Florida Bay Ecosystem Model Salinity Reconstruction

Adapted from documentation prepared by Lance Gunderson and Carl Walters

The Florida Bay Ecosystem Model (FBEM), developed by Carl Walters (UBC) during a series of workshops sponsored by the South Florida Water Management District, The Nature Conservancy, and the Florida Keys Water Quality Joint Action Group, provides a simple, calibrated model of salinity dynamics in Florida Bay. In this spreadsheet, monthly salinity changes for 1960-95 were modeled and then fit to the average salinity observed at a selected set of stations (Terrapin Bay, Whipray Basin, Garfield Bight, Rankin Bight, Murry Key) since 1991. This model is based on the simple assumption that change in total salt over any month is equal to the net inflow of seawater containing salt, times the salinity of this inflow, less the total outflow of water times the concentration present at the start of the month. The total outflow of water is assumed to equal total inflow, and this total outflow is calculated as M+P+R-E, where M = volume of water entering the system (mainly from the Gulf of Mexico), P = volume of rainfall, R = volume runoff, and E = volume of evaporation. In months of negative net outflow (high E, low P, R, M), salt is added to the mass balance at the seawater boundary concentration rather than removing it at the current bay concentration. The key uncertainties in this calculation are M and R, the oceanic mixing and freshwater runoff volumes. M is computed as Mt=Mo+M1Wt where Wt is mean wind speed over the Bay in month t, and R as Rt=k1(Taylor Slough runoff)+k2(Shark Slough runoff), where Taylor Slough runoff for each month has been estimated by using hydrology models (University of Florida Adaptive Environmental Assessment Model (UFAEA) for 1960-88; South Florida Water Management Model (SFWMM) for 1989-95), and measured flow past Tamiami Trail is used as a predictor or index of Shark Slough runoff. Presumably k1 simply measures bias in model estimates of Taylor Slough runoffs, but k2 contains effects of net runoff changes from Tamiami Trail to the Gulf and of mixing loss of Shark Slough water into Gulf water that does not all enter the Bay. Mo, M1, K1, and k2 are estimated by a least squares calibration procedure: the sum of squares deviations between observed and predicted monthly mean salinities, 1991-95 is minimized by Excel's Solver routine, treating the M and K values as variables.

The simple salt balance model fits the 1991-1995 data very well, and indicates a complex long-term pattern of changes in salinity. The best fitting parameter estimates provide interesting insights about water sources for the Bay. The average value of seawater volume exchange Mt is estimated to be around 0.2V=180,000 acre ft./ month, where V=Bay volume (around 900,000 acre ft.). The best fitting estimates for the mixing parameters are Mo/V=0.64 and M1/V=-0.09. The negative value for M1 implies that increasing wind speed tends to decrease volume turnover. This is expected considering that prevailing winds are from the south, while the sea surface slope is from the north so that winds tend to push against the southerly flow caused by the Gulf of Mexico sea surface anomaly. In comparison to M, long term average monthly values of P-E are around -0.1 ft./month x V=-31,000 acre ft./month (94,000 acre ft./month local rain, 125,000 acre ft./month evaporation), and Taylor Slough runoff contribution to R has averaged around 28,000 acre ft./month. Thus in the absence of Shark Slough contribution to the Bay, local rainfall and evaporation along with marine volume exchange tend to dominate the salinity balance except on rare occasions of very high Taylor Slough runoff. Considering how large M is, in comparison to the local net P-E+R rainfall and runoff components of the mass balance, it is not surprising that even a modest effect of Shark Slough on the salinity of the component of M representing input water around Cape Sable can have a large effect on average salinity over at least the western portion of the Bay.

Sample Formula

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AI66 =AI65+ (vc+wp*$W65)*so-IF($F65<0,$F65/d*so,0) -((vc+wp*$W65) rk*AG65/d+rkt*AH65/d)*AI65-IF($F65>0,$F65/d*AI65)
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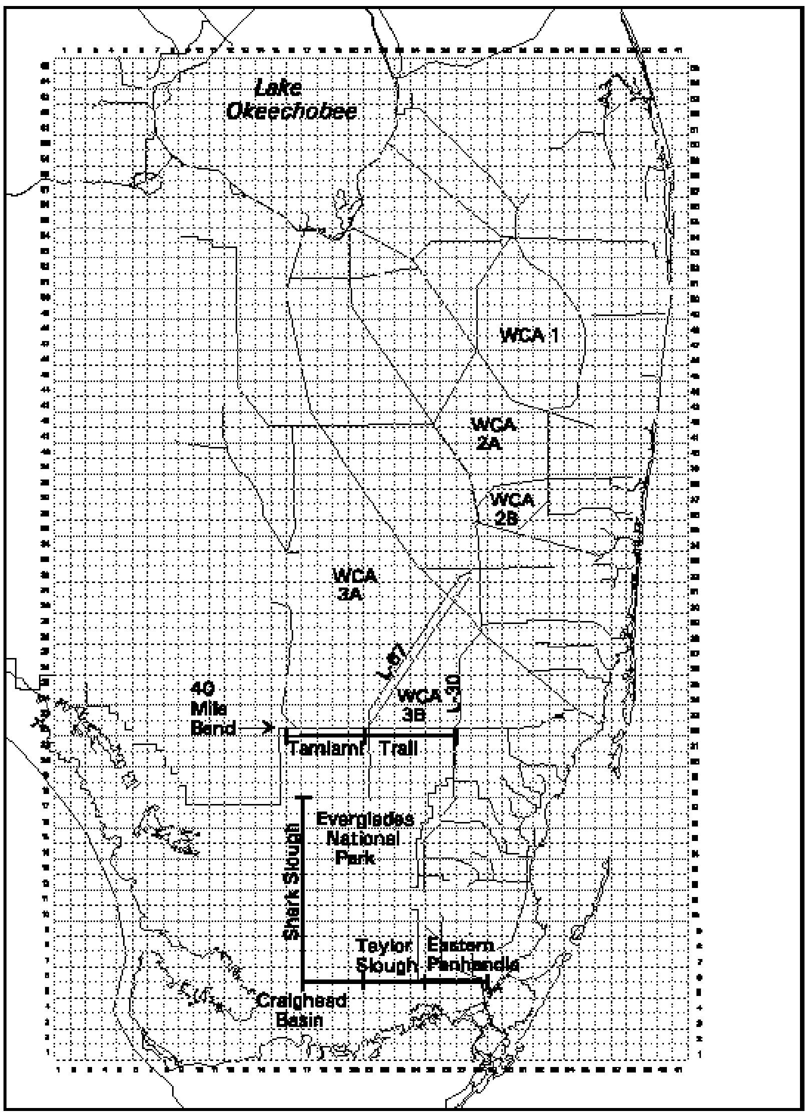
Where:

AI66 = predicted salinity
AI65 = previous months salinity
vc = volume coefficient
wp = wind effect parameter
w65 = total wind for previous month

so = salinity at ocean boundary
F65 = net rain from previous month (rain-et)
rk = flow coefficient for shark and Taylor Slough runoff
**AG65 = estimated total Shark and Taylor Slough runoff (at southern end) during previous month (in 1000 af)
d = average bay depth
rkt = flow coefficient for Tamiami Trail discharge
**AH65 = estimated Tamiami Trail flow section discharge during previous month (in 1000 af)

** Simulated flows calculated from flow transects in SFWMM (see figure below)



SELECTED FLOW LINES FOR DETERMINING FLOWS TO ENP & FLORIDA BAY