A Salinity Performance Measure for Everglades Restoration Planning and Assessment

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Introduction and Background

The Restoration Coordination and Verification (RECOVER) Program of the Comprehensive Everglades Restoration Plan (CERP) evaluates restoration alternatives and assesses empirical data to provide regional and system-wide views of this large-scale restoration effort. Among other means, RECOVER uses performance measures to accomplish this objective. The Southern Coastal Systems Subteam of RECOVER has recently completed a major revision of the salinity performance measure that it will use in the Florida Bay region of CERP. The purpose of this presentation is to describe this performance measure and show examples of its use.

Restoration Target

Salinity targets for Florida Bay are derived from simulated historical hydrologic conditions using the South Florida Water Management District's Natural Systems Model (NSM) Version 4.6.2 and multiple linear regression (MLR) statistical models to estimate salinity response at all Marine Monitoring Network (MMN) stations in Florida Bay (Marshall et al. 2011). The NSM salinity time series values at each MMN station are then adjusted based on paleo-salinity information provided by USGS studies in Florida Bay (Wingard and Hudley 2011, Wingard et al. 2007, Wingard et al. 2010, Marshall et al. 2009). These adjustments provide a more accurate pre-water management salinity condition than the unadjusted NSM provides.

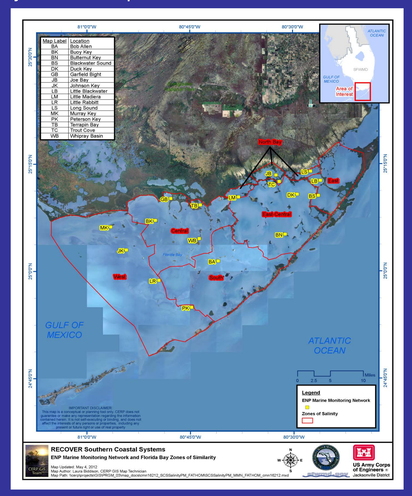

Figure 1. Map showing MMN stations and zones of similarity.

References:

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Marshall, F. E., G. L. Wingard, and P. Pitts. 2009. A simulation of historic hydrology and salinity in Everglades National Park: Coupling paleoecologic assemblage data with regression models. Estuaries and Coasts 32(1):37-53.

Wingard, G.L. and J.W. Hudley. 2011. Application of a weighted-averaging method for determining paleosalinity: a tool for restoration of south Florida's estuaries. Estuaries and Coasts. DOI:10.1007/s12237-011-9441-3.

Wingard, G.L., J.W. Hudley, and F.E. Marshall. 2010. Estuaries of the Greater Everglades Ecosystem: Laboratories of Long-term Change. U.S. Geological Survey Fact Sheet 2010-3047. [Available at http://pubs.usgs.gov/fs/2010/3047/index.html]

Metrics

The performance measure is comprised of three separate, but inter-related metrics. For each metric, either simulations of CERP alternatives or monitoring data are compared against the target. Each metric is appraised on a monthly and seasonal basis (wet season = June through November; dry season = December through May) at each MMN station.

Regime Metric – This metric examines the central tendency of salinity distributions by comparing the overlap between the mid-ranges of the target and the observed or predicted (CERP alternative) time series. The mid-range is defined as the salinity range between the 25th and 75th percentiles. Results are presented as ribbon plots and each site is scored as a percentage of the observed data or alternative simulation values that overlap within the target mid range.

Offset Metric – This metric provides a measure of the magnitude that the observed data or predicted (CERP alternative) output may deviate from the target. It is determined by calculating absolute value of the difference between the target monthly (or seasonal) salinity mean and the observed (or predicted) monthly (or seasonal) salinity mean.

High Salinity Metric – This metric focuses on the exceedences (in days) of the observed or predicted data above a high-salinity threshold. The high-salinity threshold is defined as the 90th percentile value of the 36-year period of record of the paleo-adjusted NSM and is determined separately. Target exceedences are then calculated on a monthly and seasonal basis by determining the number of days in the month (or season) in the paleo-adjusted NSM data that exceeds the threshold. For assessment purposes, the number of days in a given month or season in the observed data for the year of interest exceeds the 90th percentile target value is determined. The metric score is then calculated by dividing the number of days of exceedence in the observed data into the exceedence target.

Examples

Figure 2 below shows results of the metrics as applied to observed salinity data from Whipray Basin in 2003. The gray ribbon represents the target mid-range and the orange ribbon represents the mid-range of the observed data. The darker orange ribbon shows the overlap area. The target mid-range distribution is significantly wider than the 2003 observed data distribution because the target is an average distribution of a 36-year record versus only 1 year of observed data. For 2003, the regime overlap score during the wet season is 0.13, which is less than during the dry season (0.37). Monthly scores for all metrics are shown just above the X-axis. For 2003, the mean offset during the wet season (4.51 psu) is larger than the offset during the dry season (2.24 psu). The ideal condition (i.e., desired) is a mean offset score of 0.0. For the high salinity metric, the months of Feb-Jun and Nov-Dec scored a maximum of 1.0, meaning that there was no appreciable concern with high salinities in Whipray Basin during that time period. The months of Jan, Aug, and Sep exhibited scores of 0.10 to 0.12, indicating a significant high salinity problem during those months.

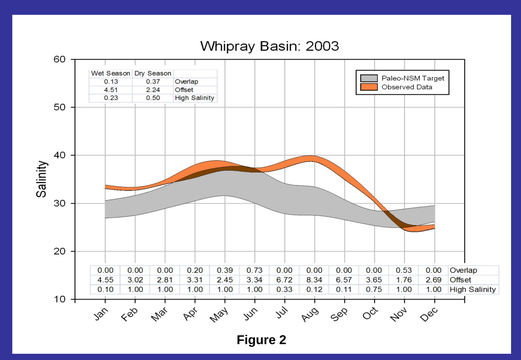
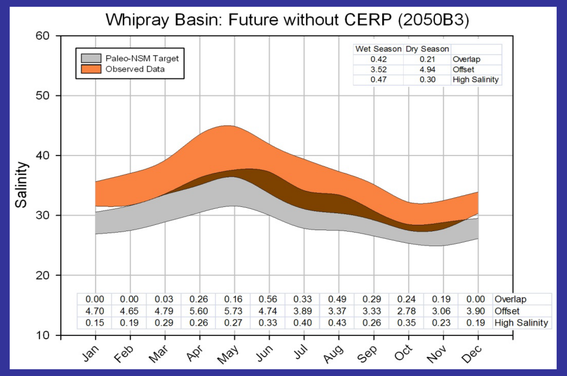
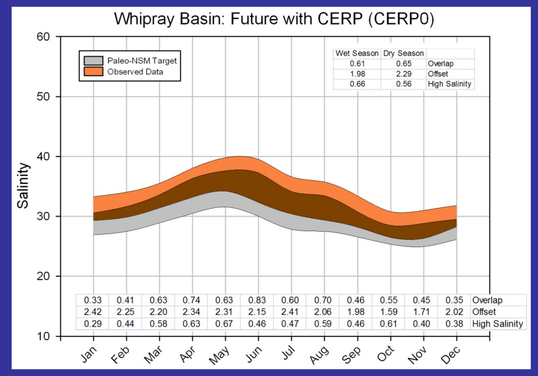


Figure 2





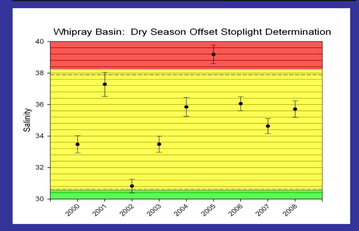
The figure above shows an example of the metrics as used for CERP alternative evaluations. The left panel shows 2050B3 (i.e., future without CERP) compared to the target for Whipray Basin; the right panel shows CERP0 (i.e., future with CERP) versus the target for Whipray Basin. Note that the future with CERP provides significant improvement for all three metrics during both the wet and dry seasons compared to the future without CERP.

Metric Reporting

Information from the three metrics will be used to evaluate an alternative or assess a period of observed data compared to the target using a "stoplight report-card" approach. This approach is a common format for displaying high-level, highly aggregated information to scientists and resource managers. A red stoplight color indicates substantial deviations from restoration targets creating severe negative conditions that merit action; yellow indicates the current condition does not meet restoration targets and merits attention; green indicates good conditions and restoration goals or trends toward those goals have been reached.

Score Regime Overlap and High-salinity Metrics	Stoplight Evaluation
<0.33	Red
0.33-0.67	Yellow
>0.67	Green

For the regime overlap and high salinity metrics, the stoplight scale shown at left will be used. Those two metrics are normalized to a 0-1 scale with each color category comprising one third of the 0-1 range.

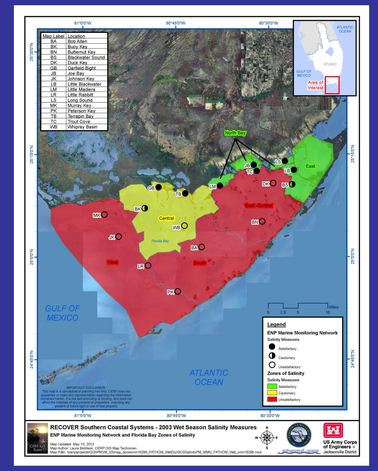


Stoplight colors for the mean offset metric are determined by comparing the mean and 90% confidence limit (CL) of the target with the assessment or evaluation data (see example in figure at left). The red threshold is defined by the mean and 95%CI of the 1989-90 paleo-adjusted NSM-dry time period (2 very dry years that resulted in harmful high salinities in the bay). The green threshold is defined by the mean and 90%CL of the full target period of record. If the observed data mean falls above the NSM-dry condition mean, the stoplight color is red. If the observed data mean falls below the full NSM target mean, the condition is green. If the observed data mean falls between the target and NSM-dry means, the 90%CLs determine the stoplight color (if no overlap, the condition is yellow). In the example above, 2001 is a red condition because the 90%CL of the observed data overlaps the 90%CL of the NSM-dry condition.

Overall stoplight values are obtained by aggregating individual metric stoplight values after re-assigning numeric values to the colors (red=0, yellow=0.5, green=1). The overall stoplight value is the mean of the 3 metric values applied to the stoplight scale used for the regime overlap and high-salinity metric shown above.

MMN Station	Dry Season: Mid-range Overlap	Dry Season: Mean Offset	Dry Season: High Salinity	Dry Season: Overall Stoplight Score	Wet Season: Mid-range Overlap	Wet Season: Mean Offset	Wet Season: High Salinity	Wet Season: Overall Stoplight Score
Joe Bay (JB)	R	R	R	R	G	G	G	G
Little Madeira Bay (LM)	Y	Y	R	Y	G	G	G	G
Long Sound (LS)	R	Y	R	R	G	G	G	G
Trout Cove (TC)	R	R	R	R	Y	G	G	G
North Bay average	R	R	R	R	G	G	G	G
Blackwater Sound (BS)	R	Y	R	R	Y	Y	G	Y
Little Blackwater Sound (LB)	R	R	R	R	G	Y	G	G
East average	R	R	R	R	G	Y	G	G
Butternut Key (BN)	R	Y	R	R	R	Y	R	R
Duck Key (DK)	R	Y	Y	R	R	Y	R	R
East-central	R	Y	R	R	R	Y	R	R
Buoy Key (BK)	G	Y	G	G	G	Y	Y	Y
Garfield Bight (GH)	Y	Y	Y	Y	G	Y	G	G
Terrapin Bay (TB)	Y	Y	Y	Y	G	G	G	G
Whipray Basin (WB)	Y	Y	Y	Y	R	Y	R	R
Central average	Y	Y	Y	Y	G	Y	Y	Y
Bob Allen Key (BA)	R	Y	G	Y	R	Y	R	R
South average	R	Y	G	Y	R	Y	R	R
Johnson Key (JK)	G	Y	G	G	R	R	R	R
Little Rabbit Key (LR)	G	G	G	G	R	R	R	R
Murray Key (MK)	Y	Y	G	Y	R	Y	R	R
Peterson Key (PK)	R	Y	R	R	R	Y	R	R
West average	Y	Y	G	Y	R	R	R	R

Summary stoplight assessment for each MMN station for 2003.



Map showing stoplight scores for 6 salinity zones for the 2003 wet season.