Dear Editor,

Thank you for giving us the opportunity to re-submit a revised draft of our manuscript newly titled, "*Assessing the need for temporary fishing closures to support sustainability for a small-scale octopus fishery*". 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 Feedback

I appreciate both of the reviewers for their attentive and considerate reviews. While there are still some disagreements that need to be sorted out, I am generally happy with the revision and I see think I see a way forward to address the remaining issues while retaining the useful aspects of this work.

I see the biggest issue remaining the making the modelling the central aspect of the paper. Reviewer #1 notes the worry about the lack of data, lack of either a data rich application or simulation testing to demonstrate proof of concept, the lack of uncertainty reporting, and the empirical evidence that these particular octopus stocks are resilient to 15+ years of management since the data being used in this study.

I offer a possible solution to addressing those concerns while being able to provide the current work an avenue for publication. I think the modeling aspect should not be a central piece of the paper, including not featured in the title. The current title is "Using matrix models to assess temporary closure strategies for small scale fisheries". An alternative title could be "Assessing the need for temporary fishing closures to support sustainability for a small-scale blue octopus fishery off Madagascar". The first line of the abstract would be deleted to take away the focus on the lack of data and modelling, and instead re-written to focus on the general need to monitor and evaluate the status of octupus in Madagascar. This will of course play through the whole paper, taking away the focus on modelling, and more on the fishery itself, with model a support tool to determine status and thus need for action. This would likely eliminate the first two paragraphs (or at least move them to the methods or something).

Thank you for the helpful feedback. We completely agree that a change in the title and abstract would help reframe the rest of the paper. We have also removed the first two paragraphs of the introduction.

We have modified the title to "*Assessing the need for temporary fishing closures to support sustainability for a small-scale octopus fishery"*. The only reason we left out "blue" and "off Madagascar" was to downplay the idea that this paper was designed to be a stock assessment of a particular population.

We also think it is worth highlighting here the changes we made to the abstract as it guides the rest of our model changes.

Abstract

The blue octopus (*Octopus cyanea*) fishery off the southwest coast of Madagascar is important for coastal communities. This fishery is a key economic resource for the local community as blue octopus catch is sold by local fishers to international and local export markets. Thus, it is important to monitor and evaluate the status of octopus to ensure its sustainability. One common octopus management approach is through the use of temporary spatial closures. Models can be a useful support tool to evaluate the status of a population and assess different possible management strategies. One common octopus management approach is through the use of temporary spatial closures. To better understand the biology and assess the sustainability of blue octopus, we parameterize a Levkovitch population matrix model using existing catch data. We found that the octopus population was experiencing a 1.8% decline per month at the time of data collection in 2006. However, since 2006, a number of management practices, including temporary closures lasting several weeks to several months have been implemented successfully. In line with these efforts, our model indicates that the fishery has likely been sustained since 2006 due to these annual closures. Our model provides support to the idea that temporary closures have restored this population and that temporary closures provide flexibility in management strategies that local communities can tailor to their economic and social needs. In addition, we were able to estimate several important life history metrics, such as time in each stage, stable stage distribution, reproductive value, and per stage survivability, that can be used in future work. Collectively, our study provides insight into the biology of blue octopus as well as demonstrate how temporary closures can be an effective conservation strategy due to the wide range of implementation options.

On lines 124-127 of our methods, we add "Population matrix models are a commonly used mechanistic model to predict future population dynamics by splitting the life history of the study organism up into a Leslie Matrix (Leslie, 1945) where a population is split up into groups of ages, and a transformation matrix is applied to predict what the population makeup will be in future years."

We have moved the fourth paragraph of the original discussion to be the first paragraph, as we want to highlight the life history traits uncovered by the model first.

On lines 264-267 , we add " Thus, given data and model limitations, this study serves mainly to show how temporary closures are an effective tool for conservation, and caution should be taken when considering whether the octopus population was actually in decline or not in 2006. We describe this limitation more below.

On lines 218-289, "and how the relationship between closure lengths and their effect on mortality rates can result in multiple different temporary closures that can successfully conserve a fishery. Thus, despite the simplicity of our model, our findings for possible closure lengths is very close to those currently practiced in Madagascar and elsewhere, and therefore suggest that temporary closure efforts in Madagascar are both necessary and have been effective in conserving this fishery. As we describe later, more realistic extensions of this model can be built to guide specific management practices" was added.

On lines 293-295, we add " this study serves to highlight the effectiveness of these temporary closures and explore some of the available strategies to make population predictions and conservation strategies with limited data sources (Westlund, 2017)."

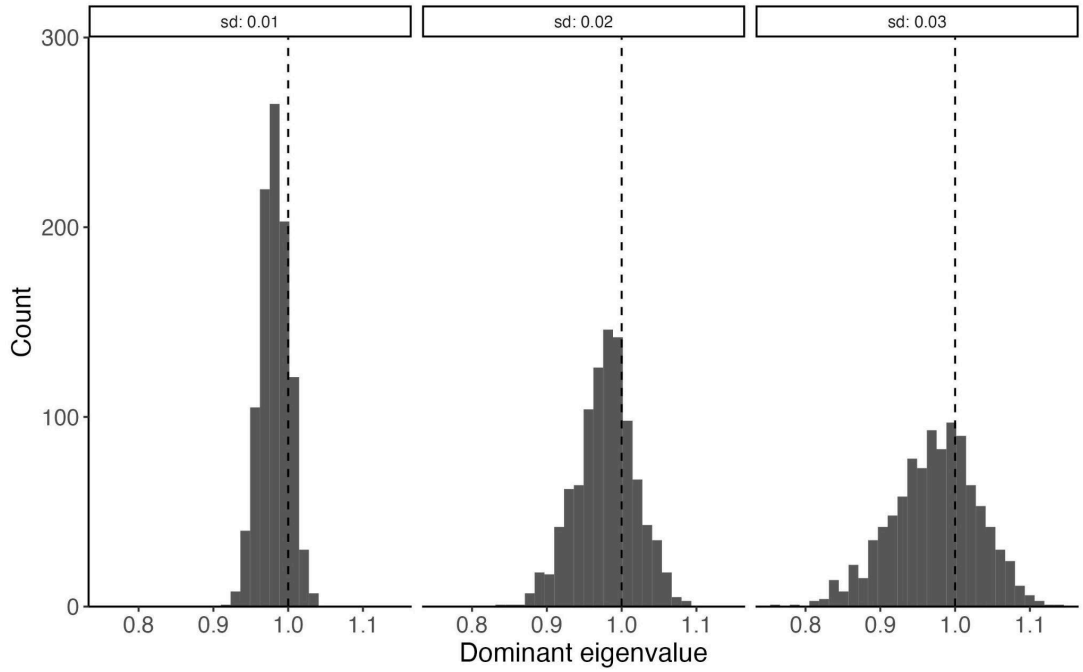
We have rewritten the conclusion on lines 352-363 to say "With a short generation time, cephalopod species respond more quickly to new management strategies. As a population with highly variable population dynamics, continuous monitoring of landings, fishing effort, and where catch is found is extremely valuable in understanding the status of Octopus cyanea in Madagascar. This research confirms thae need for temporary closures on this fishery. Similar data has been collected by Blue Ventures on this fishery since 2015 and shows there has been an improvement to this fishery since 2006 due to local efforts, including temporary closures. Further, this collection effort does not include maturity data which would improve the analysis of this study through incorporation of multiple years of catch data (Roa-Ureta, 2022). However, this study serves to confirm the effectiveness of these closures. Finally, as the people of southwestern Madagascar are actively taking steps to conserve the health of their fisheries, we hope that studies such as these can serve to facilitate the understanding of what options are available when choosing how and when to impose fishing restrictions. We also hope that future work can build on our models to be more realistic for this system and produce specific management guidance."

The treatment of the matrix model will thus be in the spirit of Caswell and others where it is used as a strategic tool rather than as a stock assessment. As you note, this gives the opportunity to improve the life history information going into such a model, use the model as a static picture of octopus and how in general its matrix inputs affect its population growth, provide the results to show how those can help improve the population growth, and follow through with how the subsequent years of management offer evidence in support of what you are demonstrating through this simple modelling exercise. Usually models are done and then the management is carried through-- in this case you have the opportunity to use a fairly well known modeling system to confirm the need and effectiveness of ongoing management of this stock.

We agree with comparison to the work of Caswell and others that the work is a strategic tool. We have emphasized this more in the abstract, introduction, and discussion.

Regarding uncertainty, there should be a way to Monte Carlo draws for inputs (so each life history input has a distribution) which provides within model uncertainty. The sensitivities you do would also provide estimates of uncertainty for different model specifications. These together would seem to provide a good estimate of uncertainty for your analysis.

We agree with this suggestion. We have now replaced figure 3 (see below) with Monte Carlo draws for matrix inputs. Specifically, we ran 1000 simulations where we drew matrix entries from a normal distribution centered on our default estimate for that matrix entry. We then evaluated the resulting dominant eigenvalue for different levels of variability (which was the standard deviation used in the random draws for each matrix entry). The resulting analysis shows that the resulting dominant eigenvalues are still below 1 on average, but there is a lot of variability around the mean of 0.98. We have now included additional text to explain these findings in the results and discussion.



On lines 187-192, we add " In order to incorporate uncertainty in the model, we use a Monte Carlo simulation to draw 1,000 new matrix entries from a normal distribution centered on our default estimate for that matrix entry. We test different levels of variability by increasing the standard deviation used in the random draws for each entry. The maximum standard deviation tested was 0.03 because higher standard deviations resulted in matrix entries that were too high to have realistic biological interpretations. We then calculate and evaluate the resulting dominant eigenvalues for the new matrices"

On lines 220-222, we add “The analysis of the Monte Carlo simulation shows that the resulting dominant eigenvalues are still below 1 on average, but there is a lot of variability around the mean of 0.98 (Figure 3). As the standard deviation increases in the simulation, the proportion of matrices with dominant eigenvalues above one also increases.”

On lines 259-267, we add “Uncertainty in model parameters can lead to situations where the the population would be assessed as increasing in 2006, as demonstrated by the Monte Carlo simulation (Figure 3), even though the average eigenvalue of these simulations remain below 1. This demonstrates the need for further investigation into this fishery, as octopus population dynamics can be highly variable (Humber et al., 2006), and therefore a Lefkovitch matrix may not be able to capture all of the nuances of blue octopus population dynamics. Thus, given data and model limitations, this study serves mainly to show how temporary closures are an effective tool for conservation, and caution should be taken when considering whether the octopus population was actually in decline or not in 2006. We describe this limitation more below.”

On lines 304-309, we add “As octopus population dynamics are extremely variable, one year of data collection may not be sufficient to get a comprehensive understanding of this population’s growth rate, as shown by the uncertainty analysis in this paper, where some simulations of uncertainty resulted in stable populations. Although this is not enough data to conduct a full stock assessment, this speaks to the utility of mechanistic modeling, where we are able to estimate population patterns and other life history traits despite this lack of data.”

On lines 335-337, we add “ Further, explorations into uncertainty analysis of this population would help better understand the sustainability of this fishery.”

I hope these are reasonable suggestions. I do think the focus on the modelling, while important, can be framed differently and allow the reader to not get caught up on the data only being from 2006, but instead on how management can aid the sustainability of this fishery.

We agree that these are very reasonable suggestions. With the combined new analysis and edits to the manuscript, we hope our paper now reflects the story of how management can aid the fishery generally without getting into specifics of the data date or a specific stock assessment.

Specific Reviewer Comments

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 #1: I am inclined to believe that the methodology presented is a good addition to determine seasonal closures, but in order to present a new methodology paper authors need to expand their objectives to show its utility in more cases. The example presented is unfortunately too old and too limited in data. Authors need to add a more recent and data-rich case alongside the Madagascar octopus example, in order to compare results of the new method against something firm, like the assessment of a data-rich stock. Authors replied it was not fair to ask for more cases for illustration of their approach. The introduction of a new method to assess fishery stocks is not a walk in the park. It is hard work. In my opinion you need to present your method with a data-rich case to cross-check predictions and you need a challenging simulation setting with an operating model.

Thank you for the additional feedback. We have decided to reframe the manuscript (especially in the abstract, beginning of the introduction, and in parts of the discussion) to downplay the article as being a new methodology paper. We do not view our method as being new in the fisheries literature, but it is new for this population and region. Thus, our goal is not to explain a new method nor provide a stock assessment for this octopus population. Instead, we have tried to frame the paper around the idea that models can be used to inform management decisions for blue octopus. Our results show that temporary closures can be a useful management tool for blue octopus in Madagascar. Our results are exactly in line with what has been seen in the field. Yearly closures of a couple weeks-months have been shown to be a useful management tool for octopus, which is verified with our modeling approach.

We also conduct a more detailed analysis of uncertainty (see response to the editor comments above) that are in line with the suggestions from reviewer #1 in the previous round of revisions.

Reviewer #2: Yes this is clearer now

Thank you for the encouragement.

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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 #1: Mark as appropriate with an X:
Yes [] No [X] N/A []

Provide further comments here:
The method needs to be tested against simulated data from a challenging operating model, in order to understand its limitations and strengths.

As detailed above, we have taken an alternative path where we downplay the method used in the article. Instead, we focus on how models can help inform management broadly. However, we do conduct a new uncertainty analysis that we believe will help address some of these concerns. In particular, we show that (see above figure in editor comments section) uncertainty in model parameters can lead to situations where the population would be assessed as increasing in 2006. The model uncertainty in model parameters, the more simulations that would have an eigenvalue above 1 (i.e., positive growth rate). In all cases, the mean growth rate is still negative, but we think this new result (and additional text) does highlight the importance of addressing uncertainty in model parameters.

Reviewer #2: Fine

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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 #1: Mark as appropriate with an X:
Yes [] No [N] N/A []
Provide further comments here:
There are no p-values, confidence intervals, credible intervals, standard errors.

As detailed above, we now include an uncertainty analysis to allow the generation of a distribution for the dominant eigenvalue as opposed to a single value.

Reviewer #2: Please refer to reviewer 1 feedback on this

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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 #1: Yes. It needs display components from results of at least a second application and simulation testing.

See above comments regarding the new uncertainty analysis

Reviewer #2: No

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

The data is too old and scarce.

The data is old, but we also don't make conclusions beyond the scope of the data. We don't make any claims beyond what the model suggests. In particular, we note that the model suggests the population was declining in 2006 (but that there is uncertainty about this claim). We show that temporary closures of a few weeks to months can improve the sustainability of the octopus population, which is exactly in line with how octopus management has developed in Madagascar over the past 15 years. Our model suggests management action was needed after 2006. Management action was taken after 2006 in line and worked exceptionally well in many places, which is also supported by our model.

Reviewer #2: This is improved now and small detailed comments are included below

Thanks. We have addressed the specific detailed comments below.

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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 #1: Yes, they have done a good job understanding the limitations of their case after two rounds of review.

Thanks!

Reviewer #2: Yes

Thanks!

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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 #1: Yes, see above.

Thanks!

Reviewer #2: Yes this is much clearer now

Thanks!

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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 #1: No comment.

Reviewer #2: No

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9. Could the manuscript benefit from language editing?

Reviewer #1: No

Reviewer #2: No

Reviewer #2: Another big improvement, with clearer conclusions and a more realistic awareness of the limitations of the data and what the paper can say. A general proof read would be good as

there are a few extra spaces and some clunky phrasing. More specific comments below:

Line 47-49: there are definitely newer references which could be used for the scale/extent of SSF eg SOFIA report 2022

On line 22-24, this has been changed to read " Worldwide, an estimated 58.5 to 60.2 million people make their livelihood in small-scale fisheries, a subsector in which 90 to 95% of fish is distributed for local consumption, making these marine products a vital source of nutrition for these communities (FAO, 2022; FAO et al., 2023)."

Line 67-68: this doesn't read well and needs a small tweak

On lines 41-43 , this has been changed to "In Madagascar, the use of LMMAs has increased significantly since 2004, which has resulted in increased landings and Catch Per Unit Effort for local fishers (Benbow & Harris, 2011; Gilchrist et al., 2020)."

Line 93: "However, previous temporary closures on the fishery resulted in population increases, indicating that this fishery has the ability to recover when fishing pressure is decreased" Be careful with assumptions here and remember the limitation of as fisheries dependent dataset. The temporary closures have increase octopus catches, I think it is less clear that they increased the overall population of octopus in any given area. Similarly in line 95 reference to stock declining is an assumption as a stock assessment was not undertaken and the authors are referring to declining catches

This has been changed on 66-70 to read "However, previous temporary closures on the fishery resulted increases in octopus, possibly indicating that this fishery has the ability to recover when fishing pressure is decreased (Humber et al., 2006; Katsanevakis & Verriopoulos, 2006; Benbow et al., 2014). However, right after reopening, catch began to decline again, which has been attributed to heavy fishing pressure right after reopening (Humber et al., 2006; Benbow et al., 2014; Oliver et al., 2015). "

Lines 134-136: it would be good to add timings here, ie when the regional closures started and to note that only 1 temporary village closure was 7 months, and the standard is now 2-3 months

Lines 108-114 has been changed to read "Ever since 2004, the western Madagascar region currently institutes a yearly closure of six weeks from December 15 to January 31. In addition to the regional closure, individual villages institute their own local closures once a year, typically lasting 2-3 months. 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 one of these closures (Aina, 2009; Humber et al., 2006; Benbow & Harris, 2011; Westerman & Benbow, 2014; Oliver et al., 2015; Rocliffe & Harris, 2015, 2016)"

Line 257-258: "Octopus population recovery has been shown to result in economic gains from fishers in this community" would prefer if this sentence was reworked to focus on octopus catches rather than population recovery ie "A successful short term closure management regimes has been shown result in economic gains from fishers in this community"

This has been changed on line 168-271

Line 269: again reference to the 2-7 month length of closures could be more clearly written. After the first few years closures have standardised at between 2-3 months, and 7 months was a big outlier

This has been rephrased on line 279 as "These closures typically span 2-3 months"

Line 296: this is misleading, they are still landing the small octopus just not selling it. There is a clearer reference to this practice in line 120 where you reference to household consumption

This has been changed on line 238-240 as "However, as the immature stage has a high survivability of 90.4% and a longer duration than the other stages of 2.7 months, could challenge the assumption made in the model that octopus harvest does not distinguish by size."