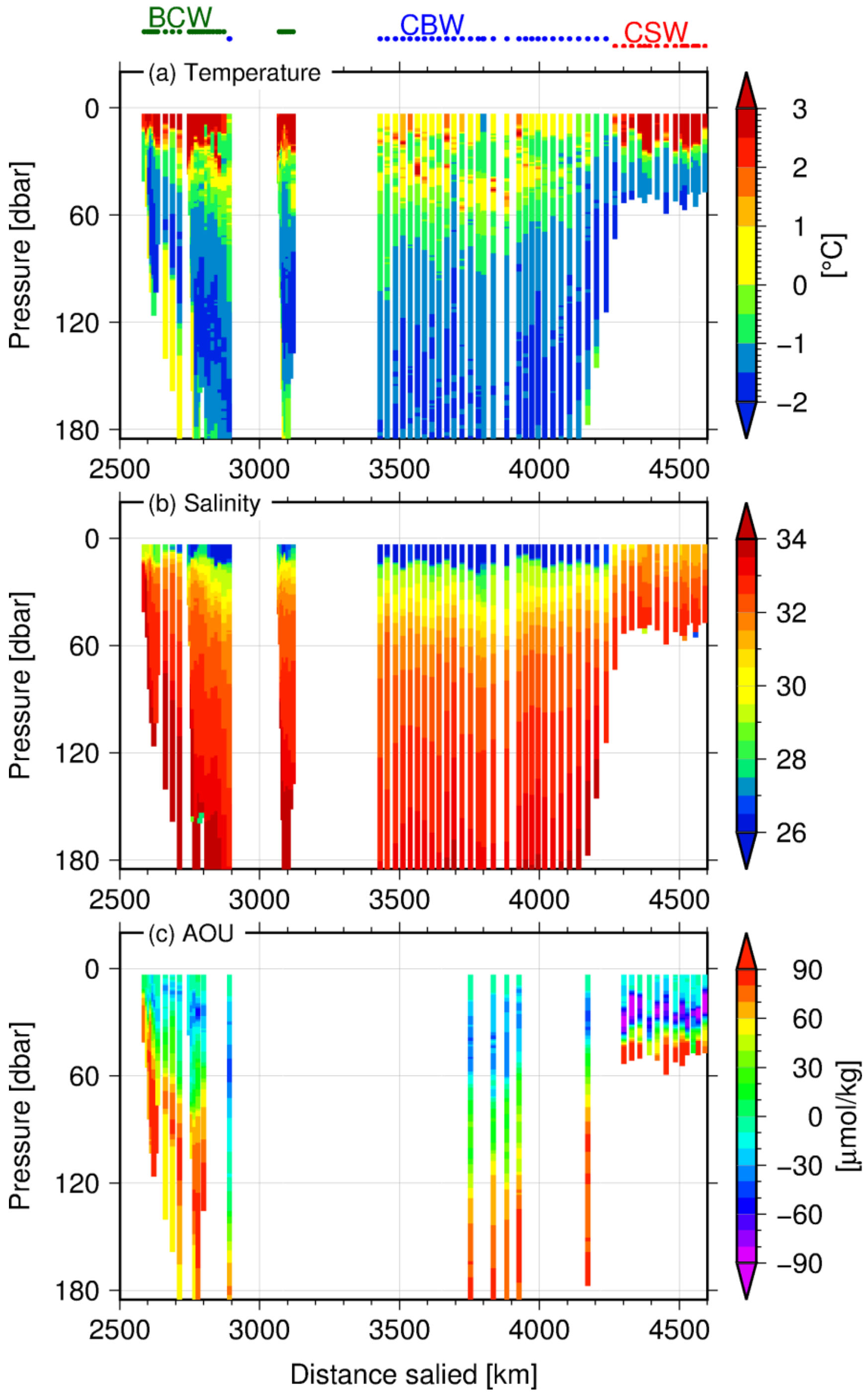

Figure 5 (revised) Column profiles of (a) temperature, (b) salinity, (c) apparent oxygen utilization (AOU), (d) pCO_2^{sea}, (e) f_{SIM}, and (f) f_{RRO} along the cruise track in the period 4–11 September 2013. Data were obtained by CTD and XCTD in (a) and (b), by oxygen sensor SBE 43 on CTD in (c), and by discrete bottle samples in (d), (e) and (f). Water types BCW (Barrow Coastal Water, CBW (Canada Basin Water), and CSW (Chukchi Sea Water) are indicated at the top of the figure.

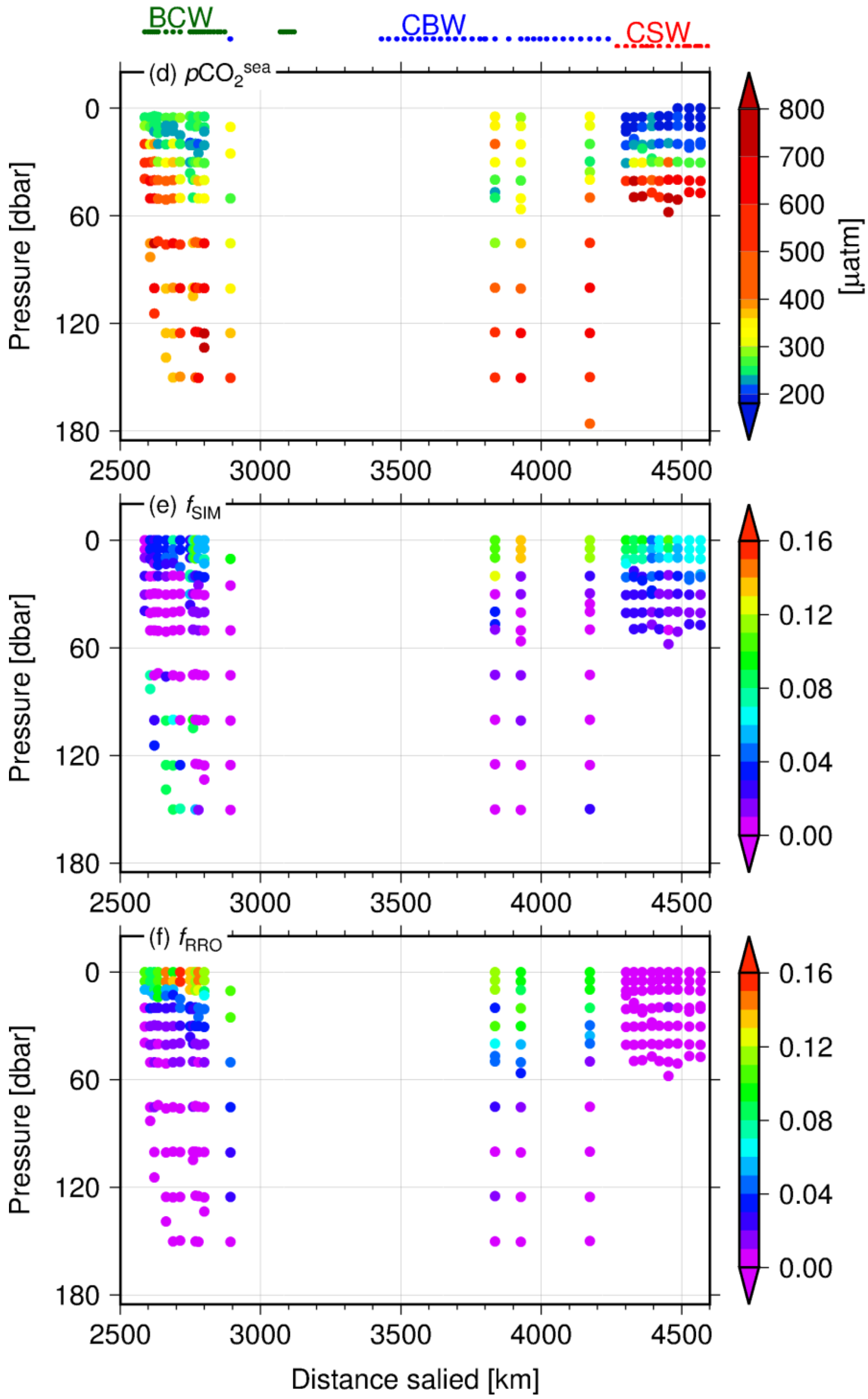

Figure 5 (revised; continued)

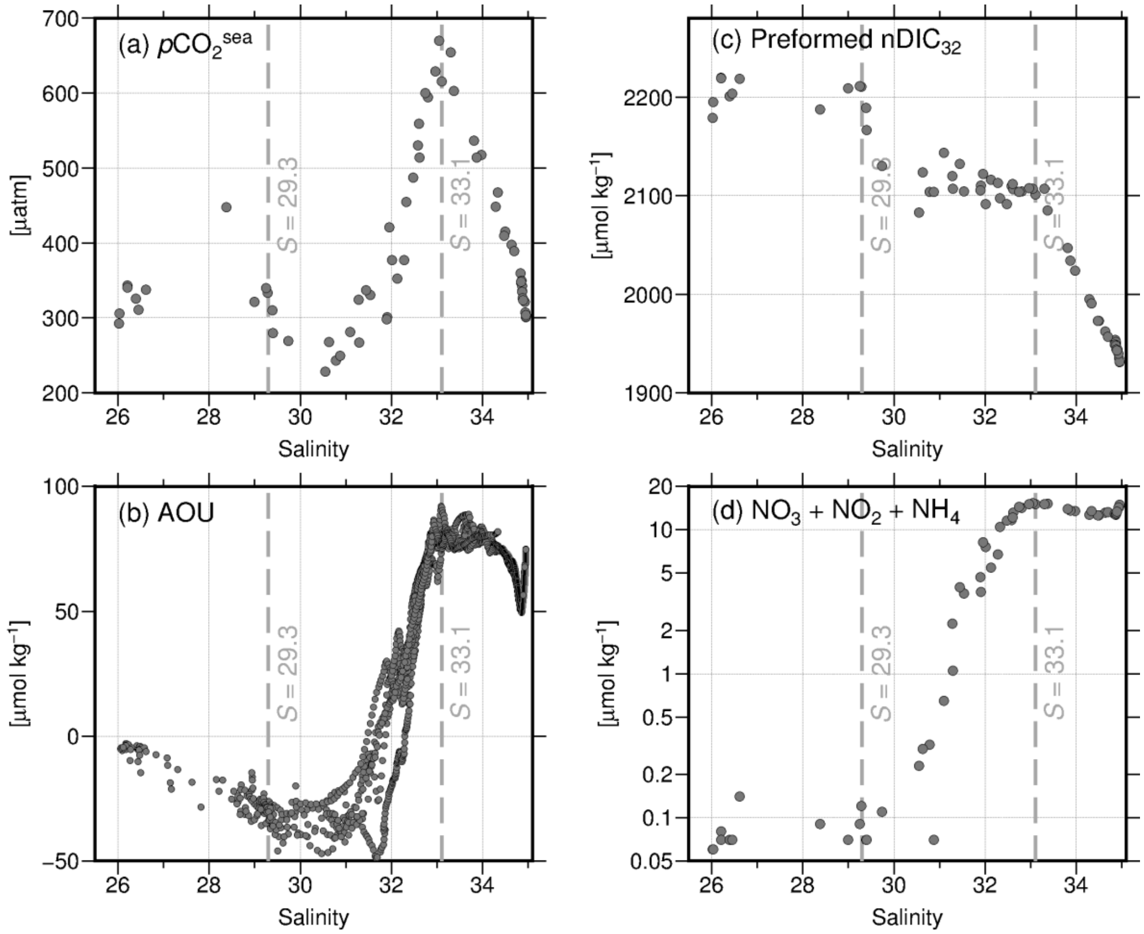

Figure 6 (revised) Canada Basin Water values for (a) salinity and pCO_2^{sea} in discrete bottle samples, (b) salinity and apparent oxygen utilization (AOU) from CTD cast data, (c) salinity and preformed $nDIC_{32}$ (= {DIC – AOU} / S · 32) in discrete bottle samples and (d) salinity and ($NO_3 + NO_2 + NH_4$) in logarithmic scale in discrete bottle samples. Salinity of rWML (S = 29.3) and PWW (S = 33.1) were indicated as gray dotted lines.