Review Comments on Proposal "Evaluation of Key Assumptions Underlying Analyses of Delta Smelt Survey Data"

Reviewer #3

General comments:
The proposal is aimed at investigating two assumptions that are frequently made in analyzing data from the Fall Mid-Water Trawl (FMWT) and the Spring Kodiak Trawl (SKT): (1) that the catchability remains constant over the spatial-temporal extent of the study and (2) that the observed catches per unit effort (CPUEs) are spatially and temporally independent.

The Principal Investigator (PI) notes that there are two distinct statistical methodologies that can be used to analyze survey-type data: design-based and model-based. These two approaches utilize very different theoretical bases. In particular, they are based on completely different probability spaces, so that any reference to an expectation (e.g., mean value, variance, correlation, independence) must explicitly identify the relevant probability space.

The probability space for a model-based analysis is inherent in the model proposed to analyze the data. For example, the PI has reported that a zero-inflated negative binomial generalized linear model effectively models CPUE data. The relevant probability space is defined by that assumed model. For another example, if there is concern over spatial correlation, one might begin by assuming a Gaussian stationary isotropic random field model. The key point is that the model is assumed to apply, and that the probability space is defined by the model.

In contrast, the probability space for a design-based analysis is created by the design. Thus, a designed-based analysis is possible only with data generated using a rigorous sampling design. Such a sampling design must have the following attributes:

- The target population is explicitly defined, and a frame exists (or is created) to make the target population amenable to sampling.
- The sample is selected using a mechanism that explicitly includes a random component.
- Every element in the target population has a known (or knowable) chance of being included in the sample (the inclusion probability).
- If inferences based on the design are to be unbiased, the every element must have a positive inclusion probability.

With a rigorous design, a design-based analysis is possible. All expectations (means, variances, independence) are calculated using the probability space generated by the random mechanism used to select sample points. In particular, if sample points were selected using a design that guarantees independence (e.g., simple random sampling), then those points are and forever will be independent. Concerns about spatial or temporal independence are unfounded, and in fact, cannot even be sensibly articulated under the design probability space.

I have not been able to locate complete documentation of the design of either the FMWT or the SKT. The web pages associated with the studies show maps of sample locations; however, there

is no description of how the locations were selected. The selection method is critical to determining whether design-based analysis methods are applicable. I do not believe that either design qualifies as a rigorous sampling design. Apparently, the FMWT does as it name suggests: samples are confined to mid-channel. From the sample point maps, it appears that the sample points were selected more or less systematically along the mid-channel line. Thus, it fails as a rigorous design because of the lack an explicit population frame, lack of an explicit random selection component, and because some population elements have no chance of being included in the sample. Note: this does not mean that the FMWT is a bad sample; it simply means that the design does not supply a foundation for a design-based analysis.

The same is true of the SKT. These two data sets (FMWT and SKT) may be the best available data, but they are not well-suited to addressing the questions posed. In regard to catchability, the investigator notes that survey catch can be conceptually represented by the equation $C = q_a q_e EN$, where C is the catch, q_a is the availability coefficient, q_e is the gear efficiency coefficient, E survey effort, and N is the total population abundance. In the proposal, catchability invariance will be investigated by using a variety of models to quantify the effect of environmental covariates on CPUE. The proposed approach may very well identify covariates that influence CPUE; however, the FMWT and the SKT do not have information that will make it possible to attribute that influence to variation in q_e. The PI recognizes this: it is stated on p.8 of the proposal "that application of GLM-type models requires making the assumption that delta smelt relative abundance is constant within combinations of other covariates included in the analysis." In other words, the data from the FMWT and the SKT cannot be used to distinguish variability in q_e from variability in q_a. A data set with an independent assessment of local availability is necessary to distinguish between variability in availability and variation in catchability.

The other question posed is that that the observed catches per unit effort (CPUEs) are spatially and temporally independent. The methods proposed by the PI to investigate the questions are appropriate; however, again, the available data are totally inadequate. I noted above that the FMWT appears to be a nearly systematic sample along mid-channel. Systematic samples are notoriously poor for estimating spatial covariance functions. What is needed is a data set that contains points at a variety of spatial separations; in particular, some points relatively close together are essential. Because the FMWT samples are approximately systematic along the mid-channel, the FMWT will provide a cluster of points at approximately the minimum separation, twice the minimum separation, and so on.

That said, the investigation may succeed in answering the question of independence of sample points. Spatial covariance tends to decrease with increasing distance between points. The investigation may be able to establish that the minimum separation of the FMWT and SKT surveys is great enough so that correlation is minimal or non-existent.

Responses to charge questions:

1. Are *goals, objectives, hypotheses and questions clearly articulated and internally consistent?*

Yes, the proposal is very clear about the goals, objectives, hypotheses, and questions.

2. Will *the proposed work contribute to our overall understanding of the Delta Smelt lifecycle?*

Probably not. There is some chance that the work will shed some light on covariates that influence CPUE. However, no analysis of the existing data can distinguish between covariates that influence local availability and covariates that influence gear efficiency.

3. Does *the proposed work take a feasible approach to addressing questions such as spatial autocorrelation in the data, correction covariates for covariates affecting catchability and uncertainties concerning abundance indices?*

The approach is feasible, but I am extremely skeptical that the data are suitable for the proposed study. There is no way to distinguish between covariates affecting catchability and covariates affecting local availability. Lacking an independent assessment of local abundance, one simply has to assume that the availability is constant and the variability is due to influence on catchability. That does not seem to be a tenable assumption. Nor is the data set suitable for an investigation of spatial dependence. Developing a variogram model requires a data set with a variety of point separation; in particular, some points with small separation are essential to distinguish between various variogram models. The semi-systematic design of the FMWT and SKT is unlikely to provide a sufficiently rich collection of separations to develop a variogram model. Nevertheless, it may be possible to establish that the sample points are sufficiently separated to ensure effective independence.

Are there other approaches that could be used in the analysis?

No. The problem is not with the analytical methods but with the inadequate data.

4. Are the budget and the schedule reasonable and adequate for the work proposed?

Yes.

5. *Will the results from this proposal add value to other work that uses these survey data, and if so, how much confidence can be added from the analyses?*

The results may identify some covariates that influence observed CPUE, but I don't see how that will be useful to other work that uses these survey data. Because the data does not permit separation of variability in q_a from variability in q_e, the results will not be useful in adjusting CPUE for variability in catchability. As noted above, the results may settle any question of spatial independence in the FMWT and SKT data.

6. *Are the proposed analyses suited to constructively inform management actions, such as those associated with the existing biological opinions?*

The results of the proposed analyses may identify some covariates that influence CPUE which may increase understanding of population distribution of Delta smelt. If the analyses detect

spatial or temporal correlation in the sample points from the FMWT or SKT surveys, then that will help guide interpretation of these data or inform a potential re-design.

7. *Does the proposal address the most important potential data limitations relevant to questions about Delta Smelt entrainment and Fall outflow?*

No. The most important data limitations stem from the design of the FMWT and the SKT. No amount of sophisticated analysis can overcome those fundamental limitations. Again, the FMWT and the SKT are not poorly designed studies; they were simply not designed to address the questions being asked.