Review of:

April 2020 DRAFT RECOVER Northern Estuaries Performance Measures: Salinity Envelope and Hydrologic Criteria (April 2020 Version)

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Summary: The 2020 draft revision of the RECOVER salinity performance measure (PM) is a vast improvement over the 2007 version. The time and effort that the Northern Estuaries Team put into the performance measure update is apparent and much appreciated. Comments on the February 2020 Draft were previously provided to the Northern estuaries RECOVER Team and changes made in the April Draft address many of them. Prominent among the improvements is the addition of Appendix A which provides details of the CH3D hydrodynamic model and an expanded discussion of the process and measures that will be used to evaluate CERP Projects and RSM Model output. The latter is relevant to LOSOM.

A few clarifications, detailed below, would improve the April Draft, these include: providing statistical measures of the uncertainty in CH3D model predictions of salinity, clear definition of how 14-day average salinities were computed, clear description of how the flow boundary between stressful and damaging flows (for the St. Lucie 1700 cfs) was derived and justification of the evaluation targets for stressful (no more than 2) and damaging (no more than 1) flow events in a 51-year period of record.

Lastly, the previously supplied thoughts on application of the performance criteria to LOSOM are reiterated and expanded.

General Comments:

The 2020 draft revision of the RECOVER salinity performance measure is a vast improvement over the 2007 version. The time and effort that the Northern Estuaries Team put into the performance measure update is apparent and much appreciated. Strengths of the updated version include: identification of new flow and salinity categories (optimal, stressful and damaging), use of a common modeling platform to relate flow and salinity and definition of evaluation criteria that will be used to assess CERP Projects. Comments on February 2020 Draft were previously provided to the RECOVER Northern Estuaries Team. Many of these comments have been adequately addressed in this new version.

CH3D Model:

The CH3D is a numeric model that can represent hydrodynamic processes occurring in an estuary including vertical and horizontal transport. In the current draft, an additional appendix, Appendix A, detailing the CH3D hydrodynamic model has been added and many aspects of its use in deriving flow envelopes have been clarified in the CERP System-wide Performance Measure Documentation Sheet. In short, a 51-year record (1965-2015) of daily freshwater inflow, tides and other climatic data were used as input to drive the model. Freshwater inflows, used as input, were a combination of flows measured at coastal structures (e.g. S-79) and modeled inflows for ungauged sources (e.g. tidal basins). The CH3D model output was a 51-year POR of "14-day averaged" (see Appendix A: lines 40-41) salinity for each cell in the model grid.

Neither the February or April draft sufficiently discussed uncertainty in model predictions, particularly of salinity. It is claimed that "*Uncertainty associated with the CH3D model validation of modeled versus observed salinity is very low (R^2 >0.9; Appendix A)*" (see lines 805-806 in Documentation Sheet). The CH3D model can predict salinity on many time scales (see lines 42-43 of Appendix A). What time scale is referred to here (e.g. daily salinity, 14-day average salinity, 14-day moving average salinity)? Furthermore, reading of Appendix A will show that no data concerning model uncertainty in the prediction of salinity are presented for either estuary. Since the "*major output application for this Salinity Performance Measure was 14- day averaged salinity at every grid cell"* (see lines 41-42 of Appendix A), at the very least, uncertainty in prediction of this 14-day average salinity should be presented for both estuaries.

A knowledge of model uncertainty is critical for interpretation of results and tells us how much confidence we should have in them. Presenting statistical measures of model uncertainty is standard practice and should be followed here.

Derivation of Flow Envelopes:

The description of the derivation of flow envelopes is much better in this draft, but further clarification is necessary. Using information from the literature and results from laboratory experiments and field monitoring, optimal, stressful, and damaging salinity ranges for each of three indicator species (eastern oyster, shoal grass, tape grass) were identified. These ranges are strongly supported and are a strength of the document.

The derivation of the Optimal Flow Envelopes is described in Appendix B: A Conceptual Habitat Area-Based Approach for Flow Envelope Alternatives. The area in each estuary that experienced optimal salinities under the 2007 PM flow envelopes was calculated. For the St. Lucie, the 2007 PM envelope was 350 to 2000 cfs. The upper bound and lower flow bounds were incrementally adjusted, with area of optimal salinity being calculated for each adjustment. This analysis resulted in a series of sensitivity curves showing the change in area of optimal salinity as a function of different upper and lower envelope bounds, relative to the 2007 PM area. This analysis was conducted for each indicator with final selection of an envelope that "best balanced benefits across all species" (see Appendix B lines 90-91).

For the St. Lucie, "*Selecting Optimum Flow Envelope alternatives for the SLE was straightforward in that shoal grass was not a sensitive indicator for the flow envelopes tested*" (see lines 98-99 Appendix B). Flow envelopes for the St. Lucie were ostensibly based on salinity tolerances of shoal grass and oysters. Since shoal grass turned out to be an insensitive indicator, the Optimum Flow envelope for the St. Lucie is arguably based only on salinity tolerances of the Eastern Oyster.

A few thoughts are offered in this regard. It can be reasonably argued that the restoration of the St. Lucie estuarine ecosystem is primarily based on restoring oysters, which amounts to single species management. The document does state that the indicator species chosen "perform a key function in an ecosystem including the provision of habitat as living spaces, refugia, and foraging ground for other desirable species" (see lines 244-245 in Documentation Sheet). The RECOVER team should add a paragraph detailing the ecosystem services provided by oyster reefs and SAV beds. This would only take a sentence or two for each indicator. Further, perhaps a project to identify additional sensitive indicators in the St. Lucie should be added to the supporting science program (See Appendix C).

To derive stressful and damaging flow ranges: "*The same modeling exercise was conducted for incremental ranges of flow greater than the Optimum Flow Envelope for the SLE and CRE. The manner in which Stress Flows and Damaging Flows were differentiated was based on resulting salinity maps where salinities were within the Stress Salinity Envelope and Damaging Salinity Envelope (Table 1), respectively*" (see lines 684-687 of Documentation Sheet).

This is the only description of the derivation of Stressful and Damaging flows given in the Documentation Sheet or in Appendix B and it is too vague. More clarification of what is meant by "*The same modeling exercise was conducted for incremental ranges of flow greater than the Optimum Flow Envelope for the SLE and CRE."* While it is easy to determine the area of a particular salinity range at any given flow, how was the flow boundary between stressful and damaging flows determined?

Salinity Average:

The use of a standard averaging period (14-days) for flow and salinity for both estuaries is important and a strength of the revised performance measures. It is equally important to justify this averaging period. In other words, why was it chosen? Why is it more relevant than a 7-day, 21-day or monthly averaging period? For example, the document states that the average residence time of water in the St. Lucie Estuary is 7-days. Based on this information wouldn't a 7-day average salinity be more representative of conditions that the indicator species experience in the St. Lucie. Lack of such justification was a deficiency of the February Draft as well.

It is equally important to accurately define how the average was calculated as this will allow independent verification of salinity and flow performance by stakeholders. In the documentation sheet, the salinity average is described as a 14-day moving average 10 times and as a 14-day average 2 times. In Appendix A, model output is described as a 14-day average.

A moving average is a method for smoothing a time series by averaging a fixed number of consecutive terms. The averaging "moves" over time, in that each point in the time series is sequentially included in the averaging, while the oldest data point in the span of the average is removed. For example, the POR begins on Jan 1, 1965. The first 14-day moving average would include salinities for Jan 1 through Jan 14, the second moving average would include Jan 2 through Jan 15, the third average would include Jan 3 through Jan 16 and so on.

In Appendix B, the salinity average is defined mathematically as *"S is salinity averaged over a 14-day period, and i is the number of 14-day periods counted from January 1, 1965."* (see lines 48-49 in Appendix B). This definition implies that the time series has been divided into consecutive, non-overlapping 14-day periods and an average of salinity (or flow) calculated for each 14-day period. This is not a moving average. Rather, it is a 14-day average (analogous to a monthly average, weekly average, or daily average). For example, the first 14-day average would include salinities from Jan 1, 1965 through Jan 14, the second average would include Jan 15 through Jan 28 and the third Jan 29 through February11.

It is imperative that somewhere in the Documentation Sheet a definition of 14-day average be given so that PM's may be calculated and independently verified by all interested parties.

Evaluation:

This most recent draft includes an expanded discussion of how the performance measures and other related data that will be used to evaluate CERP projects and progress towards restoration. Table 3, which summarizes the evaluation measures, is an excellent addition. The spreadsheet of monthly average flows is a great tool for evaluating the timing and duration of stressful and damaging events. However, some concerns raised during review of the February draft remain.

The updated performance measures address the frequency and duration of Stress and Damaging Flows with the following statement (see lines 38-44 of the Documentation Sheet)

"*For the purposes of CERP project alternative evaluation, the distribution of 14-day moving average flows over the 50-year modeling period of record (POR) in each Flow Envelope will be generated from the Regional Simulation Model (-Basins [RSM-BN]). Ideally, project alternative simulations over the POR would yield no more than two (2) consecutive 14-day moving average flow periods in the Stress Flow Envelope, and no more than one (1) consecutive 14-day moving average* *flow periods in the Damaging Flow Envelope, in either the SLE or CRE. More Optimum Flows and fewer repeated Stress or Damaging Flows are better*."

1. "14-day moving average" should be changed to "14-day average".
2. "50-year modeling period" should be changed to "51-year modeling period" as the period Jan 1, 1965 – December 31, 2015 encompasses 51 years.
3. The basis for the frequency of 2 stress events and 1 damaging flow event over the POR should be justified. Currently, these constraints seem arbitrary and require some ecological justification.

The addition of Figure 5, showing an example of RSM model output of the evaluation criteria addresses another concern raised during the review of the February Draft. However, it would be instructive to know which alternatives of which CERP project are being compared. This would add some realism to the results depicted in the figure which are now lacking.

Application to LOSOM:

The review of the February Draft included some thoughts regarding application of these performance measures to the LOSOM project. They are reproduced and expanded here.

The revised RECOVER Salinity Performance Measures are certainly applicable to LOSOM and can be used to help distinguish between alternative Lake Regulation Schedules. However, the lower bound for Damaging Flows for both systems is relatively low when compared to the range of high deleterious flows that these systems experience. In short, high flows that may be damaging to downstream lagoons (e.g. Indian River), Bays (e.g. San Carlos) and offshore ecosystems are not identified or quantified. The frequency and duration of such flows is an important consideration in formulating and choosing a regulation schedule for Lake Okeechobee. Because the lower limit for damaging flows is 1700 cfs, the PMs do not address or permit evaluation of the higher flows that the St. Lucie experiences.

The Documentation Sheet (lines 749-750) states that "*Additional flows were modeled in iterations of several hundred cfs between 1700–3000 cfs, none of which caused Damaging salinities to move downstream of the US1 Roosevelt Bridge for either indicator species*." Comments on the February Draft noted that these results seemed at variance with previous modeling and empirical analysis of salinity-flow relationships in the SLE. We also know however, that freshwater discharges do in fact cause damage below the US1 Bridge, in the middle and lower estuary, the Indian River Lagoon and offshore. As a rule of thumb, as freshwater discharge increases stressful and damaging salinities are translated down-stream and the area of the estuary that is negatively impacted by these flows increases. According to the CH3D model, what are damaging and/or stressful flows to these areas?

The RECOVER Salinity PM will have to be expanded in order to fairly assess alternative Lake Regulation Schedules because the PM does not address higher flows that cause stress and damage to areas downstream of the US1 Bridge.   As flows increase above the current high flow boundary of 1700 cfs, the area impacted downstream increases progressively (i.e 3500 cfs will affect a larger area than 1750 cfs). The current PM does not quantify this progressive damage. Two weeks of flow at 1750 cfs is equivalent to two weeks of flow at 3500 cfs, despite the fact that 3500 cfs will affect a larger area.

Suggest starting with the following flow categories:

Cfs

<150 – Stressful

150-1400 -Optimal

1400 – 1700 Stressful

1700 – 3000 Damaging Lower Estuary

3000- 4000 Damaging Indian River Lagoon

>4000 Damaging Offshore

Finally, it is recommended that high flow categories, at flows greater than 1700 cfs be established with the CH3D model using salinity and geographic boundaries such as the A1A Bridge in the lower estuary, Hell’s Gate at the mouth of the St. Lucie, Boy Scout Island etc.