**Response to Editor**

We appreciate the opportunity to respond to the thoughtful comments and suggestions raised by the reviewers. We have discussed these and have included these in the manuscript where appropriate. In general we agree with the overarching thought of Reviewer 1, which was to further reduce the scope of this manuscript by omitting the inclusion of the physical-biological coupling from our results, yet retain this in the discussion. Reviewer 3 had many helpful suggestions, but we respectfully disagree with their suggestion to replace key figures in the text with figures from the previous version of the manuscript. Based on the time frame left for this special issue we prefer to remove figures 9 and 10 but retain all other figures.

Our treatment of how we dealt with all comments and suggestion is detailed below. Items in *italics* are reviewer comments, and items in **bold** are our treatment of these comments. Again, we appreciate the tame and patience of all reviewers as well as the Guest Editors of this special issue.

Minor revisions:

*Title*

*Reviewer #3 requested a change to Northeast Pacific. I am happy with leaving it as North Pacific if you add “along 158° W” after 2008-2011.*

**We have added “along 158°W” to the title as suggested.**

*Abstract*

*“derive” appears too frequently in the first few sentences.*

**We changed the first instance of “derive” to “estimate,” and removed the next two instances of the word “derive.”**

*In the last sentence “assist in our continued understanding” .....can you explain what this really means?*

**Changed sentence from:**

**“**

**Continued in-situ and remote monitoring will assist in our continued understanding of biological variability in this important ecological region.”**

**TO:**

**“Continued in-situ and remote monitoring, specifically during El Niño and ENSO neutral phases, will provide additional ecological information to help understand mechanistic causes of phytoplankton variability in this important ecological region.”**

*Introduction*

*Page 3, Line 10. How about “This zone serves as a key migratory route and foraging ground for...”*

**We changed this line from:**

**“This zone has high ecological importance, serving as key migratory and forage grounds for”**

**to:**

**“This zone serves as a key migratory route and foraging ground for…”**

*Page 3, Line 19: How 'bout dropping “high” as it still leaves the reader with the same meaning.*

**We removed the word “high” as suggested.**

*Page 3, Line 56. Insert 'pattern' after (SLP)*

**Inserted the word “pattern” as suggested.**

*Page 4, Line 7. This sentence talks about “driving” convergence frontal areas 'southward'. Perhaps you need to tell readers which are convergent fronts; are the STF and TZCF convergent fronts. Presumably, the location of the boundary between the Subtropical Gyre and the Subarctic Gyre does not vary by 1000 km beneath the mixed layer. You may want to note that you are discussing only the surface layer.*

**Sentence changed to clarify TZCF and upper water column. Sentence changed from:**

**“Increased wind forcing during winter drives the convergent frontal areas south, leading to annual meridional displacements of up to 1,000 km from the northern maximum…”**

**To:**

**“Increased wind forcing during winter drives the convergent TZCF south, leading to annual meridional upper water column displacements of up to 1,000 km from the northern maximum…”**

*Page 4, Line 31. 'variability' rather than 'changes'*

**Changed to variability as suggested**

*Methods*

*Page 5, Line 32. I found myself wondering why you've chosen 17-18C when previous authors has picked a single isotherm?*

**Hi Skip, the range was chosen to ensure that at least a few stations could be used analysis and that we didn’t end up with n=1. As 17°C and 18°C have both been used to represent the STF I took the range.**

*Page 6, last line. If you just said linear regression, or OLS linear regression, I think people would get it.*

*I have no idea what model I regression is.*

**I actually pulled this from Seki et al. 2002 for continuity in methodologies since at first we were using the same data, but since that’s now different I changed the sentence from:**

**“Laboratory-measured chloropigment concentrations were used to correct in situ chloropigment using a model I least squares linear regression (r2=0.72, (Laws, 1997))”**

**to:**

**“Laboratory-measured chloropigment concentrations were used to correct in situ chloropigment using linear regression (r2=0.72)”**

*Page 7, line 1. I'm sure that Laws isn't the originator of the linear regression....seems like something that Karl Peterson or Ronald Fisher would have invented, but unless you've done something unusual, I'd drop the reference.*

**Mike was referencing a book by Ed Laws describing laboratory methods. At least we don’t have to go back to “Student” for a T-Test anywhere. I removed this while addressing the above comment.**

*Page 7, line 56. Throughout the document, the curved apostrophe character is not the correct character. I think it should look more like the minute symbol ( ' ).*

**This was an annoying Word thing. I finally just used an equation to make it the right prime.**

*Page 8, line 9. There is only 1 equation so drop the plural.*

**Done.**

*Results*

*Page 9, line 15. 'remained stratified' seemed like an unusual expression because the figure indicates that upper part of the water column (< 100m) is entirely unstratified.*

**Good catch, yes I mean well-mixed, unstratified, homogenous…**

*Page 9, line 18. 'apparently' isn't really needed.*

**Removed**

*Page 9, line 39. I had trouble with the idea of a gradual thermocline. Perhaps try “lowest rate of change with depth” or something like that.*

**Changed sentence from:**

**“The shallowest mixed layer and gradual thermocline was in 2008, while the steepest thermocline and deepest mixed layer of all years was in 2009 (Fig. 3a).”**

**to:**

**“The shallowest mixed layer and lowest rate of change was in 2008, while the strongest thermocline and deepest mixed layer of all years was in 2009 (Fig. 3a).”**

*Page 9, line 50. CTD-based fluorescence is a difficult thing to wrap one's brain around because it has nothing to do with conductivity or temperature. Why not just say “The fluorescence profiles...”*

**Removed CTD-based as suggested**

*Page 9, line 57. I saw no correlation so change “correlated to” to “corresponded with”*

**Change “correlated to” to “corresponded with”**

*Page 10, line 25. change the order of 'equally' and 'comprised'*

**Changed order of equally and comprised**

*Page 10, line 37, put dominate in the past tense.*

**Put dominated in past tense**

*Page 10, line 54. I found myself comparing your text with the figure. The latter does not show the DCM so it is difficult to make the connection; perhaps the figure should indicate the DCM.*

**Hi Skip, we’re defining the DCM here as the peak in the chlorophyll at depth, so this should be implicit in the figure. Steven and I discussed and feel it’s ok as written, but if you disagree we can revisit. Thanks, Evan**

*Page 13, line 7. Please indicate what the response (dependent) variable is in the ANOVA.*

**Changed to reflect the integrated chlorophyll-*a* as the response variable. Paragraph changed from:**

**“Results from the 3-way analysis of variance indicate that there is a statistically significant difference amongst the three size classes between the two frontal zones, as well as the interaction between them (3-way ANOVA: p < 0.001 for PSC group, p = 0.03 for frontal zone group, p = 0.02 for PSC x zone interaction; Table 3). This relationship can be seen when comparing the mean integrated PSC concentrations by zone (Fig.8). Overall the PSC is different between the two frontal areas, with on average twice the density of microphytoplankton and nanophytoplankton over picophytoplankton persisting through time in the TZCF.”**

**To:**

**“Results from the 3-way analysis of variance indicate that there is a statistically significant difference in integrated chlorophyll-a amongst the three size classes between the two frontal zones, as well as the interaction between them (3-way ANOVA: p < 0.001 for PSC group, p = 0.03 for frontal zone group, p = 0.02 for PSC x zone interaction; Table 3). This relationship can be seen when comparing the mean integrated chlorophyll-a concentrations for PSC by zone (Fig.8). Overall the PSC concentrations are different between the two frontal areas, with on average twice the density of microphytoplankton and nanophytoplankton over picophytoplankton persisting through time in the TZCF.”**

*Discussion*

*Observed variability in phytoplankton concentration.....This title does not really match what you discuss.*

**Removed the word concentration from subheading. Subheading now reads: “Observed variability in phytoplankton”**

*Page 14, line 11. You don't really know the species composition. Perhaps 'taxonomic' composition is safer.*

**Changed “species composition” to “phytoplankton composition”**

*Page 14, line 13. Twice is an exact quantity. Change to 'approximately twice'*

**Added the word approximately before “twice”**

*Page 15, line 15. change to 'there was no significant difference ....' and clarify whether it applied to both fronts.*

**Changed sentence from:**

**“However, there was not an observed significant difference in phytoplankton composition between the study years”**

**TO:**

**“However, there was no significant difference in phytoplankton composition between the study years within either the STF or TZCF”**

*Page 15, line 18. Delete 'In terms of phytoplankton'*

**Deleted**

*Page 15, line 28. It's difficult to imagine that 18C is 'cold'. This long sentence had me befuddled. At the start of the sentence, it says “delineation has been reported in previous studies', but then it talks about the delineation being not explicitly stated. Help me out here.*

**Changed from:**

**“This delineation has been reported in previous studies either on the cold side of the STF (Leonard et al., 2001; Seki et al., 2002), or at the TZCF (Karl et al., 2001; Juranek et al., 2012), yet previously the delineation in phytoplankton communities at the STF and TZCF was not explicitly stated.”**

**To:**

**“This delineation has been reported in previous studies either on the northern side of the STF (Leonard et al., 2001; Seki et al., 2002), or at the TZCF (Karl et al., 2001; Juranek et al., 2012).”**

*Page 14, line 43. What is phytoplankton 'activity'?*

**Changed from:**

**“…showed that eukaryotic phytoplankton activity…”**

**To:**

**“showed that eukaryotic phytoplankton production…”**

*Page 14, line 58. Reviewer 3 commented on the 2009 results and you responded, but I don't recall seeing your point discussed.*

**Please see our comment regarding 2009 observations below (\*)**

*Page 15, line 21. change to 'relatively productive' because someone studying coastal waters of North America wouldn't agree that it is a 'productive' region.*

**Changed to “relatively productive”**

*Page 15, line 30. 'impacts' on what?*

**We do feel that the next sentence describes what is impacted ecologically, and are hesitant to add more here as we fear it would be redundant.**

*Page 15, line 35. Just 1 albatross species? If so, say Laysan albatross.*

**Changed to Laysan albatross**

*Page 15, lines 38-40. Change 'was shown to positively influence' to 'has a positive influence on....'*

**Changed line from: “For example, a more southerly TZCF was shown to positively influence the survival of juvenile Hawaiian monk seals in the Northwestern Hawaiian Islands.”**

**To:**

**“For example, a more southerly TZCF has a positive influence on the survival of juvenile Hawaiian monk seals in the Northwestern Hawaiian Islands”**

*Page 15, line 40. Does Northwestern warrant a capital letter?*

**We do capitalize Northwestern in Northwestern Hawaiian Islands (NWHI)**

*Page 15, line 42. Delete 'described'*

**Deleted**

*Page 15, last line. The common name is 'Hawaiian monk seal'*

**Changed from “monk seals” to “Hawaiian monk seals”**

*Page 16, first line. Delete 'still'*

**Deleted**

*Page 16, line 19. change 'feed on prey aggregation areas such as' to 'feed on aggregations of prey at locations such as'*

**Changed from:**

**“…during their brooding period to feed on prey aggregation areas such as the TZCF…”**

**To:**

**“…during their brooding period to feed on aggregations of prey at locations such as the TZCF…”**

*Page 16, line 29. Please clarify what you mean when you say that an elephant seal or a pelagic fishery is geographically fixed. Both roam widely.*

**Changed language to clarify that “geographically fixed” referred to a fixed home base (land for birds, ports for fishing vessels). Sentence changed from:**

**“…but may affect other geographically fixed predators such as elephant seals or pelagic fisheries.”**

**To:**

**“…but may affect other predators such as elephant seals or pelagic fisheries that have a geographically fixed home location.”**

*Climate variability and potential impacts on the TZCF*

*The field work occurred in March of 2008, 2009, and 2011 so presumably, these years were affected by the winters that immediately preceded them. You chose an interesting time to be out there. My own Aleutian Low Integral Index (DJF) indicates that 2009 and 2011 were the weakest and third weakest winter AL in the record since 1949; 2008 was near the long-term average. 2010 was the 11th strongest (typical of an elnino year) but you weren't out then. I suppose this has some bearing on your ability to generalize your findings.*

**Yes, we missed 2010, much to our chagrin. That was the year the Sette was in the Marianas for the field season. On the bright side, the Sette is returning from the area today, so we hope that the data can help us understand more mechanistically.**

*Your Fig. 2 shows that the location of the TZCF was more similar in 2008 and 2009 than in 2011...which is a puzzle when you consider the state of the AL. The Ayers-Lozier hypothesis would have 2008 as the southernmost location (because the AL was stronger) and 2009 and 2011 as the northernmost locations. Surprisingly, your Fig. 2A indicates that 2009 had the most uniform temperature from surface to thermocline, which suggests more wind in 2009 (to generate the uniform T in the ML) than in 2008 or 2011. Anyway, there seem to be a few inconsistencies that need attention, especially where you are providing strong support for Ayers-Lozier.*

**We agree that the Ayers-Lozier horizontal mechanism doesn’t cleanly explain everything, and agree that 2009 was an anomalous year with a weak Aleutian Low and low winds. An evaluation of OSCAR surface currents (not shown) revealed the southward transport to be extremely weak. We do, in fact, see the TZCF at a higher latitude in 2009 than the other years (Fig. 2d), as would be expected by Ayers-Lozier. Yet when we look at SSH it’s not quite consistent with the wind patterns. That, coupled with the homogeneity and colder water column further north that the other two years in 2009 leads us to think that some combination of horizontal and vertical forcing is at play here. We’ve added the following text to the Climate variability and potential impacts on the TZCF section of the discussion, starting after the sentence “Additionally, recent work by (Whitney, 2015) showed that anomalously high winter winds from the south constrained the TZCF in the eastern Pacific further to the north in 2014.”**

**New:**

**“However, this horizontal mechanism alone does not fully explain the anomalous values observed in 2009. During that year, the Aleutian Low was weaker than average, with a weaker wind field and decreased southern flow observed in analysis of OSCAR surface currents (not shown). The appearance of the TZCF at higher latitudes is consistent with the Ayers-Lozier hypothesis, yet the homogenous upper water column in 2009 may also suggest a vertical influence on the area as well as a decrease in mesoscale eddy variability. Qiu and Chen (2011) observed quasi-decadal sea surface height (SSH) variability in the central North Pacific covering our study area, and theorized that this was caused by westward propagation of Rossby waves generated from wind stress curl in the eastern North Pacific. This variability would lead to changes in the SSH field resulting in vertical shifts of the thermocline and nutricline in this area (Polovina, this issue). Therefore it follows that it is a coupling of vertical and horizontal mechanisms that cause variability in the position of the TZCF.”**

*The last pp. could use some work as it seems a bit too general at the moment. I suggest that you not recommend ongoing monitoring in the hope that some greater understanding will arrive (sentence 2).*

*I'd rather see some new questions that arise from your work, such as the ENSO phase focus you mentioned, but also how you might go about testing them. If you agree with my interpretation of how unusual 2009 and 2011 were, the first thing to do might be to conduct more monitoring during less extreme years (or pick some contrasting high AL years).*

**We have changed the last line of the discussion to**

**From:**

**“Additional transects, including sampling during climate events such as different ENSO phases, would fill in information that was not captured during this study period as well as confirm or augment the results of this study. Overall, continued oceanographic research in this region, especially during El Niño or ENSO neutral years, coupled with additional ecosystem monitoring and modeling studies is necessary to continue to advance our understanding of how these physical changes may impact ecosystem dynamics.”**

**To:**

**“However, questions remain concerning the roles of horizontal and vertical advection on phytoplankton at these fonts, as well as how these mechanisms may change within different climate phases. Continued physical and biological oceanographic sampling along the 158°W transect, specifically sampling during El Niño or ENSO neutral phases, would provide more information to help address these questions regarding phytoplankton variability at these ecologically important North Pacific frontal regions.”**

*Acknowledgements*

*You don't put editors in this list.*

**Removed acknowledgement to editor**

*References*

*The current guide for authors is at*

*http://www.elsevier.com/journals/progress-in-oceanography/0079-6611/guide-for-authors#20300*

*...and you haven't followed it. Please fix that.*

**Fixed according to PiO style.**

*In addition:*

*Ayers and Lozier is incomplete,*

**Added JGR Page identifier.**

*Chiba et al. The title should be in sentence case.*

**Fixed**

*You use a mix of full journal names and abbreviations throughout.*

**Fixed**

*Polovina et al. 2004 has an odd mix of alpha-characters at the end of the author list.*

**Fixed**

*Polovina et al. 2008 doesn't appear in the text...and I couldn't find Vazquez et al. 1998.*

**Removed, possibly a track changes remnant? Both were no longer there when I checked.**

*Figure captions*

*Fig. 2. There is a discrepancy between the caption and what appears in the text of the paper. This seems to be leftover from a reviewer's comment on the same topic. In the latter, you define a boundary by a range of T or a range of Chl-a. To apply these boundaries to the figure, you could simply select a different colour (e.g. yellow) to indicate the interval between the upper and lower limits of the boundary. The red boxes include temperatures and chlorophyll concentrations that are beyond the bounds you have defined.*

**The main issue is that we chose the areas based on the actual profiles, and the transects were created from the profiles for a visual cue. The colors are a good idea but also somewhat misleading as we used the 0-20 m average to choose the stations. I realize that this was not in the methods and therefore added that in to the methods**

**“As we were interested in understanding whether this physical-biological relationship occurred within our study region we defined the main temperature frontal region (hereafter STF) as the region between the surface expression (0-20 m) of the 17°-18°C isotherms. The main biological frontal region (hereafter TZCF) was defined as the spatial region between the surface expression (0-20 m) of the 0.15-0.25 mg m-3 chlorophyll-a isopleths and containing at least three contiguous stations.”**

**We also added a red arrow to the central location of each front and changed the last sentence of the figure caption to read:**

**“Red arrows represent the approximate central location of the frontal zones.”**

*Fig. 3. Last sentence. Perhaps add “in all panels” somewhere if it is true.*

**Sentence changed from:**

**“Horizontal dashed lines represent the depth of the nutricline for each year.”**

**To:**

**“Horizontal dashed lines in all panels represent the depth of the nutricline for each year.”**

*Tables*

*Table 1 has a bunch of invariant information (Lat, Long, transect length). I suggest that you put that information in the caption and delete these columns from the table.*

**Caption changed to add the sentences:**

**“All transects were from 26°-36°N along 158°W. Frontal positions were determined using CTD profile data.”**

*Table 2 – prymnesiophytes is spelled incorrectly.*

**Fixed spelling**

*Table 3 – In the caption, can you clarify the difference between PSC concentration (the response variable) and PSC (factor in the ANOVA).*

**Changed caption to clarify chlorophyll-a as response variable. Caption now reads:**

**“Table 3. Results of the analysis of integrated chlorophyll-a concentration using a 3-way ANOVA. Bold denotes significant results.”**

*Figures*

*Fig. 4 and Fig. 5. '-3' needs to be a superscript on the abscissa(s).*

**Bizarre, they are superscript in my Illustrator files but I see they aren’t in the PDF… At any rate I double checked and they are superscripts. Thank you for heads up though.**

*Fig. 6 – The figure legend uses a combination of capital letters and small letters. This differs from how they are written in Fig. 4. Please use a consistent approach (Fig. 8 too).*

**Fixed legends for figures 6-8 to read “Integrated chlorophyll-a…”**

*Fig. 8 – Has 'Zone' capitalized with no 1- or 2- on the abscissa, whereas Fig. 6 and 7 has 'zone' and 1- and 2- on all legends. Needs consistency. My version also had Figure 8 in bold across the top left corner of the image...maybe a pdf-printer thing but maybe not.*

**Changed all to “Zone” and “STF” and “TZCF”. Yes “Figure 8” was automatically generated when they made the PDF and isn’t in the original image. Again, thanks for pointing out though.**