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Biogeosciences Discussions

Interactive comment on "Foraging segregation of two congeneric diving seabird species (common and thick-billed murres) breeding on St. George Island, Bering Sea" *by* N. Kokubun et al.

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Dear Editor and Reviewers,

We would like to submit our final response to the reviewer's comments on our manuscript entitled "Foraging segregation of two congeneric diving seabird species (common and thick-billed murres) breeding on St. George Island, Bering Sea" by Nobuo Kokubun, Takashi Yamamoto, Nobuhiko Sato, Yutaka Watanuki, Alexis Will, Alexander S. Kitaysky and Akinori Takahashi. At first, we would like to draw your attention that we hope to change the title to "Foraging segregation of two congeneric diving seabird species breeding on St. George Island, Bering Sea " for simplification. We

apologize that the submission became late. We hope that the paper will be considered suitable for further revision, as a research article in the special issue "Catastrophic reduction of sea ice in the Arctic Ocean – its impact on the marine organisms and ecosystems in the polar region" in Biogeosciences.

Sincerely yours, Nobuo Kokubun

RESPONSE TO THE REVIEWERS

We are grateful to Prof. George Hunt and Dr. David Ainley for their helpful comments and suggestions. We would like to express our thanks to them in the acknowledgements. We showed our response to the reviewers by the marks "REPLY", right after original messages.

Prof. Hunt G. L. Jr.

General Comment Kokubun et al examine ecological segregation of two closely related seabirds by providing a thorough analysis of their diving behavior. They find that the common murre, with smaller wings, was more agile underwater and brought larger fish to its young than the thick-billed murre, with larger wings and a heavier body. Prey choice resulted in common murres foraging at a higher trophic level than thick-billed murres. They suggest that the greater underwater agility of common murres allows them to be more flexible in the marine habitats that they inhabit. The paper has two themes, neither of which is developed in much depth. On the one hand is ecological segregation, a concept that two species cannot inhabit the same ecological niche. The second theme is that climate change will challenge species to be flexible in their behaviors as new opportunities emerge and old resources decline. The first theme is investigated thoroughly using recording devices that document the details of underwater behavior of the birds, and stable isotope analyses to document differences in trophic levels. The methods used here are state of the art, and the results are compelling. Fig. 2 is particularly effective in showing the diving behavior over the daily cycle, whereas Fig. 3 shows how the dives of the two species differed. In the diet analyses, it was good

to have observations of foods brought to chicks as well stable isotope analyses of red blood cells from adult birds that provide an indication of foods used by the adults. That said, they do not place their results in the broader context of where this field has gone. The discussion of the relevance of the differences in foraging behavior to adaptability to climate change seemed to be an afterthought tacked on at the end. This theme of the paper is probably of more general interest than the ecological segregation analysis, as many people are interested in predicting which species will be winners or losers in a world with a warming climate. I would have liked to see this theme developed in the Introduction, with the aim of exploring the characteristics that might improve adaptability and then asking if one of the two murre species was likely to thrive more that the other. For advancing this theme, it would have been valuable to: 1) describe the observation that common murres cope with environmental variability better than thick-billed murres; 2) evaluate how the eastern Bering Sea ecosystem responds to years with late ice retreat and warm water temperatures and how the prey field likely available to the murres would change; and 3) hypothesize that the common murres are more flexible in their foraging because they can dive deeper, turn faster, and take a wider size range of fish.

REPLY We are very grateful for the helpful comments provided by Prof. George Hunt. We recognize that we do not have enough evidence for evaluating how foraging COMU and TBMU respond to changes in Bering Sea ecosystem due to limited data from only one field season. According to the suggestions, we would like to modify the introduction and mention what was our initial expectation about inter-specific difference in foraging behavior between COMU and TBMU deduced from previous literature. We also would like to develop the discussion on implications of our results (despite limited) about how inter-specific difference in foraging behavior relates to response to environmental changes in the southeastern Bering Sea.

Specific comments: Abstract- There is a big jump from the first sentence on environmental change to the second on what you did to look at murre foraging behavior. Do

you have ideas about what changes are expected and what impacts they might have on predators?

REPLY We would like to modify the first sentence to relate foraging behavior, food resources and response to environmental changes.

Page 18153, line 22-24: What are the differences in the responses of these two species to long term changes, or do you mean predict how they might respond? I think that you can do a better job of setting up the question and/or hypotheses up front, and then telling us what to do and what you found. It would then be good to finish off with your take on why this research is important and/or your predictions.

REPLY We consider that we can not provide a clear hypothesis on long term changes in population trends of both species due to limited information available, nevertheless we would like to modify the related sentences in first and last paragraphs of Introduction.

Page 18154, line 2: There are more recent USFWS reports.

REPLY We will add the reference (Dargoo et al., 2015).

Page 18154, line 6: Add Hunt et al., 2011

REPLY We will add the reference.

Page 18154, line 14: Is this driven by ocean temperature directly, or by something that ocean temperature affects?

REPLY Based on the range-wide comparison of COMU and TBMU, Irons et al. (2008) suggested that this reflects importance of bottom-up effects of climate variability. We would like to add this explanation.

Page 18154, lines around line 25: There are several Hunt group papers that deal with prey difference in the two murres at St. Paul and St. George Islands. Also, the nest sites preferred by the two murre species are quite different.

REPLY We will add the references (Hunt et al., 1981a; Squibb and Hunt, 1983).

Page 18155, line 7: Again, cite papers on murre prey use at the Pribilof Islands.

REPLY We will add the reference (Hunt et al., 1981a).

Page 18155, line 25 - 27: Can you propose this as a hypothesis?

REPLY We would like to modify the last section of Introduction to provide what was our initial expectation about inter-specific difference in foraging behavior.

Page 18157, line 14: ? should this be mËĘ-2?? I am not sure.

REPLY m-2 is correct, as Prof. Hunt pointed out. We will modify.

Page 18158, lines 4-7: Why put mention of the GPS data in if it was not the focus?

REPLY We will remove the part “The regression analyses using GPS track was not the main focus of this study, thus“.

Page 18159, line 21: delete “following”

REPLY We will correct as Prof. Hunt suggested.

Page 18160, lines 19-23: In thinking about enrichment values, 13 C values vary on and off the shelf, and with rates of primary production. Also, in summer, micro-zooplankton play a very important trophic role and can bounce 15N values up by a trophic level. If all of your murre samples were collected in the same year and at about the same date, this should not be a problem, but it is something to think about in evaluating your enrichment results.

REPLY We recognize that prey stable isotope signatures may vary spatially (Jones et al., 2014; between on-shelf and off-shelf regions in the Bering Sea) and/or temporally (among years). However, we are primarily interested in comparing COMU and TBMU diets within the same season at the same breeding location, and thus use these source values as a proxy to compare the relative trophic position and obtain insights on po-

tential inter-specific differences in prey composition (e.g. Fig. 6). We would like to add these consideration.

Page 18163, line 13 - 23: Did you expect to find differences, and if so, why?

REPLY We would like to add purpose of these analyses in Introduction with relating references (Kinder et al., 1983; Coachman 1986; Takahashi et al., 2008).

Page 18164, line 2: fewer rather than “less”

REPLY We will correct as Prof. Hunt suggested.

Page 18164, line 14: Did you expect to find differences? This would make a difference between a one-tailed and a two-tailed test. What about using AIC methods to identify the dive characteristics that may differ most between species?

REPLY We used two-tailed test throughout the paper, because we did not have prior expectations which sex has larger or smaller values. We did not present the AIC value of each model to make the manuscript concise, but AIC was lowest when only the term ‘species’ was included (when significant inter-specific difference was detected).

Page 18165, line 13: When murres are bringing back meso-zooplankton (and maybe squid), higher quality prey may be scarce. Historical data might show whether, in years when squid were common in murre diets, growth rates of young were lower.

REPLY We are grateful to the suggestion. We would like to add a reference regarding it in the discussion (Renner et al., 2014).

Page 19165, line 21: Because of, not “according to”

REPLY We will correct as Prof. Hunt suggested.

Page 18166, lines 5 – 11: why look at CORT? Did you expect one of the murres to be working harder to feed its young? I do not recall you mentioning stress or CORT in either the Abstract or the Introduction.

REPLY We would like to add brief explanation about stress hormone analyses, in Abstract and Introduction.

Page 18166, line 14 – 16: Why do you conclude that they use similar foraging areas? One could be going off the shelf and the other toward the middle shelf.

REPLY Both species used similar thermal environments at sea, with no significant inter-specific differences in SST, temperature at depth, thermocline depth and intensity (Fig. 1). Thus the two species appeared to forage in similar stratified water masses, presumably in the middle- or outer shelf domains around St. George Is. (Kinder et al, 1983; Takahashi et al., 2008). We would like to add these explanation.

Page 18166, line 19: How did you determine their ages?

REPLY This was estimated from SIAR models. We would like to add the explanation.

Page 18166, line 24: Why? I am a bit confused by this whole sentence. Could thick-billed murres be switching more to fish when in the chick-rearing period? What do you mean by isotopic distance? Between what and what?

REPLY Sorry for the confusing description. We would like to provide detailed explanation based on Barger et al. (2016).

Page 18167, line 6: Can you test this with your data?

REPLY We could not test this with our data, due to the lack of simultaneous records of feeding events.

Page 18168, line 10-13: There is an old Hunt et al. paper that discusses the impact of living in a larger colony.

REPLY We will add the reference (Hunt et al., 1986).

Page 18169, lines 18- 29 and top page 18170: This is really the first that you have brought this up. If prey niche breadth and foraging behavior breadth are tied to better

performance in a variable climate or a poor one, then highlight this in the Introduction as an hypothesis.

REPLY We could not provide a clear hypothesis on long term changes in population trends of both species due to limited information available, nevertheless we would like to modify the related sentences in Introduction and Discussion.

Fig 2: Do you have any idea as to the depth at which light is sufficient for visual predators? Are prey bioluminescent?

REPLY According to Regular et al., 2011 Plos One, it seems that both COMU and TBMU foraged under light levels higher than ambient moonlight, which means they mostly use visual cue during diving. We have no evidence that the prey observed in this study was bio-luminescent. As we considered that this was out of scope of this study, we would like to omit these descriptions in the manuscript.

Fig. 3. Are there differences in wing stroke characteristics in the upper water column in day and night? Do the murres work as hard or harder at night?

REPLY The number of wing strokes during the bottom phase of the dive was slightly higher during the daytime for both COMU (GLMM with LRT, $\chi 2$ = 8.551, P = 0.003) and TBMU (GLMM with LRT, $\chi 2$ = 20.052, P < 0.001). We would like to include this in Results.

Dr. Ainley D. G.

General Comment Other than perhaps some editing here and there so that in places it conforms better to proper English, the paper is suitable for publication. I would think that the two English-speaking co-authors could correct this. Otherwise, in fact, it is a very interesting synthesis of morphology with ecology and foraging behavior, and thus a very valuable contribution to our understanding of the ecology of marine birds. Thus I recommend its publication. The one issue that I might mention, and it is a minor one, revolves around what is said at line 15, p 18155, in regard to species attempt-

ing to avoid competition. It is competition for a resource that drives the separation of abilities among individuals, eventually leading to differing adaptations between species that allow access to the resource in question. Without competition, there would be no between-species divergence. Adaptations are a way to solve competition, not necessarily avoid it.

REPLY We are very grateful for the positive comments provided by Dr. David Ainley. We would like to modify the sentence accordingly, “to enhance resource partitioning between the species“.

Interactive comment on Biogeosciences Discuss., 12, 18151, 2015.