Author's responses to anonymous referee #1.

We really appreciate thoroughly giving comments and helpful suggestion to our study by anonymous reviewer #1. We have answered all the comments made by the referee #2. RC, AR and RS stand for Referees comment, Authors response and Revised sentence, respectively. We hope that our explanations and revise plan are acceptable and satisfactory. In addition, I will change the abbreviations of large and small Arctic copepods ($Cop_{arc}L$ and $Cop_{arc}S$) to $CopL_{arc}$ and $CopS_{arc}$, respectively. I carefully proofread English and revise the manuscript before the submission of the revised version.

[RC1] Figure 1 is not as informative as I expect. The authors described different water masses in the northern Bering and Chukchi Seas (Table 1). However, the interactions of these water masses, especially during the summer season when zooplankton samplings were conducted, are not well demonstrated and described. In Figure 1, consider adding more features for better illustrations of this shallow and highly advective system: 1) ocean bathymetry as colored background or contour lines; 2) locations and names of geographical places, e.g., St. Lawrence Island, Bering Strait, Herald Shoal, Herald Canyon, Hanna Shoal, Barrow Canyon; 3) arrows demonstrating dominant summer circulation patterns, including Alaska Coastal Current, Anadyr Water, Bering Shelf Water, Siberian Coastal Current etc. Excellent examples are shown by Grebmeier 2012 Figure 1, Day et al. 2013 Figure 1 and Spall et al. 2014 Figure 1 (Spall, M. A., Pickart, R.S., Brugler, E.T., Moore, G.W.K., Thomas, L., Arrigo, K.R., 2014. Role of shelfbreak upwelling in the formation of a massive under-ice bloom in the Chukchi Sea. Deep. Res. Part II, 105, 17–29. doi:10.1016/j.dsr2.2014.03.017).

[AR1] We appreciate for giving us helpful comments to revise Figure 1. Thank you for the information and helpful excellent examples. I will revise Figure 1 as the reviewer suggested. Please check the figure and its caption [RS1].

[RS1] Figure 1. Study area and sampling stations in the northern Bering Sea and Chukchi Sea during the summers of 2007, 2008 and 2013. The symbols denote the sampling stations where NORPAC net and CTD water samplings were conducted. The color scale indicates bottom water depth (m). Modified from figure presented in Spall et al. (2014) and Grebmeier et al. (2015).

[RC2] The calculation of vertical density gradient and variability of depth of maximum density gradient are not straightforward to me. Was the density gradient at the each depth calculated by the difference between 1 m above and 1 m below the specific depth using a central difference scheme? Then, how about the most top and bottom depths? How variable are the depths of maximum density gradient, from year to year and from station to station? The depths of maximum density gradient further determine mean values of temperature, salinity and chlorophyll, and later statistical analyses. From readers' perspective, it may be helpful to spatially illustrate Table 3 explanatory variables at all stations using colored dots. If allowed by the journal, consider including these figures as supplementary materials.

[AR2] We are sorry for not sufficiently explaining the calculation of vertical density gradient and variability of depth of maximum density gradient. The answer for the first question, "Was the density gradient at the each depth calculated by the difference between 1 m above and 1 m below the specific depth using a central difference scheme?" is "No". We calculated a vertical density gradient at a specific depth using 2m-mean densities just above and below the specific depth. This calculation was conducted at **all depths except at the top, second top, bottom and second bottom depths**. Then we evaluated maximum density gradient and the depth of maximum density gradient at each profile. Further, we calculated temperature; salinity and chlorophyll-*a* concentration averaged at the upper and the bottom layers. We revised the manuscript to explain the methods more straightforwardly. We further added maps of Table 3 environmental variables (Figure A1–A4 in Supplementary Materials).

[RS-2] As the vertical structure of the water mass in our focused region basically forms a one- or two-layered structure because of its shallow bathymetry, we can divide the water column into a maximum of two layers (i.e., the layers above and below the pycnocline are defined as the upper and bottom layers, respectively). The density (ρ) was calculated from the temperature and salinity measured by CTD profiles with a vertical data resolution of 1 m. We calculated the vertical density gradient ($\frac{d\rho}{dD}$) at a specific depth using 2 m-mean densities immediately above and below the specific depth. $\frac{d\rho}{dD}$ was calculated for all depths except the top, second-top, bottom, and second-bottom depths. The depth of the maximum density gradient ($\frac{d\rho}{dD_{max}}$) was defined as the pycnocline of each sampled site. Then environmental variables (temperature, salinity, and log-transformed chlorophyll *a*) were vertically averaged within the upper and bottom layers and defined as T_{UPP}, T_{BOT}, S_{UPP}, S_{BOT}, Chl.a_{UPP} and Chl.a_{BOT}, (see Table 3 and Figure A1–A4 in Supplementary Materials).

[RC3] The sea ice concentration (SIC) of 50% seems a bit arbitrary. The conventional sea ice studies used 15% to represent an ice free or open water region. I know this threshold value is probably too small for the months from June to August in this region. A better explanation of this would be valuable. For instance, how sensitive are the anomaly timing of sea ice retreat and the GAM results to this threshold? For instance, will SIC thresholds of 60% or 40% change the overall conclusion regarding the impact of early ice retreat on zooplankton abundance? Since ice retreat timing is very critical for the marine ecosystem, I would like to see figures showing spatial distribution of the climatological mean sea ice retreat date of 1991-2013 (one panel) and the anomaly of sea ice retreat at all sampling locations in 2007, 2008 and 2013 (similar to Figure 3 and 4 except color dots representing anomaly days).

[AR3] We appreciate for helpful comments. As you suggested, we made the climatological mean sea ice retreat date of 1991-2013 (Figure B1) and the anomaly of sea ice retreat at all sampling locations in 2007, 2008 and 2013 (Figure B2). Furthermore, we tried to reconstruct GAM using the anomaly of sea-ice retreat date (aTSR) with SIC thresholds of 10–50%. The definition of "non-ice-covered pixel" actually causes the absolute TSR, but calculating the anomaly of aTSR has less impact on the result of GAMs. The correlation charts with aTSR thresholds of 50 % and that of 10–40 % are shown in Figure B3. In addition, the smaller SIC thresholds (10–30%) sometimes lead to derive unrealistic TSR because of microwave contamination from lands in late season especially in the near-shore area. Using aTSR with 40% and 50%, sea-ice retreat date was slightly different depend on threshold. Because several outliers affect the result of GAM when we use the threshold of 40 %, we use the threshold of

50 % in this study. We are so sorry for lacking the description. We will add more explanation on revised manuscript.

[RC4] In Section 3.2 Copepods abundance, the authors should try to use statistical tests (e.g., ANOVA or T-test) to compare spatial and inter-annual differences in copepod abundance of three groups.

[AR4] We appreciate for helpful suggestion. I tried to use statistical test to compare spatial and inter-annual differences in copepod abundance of three groups. In our case, we did the non-parametric Kruskal-Wallis tests because the abundance of copepods of each group was not assumed its normality. The result of Kruskal-Wallis tests showed no inter-annual difference in sampling station, and the abundance of Arctic small copepods ($p > 0.5$). The abundance of Arctic large and Pacific copepods was different among years ($p < 0.001$). However, these differences in abundance of them could be regarded as the cause of habitat environment in each year because there were no inter-annual differences in the sampling stations, spatially.

[RC5] I had a really hard time in interpreting Figure 5 and consequently understanding Section 3.3 Habitats of copepods. In Section 2.3, the authors described that GAM used additive smoothing functions. But throughout the paper, the forms of smoothing functions for the explanatory variables were mystery to authors, which made the interpretations of functional responses of copepod abundance (i.e. independent variables) to explanatory variables in Figure 5 almost impossible. To me, the GAM here looked more like a black box and for the sake of best model fitting to the observation. This authors need to explain more thoroughly GAM underlying assumptions and result interpretations.

[AR5] We are sorry for not explaining well enough about Figure 5. In GAM, for instance in the Model of Arctic large copepods (Cop_{arc}-L, e.q. 1.1)

$$Cop_{arc}\text{-L} \sim s(aTSR)+s(PC1)+s(PC2)+s(PC3)+s(Chl.a_{UPP})+s(Chl.a_{BOT})+s(Bdepth) + \varepsilon \quad (1.1)$$

where aTSR, PC1–3, $Chl.a_{UPP}$, $Chl.a_{BOT}$, Bdepth are explanatory (independent) variables which affect the abundance of Cop_{arc}-L. s(XXX) is a smoothing function for each variable as similar role as a regression coefficient in a regression model. However, we

don not have a direct access to a mathematical expression because it is summarized the smooth function in several parts of scatter plot. In GAM plot, small circles show the standardized residuals where a constant term is ε. In Figure 5, the horizontal axes show the range of each independent variable and the vertical axes show the estimated smoother for them. The estimated smoother converts the explanatory variable to fit the models, so it shows positive effects for response variables and the magnitude of its effects when estimated smoother is positive, and vise versa. I will add this explanation on the figure description.
[RS-5] Figure 5. GAM plot of the best model in each copepod groups: large Arctic (Coparc-L), small Arctic (Coparc-S) and Pacific (Coppac) copepods. The horizontal axes show the explanatory variable: the anomaly of the timing of sea-ice retreat (aTSR), principal component score (PC1–3) averaged log-transformed chlorophyll *a* concentration within the layer above and below pycnocline, (Chl a_{UPP} and Chl a_{BOT}) and bottom depth (Bdepth). Shade area represents 95% confidence intervals. The vertical axes indicate the estimate smoother for the abundance of copepods. The estimated smoother converts the explanatory variable to fit the models, so it shows positive effects for response variables and the magnitude of its effects when estimated smoother is positive, and vise versa. Short vertical lines located on the *x* axes of each plot indicate the values at which observations were made.

[RC6] I am also interested to know whether early ice retreat (and ocean warming) could also allow *C. glacialis* to develop much faster in 2007 than in 2008 and 2013. Of course, such analysis requires other information on zooplankton biomass and stage composition, which were not included in this study and probably not lab analyzed.
[AR6] We appreciate for helpful suggestion. I am also interested to know the abundance and development of *C. glacialis* in response to earlier sea-ice retreat. The prediction of the abundance of *C. glacialis* response to only earlier sea-ice retreat might be possible. However, we don’t have the detailed information of zooplankton biomass and stage composition as referee a reviewed. Therefore, we are sorry that it is difficult to investigate the development of *C. glacilis* in response to much earlier sea ice retreat.

[RC7] The authors should proofread the paper to correct all typos. Just provide a few examples of typo corrections in bolded below:
Page 18672 Line-4: six water **masses** Page 18674 Line-7: accumulate more **lipids** Page 18674 Line-10: cold IMW and DW in **spring** Page 18674 Line-14: Pacific **zooplankton** Page 18675 Line-27: **A** plausible explanation
[AR7] We appreciate for indicating them. We are sorry for my misspelling. I will proofread the paper to correct typos.

Author's responses to anonymous referee #2.

We really appreciate for your thorough giving comments and helpful suggestion to our study by anonymous referee #2. As you pointed out, our results were obtained from 3-year dataset that includes 2-years (2007-2008) dataset used in Matsuno et al. (2011). Their result, however, mentioned year-to-year changes of mesozooplankon community and not to quantify relationships between the abundance of zooplankton and oceanographic features. We could show the possibility of increasing copepods with early sea-ice retreat quantitatively by using generalized additive models (GAM). Previous studies show the relationships between zooplankton community and water mass structure, however; most of them are presented using clustered water mass structure (Eisner et al., 2013; Ershova et al., 2015). It is difficult to integrate the clustered water mass into statistical models such as GAM. Therefore, we could quantitatively index water mass structure using principal component analysis. Integrating indexed water mass structure and sea-ice retreat timing into GAM, we could quantify the relationships between zooplankton abundance and environments in the northern Bering Sea and Chukchi Sea. Of course, our results support the previous published observations. These models could be developed to predict future zooplankton abundance. In this study, we couldn't find the depth where copepods much abundant because we use the abundance of copepods sampled using NORPAC net. Therefore, we assessed the abundance of copepods within whole water column and evaluate the relationships between their abundance and habitat. We use the water mass combination made by two-layered water column as one of the parameter presented the environment of habitat of copepods. As described below, I will revise our manuscript. RC, AR and

RS stand for Referees comment, Authors response and Revised sentence, respectively. In addition, I will change the abbreviations of large and small Arctic copepods (Cop_{arc} L and Cop_{arc}S) to $CopL_{arc}$ and $CopS_{arc}$, respectively. I carefully proofread English and revise the manuscript before the submission of the revised version.

Specific Comments:

1. Abstract

[RC1-1] could be made shorter. The description of the method is too detailed and the part on the T, S and chl a analysis should be skipped. The methods are standard and the data are ancillary anyway.

[AR1-1] Yes. I will delete the detailed description of the part on the T, S and chl*a* analysis. I will make abstract more shorter.

[RS1-1] The advection of warm Pacific water and the reduction in sea ice in the western Arctic Ocean may influence the abundance and distribution of copepods, a key component of food webs. To quantify the factors affecting the abundance of copepod in the northern Bering and Chukchi Seas, we constructed habitat models explaining the spatial patterns of large and small Arctic and Pacific copepods, separately. Copepods were sampled using NORPAC nets. The structures of water masses indexed by using principle component analysis scores, satellite-derived timing of sea ice retreat, bottom depth, and chlorophyll *a* concentration were integrated into generalized additive models as explanatory variables. The adequate models for all copepods exhibited clear continuous relationships between the abundance of copepods and the indexed water masses. Large Arctic copepods were abundant at stations where the bottom layer was saline; however they were scarce at stations where warm fresh water formed the upper layer. Small Arctic copepods were abundant at stations where the upper layer was warm and saline and the bottom layer was cold and highly saline. In contrast, Pacific copepods were abundant at stations where the Pacific-origin water mass was predominant (i.e. a warm, saline upper layer and saline and a highly saline bottom layer). All copepod groups showed a positive relationship with early sea ice retreat. Early sea ice retreat has been reported to cause spring blooms in open water, allowing copepods to utilize more food while maintaining their high activity in warm water without sea ice and cold water. This finding indicates that earlier sea ice retreat has positive effects on the abundance of all copepod groups in the northern Bering and Chukchi Seas, suggesting a change from a pelagic–benthic-type ecosystem to a pelagic–pelagic type.

[RC1-2] Line 3: remove “i.e”
[AR1-2] I will remove “i,e”.

[RC1-3] Line 7: replace “by” by “using”
[AR1-3] I will replace “by” by “using”.

[RC1-4] Line 8: remove “in the seawater”
[AR1-4] I will remove “in the sea water”. I will delete this part from abstract.

[RC1-5] Line 10: remove “the” before “satellite” and put an “s “ at “image”
[AR1-5] I will remove “the” before “satellite” and put an “s “ at “image”.

[AR1-6] Line 11: What is magnitude of pycnocline?
[AR1-6] We described the density gradient as magnitude of pycnocline. We revised this sentence.

[RS1-6] The depth of the maximum density gradient ($\frac{d\rho}{dD_{max}}$) was defined as the pycnocline of each sampled site.

[RC1-7] Line 23: remove “the” before “sea ice” and replace “at earlier timing” by “early”
[AR1-7] I will remove “the” before “sea ice” and replace “at earlier timing” by “early”.

[RC1-8] The Conclusion reaches too far considering the results that are limited to the shallow (<60 m) Bering and Chukchi Sea. In the deeper Arctic Ocean proper, other important copepods like *Calanus hyperboreus* and *Metridia longa* dominate zooplankton biomass.
[AR1-8] As you pointed out, we should not mention the conclusion about bottom

around this limited area, so this sentence will be deleted from the revised manuscript.

2. Introduction

[RC2-1] The message could be straighten up. This is a very long first paragraph to introduce the subject and it covers a lot of ground. I think that it would gain by being more focused on the topic of the study. First sentence should be rewritten.

[AR2-1] Thank you for your helpful comment. The first paragraph will be deleted and a part of it will be integrated with the second paragraph. The new paragraph will be divided it in two paragraphs

[RS2-1] Over the last decade, seasonal sea ice coverage appears to have changed dramatically in the northern Bering and Chukchi Seas (Comiso et al., 2008; Parkinson and Comiso, 2012), possibly because of an increase in the inflow of the Pacific water from the Bering Sea through the Bering Strait (Shimada et al., 2006). The Bering Strait is very shallow (<30 m) and has a gentle shelf extending to the Arctic Shelf break through the Chukchi Sea. This shallow shelf plays an important role in the Arctic in the shelf, the food webs are short and efficient, and even small changes in production pathways can affect organisms at higher trophic levels (Grebmeier et al., 2006). The recent change in sea ice melt timing contributes to stratification, nutrient trapping at the surface, and lower primary production with insufficient sunlight (Clement, 2004). In contrast, it has been suggested that the timing of the phytoplankton bloom has also altered (Kahru et al., 2011) and that its annual primary production has increased (Arrigo et al., 2008). Changes in the timing and location of primary production and associated grazing by zooplankton have a direct influence on the energy and material transfer to benthic community (Grebmeier et al., 2010).

In the Bering and Chukchi Seas, several water masses have been identified on the basis of salinity and temperature (Table 1). The water masses include the relatively warm/low-salinity Alaskan coastal water (ACW; temperature 2.0–13.0 °C and salinity <31.8) that originates from the eastern Bering Sea; the warm/saline Bering shelf water (BSW; 0.0–10.0 °C and 31.8–33.0) from the middle Bering shelf; and the cold/higher-salinity Anadyr water (AW; −1.0–1.5 °C and 32.3–33.3) originating from the Gulf of Anadyr at depth along the continental shelf of the Bering Sea. The BSW and AW merged to form the Bering Sea Anadyr water (BSAW; Coachman et al., 1975; Springer et al., 1989). In addition, cold/lower-salinity ice-melt water (IMW; <2.0 °C and <30.0) originates from sea ice, and colder/high-salinity dense water (DW; less than −1.0 °C and 32.0–33.0) forms in the previous winter during freezing of both the Bering and Chukchi Seas (Weingartner et al., 2013). These water masses often show vertical consistency both geographically and seasonally (Iken et al., 2010; Eisner et al., 2013; Weingartner et al., 2013).

[RC2-2] Line 5: "bloom" instead of "blooming".
[AR2-2] I will replace "blooming" "bloom".

[RC2-3] To me, formation of sea ice does not stabilize the water column but sea ice melt can contribute.
[AR2-3] Yes, as you indicted, sea ice melt can contribute stabilize the water column. We are sorry for my misuse of the term.

[RC2-4] Line 7: "progresses"? I don't get it.
[AR2-4] As you pointed out, "progress" might be wrong. However, I will delete this term along with the revision.

[RC2-5] Line 8: remove "the"
[AR2-5] I will remove "the".

[RC2-6] Line 10: "to" instead of "the" before "stratification", "nutrient trapping"
[AR2-6] I will add "to" and delete "the" before "stratification", "nutrient trapping".

[RC2-7] Line 12: remove "on" before "higher"
[AR2-7] I will remove "on" before "higher".

[RC2-8] Line 13: Remove "The" before "change"
[AR2-8] I will remove "The" before "change".

[RC2-9] Line 16: "to" after "leads"
[AR2-9] I will add "to" after "leads".

[RC2-10] Line 21: remove " been"
[AR2-10] I will remove "been" before "changed".

[RC2-11] Line 25: "relatively warm" instead of "warmer"
[AR2-11] I will use "relatively warm" instead of "warmer".

[RC2-12] Line 26: here and after put "oC" after the first range and not the second that relates to salinity. Otherwise 31.8-33.0 oC is indeed warm.
[AR2-12] We are sorry for my mistake. As you pointed out, I will modify them.

[RC2-13] Page 18664, line 1: remove "the" before "depth"
[AR2-13] I will remove "the" before "depth".

[RC2-14] Line 7: remove "the" before "both"
[AR2-14] I will remove "the" before "both".

[RC2-15] Line 13: "are" instead of "could be"
[AR2-15] I will use "are" instead of "could be".

[RC2-16] Line 17: the use of "quantify"? I wonder if "assess" would be better
[AR2-16] As you suggested, I will use "assess".

[RC2-17] Line 20: remove "sized" after "large" and after "small"
[AR2-17] I will remove "sized".

[RC2-18] Line 22: replace "distributed" by "abundant"
[AR2-18] I will replace "distributed" by "abundant".

[RC2-19] Line 23: "Metridia" instead of "Meridia". "Neocalanus" instead of "Neocalunus"
[AR2-19] We are sorry for my misspelling. I will modify "Meridia" to "Metridia" and "Neocalunus" to "Neocalanus".

[RC2-20] Line 26: the inflow is not always warm.

[AR2-20] As you pointed out, Pacific inflow is not always warm, so we will delete "warm".

[RC2-21] Line 27: sentence should be rewritten.

[AR2-21] As you suggested, I will rewrite the description.

[RC2-22] Page 18665, line 1: "their" instead of "its"

[AR2-22] I will use "their" instead of "its".

[RC2-23] Line 2: sentence should be rewritten for sake of clarity. Probably some redundancy with sentence at line 17 of previous page.

[AR2-23] As you pointed out, I will rewrite the sentence and delete line 17 of Page 18664.

[RS2-23] To predict these responses of copepods to the environmental changes from now on, it is important to quantitatively understand the spatial patterns of copepods and characteristics of their habitat.

[RC2-24] Line 7: The ship did not collect the data. Some parts of the last paragraph would probably fit better in the Materials and Methods.

[AR2-24] As you pointed out, the ship did not collect the data. We collected the data on the ship. We are sorry for my misuse. And, I will move the explanation of the survey methods to the section of Materials and Methods.

3. Materials and Methods

[RC3-1] Line 3: Again, it is not the ship by itself that conducted this sampling. "(1392t)" not useful.

[AR3-1] As you pointed out, the ship did not collect the data. I will delete "(1392t)".

[RC3-2] Line 10: "of" instead of "with"

[AR3-2] I will use "of" instead of "with".

[RC3-3] Line 12: “to” instead of “with”.
[AR3-3] I will use “to” instead of “with”.

[RC3-4] Line 12: “Depended on distribution, generation length and reproduction of copepods referred Falk-Petersen et al. (2009) and Dvoretsky and Dvoretsky (2009), and we summarized the copepods species into three groups :” This first part of the long is difficult to understand. It should be rewritten.
[AR3-4] Thank you for useful suggestion. As you pointed out, I will reconstruct and rewrite the sentence.
[RS3-4] Falk-Petersen et al. (2009) and Dvoretsky and Dvoretsky (2009) referred the characteristic of distribution, length of generation and reproduction of copepods. In accordance with these two references, we summarized the copepods species into three group:”

[RC3-5] Line 16: Here and after: “s” at “occur”. “Once” instead of “at one time”
[AR3-5] I will add “s” at “occur”, and use “Once” instead of “at one time”“

[RC3-6] Line 20: “using a” instead of “by”
[AR3-6] I will use “using” instead of “by”.

[RC3-7] Line 21: “Water samples for chlorophyll a were taken with:”
[AR3-7] I will modify.

[RC3-8] Line 24: “with” instead of “by”
[AR3-8] I will use “with” instead of “by”.

[RC3-9] Page 18667, Line 1: “obtained” instead of “calculated by using NASA Team
[AR3-9] I will use “obtained”.

[RC3-10] Page 18667, Line 11: “environmental variables” instead of “environments”
[AR3-10] I will use “environmental variables” instead of “environments”.

[RC3-11] Page 18667, Line 13: remove “them” after “defined”

[AR3-12] I will remove “them” after “defined”.

[RC3-12] Page 18667, Line 19: remove “Given”
[AR3-12] I will remove “Given”.

[RC3-13] Page 18667, Line 21: “their” instead of “its”
[AR3-13] I will use “their” instead of “its”.

[RC3-14] Page 18667, Line 25: “s” at “image”
[AR3-14] I will add “s”

[RC3-15] Page 18668, line 20: “verify” instead of “verifying”
[AR3-15] I will replace “verify” to “verifying”

[RC3-16] Page 18668, Line 22: “Explained deviance”?
[AR3-16] This is correct. “Deviance explained ” is index of fitting and calculated as follows:

(1- Residual Deviance/Null Deviance)*100

where Residual deviance indicates the deviance produced by the model that includes explanatory variables. Null deviance indicates the deviance produced by the model with out explanatory variable. If needed, I will add a short note on this Table.

4. Results
[RC4-1] Divide the long first sentences into 2 sentences.
[AR4-1] I will think more constructively about your suggestion.
[RS4-1]The first principal component (PC1) explained 47.1 % of the total variability. In the PC1 score, the coefficient of loading was positive for $\frac{d\rho}{dD}_{max}$, indicating that the magnitude of stratification increased with an increase in PC1. In contrast, PC1 was strongly negative for T_{UPP} and T_{BOT}, indicating that lower temperatures in the whole water mass resulted in smaller PC1 (Table 4).

[RC4-2] Page 18670, Line 10: “especially with”

[AR4-2] I will use “especially with”.

[RC4-3] Page 18670, Line 19: if *Calanus glacialis* is the only member of Coparc-L, why not keep its name instead of the less meaningful Coparc-L acronym?
[AR4-3] As you pointed out, the name *Calanus glacialis* might be used in manuscript. However, we have divided copepods thorough the perspective of life history, so we wanted to use “Large” for *C. glacialis*, which have 2-year lifetime.

[RC4-4] Page 18670, Line 20: “represented” instead of “occupied”. “of the total abundance” after “%”. “was” after “and”
[AR4-4] I will use “represented” instead of “occupied”, and add “of the total abundance” and “was” after “%” and “and”, respectively.

[RC4-5] Page 18670, Line 22: I guess Coparc-S included other taxa than Pseudocalanus? Then what would be the point of mentioning that Pseudocalanus was included into this group? Or did the authors mean to indicate that Pseudocalanus dominated this group?
[AR4-5] The taxa included in Cop_{arc}-S are shown in Table 2. In this table, Pseudocalanus includes “undefined Pseudocalanus taxa”, not indicating “the group dominated by Pseudocalanus”.

[RC4-6] Page 18671, Line 9: “s” at “stations”
[AR4-6] I will add “s” at “station”.

[RC4-7] Page 18671, Line 10: remove “the” after “where”
[AR4-7] I will remove “the” after “where”.

[RC4-8] Page 18671, Line 20: “ranging” instead of “ranged”
[AR4-8] I will use “raging” instead of “ranged”.

5. Discussion
[RC5-1] Subsection 4.1. I think it’s a mistake not to start the Discussion with selling the most compelling results of the study. As it is now, it does not entice the reader

interested in zooplankton distribution in the Bering-Chukchi region to read further. I would reshuffle altogether the information in this subsection of the Discussion to present it with the copepods distribution to describe in a more synthetic way their different habitat.

[AR5-1] Thank you for useful suggestion. As you pointed out, we will reconstruct Discussion and integrate this subsection with other two subsections.

[RC5-2] Subsection 4.2 Line 8: remove "were" after "species"

[AR5-2] I will remove "were" after "species"

[RC5-3] Line 11: "For example, large Arctic copepods (Coparc-L) were slightly abundant in the water with cold/lower salinity IMW at upper layer and the colder/high salinity DW in bottom layer corresponding to higher PC1 and low–medium PC2 and PC3, or cold/high–higher salinity BSAW and AW in both layer corresponding to medium PC1, medium–high PC2 and low–medium PC3." I find this sentence terribly difficult to understand. The authors should try to rework it and avoid jargons in the Discussion. In general I find this first paragraph hard to read.

[AR5-3] We are sorry for our lack of explanation. As you pointed out, we have to reconstruct our explanation about the interpretation to avoid jargons.

[RS5-3] $CopL_{arc}$ were relatively abundant in the northern part of the Chukchi Sea (>69°N), which is dominated by the water with cold/lower-salinity IMW in the upper layer and the colder/high-salinity DW in the bottom layer ($PC1 > 1$, $-1 < PC2 < -0.8$, and $-1 < PC3 < 0$; Figs. 3, 4). This combination of water masses positively affects the abundance of $CopL_{arc}$ (Fig. 5). *Calanus glacialis*, which represents $CopL_{arc}$ in this study, is considered to be native to Arctic shelves (Conover and Huutley, 1991; Ashujian et al. 2003). The Arctic population on *C. glacialis* is distributed in winter water (Ershova et al., 2015). Our results reflected these $CopL_{arc}$ habitats. Previous findings have reported that *C. glacialis* were also abundant in water masses with ACW in the upper layer and BSAW in the bottom layer (Eisner et al., 2013). In this study, $CopL_{arc}$ were relatively abundant in the Bering Strait, in areas dominated by cold/high to higher-salinity BSAW and AW in both layers ($-1.5 < PC1 <1$, $-0.8 < PC2 <1.2$, and $PC3 < -1$) in 2013.

[RC5-4] Line 16: "more abundant" instead of "concentrated"?

[AR5-4] I will use "more abundant" instead of "concentrated".

[RC5-5] Line 20: But then, where do we go once this is said?

[AR5-5] We are sorry for lacking disruption. *Calanus glacialis* which categorized as Cop_{arc}-L in this study has been reported that they are abundant in the water mass with ACW at the upper layer and BSAW at the bottom layer (Eisner et al. 2013). Although Cor_{arc}-L is abundant in the water mass with BSAW/AW, they are not abundant in the water mass with ACW in our study. Our result slightly contradicts previous study, however, the presence of BSAW/AW is important for Cop_{arc}-L. I add the description on the revised manuscript.

[RS5-5] Previous findings have reported that *C. glacialis* were also abundant in water masses with ACW in the upper layer and BSAW in the bottom layer (Eisner et al., 2013). In this study, $CopL_{arc}$ were relatively abundant in the Bering Strait, in areas dominated by cold/high to higher-salinity BSAW and AW in both layers ($-1.5 < PC1 < 1$, $-0.8 < PC2 < 1.2$, and $PC3 < -1$) in 2013. However, $CopL_{arc}$ in this study were less abundant in the water off Point Hope (southern part of the Chukchi Sea): this area was characterized by ACW in the upper layer and BSAW in the bottom layer ($-2.5 < PC1 < -1.5$ and $PC3 > 0$; Fig. 5) during the summer of 2007. Our results slightly contradict those of previous study; however, the presence of BSAW/AW is important for $CopL_{arc}$.

[RC5-6] Line 24: "salinity" instead of "saline"

[AR5-6] I will use "saline" instead of "salinity".

[RC5-7] Line 27: "Pseudocalanus" instead of "Pseudocalunus"

[AR5-7] We are sorry for my misspelling. I will modify it.

[RC5-8] Page 18674, line 9: "Falk-Petersen"

[AR5-8] We are sorry for my misspelling. I will modify it.

[RC5-9] Line 10: "spring" and not "pring"

[AR5-9] We are sorry for my misspelling. I will modify it.

[RC5-10] Line 12. Pseudocalanus might not be able to accumulate as much lipids as

Calanus but it can withstand the overwintering season in the high Arctic and it can feed on ice-algae (Hattori and Saito 1997). I don't think that the argument presented by the authors is valid if Pseudocalanus spp. dominate the Coparc-S. Or the species are subarctic but then they should not be considered as arctic.

Hattori, H., and H. Saito. 1997. Diel changes in vertical distribution and feeding activity of copepods in ice-covered Resolute Passage, Canadian Arctic, in spring 1992. J. Mar. Syst. 11: 205-219.

[AR5-10] We really appreciate for your thorough comments and helpful suggestion to this part of discussion. As you pointed out, Pseudocalanus feed on ice-algae and can accumulate lipids to withstand the overwintering season in the high Arctic area (Hattori and Saito 1997), so we change the discussion as follows;

[RS5-10] In this study, the $CopS_{arc}$ were dominated by *Pseudocalanus* such as *Pseudocalanus acuspes*, *P. mimus*, *P. minutus*, *P. newmani*, and undefined *Pseudocalanus* spp. (mean 72 % of $CopS_{arc}$ abundance). *Puseudocalanus* occurs throughout the Bering Sea shelf and Arctic area (Frost, 1989). This distribution is thought to result from *Pseudocalanus* being initially abundant in the warm water originating from the Bering Sea, and so is significantly abundant in the warm water masses such as ACW and BSW.

Frost BW (1989) A taxonomy of the marine calanoid copepod genus Pseudocalanus. Can J Zool 67:525–551

[RC5-11] Line 14: remove "s" from" zooplanktons"

[AR5-11] I will remove "s" from "zooplankton".

Subsection 4.3

[RC5-12] The first paragraph is too long and too far from the results of this study. Start by presenting the findings of your study before spending a lot of time on other things such as timing of blooms. Furthermore, this topic has already ben touched upon in the Introduction.

[AR5-12] We really appreciate for your thorough comments and helpful suggestion to this part of discussion. We will delete the first sentence and reconstruct the paragraph. Please check the discussion part.

[RC5-13] Page 18675, line 22: The lack of strong relationship between abundance of small copepods and phytoplankton may also be due to the fact that the coarse net (>300 μm) used does not sample quantitatively the young copepodite stages.
[AR5-13] As you pointed out, the young copepodite stages were suspected not to be sampled quantitatively by using the coarse net (> 300μm) such as NORPAC net used for our sampling. Therefore, we add the short note about it on the discussion part.

[RC5-14] Page 18676, line 2: "Falk-Petersen"
[AR5-14] We are sorry for my misspelling. I will modify it.

[RC5-15] Line 16: "shallower" and not "sallower".
[AR5-15] We are sorry for my misspelling. I will modify it.

[RC5-16] It is difficult to gauge the argument presented here because the authors don't give the minimum salinity in the shallower areas or the total copepod abundances. To some extent in deeper areas, there are more niches and thus more zooplankton.
[AR5-16] As you pointed out, it is difficult to lead our discussion from our result. As we mentioned in manuscript, it is the fact that the sampling stations near the land have relatively low salinity ($\rho = 0.53$, spearman's lank correlation test in S_{UPP} vs. Bdepth $p < 0.01$). The low salinity area, however, was located not only near the land also near sea-ice. Therefore, it is not enough to explain the reason why copepods are less abundant at shallower area. In this survey, because shallower area correlated with longitude ($\rho = -0.73$ spearman's lank correlation test in longitude (^{o}E) vs. Bdepth $p < 0.001$), the result was simply interpreted that copepods less abundant near the land. As shown in Figure 5, the least number of copepods are recorded at sampling station of 25 m Bdepth. Except for these two stations, Cop_{arc}-L is not so much related to Bdepth, while Cop_{pac} and Cop_{arc}-S is gradually increasing with depth. We will change the discussion.
[RS5-16] In this survey, because the shallower area is correlated with longitude ($\rho = -0.73$; Spearman's rank correlation test of longitude (°E) vs. Bdepth, $p < 0.001$), the

result reflects that copepods are less abundant near the land. As shown in Figure 5, the smallest numbers of copepods were recorded at sampling stations of 25 m Bdepth. Except for these two stations, $CopL_{arc}$ is not obviously related to Bdepth, whereas Cop_{pac} and $CopS_{arc}$ gradually increase with depth.

[RC5-17] Line 19: remove " and its communities". "has" instead of "have"
[AR5-17] I will remove "and its communities" and replace "have" "has".

Figure captions

Figure 1. Study area and sampling stations in the northern Bering Sea and Chukchi Sea during the summers of 2007, 2008 and 2013. The symbols denote the sampling stations where NORPAC net and CTD water samplings were conducted. The color scale indicates bottom water depth (m). Modified from figure presented in Spall et al. (2014) and Grebmeier et al. (2015).

Figure A1. Maximum density gradient (10^{-3} kg m^{-1}) at each sampling station.

Figure A2. Horizontal distributions of temperature (°C) averaged within the upper (T_{UPP}, top panels) and the bottom (T_{BOT}, bottom panels) layers at each sampling station in 2007 (left panels), 2008 (middle panels) and 2013 (right panels).

Figure A3. Same as figure A2 but for salinity (S_{UPP} and S_{BOT}).

Figure A4. Same as figure A2 but for Chlorophyll-*a* concentration ($Chla_{UPP}$ and $Chla_{BOT}$).

Figure B1. Climatological mean sea ice retreat date of 1991-2013.

Figure B2. The anomaly of sea ice retreat at all sampling locations in 2007, 2008 and 2013 based on daily passive microwave sea ice concentrations using a threshold of 40%.

Figure B3. Correlation charts of with aTSR thresholds of 50 % vs. 0–40 %.