Dear Editor,

Thank you for giving us the opportunity to re-submit a revised draft of our manuscript titled, “Using mechanistic models to assess temporary closure strategies for small scale fisheries”. We thank the reviewers for their constructive comments on the manuscript. We have now altered our framing, addressed limitations in the data, and clarified other points in the text.

Below we detail the changes we made to our manuscript in response to each reviewer comment. We leave the *original reviewer comments in red, italicized font*. Our responses are in black, Roman font. We have also included line numbers of the revised manuscript for each response.

**Editor Comments**

*Both reviewers had issues with the only data being almost 2 decades old. While this is not ideal and needs to change, I think it speaks more to the framing of the approach (as mentioned by one of the reviewers) rather than the to paucity of data.*

We appreciate this concern and have worked on reframing the paper. Unfortunately, as we discuss below, there is no available data that is more recent. The paucity of data is addressed on lines 303-307, as this is a mechanistic approach, one benefit from this method is that less data is needed to parameterize a model and there is no other existing data available to the authors to parameterize a Lefkovitch matrix. Framing of the approach is addressed on the following lines: 1-20, 30-31, 96-97, 122, 125, 142, 239-242, 264, 280-285, 315-321, 326-328, and 348-358. Here, we de-emphasize any management recommendations and instead discuss the biological implications as well as explain how the “closure scenario” analysis was not intended to give any recommendations, only to explore how temporary closures are a flexible method of conservation.

*Matrix models are life history approaches that basically show if the intrinsic population growth rate is below or above replacement. This work here is conditioning that evaluation on very old catch data, thus has very high degree of uncertainty on the fishing mortality.**Additionally, there was no attempt to come up with a natural mortality rate to compare to the total death rate (1-survivorship used in the model) in order to tease out the fishing or natural sources of mortality. This additional step of proposing possible natural mortality rates to gauge fishing mortality is needed.*

We now add additional context around the natural mortality rate on lines 271-279. We discuss how our estimates compare to other, independent estimates, of the natural mortality rate. We highlight the limitations of past work on natural mortality rate, mostly that there have not been stage-specific estimates of mortality. Our study is the first to provide these.

*All of this leads to a much more extensive exploration of the uncertainty in the inputs that really needs to be added to this work. The overall lambda needs to incorporate more sources of uncertainty before the next step of seeing what it takes to get it above 1 happens.*

Discussions about how uncertainty can be implemented into the model are included on lines 331-333. We have tried to highlight where future work could go by building on this model. In particular, if field estimates of stage-specific survival (with uncertainty) were estimated, this could be incorporated into our model. We also note that the sensitivity analysis of running different management scenarios in our main figures and the supplemental material helped provide some context for how outcomes can vary.

*While there are major considerations offered by the reviewers, and even one recommendation of rejection, I invite you to address all reviewer comments while also providing a more extensive presentation of the uncertainty and what management can do given that uncertainty. Ultimately, I do think there is some important management advice that can come from such a simple analysis and hope by addressing reviewer comments and an expanded analysis, this can be achieved.*

We appreciate the review suggestions and have tried to address them below.

*I also think some very specific recommendations on future data collection and other management measures could also be included in the Discussion. Please consider those aspects as well in a revision.*

Future data collection recommendations were addressed on lines 348-355

**Reviewer #1 Responses to Questions**

**Reviewer 1 Specific Comments**

**Overview:**

*This ms. is well written and shows an interesting quantitative approach to obtain knowledge on the condition of the octopus stock in SW Madagascar under data-limited conditions. It implements a stage-classified matrix population model to proportions of octopus at 4 stages and fecundity using data from a paper published in 2012. The main purpose is to determine the duration of seasonal closures (in months) that would lead to stock’s abundance growth underfishing.*

*Unfortunately, I believe the results are not sufficiently credible because of too little data (only one year) that is also too old (2005 to 2006). I would very much support using these techniques to examine seasonal closures with data from at least a few years and closer to the present time. As correctly remarked by the authors, octopus population dynamics is extremely variable and therefore it is too risky to present stock status results and offer management advice with just one year of data.*

*In spite of this negative evaluation I very much encourage the authors to obtain more and more recent data from this fishery and then apply these methodologies to determine best duration (and possibly, timing) of seasonal closures compatible with sustainable stock’s health and fishers income. I know that the Blue Ventures Charity in England is doing data collection from this fishery in SW Madagascar since 2012 or 2013 and that that effort is still on-going, so probably getting more and more recent data is feasible and will lead to more solid results.*

We understand that Blue Ventures has been collecting data on blue octopus in Madagascar since 2015, and this has been acknowledged on lines 3348-355. However, this is not data that the authors have access to as we are not members of Blue Ventures. Further, as mentioned by Roa Ureta 2022, Blue Ventures has **not been collecting maturity data** on blue octopus during this time, so a Lefkovitch matrix could not be applied to any of the data that has been collected. Age/stage data is needed to estimate these types of models.

We have altered the framing of this study. We do not intend for this work to serve as a stock assessment. Instead, our goal was to understand how seasonal closures broadly may be helpful and to discuss the biological implications (lines 1-20, 30-31, 96-97, 122, 125, 142, 239-242, 264, 280-285, 315-321, 326-328, and 348-358 ).

**Specific Comments:**

*L. 21. Your emphasis on using mechanistic models is well received but I feel that you don’t really explain clearly the difference between mechanistic and phenomenological models. The key difference is that mechanistic models are cause-effect with natural parameters while phenomenological models are linear approximations with somewhat ad hoc parameters. There is a book by Hilborn and Mangel (The Ecological Detective) that provides a good contrast between these two modeling approaches. More mechanistic models in stock assessment are very much welcome and your approach is fresh and potentially very important in data limited fisheries.*

Thanks for this comment. We have answered on lines 25-27 and note that “Biological processes are therefore hypothesized in the model, and each parameter represents these mechanisms and can be measured independently of the data collected. This differs from statistical or phenomenological models, which instead use estimations of relevant parameters to explain the data itself.”

*L. 78. ”Since 2003, when this marine resources in Madagascar first ...”. Fix the English, resources is plural, this is singular.*

Fixed on line 88

*L. 92. ”However, once fishing resumes, populations can suddenly and rapidly decline although in some examples, this could be attributed to heavy fishing pressure in the area right after reopening.” I don’t feel ’although’ is correct in this context.*

Fixed on line 94

*L. 102. ”Size limits have been shown to be the most effective method of conservation for cephalopods in general as it ensures individuals will breed before being harvested (Nowlis 2000; Emery, Hartmann, and Gardner 2016)”. Octopus cannot be harvested after they breed because they die after they breed, so perhaps you want to say something different here. Also, the best method of conservation in fisheries is harvest control rules from stock assessment results. Size limits help in connection with other regulation.*

*Octopus cyanea* live for about a month post-laying so therefore can be caught over the course that month (Heukelem 1973). This is also exemplified in the data collected by Raberinary and Benbow 2012, which did find post-laying individuals in the catch being brought up by fishers.

We have changed the phrasing from “Size limits have been shown to be the most effective method of conservation for cephalopods in general as it ensures individuals will breed before being harvested (Nowlis 2000; Emery, Hartmann, and Gardner 2016).” To “Size limits have been shown to be effective methods of conservation of species like \*O. cyanea\* that are harvested before maturity, and are restrictions that are easy to understand and implement in small scale fisheries (Nowlis 2000). However, even though this is a conservation strategy often implemented in octopus fisheries, it has been shown to be less effective than institution an overall cap on fishing effort, such as effort rotation or limiting the number if fishers (Emery, Hartmann, and Gardner 2016)” on lines 111-115.

*L. 120. ”Currently, the octopus fishery in this region of Madagascar is closed for the three months between June and August on a yearly basis (Benbow and Harris 2011; Westerman and Benbow 2014) which was decided in 2011.” I know for a fact that this is not correct. The fishing occurs nearly year round, only stopping in December and two weeks of January from 2015 to the present. I’ve seen the data collected by Blue Ventures in the region.*

We agree this is an important point. We dove back into the literature to explore this point in more depth. We found a lot of information on the various closure lengths tested. We add more of this context:

On lines 131-137 we add “Following dozens of experimental closures in the region ranging from six weeks to 7 months, the western Madagascar region currently institutes a yearly closure of six weeks from December 15 to January 31. These closures do not completely restrict octopus fishing, but instead institute an area where fishing is not allowed which takes up about 25% of the fishery's spatial extent. Therefore, some octopus harvest does occur even during a closure (Aina, 2009; Langley, 2005; Humber et al., 2006; Benbow & Harris, 2011; Westerman & Benbow, 2014; Oliver et al., 2015; Rocliffe & Harris, 2015, 2016).”

On lines 319-321 we add “As the community of southwest Madagascar has been involved in deciding when closures should occur and their lengths, this study serves to show the various options available (Benbow & Harris, 2011).”

On lines 266-271 we add “This is similar to other studies on temporary closures in this fishery as Oliver et al. 2015 showed that extending the regional closure beyond the conventional six weeks increased octopus catch. Further, a 2-3 month closure was suggested for this area in 2011 in order to maximize catch-per unit effort (Benbow and Harris 2011). Benbow et al. 2014 demonstrated that a 20 week closure had similar positive effects on octopus catch to a seven month closure, yet resulted in less strain on fisheries management investment than the longer seven month closure.”

*L. 138. ”Lefkovitch matrices have not yet been applied to Octopus cyanea populations and therefore could be a useful methodology to understand the dynamics of this population in the western Indian Ocean to better inform management strategies.” Are you really able to understand the dynamics with one year of data. It seems you assumed that the proportions of octopus at each stage was constant when you projected the stock using stage-classified population matrices.*

The paucity of data is addressed on lines 303-307, as this is a mechanistic approach, one benefit from this method is that less data is needed to parameterize a model and there is no other existing data available to the authors to parameterize a lefkovitch matrix. Matrices don’t assume a constant proportion of octopus at each stage, as exemplified in the initial transient dynamics. They do predict that the population will converge to a certain proportion of octopus at each stage. This “stable age distribution” can be thought of as an “average” proportion as it was calculated from twelve months of data, each with different proportions of octopus at each stage. It’s kind of like assigning a growth rate to project: the population will change growth rates year to year, but using a growth rate in a model is assuming an average.

*L. 173. ”Further, as all of the parameters are scaled to a value between 0 and 1 except F4 , a unit change in these parameters will have a greater proportional effect on the eigenvalue than F4.” What do you mean by a unit change?*

Onlines 191-193, we now note “Further, as all of the parameters are scaled to a value between 0 and 1 except F4, the different order of magnitude of these parameters have a lower proportional effect on the eigenvalue than F4.”

*L. 179 and 181. R package Rage is named with upper and lower case.*

Addressed on line 200 to make them both “Rage”. Thank you for catching that

*L. 189. ”We then multiplied higher powers of the original matrix during months that were simulated to be “open fishing ...” Multiplied by what?*

Addressed on lines 187-190 and 208-209

*Table 1. Is it variance or standard error? I suggest putting there the standard error of the estimate.*

Unfortunately, standard error is not possible to calculate using this method as there is no sample size of an input of a Lefkovitch matrix. To help readers, we now use standard deviation. Also some of the references in the caption of this table were fixed. This was also fixed on line 223.

*L. 219. ”Decline in population presents an economical issue for individual fishers as their catch will become less lucrative ...” I don’t think you can make that claim because less catch (due to population decline) may lead to higher prices. Lower supply leads to higher prices if demand does not migrate to other products.*

That could be the case but we couldn’t find any supporting literature that shows that for octopus fisheries in Madagascar. The studies cited show that overall income increased after closures/fishery recoveries, so we changed “and a recovery of this population will also result in economic gains from fishers in this community” to “and a recovery of this population has been shown result in economic gains from fishers in this community” on lines 244-245

*L. 219. ”Based on our calculations of growth rate over different closure scenarios, any closure less than three months will not be effective in preserving blue octopus stocks, ...” Nevertheless, since 2015 the closures have been very short (6 weeks on average) and yet total landings have increased up to 2021, so your prediction has not turned out to be right. This is not your fault. You need more and more recent data to arrive at credible predictions that can be used by managers.*

We appreciate this additional insight and context. We think it is a great issue to dive into further in a future paper with different data or modifications to the model. We have tried to address this comment in several ways:

* Discussions of current closures have been fixed on 131-137, 319-321, and 266-271.
* Further, the purpose of this study was not to create credible predictions that can be used by managers but instead uncover some estimations of life history traits of blue octopus and show how temporary closures are an effective conservation strategy for fast growing species.
* The authors haven’t seen how landings have increased, as they don’t have access to the data collected by Blue Ventures.
* Roa-Ureta 2022 has noted recovery in the 2010’s, but says that the fishery is still likely being overfished.
* Our results serve to report the conclusions of the mechanistic model itself, not the findings of this data collection by Blue Ventures.

*L. 272. ”Even though daily collections occurred daily ...” Take out one ’daily’.*

Addressed on 307-308

*L. 277. Typo: imputted should be imputed.*

The word used was inputted, not imputted. Talking about the initial conditions that were inputted into the model. This sentence is now on line 241.

**Reviewer #2 Responses to Questions**

*Note: In order to effectively convey your recommendations for improvement to the author(s), and help editors make well-informed and efficient decisions, we ask you to answer the following specific questions about the manuscript and provide additional suggestions where appropriate.  
  
 1. Are the objectives and the rationale of the study clearly stated?  
  
 Please provide suggestions to the author(s) on how to improve the clarity of the objectives and rationale of the study. Please number each suggestion so that author(s) can more easily respond.*

*Reviewer #2: Yes, but I believe they could be improved if the framing of the paper is reworked. limitations of the old dataset are discussed, but more discussion around larval movement should be included before linking to the octopus population in southwest Madagascar.*

We appreciate this point and have made a number of changes to rework the overall framing. Conversation about larval movement and ocean currents were added on lines: 104-110 and 157-159. Framing of the approach is addressed on the following lines: 1-20, 30-31, 96-97, 122, 125, 142, 239-242, 264, 280-285, 315-321, 326-328, and 348-358. Here, we de-emphasize any management recommendations and instead discuss the biological implications as well as explain how the “closure scenario” analysis was not intended to give any recommendations, only to explore how temporary closures are a flexible method of conservation.

*2. If applicable, is the application/theory/method/study reported in sufficient detail to allow for its replicability and/or reproducibility?  
  
 Please provide suggestions to the author(s) on how to improve the replicability/reproducibility of their study. Please number each suggestion so that the author(s) can more easily respond.*

*Reviewer #2: Mark as appropriate with an X:  
 Yes [X] No [] N/A []  
 Provide further comments here:*

*3. If applicable, are statistical analyses, controls, sampling mechanism, and statistical reporting (e.g., P-values, CIs, effect sizes) appropriate and well described?  
  
 Please clearly indicate if the manuscript requires additional peer review by a statistician. Kindly provide suggestions to the author(s) on how to improve the statistical analyses, controls, sampling mechanism, or statistical reporting. Please number each suggestion so that the author(s) can more easily respond.*

*Reviewer #2: Mark as appropriate with an X:  
 Yes [X] No [] N/A []  
 Provide further comments here:  
 Statistics are not my personal strength but the modelling method seems comprehensive*

*4. Could the manuscript benefit from additional tables or figures, or from improving or removing (some of the) existing ones?  
  
 Please provide specific suggestions for improvements, removals, or additions of figures or tables. Please number each suggestion so that author(s) can more easily respond.*

*Reviewer #2: This seems fine*

*5. If applicable, are the interpretation of results and study conclusions supported by the data?  
  
 Please provide suggestions (if needed) to the author(s) on how to improve, tone down, or expand the study interpretations/conclusions. Please number each suggestion so that the author(s) can more easily respond.*

*Reviewer #2: Mark as appropriate with an X:  
 Yes [] No [X] N/A []  
 Provide further comments here:  
 I think more weight needs to be given to the likely distances of larval dispersal and the possible larval supply locations that are settling in SW Madagascar. Have the authors considered whether the population can be defined?  
  
 The study is based on modelling data collected in another study but for a fishery which has now been studied, and under management for nearly 20 years. I question what this research is adding to broader science with the current framing.*

We appreciate this point and have now worked more on the framing. Conversation about larval movement and ocean currents were added on lines: 104-110 and 157-159. Framing of the approach is addressed on the following lines: 1-20, 30-31, 96-97, 122, 125, 142, 239-242, 264, 280-285, 315-321, 326-328, and 348-358. Here, we de-emphasize any management recommendations and instead discuss the biological implications as well as explain how the “closure scenario” analysis was not intended to give any recommendations, only to explore how temporary closures are a flexible method of conservation.

*6. Have the authors clearly emphasized the strengths of their study/theory/methods/argument?  
  
 Please provide suggestions to the author(s) on how to better emphasize the strengths of their study. Please number each suggestion so that the author(s) can more easily respond.*

*Reviewer #2: Yes, they acknowledge a paucity of reproductive studies on octopus in this area, so the modelling has the potential to add value, but the interpretation of the results should be improved.*

Framing of the approach is addressed on the following lines: 1-20, 30-31, 96-97, 122, 125, 142, 239-242, 264, 280-285, 315-321, 326-328, and 348-358. Here, we de-emphasize any management recommendations and instead discuss the biological implications as well as explain how the “closure scenario” analysis was not intended to give any recommendations, only to explore how temporary closures are a flexible method of conservation.

*7. Have the authors clearly stated the limitations of their study/theory/methods/argument?  
  
 Please list the limitations that the author(s) need to add or emphasize. Please number each limitation so that author(s) can more easily respond.*

*Reviewer #2: Limitations should touch on larval dispersal rates and distances.*

Conversation about larval movement and ocean currents were added on lines: 104-110 and 157-159

*8. Does the manuscript structure, flow or writing need improving (e.g., the addition of subheadings, shortening of text, reorganization of sections, or moving details from one section to another)?  
  
 Please provide suggestions to the author(s) on how to improve the manuscript structure and flow. Please number each suggestion so that author(s) can more easily respond.*

*Reviewer #2: This is fine*

*9. Could the manuscript benefit from language editing?*

*Reviewer #2: No*

**Reviewer #2 Specific Comments**

**Overview**

*Reviewer #2: I find the research and modelling included in the paper valuable but think that the framing needs to be reworked. I very much agree with your recommendations and conclusions but think you would be better of focusing on the biological/reproductive results from the modelling. The conclusion that the fishery was in decline from 17 year old data seems weak, and I am unsure what value this adds to the scientific community unless you can follow this up and repeat it with newer data which eg shows the results of the fisheries management has now resulted in x (hopefully long term maintenance of the fishery).* *I also question the term population without reference to the likely movements of the octopus larvae,a nd think a wider literature research on this element could add value to your work****.*** *There is also a fundamental flaw in your interpretation of the closure models. Further reading of Benbow et al 2014 or Oliver et al 2015 should provide more info on the closure timings.*

Conversation about larval movement and ocean currents were added on lines: 104-110 and 157-159. Closure conversations were fixed on 131-137 and 319-321, and we directly compared our results to Benbow et al 2014 and Oliver 2015 on lines 266-271 by stating: “This is similar to other studies on temporary closures in this fishery as Oliver et al. 2015 showed that extending the regional closure beyond the conventional six weeks increased octopus catch. Further, a 2-3 month closure was suggested for this area in 2011 in order to maximize catch-per unit effort (Benbow and Harris 2011). Benbow et al. 2014 demonstrated that a 20 week closure had similar positive effects on octopus catch to a seven month closure, yet resulted in less strain on fisheries management investment than the longer seven month closure.”

Framing of the approach is addressed on the following lines: 1-20, 30-31, 96-97, 122, 125, 142, 239-242, 264, 280-285, 315-321, 326-328, and 348-358. Here, we de-emphasize any management recommendations and instead discuss the biological implications as well as explain how the “closure scenario” analysis was not intended to give any recommendations, only to explore how temporary closures are a flexible method of conservation.

*Line 32: ocean environments should be singular*

Fixed on R2L32

*Line 33: "sand bed" is a strange phrase, please clarify what you mean by this.*

Changed to “extensive tidal flats” on line 37

*Line 37: Humber reference is specific to octopus not fish, please rephrase so this is clear*

Changed from Madagascar to “Madagascar’s octopus fishery” on line 41

*Line 39: typo near-SHORE*

Fixed on line 44

*Line 58: personally I wouldn't class seasonal octopus closures as MPAs, they are fisheries management measures or OECMs at a push, but as they are temporary I would also question this*

Topics changed from discussing MPAs to LMMAs on lines 55 and 61.

*Line 78: delete 'this'*

Fixed on line 88

*Line 78: also be careful about conflating octopus with all marine resources/fish exports. This sentence should be re written to provide clarity on this*

Fixed on lines 88-90

*Line 81: yields have been shown to decrease citing a 2006 paper which documents that but is now 17 years old. This sentence is misleading and should be re written. Noting that you use the same reference for population bounce back in line 91.*

Changed “yield from this fishery has decreased in regions of this island” to “yield from this fishery subsequently decreased in regions of this island” on line 91.

The paragraph in lines 81-98 was rewritten to specify octopus as well as re-worded for better flow to clarify the Humber reference.

*Lines 83- 97: you are referencing cephalopods but majority of the references relate to octopus, so why not just use octopus as the focus of the paper?*

This was fixed throughout the paragraph in line 81-98 which changes to octopus except for one sentence describing food webs which referred to cephalopods in general.

*Lines 120-123: this is not what those references state…. Please check and revise this sentence*

Discussions of closures are fixed on the following lines:

On lines 131-137 we add “Following dozens of experimental closures in the region ranging from six weeks to 7 months, the western Madagascar region currently institutes a yearly closure of six weeks from December 15 to January 31. These closures do not completely restrict octopus fishing, but instead institute an area where fishing is not allowed which takes up about 25% of the fishery's spatial extent. Therefore, some octopus harvest does occur even during a closure (Aina, 2009; Langley, 2005; Humber et al., 2006; Benbow & Harris, 2011; Westerman & Benbow, 2014; Oliver et al., 2015; Rocliffe & Harris, 2015, 2016).”

On lines 319-321 we add “As the community of southwest Madagascar has been involved in deciding when closures should occur and their lengths, this study serves to show the various options available (Benbow & Harris, 2011).”

On lines 266-271 we add “This is similar to other studies on temporary closures in this fishery as Oliver et al. 2015 showed that extending the regional closure beyond the conventional six weeks increased octopus catch. Further, a 2-3 month closure was suggested for this area in 2011 in order to maximize catch-per unit effort (Benbow and Harris 2011). Benbow et al. 2014 demonstrated that a 20 week closure had similar positive effects on octopus catch to a seven month closure, yet resulted in less strain on fisheries management investment than the longer seven month closure.”

*Line 219: change economical to economic*

Changed on line 243

*Line 231: first reference to the larval stage. I would like to see more information about the possible dispersion distances during this stage and how this would impact on the 'population' being assessed in the model*

Conversation about larval movement and ocean currents were added on lines: 104-110 and 157-159

*Line 250: don't like the use of preserving, better to use conserving, stock maintenance*

This line was actually deleted due to other edits.

*Line 282-284: I agree! And wonder whether this would be a better paper for the authors, given the octopus fishery is still ongoing 17 years after the data that this model was built on it seems a fundamental flaw in the conclusions, and questions the value of the conclusion that the octopus stocks are in decline.*

We appreciate this concern in general. We have tried to reframe to note that the purpose of this paper was not to create a comprehensive stock assessment or develop concrete management decisions. Instead, it is supposed to provide a theoretical test of how different closures would affect this population’s sustainability. Framing of the approach is addressed on the following lines: 1-20, 30-31, 96-97, 122, 125, 142, 239-242, 264, 280-285, 315-321, 326-328, and 348-358. Here, we de-emphasize any management recommendations and instead discuss the biological implications as well as explain how the “closure scenario” analysis was not intended to give any recommendations, only to explore how temporary closures are a flexible method of conservation.

In addition, we note that our findings hold up qualitatively even with different management scenarios (see Supp Mat). Thus, the specific number of months or fishing pressure requirements of a sustainability fishery may vary, our results still show that temporary closures can be a good strategy for short-lived species.

*Line 312: change build off of, to build on*

Sentence was deleted due to other edits.