Response to Reviewers

Please note that while responding to reviewer comments, all line number positions we reference are in the tracked-changes document.

# Reviewer 1

Comment #1: *Response to "standardized interactions observed between smolts and Bull Trout varied among deployments"; Didson sonar placement details are insufficiently described to allow a more comprehensive understanding of site conditions relative to observations, recommendations and subsequent analysis - i.e. velocities, stream depths, or additional factors that might be considered when reflecting on results. Presented as a proof of concept on a limited study duration as this one might suggest that additional time and resources are needed to meet full publication - this currently would seem to be within an extension note type of publication.*

Author response #1: We have reframed our manuscript as a Management Brief – presenting our findings and use of DIDSON as a proof of concept for observing and quantifying predator-prey interactions at fine spatial scales (L127 - 154), but also with a more focused story regarding the fence (in response to the Associate Editor’s comments). We have also added text (Methods L176, 188 - 193) that provides further environmental context (site depth, width, and river discharge) for our data.

Comment #2: *Line 36: might be good to articulate "broader scale" - assume this is elsewhere?*

Author response #2: Thank you for the suggestion. We have clarified “broader scale” to be more direct – that our results corroborate the prior telemetry and diet studies (L33,41) in the same system.

Comment #3: *Line 136: generally identifiable - given piscavore rainbow occur in Chilko is there further comment that could be provided on the ability to provide frequency of occurrence or distinction of species - i.e. acknowledgement of uncertainty, reconciled against video and Didson timestamps?*

Author response #3: We have provided further comment on the occurrence of smaller sized fish observed via DIDSON (L221-231). In short, these other (non Bull Trout) fishes are indeed of smaller body size (from angling as well as GoPro footage) and do not appear to eat on smolts, at least regularly (from unpublished diet data); thus, they are unlikely to “interact” with smolts in the way we describe and observe via the DIDSON. Furthermore, we provide a relative estimate of uncertainty with respect to individuals observed that may not have been from Bull Trout by comparing the empirical cumulative density function of measured DIDSON Bull Trout lengths and minimum size estimates of Bull Trout in the same system obtained via hook-and-line sampling (Kanigan 2019); 19% of fish identified of Bull Trout are of small enough size to potentially be another species (Fig. S2 and text from L358-373). This 19% is likely an overestimate, as angling from Kanigan 2019 likely targets larger bull trout; thus many of these smaller fish are also likely bull trout.

# Reviewer 2

Comment #1: *Lines 91 – 94: The 2 objectives are redundant. Recommend rewording to: “to investigate spatial and temporal differences in potential Bull Trout feeding activity relative to smolt density” Or “**determine if Bull Trout activity is synchronized with Sockeye Salmon migrations.” I prefer the latter.*

Author response #1: We have used the reviewer’s second suggestion. However, the spatial variability is still important – it is possible that in one site Bull Trout activity is synchronized, and others not (indeed, this is what we observed). So, we added a third objective, but it is more specific (“determine if such synchrony is location-specific”). (L129-154). We also added an objective to simply compare amount of activity among sites to better match our statistics and in response to comments from the Associate Editor.

Comment #2: *Supplementary Figure: A photo of the counting fence set up at site would be helpful to readers to understand how constricting the fence may be and where the array was set up relative to the fence*

Author response #2: We have added a supplementary figure of the counting fence, as suggested (Fig. S1).

Comment #3: *Lines 113 and 116: Include distance between fence and array*

Author response #3: We have provided more details on the location of the DIDSON deployments (L176-177).

Comment #4: *Lines 121-123, Table 1: The detection window area for the second deployment at UF is much smaller than during the first deployment and all other locations. Why was the detection window changed between deployments of UF and could this inconsistency impact your conclusions?*

Author response #4: We used different window areas purely for exploratory reasons (to see if one window would perform better or not; however, our ability to identify bull trout and predator-prey interactions were consistent across window sizes (larger window did not result in a large enough loss of resolution to impair our abilities). Furthermore, we standardize our metrics for statistical tests per unit area (per m2 per time interval) which should help address such bias. However, if this inconsistency were to impact our conclusions, we would expect to find a larger proportion of zeros (no interactions over a 30-minute time window) observed in the smaller detection window compared to the larger one. However, this was not the case when comparing between parallel sites (UF2021: 29.27 m2; UF272829: 9.87 m2). Specifically, UF2021 with the larger window (0.25) had a greater proportion of zeroes than UF272829 (0.12) with the smaller window. We added this qualitative comparison to our text (L352-358).

Comment #5: *Lines 131-133 : What does “reacted to” mean? I assume you could visualize the cloud of smolts moving rapidly away from a larger shape? Please include more detail so these methods could be easily replicated by another researcher.*

Author response #5: We have clarified what “reacted to” means to hopefully improve replicability. Furthermore, we have attached supplementary videos to provide a couple examples of what constituted an interaction (L203-206, Supplementary Video 1 and 2).

Comment #6 *Lines 135-137: “We measured...”. Did you measure Bull Trout as part of this study? If so, please add to methods and results. If not, please clarify. Provide specific size ranges of Mountain Whitefish and Rainbow Trout to strengthen your argument that larger fish were probably Bull Trout. Or, be more clear that you assumed larger fish (over a specific size, or characterized by a specific presentation in the video) were Bull Trout. Discuss this assumption and the implications in the discussion.*

Author response #6: We did measure Bull Trout as part of this study and have provided methods and results associated with these measurements. We do not have direct length measurements of Mountain Whitefish and Rainbow Trout, but they tend to be smaller (15-30 cm length) in these habitats and during the smolt emigration, such that only the largest individuals overlap with the smallest potential bull trout (24 cm) measured via DIDSON. We also use measurements of Bull Trout length observed in the field via hook-and-line sampling (Kanigan 2019), to compare the lower bound of an empirical cumulative density function to understand the probability of observing a Bull Trout individual that was ≤ 41cm (about 19%) (minimum Bull Trout size captured by hook-and-line). Note that this uncertainty estimate is conservative considering that Bull Trout of smaller length are very likely to exist in the Chilko system (but anecdotally tend not be present in the system at this time, potentially due to competition with larger bull trout(?) as well as less likely to be caught by angling). We have added text to the Methods (L221 - 231) and Results (L358-373) to provide these details. Also see response to Reviewer #1, Comment #3.

Comment #7: *Line 167: As you are investigating temporal patterns of Bull Trout activity relative to smolt migration, the fact that the fence is closed during the day is a pretty important element to the study design. Do you mean the fence is physically closed to migrating fish? If so, please add this to Paragraph 100-107 so readers can keep this in mind while considering the data. Could also clarify in Figure 3 – I’m not sure if smolt densities were naturally zero during the day or if the fence was physically closed. The only day time fence closure mentioned in Figure 3 was for N29.*

Author response #7: Thank you for pointing out these important details. We have clarified that the fence was closed when smolts were not present at the counting fence site – typically during the day (L168 - 169). We have added this clarification to the requested paragraph and the figure caption. Furthermore, we have added points to Figure 3 to better convey periods where the counting fence was closed, which is also reflected in the figure caption.

Comment #8: *Line 182: Mean value is missing unit*

Author response #8: Thank you for pointing this out. Missing units have been corrected throughout.

Comment #9: *Lines 199-213: Although a significant relationship between diel cycle and interactions was found when the data were aggregated, follow-up analysis showed that this was only observed at the location upstream of the fish fence. Therefore, I don’t agree there is enough evidence to support the general conclusion that interactions increase during nighttime hours.*

Author response #9: We appreciate this comment. However, we believe that context is important for the other deployments that did not show significant differences in interactions between day and night. For example, we could not make diel comparisons for two of the three non-significant deployments, as we only had data for daytime periods in both (N2526 and N29). For DF2334’s deployment, very few interactions were observed regardless of diel period and thus overall low bull trout activity. And after including zeros (as requested by the Associate Editor; comment 7), deployment DR2122 is now also significant (daytime mean = 0.02 m-2; SD = 0.05 m-2, nighttime mean = 0.10 m-2; SD = 0.11 m-2; W = 49.5; *P* = 0.01; Fig. 3B). We have changed the text to reflect this (L335 – 336). Regardless, we do think we have evidence of more bull trout activity at night than during the day broadly. However, given how weak our power is throughout the study, we recognize the need to be careful with our tone. Thus, we have modified these sentences to be softer in our language (L401 - 402) to recognize caveats.

Comment #10: *Lines 225-231: Would also recommend monitoring Bull Trout x smolt interactions in systems with no fish fences.*

Author response #10: We appreciate the excellent suggestion – we have added this to the end of this paragraph (L398 - 400).

Comment #11: *Figure 1: One of the white triangles appears to be on land, is this correct?*

Author response #11: Thank you for catching this error – a couple of our locations were misplaced (N deployments); fixed in the revised manuscript.

Comment #12: *Figure 2: Recommend color coding data from UF site versus all other sites so readers understand diel pattern was observed at UF site only.*

Author response #12: Thank you for the suggestion. We have color-coded observations from the UF site to better articulate that the diel pattern was observed only at the UF site.

Comment #13: *Figure 3: Recommend using similar range for Y axes as much as possible, or at least group deployments with similar Y axes in the same row. Remove yellow line from N29, as fence was closed. Missing period of Bull Trout interactions in N2526.*

Author response #13: Figure 3 has been altered such that ranges for the Y axes are as similar as possible across group deployments. The missing period of Bull Trout interactions in N2526 are present because the DIDSON was not deployed during that period (clarified in the figure caption). Nonetheless, we have indicated and clarified this in the caption associated with Figure 3. We chose not to remove the yellow line from N29 to reflect fence closures and to keep Figures 3A-F consistent.

# Associate Editor

Comment #1: **Overview:** I don’t see a clear hypothesis being tested, nor uncertainty that you are resolving. Potentially cool work, but please put it in a specific context of a *problem* that you *solved.* As written and described, I don’t see much new knowledge here; bulls are known to be nocturnal sometimes, predators feed on available prey, we knew the diet of bulls near the counting fence was seriously on sockeye. What is the key point of this data/study? Where is the novel finding?

I think there is something here, but it needs significant re-crafting to focus on a problem/solution. Simply looking at the graphs, it looks like only one set of scans/counts can be used show an interesting pattern (Figure 3e). The other data is more or less fragmentary.

Find a clear test or problem, and re-work your data to answer that. Could be a neat little paper.

Author response #1: We appreciate the Associate Editor’s thoughtful comment, and we feel the revised manuscript is improved due to this suggestion. We have simplified our context – we want to determine or demonstrate if DIDSON can be used to observe and quantify predator-prey interactions in a system where they are known to occur at broader scales (the general lake-river outlet), and to assess if feeding behaviors occur directly at the fence to verify/confirm prior studies (these previous studies provided gut contents, but not confirmation of where behaviors/consumption occurred). In response, our objectives (L129-154) are simplified but also clearer. We have edited text throughout the manuscript to reflect our new focus.

Comment #2: **Title:** consider stating key finding, rather than method, in a title. Makes it easier to attract interested readers.

Author response #2: We have modified the title slightly to be more active. But given this paper is largely methods-focused, we kept the essence similar (“Acoustic imaging to observe observes predator-prey interactions between Bull Trout (*Salvelinus confluentus*) and migrating Sockeye Salmon (*Oncorhynchus nerka*) smolts”). We felt adding in additional findings (fence-based details) would make the title too long while still including the method. We also felt that specifically mentioning the fence in the title might be too strong given our limited sample sizes.

**Abstract:**

Comment #3: *L31- odd concept “uncertain if these predator-prey patterns exist at finer spatial scales” One would assume they must exist. Specifically, where is the uncertainty that you are resolving? And finer spatial scale is not your key finding. It was temporal scale.*

Author response #3: We acknowledge our original text was vague. First, we have restructured text to make it clear that we are testing DIDSON’s capabilities in a system where we know predator-prey interactions are occurring (L32 – 37). Second, although stomach contents revealed bull trout captured at the fence to have more smolts in their stomachs, this assumes that such consumption occurred at or close to the location of capture (i.e., that bull trout feed heavily on smolts at the fence). Although likely a valid assumption, the DIDSON confirms that predator-prey interactions here are more frequent than elsewhere. Further, consumption and feeding activity might not have a direct relationship (if feeding is “easier” in one location vs another, or if bull trout are feeding elsewhere prior to being captured in prior diet studies) (L38). We have integrated these ideas into the text throughout and removed “uncertain if these predator-prey patterns exist at finer spatial scales”.

Comment #4: *L38 – do you mean daylight risk? If predation is high at night, they haven’t avoided risk.*

Author response #4: Thank you for pointing this out. We have clarified this to reflect presumed minimized predation risk during the daytime (L42).

***Intro:***

Comment #5: *L68-69 – why do we need to know this information? So far, the whole intro is about Sockeye.*

Author response #5: We have removed ancillary information on Atlantic Salmon for clarity, given the focus on Sockeye Salmon smolts. We have also removed information on predator-swamping here to be more concise.

Comment #6: *L70 – I appreciate your use of First Nations language as place name (well done!). Whose territory and language?*

Author response #6: Chilko Lake is under the territory of the Xeni Gwet’in first Nations and the first language of the Xeni Gwet’in is the Tsilhqot’in language. The text has been altered to reflect this – thank you for this point (L111 – 112).

Comment #7: *L81 – circular argument. We don’t know smolts responded. Do they migrate in daylight everywhere without Bull Trout? You see night predation and migration. Do we have evidence of what caused which? Are smolts responding to something else? In my experience, Bull Trout can also be nocturnal in systems without prey fish. Picky point, but you’ve jumped to a conclusion, and should ponder alternates.*

Author response #7: We have softened our language to clearly state that we presume nocturnal smolt movements and synchronization is to reduce predation (L123 – 124). The relationship does seem likely, given that once smolts are in more turbid waters (Chilcotin and Fraser Rivers), they no longer migrate nocturnally but at all times of the day (Clark et al. 2016).

Comment #8: *L83 – still don’t know why this is important to your “problem – solution” questions.*

Author response #8: Although we removed sentences of a similar notion in an earlier section, we chose not to remove information on predator-swamping here, given that the observed phenomenon provides additional context for Chilko Lake being an ideal study system to observe predator-prey interactions using DIDSON (it requires an immense number of prey to be able to “swamp” predators. Please also see our response to your comment #1 regarding clarifying our objectives.

Comment #9: *L85-91: methods are described before we know what question is being answered. It seems like this is a sonar project as its priority, rather than an “understand something important and useful about fish” project.*

Author response #9: We have reframed our text to reflect our problem-solution question of our study to better accommodate this text. Specifically, we illustrate that the present study is a sonar project as its priority, and our aims are to: determine if DIDSON can indeed observe predate-prey interactions in our model system, particularly where we assume intensive consumption is occurring (the fence) to ground-truth prior studies, and determine if such observed predator-prey interactions have correlates either by location or time (diel periods or across prey densities). (L129 – 154).

Comment #10: *L92-94 – state what you were trying to answer, or disprove. “Investigate” is too vague. Was the synchronicity in doubt? What is the value in showing non-synchronicity? It can be assumed that predators will hunt prey when the prey is available. Why do we need a study? Just ponder that and find an answer, and make it clear to the readers why this data/study matters.*

Author response #10: We have clarified this section. We now explicitly state the aims of this study and attempt to better convey the value of the study (L129 – 154).

***Methods:***

Comment # 11: *L136- any direct evidence of sonar images = bull trout?*

Author response #11: Yes, for some deployments (sites near the fence) we were able to at times use flashlights to see the bull trout sitting by the DIDSON. We also use GoPros in the system to confirm bull trout in the areas of bull trout deployment, and that bull trout were the primary species present. We have conducted work in this system for ~ a decade, and bull trout are consistently seen in the positions detected by the DIDSON.

Comment #12: *L158 – was day just when sun in sky, or was twilight included? Hence, were interactions crepuscular, rather than purely nocturnal or diurnal?*

Author response #12: Interactions classified as purely diurnal and nocturnal. We have since clarified this in the text (L271-272).

Comment #13: *L144-148 – using quite two different sampling frames and correcting down to per m2 might be introducing bias. i.e., the small frame would have more zeros. Were the differences in large and small frame data checked for this bias?*

Author response #13: We believe that potential biases introduced from using two different sampling frames and correcting down to per m2 are negligible. For example, when comparing the proportion of zeros between the same sites (UF) observed with different areas (UF2021: 29.27 m2; UF272829: 9.87 m2), we found that UF2021 (0.25) had a larger proportion of zeros had a smaller proportion of zeros (0.12), relative to UF272829 (0.12). We have reflected this in the text (results; L352 – 357).

Comment #14: *L165-168 – Your point was to show bull trout feed at night, but you exclude most day data. Really? Explain why this is not a potential source of bias?*

Author response #14 : The goal of this analysis was to assess degree of correlation between the number of Bull Trout interactions and smolt densities (i.e., to understand whether Bull Trout are responding to higher smolt densities). Nevertheless, we recognize that there is potential to bias our results by simply removing observations where smolts were not passing through the counting fence. Thus, we have removed this statement and re-ran our analyses (same analysis, but with zeros included) to reflect this change. These changes did not result in differences in the interpretation of results, but text in the Methods and Results were amended.

***Results***

Comment #15: *L178 – lowest number of interactions, but no smolts on graph. If the smolts were absent, how did interactions occur? What other metric of smolt abundance is more useful?*

*Were there no bull trout below the fence? Figure 3c suggests so. Or where there no sockeye at the Narrows (fig 3f)*

Author response #15: Although no smolts were observed to pass through the counting fence during the daytime periods, we observed smolts milling below the fence, and thus, interactions could occur (zero smolts passing through the fence is not the same as zero smolts in the system). At present, we do not have another metric of smolt abundance that may be more useful. We have clarified in the text that smolts can be present despite the fence being closed if they are downstream of the fence. We have also further clarified that the fence is typically closed during daytime hours (L168 – 169).

With respect to Figure 3C, very few (but more than zero) Bull Trout were observed below the fence. However, both Bull Trout and interactions occurred at low numbers compared to other sites and times during which the DIDSON was deployed (so it appears to be at zero, but if you look closely, the blue points often fall just above zero). Furthermore, no Sockeye Smolts were observed at the counting fence during the period where the DIDSON was deployed at Narrows (Fig 3F), which is why smolt density estimates are reported as zeros. We have provided additional clarification in the figure caption.

Comment #16: *L182 – confused, based on methods statement. Did you use daylight data or partial daylight data, or what? You show daylight data.*

*The whole results section would be much clearer if you were testing a hypothesis, or describing a pattern in relation to a hypothesized patterns. As it reads, it is not very informative.*

Author response #16: We use both daytime and nighttime data to evaluate how the number of bull trout interactions might differ across sites and diel periods. We have clarified the specific hypotheses and objectives throughout our manuscript, and hope that makes our results section clearer.

Comment #17: *L426 (caption) – what do n-values represent? I don’t understand that many “diel cycles” can be fit into 10 days in April.*

Author response #17: The number of observations made across 30-minute intervals/deployments throughout our study and are differentiated between daytime interactions and nighttime interactions observed. We have clarified this in the caption.

***Discussion***

Comment #18: *L200 – if this is a result, put it in that section and only discuss, not present. Or state it as an interpretation of previously shown graphs/data. And, to my eyes, only graphs a and e show that relationship. The others make you wonder “where were the bulls, where were the smolts?” I would be more interested in the pattern of increasing/decreasing smolts and bulls, and not a simple day/night comparison, with the day data being incomplete, and the night data actually quite thin (only one set of data shows pattern over day and night, = graph e.*

Author response #18: We have restructured our Discussion to more tightly link to the utility of the DIDSON and the impacts of the counting fence. We believe that the day-night comparison still remains valuable given the strong diel nature of this system and have decided to keep it within the manuscript, but focus more on the fence vs elsewhere (and the relationships between bull trout and smolt densities remain as in the original manuscript)

Comment #19: *L205-208: sort of circular. You don’t present data to show bulls are diurnal at other times, without smolts. Did they respond by changing a normal pattern, or do bulls feed on prey when prey is available?* *And why does this matter? Predators eat prey when prey are available, and we already knew bulls eat sockeye. I’m having trouble seeing a novel finding here.*

Author response #19: We have simplified this statement, acknowledging that we are simply observing Bull Trout being more active when prey are available, and that further studies would be needed to examine Bull Trout behavior at other times (L377-379, 397 - 400).

Comment #20: *L214-232: Odd. We knew that bulls feed a lot near the fence, so what is the point of this paragraph?*

Author response #20: Although Bull Trout captured near the fence do indeed contain large numbers of smolts in their stomach, it is unclear whether these prey items originated from predation events at the counting fence (which had been assumed up to this point) or elsewhere. We have reflected this point throughout the manuscript, and thus believe it justifies retaining this section within the text.

Comment #21: *L233-240: not really necessary here. Not part of this study, not a data set easily collected by this methods, so...not relevant here. Unless I missed a point, so change my mind.*

Author response #21: We have removed this paragraph as we agree that this is not a data set easily collected by the methods used in this study and tangential for this short Brief.

Comment #22: *L251-252 – if this is the main conclusion (i.e., bulls feed more at the counting fence), how does it differ from Furey et al. 2016b? Why is this a new conclusion from your data?*

Author response #22: Our results differ from Furey et al. 2016b because conclusions drawn resulted from bioenergetic simulations and stomach content analyses (diet studies provide a snapshot of what is in the guts, with assumptions being made in terms of the time period over which contents were consumed AND where consumption occurred). Thus, although it was assumed Bull Trout were indeed more easily consuming smolts at the fence, the DIDSON confirms that feeding activity here is intense. We have carried this point throughout the manuscript to better communicate the novelty of the present study.