

Indicator 4.1 - Salinity Patterns in Florida and Biscayne Bays

What is the desired restoration condition?

The desired restoration conditions for salinity patterns in Florida and Biscayne Bays is to reduce the intensity, frequency, duration, and spatial extent of high salinity events, reestablish common mesohaline to oligohaline conditions in mainland nearshore zones, and reduce the frequency and rapidity of salinity fluctuations derived from pulse releases of fresh water from canals.

Why is this indicator important and why is it a good indicator of CERP restoration?

The estuarine environment is sensitive to freshwater inputs. Modifications of the volume, distribution, circulation, or temporal patterns of freshwater discharges can place severe stress upon the ecosystem. Salinity patterns affect productivity, population distribution, community composition, predator-prey relationships, and food web structure in coastal waters and adjacent wetlands. The salinity patterns of South Florida's estuaries have been radically altered in time and space by water management structures and operations. One objective of the Comprehensive Everglades Restoration Plan (CERP) is to restore the natural spatial and temporal patterns of salinity, linking freshwater discharges to seasonal rainfall patterns and natural wetland hydrologic functions. Releasing fresh water to the estuaries in a manner that more closely approaches natural volumes and timing in relation to rainfall is expected to restore salinity regimes that are more supportive of native estuarine flora and fauna.

How is the interim goal for this indicator predicted?

Florida Bay

Salinity predictions for Florida Bay for the 1995 baseline (95R), future without CERP implementation (2050), interim years (2010, 2015), full CERP implementation (D13R), and pre-drainage (NSM4.5F) are based on South Florida Water Management Model (SFWMM) or Natural System Model (NSM) simulations of wetland stages and statistical models (multiple regressions from Marshall et al. 2004) of observed daily salinity at Everglades National Park platforms as a function of observed daily wetland stages, along with sea level in Key West and wind fields in Miami and Key West (Table 4.1.1). Biases between observed stages and SFWMM stages at specific locations were adjusted. Wetland sites selected for each bay site were based on best fit criteria. The period of record for these regressions varies with estuarine site, beginning between 1988 and 1994 and ending in 2002. Sites included here are along the northern Florida Bay coast (east to west: Joe Bay, Little Madeira Bay, Terrapin Bay, and Garfield Bight) and in Whitewater Bay (North River Mouth). This same regression approach is being used by the RECOVER Evaluation Team.

For each estuarine site, daily salinity and monthly averages were calculated for the 31-year simulation period. Monthly salinity values were then ranked and the mean salinity of the

highest and lowest quartile of monthly values was calculated. These upper and lower means are reported.

Table 4.1.1. Regression equations for predicting salinity from stage gages in Everglades National Park (stations CP and E146 in Taylor Slough; EVER6 near the C-111 canal; P33, NP206, NP62, and G3273 in Shark River Slough). Lags between stage and salinity of zero to six days (e.g., “lag6” for the latter) are included. Equations also include wind vectors (“uwnd” or “vwnd”) at Miami (mia) or Key West (kw) and sea level at Key West sea level (watlev).

Location	Regression Equation
Joe Bay	Salinity = 37.1 - 3.1CP - 3.5EVER6[lag6] - 10.5E146[lag6] - 0. uwndkw - 0.09 uwndkw [lag2] - 0.1vwndkw - 0.16vwndmia[lag1], Adj. R ² = 0.75
Little Madeira Bay	Salinity = 106.1 - 0.3CP[lag2] - 12.5P33[lag2] - 1.7(P33-NP206) - 0.25 uwndkw + 0.13uwndmia - 0.19vwndmia[lag1] + .95kwwatlev[lag2], Adj. R ² = 0.65
Terrapin Bay	Salinity = 106.9 - 6.3CP[lag1] - 11.1P33[lag2] - 0.45 uwndkw - 0.23 uwndkw [lag1] - 0.2 uwndkw [lag2] - 0.14 vwndkw[lag2] + 0.46uwndmia + 1.9kwwatlev[lag2], Adj. R ² = 0.75
Garfield Bight	Salinity = 56.1 - 9.2CP[lag1] - 4.6NP62[lag1] - 0.46uwndkw[lag1] - 0.48uwndkw[lag4] + 0.35uwndmia[lag1] + 0.64uwndmia[lag4], Adj. R ² = 0.68
North River Mouth	Salinity = 58.7 - 1.7G3273[lag4] - 2.6NP206[lag3] - 2.8NP62[lag2] - 2.8P33[lag1] + 0.47kwwatlev[lag2], Adj-R ² = 0.77

Uncertainty in the Model Predictions. This statistical (regression) approach used is currently the best methodology available to predict nearshore salinity, but the methodology has serious limitations. The total error in salinity predictions is a product of multiplicative errors of the SFWMM and regression models and thus is large. The regressions have mean absolute error values such that the models predict to within about +/- 3-5 parts per thousand (ppt) on the average. Maximum absolute error values indicate that all of the models can produce a single estimate of the daily salinity values that can be 15-20 ppt in error. Monthly mean estimates are likely to be more reliable than daily estimates. It should be noted that predictions based on statistical relationships of current conditions have inherent limitations - they are only valid if future conditions per set of stations do not exceed absolute values that are statistically modeled (i.e., extrapolations do not occur) and physical conditions (e.g., flow resistance from plants and creek morphology) do not change. These assumptions are unlikely to be true. It should also be noted that because each estuarine station’s regression is fitted to a unique combination of input variables, errors differ among stations. Given all of these limitations, the results below should only be used to assess relative differences with alternatives for a given station; comparisons among stations may not be valid. It is expected that a far better methodology will be available for the next report with completion of the Florida Bay and Florida Keys Feasibility Study, which will provide improved hydrologic and hydrodynamic models for this region.

Biscayne Bay

Methods for predicting Biscayne Bay salinity have not yet been developed.

What are the predictions for five-year increments?

Florida Bay

Joe Bay. Results presented in Figure 4.1.1 show that Joe Bay appears to be insensitive to CERP actions. It also indicates that current conditions within Joe Bay are predicted to be as they were in the natural system (as estimated by NSM). These findings are counter to palaeoecological evidence and counter to the best professional judgment of the scientific community (Brewster-Wingard et al. 2003). The estimated salinity levels of common high salinity periods (the upper 25 percent of months) has estimated salinity equivalent to seawater (35 ppt), rather than the mesohaline (close to 15 ppt) level that was targeted in the Central and Southern Florida Project Comprehensive Review Study, commonly referred to as the Restudy.

Little Madeira Bay. Predictions for this nearshore bay show sensitivity to CERP implementation. While high salinity values are not expected to become lower or less common through 2015, D13R (full implementation) reflects NSM output and clearly moves this portion of Florida Bay toward restoration. Low salinity values are also predicted by the NSM to have been lower and, while D13R does not equal the low value of the NSM output, progress toward achieving D13R salinity levels is predicted to occur by 2010, with lower quartile salinity levels near 10 ppt.

Terrapin Bay. The pattern of predictions for Terrapin Bay is similar to that for Little Madeira Bay, but with relatively less of a long-term improvement with D13R and only slight improvement through 2015. Note, however, that absolute salinity levels are higher in Terrapin Bay than in Little Madeira Bay because the latter naturally receives more surface water flow from Taylor Slough.

Garfield Bight. Salinity in Garfield Bight is predicted to remain very high (with 25 percent of monthly values exceeding 40 ppt) and the CERP is predicted to have little effect on this problem. Months with low salinity (25 ppt was a low salinity target in the Restudy) are predicted to be rare, even with restoration. These predicted salinity levels, however, do not greatly differ from NSM-predicted levels.

North River Mouth. North River receives water directly from Shark River Slough and, as expected, substantial progress toward restoration with CERP implementation is predicted. High salinity values are likely to drop slightly by 2010 and 2015, but a more dramatic improvement is likely after this time with full implementation (D13R). The lowest 25 percent of values for all alternatives in Figure 4.1.1 are nearly 0 ppt, so progress at low salinity is not visible in this graph. However, interim progress toward restoration is indicated by the frequency of months with salinity levels below 5 ppt: by 2010, more than 55 percent of months are predicted to be below this level; by 2015, more than 60 percent is predicted, and with complete implementation (D13R), almost 70 percent is predicted. 95R and 2050BSR range from 40-50 percent below this threshold.

Summary of All Sites. While progress toward restoration seems assured for the Shark River Slough estuaries, as represented by North River Mouth, there is less certainty regarding the prospects for Florida Bay’s nearshore waters. Salinity predictions generally show little improvement until full implementation (D13R) and in some cases show no improvement even with D13R. Evaluating the adequacy of D13R for Florida Bay restoration is an explicit goal of CERP’s Florida Bay and Florida Keys Feasibility Study. Models being built for this study should provide much better predictive power for these salinity indicators.

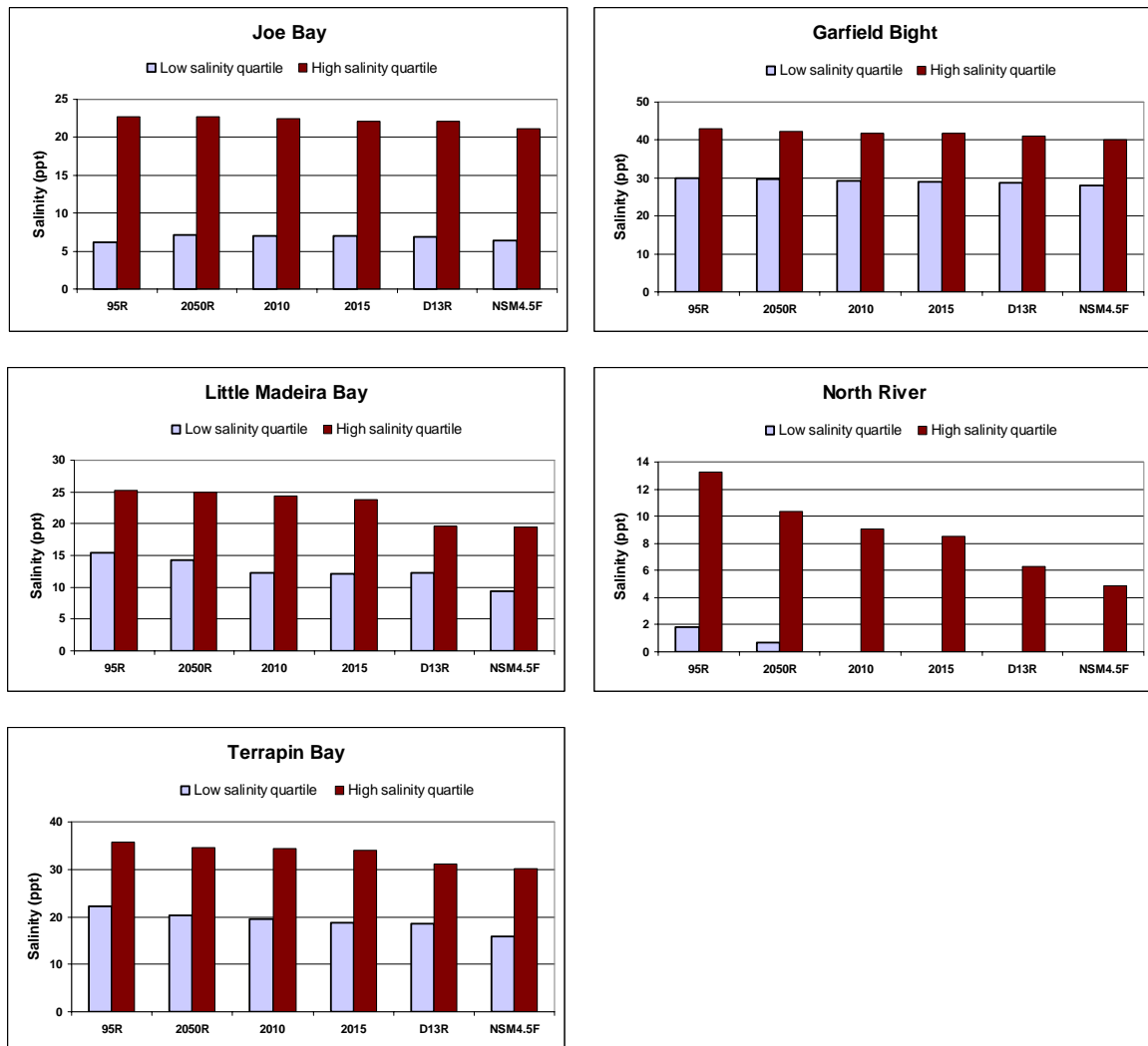


Figure 4.1.1. Florida Bay salinity predictions for five coastal areas

Biscayne Bay

Predictions for Biscayne Bay salinity could not be made at this time

How will we track whether the interim goals established for this indicator have been achieved?

The *CERP Monitoring and Assessment Plan: Part 1, Monitoring and Supporting Research* (RECOVER 2004) calls for monitoring salinity at each of these stations.

What additional work is needed to improve this interim goal?

Improved and new models are needed to improve salinity predictions. An improved hydrologic model that predicts conditions to the edge of Florida Bay (which the SFWMM does not currently do) and has a fine enough scale to model southeastern Everglades features is needed. Also needed is a hydrodynamic model within the bay. Such models are being developed as part of the Florida Bay and Florida Keys Feasibility Study.

Another needed improvement concerns the definition of restoration targets using the NSM. While this model appears reasonable for the Shark River Slough and associated estuaries, it is weaker for the southeastern Everglades, probably because of the small scale of Taylor Slough and other features. Caution should be used before accepting NSM output to define Florida Bay restoration. Restoration targets for the bay are being developed and refined in the Florida Bay and Florida Keys Feasibility Study and this effort will help guide a revised set of interim goals for the next reporting period.

References

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