Reviewer #2: In this manuscript, the author investigated the effects of different combinations of time-variation in natural mortality (M) and catchability (q) on important management parameters. Specifically, author explained the consequences of undertaking these types of assessments on management advice, emphasizing large differences in management advice underscore the importance of evidence-based approaches to incorporating time-variation in population parameters in stock assessment. Author used the eastern Bering Sea snow crab assessment to demonstrate the effect of time-variation in population parameters on management advice.   
  
Author did a good job of bringing out the idea of time-variation in vital population parameters and demonstrated that time-variation indeed improved model fit to data but with an unfortunate outcome of conflicting, sometime untenable, management advice. Author provided some advice to overcome these problems. Are there any improvements that can be made in the analytical approach and presentation to convey the message clear? Although further improvement in the analysis is difficult with currently available data, nevertheless the presentation can be vastly improved.  I will address those in the General and Specific comments sections below.  
  
The General Comments:  
  
My first impression is that the presentation needs more work to convey the message clearly to wider audience.   
  
(a) The author uses a general phrase "population processes" in several places while focusing only on catchability (q) and natural mortality (M). I suggest further clarifying this phrase focusing on present analysis. This is because in the first sentence of the abstract, author mentioned that the population processes can be mutually confounded, which is true; but the author has not looked at growth and other environmental parameters that confound with M and q estimation.  
  
(b)  I agree with the author's statement in the abstract that evidence-based approaches are needed to incorporating time-variation in M and q. But the manuscript did not provide undisputable evidence for changes in M and q by time occur in nature. In my opinion, the analysis only demonstrated that data fitted better with time variation in parameters than when they were treated invariants. So, I suggest including this caveat from the analysis to the abstract.  
  
(c)  Writeup needs editing/improvement to convey the results clearly to wider audience. I have noted them in the Specific comment section below.  
  
Specific Comments:  
  
Abstract  
  
This section is concise and conveys summary of the manuscript.  
  
A caveat can be added at the end of the abstract to convey a message "evidence-based time-variation in q and M could not be demonstrated with the available data on snow crab."  
  
Introduction  
  
This section satisfactorily introduces the subject and scope of the work. However,  
  
Line# 23: Please revise 2014 to 2019 in Stawitz et al. (2014).  
  
Line# 32: Please revise 2014 to 2013 in Taylor and Methot (2014).  
  
Line# 60: Please revise "…quotas since 2004…" to "…quotas since 2005…"  
  
Lines# 68-69: "The most recent large pseudo cohort was spawned around 2010 and recruited to the survey gear in 2015. By 2018, it was the largest pseudo cohort ever observed in the eastern Bering Sea."  
Please justify elapsed time between spawning and recruitment with any supporting reference(s).  
  
Lines: 69-72: "However, in 2019, it was much smaller than expected given estimated growth, natural mortality, and fishing removals (Figure 2). This strongly implies time-variation in some population process and catchability or natural mortality are key suspects given previous research."  
Why didn't you list movement from the survey area? Plus, please provide references to previous research.  
  
Methods  
  
This section satisfactorily explains the methodology used in the analysis. However,  
I have few comments/questions in this section:  
  
Lines# 109-110: "A smoothing penalty is added to the negative log likelihood of each model in the form of the squared norm of the second difference of each vector of additionally estimated estimated parameters multiplied by a user defined weighting factor."  
  
First, please remove one "estimated" from the repetition. Second, why do you need to add a smoothing penalty to likelihoods? You need to explain the reasons behind adding this; otherwise, some readers may not understand your reason. Finally, why didn't you undertake a sensitivity analysis on user defined weighting factor? Otherwise, the chosen weights might have some effects on the results of time-varying parameters.  
  
Lines# 122-135: This paragraph needs some revision to convey the message to readers from outside the US.   
  
Line# 129: "…average of the final 7 years of the process…"  
  
You can be more specific by stating averages of the final 7 years of M, q, and bycatch mortality????  
  
Lines# 134-135: Please add a reference as: (Amendment 24, NMFS; NPFMC, 2007).  
  
Lines# 135-136: Equation (1):  
  
Please modify the middle formula inequality part to  
     ….  if 0.25 < MMB/MMB35 <= 1  
  
Results  
  
This section satisfactorily explains the results of the work. I have few comments though:  
  
Lines# 142-147: I have already mentioned about providing the purpose of adding smoothing penalties. Here you are mentioning about " The smallest viable smoothing penalties tested…" This is puzzling me because I have not seen any specific smoothing penalty formulas in this manuscript to evaluate your point.  
  
Line# 175: Please revise "…estimated average catchabilities similar to…"  "…estimated average catchabilities were similar to…"   
  
Discussion  
This section adequately discusses the results with findings from published literatures and suggestions for further work.  
  
I agree with the first sentence of the last paragraph that ---Given the outcomes of this analysis, it is not clear if the estimation of time-variation in confounded processes is a problem we can model our way out of with the currently available data for snow crab.  
  
References  
  
The references are complete and referred to in the text. However,  
  
Lines# 248-249: page numbers not complete.  
  
Line# 263: Please expand Hilborn, R. et al. 2021.  
  
Line# 271: Please expand Johnson, K.F. et al. 2014.  
  
Lines# 322-323: Page numbers not provided.  
  
Appendix A  
  
I could not find any detectable errors in the set of population dynamics model formulas.  
  
I suggest adding the smoothing functions in this section. Also define the weights used in several likelihood formulas. Various weighs can be defined in a table.  
  
Line# 352: Then et al. (2015) reference is missing in the reference list.  
  
Tables  
  
Two tables are adequate for the main text.  
  
Table 2. Please explain in the title how did you get a mean M for the varying M scenario.  
  
Figures  
  
My document shows that there are 22 Figures to this manuscript. However, Figures 9 to 22 are not referenced to in the text. Am I missing something here?  
  
Figure 1 title: Are you sure that retained catch data are reported from observer data? I think they are reported from fish ticket data. Perhaps some aspect may be confirmed by observer sample!! Please check.