PMLevyCOLPEm Resource

From: Hambrick, Gordon A SAJ [Gordon.A.Hambrick@usace.army.mil]
Sent: Friday, May 04, 2012 2:46 PM
To: Snead, Paul
Cc: Collazo, Osvaldo SAJ; Bruner, Douglas; DavidA Pritchett
Subject: RE: PEF's Draft Environmental Monitoring Plan and Draft Aquifer Performance Test Plan for LNP raw water well field - Corps Comments and Questions (UNCLASSIFIED)
Attachments: DRAFT SCS Salinity PM - FLBay for RECOVER review.pdf

Classification: UNCLASSIFIED
Caveats: NONE

Paul:

I forgot to attach the following draft report, which is an attachment to the Comments from Recover Branch, which I sent to you earlier this morning with the email below.
Don

-----Original Message-----
From: Hambrick, Gordon A SAJ
Sent: Friday, May 04, 2012 12:08 PM
To: Snead, Paul
Cc: Collazo, Osvaldo SAJ; 'Bruner, Douglas'; 'DavidA Pritchett'
Subject: PEF's Draft Environmental Monitoring Plan and Draft Aquifer Performance Test Plan for LNP raw water well field - Corps Comments and Questions (UNCLASSIFIED)

Classification: UNCLASSIFIED
Caveats: NONE

Paul:

As you and I discussed earlier today by telephone, this email is in reference to the advanced copies of PEF's draft "Aquifer Performance Testing Plan for Levy Nuclear Plant Raw Water Well Field" (APTP) and draft "Levy Nuclear Plant Raw Water Well Field Environmental Monitoring Plan (EMP), which were provided to the Corps, NRC and EPA via e-mail on April 5, 2012. The draft plans were the subject of a joint meeting and site visit attended by representatives from PEF, NRC, EPA and the Corps on April 11, 2012. As agreed at the meeting, and with this email, the Corps is providing to PEF comments, questions and recommendations in regard to the draft plans.

Please find attached three documents, which together document to PEF, the Corps's comments, questions, requests for additional information, and initial recommendations at this time in regard to PEF's draft APTP and EMP. The three attached documents are: 1) The Final Meeting Minutes from the April 11 meeting (April 11 2012 Final Meeting Minutes.pdf); 2) a review of the EMP, as provided by Recover Branch, Jacksonville District, Corps of Engineers (RECOVER review of LNP draft EMP April 2012.pdf); and 3) comments of the EMP and APT, as provided by Engineer Division, Jacksonville District, Corps of Engineers (Comments from Engineering Division.pdf).

Also, as we discussed, you and I will telephone next Monday or Tuesday, to discuss timeframes for responses from PEF and setting up a meeting.

Thanks, Don.

Gordon A. (Don) Hambrick, III

Senior Project Manager

Panama City Permits Section

US Army Corps of Engineers

Jacksonville District

1002 West 23rd Street, Suite 350

Panama City, Florida 32401

Office: 850-763-0717, ext. 25

Fax: 850-872-0231

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Created By: Gordon.A.Hambrick@usace.army.mil

Recipients:
"Collazo, Osvaldo SAJ" <Osvaldo.Collazo@usace.army.mil>
Tracking Status: None
"Bruner, Douglas" <Douglas.Bruner@nrc.gov>
Tracking Status: None
"DavidA Pritchett" <Pritchett.DavidA@epamail.epa.gov>
Tracking Status: None
"Snead, Paul" <paul.snead@pgnmail.com>
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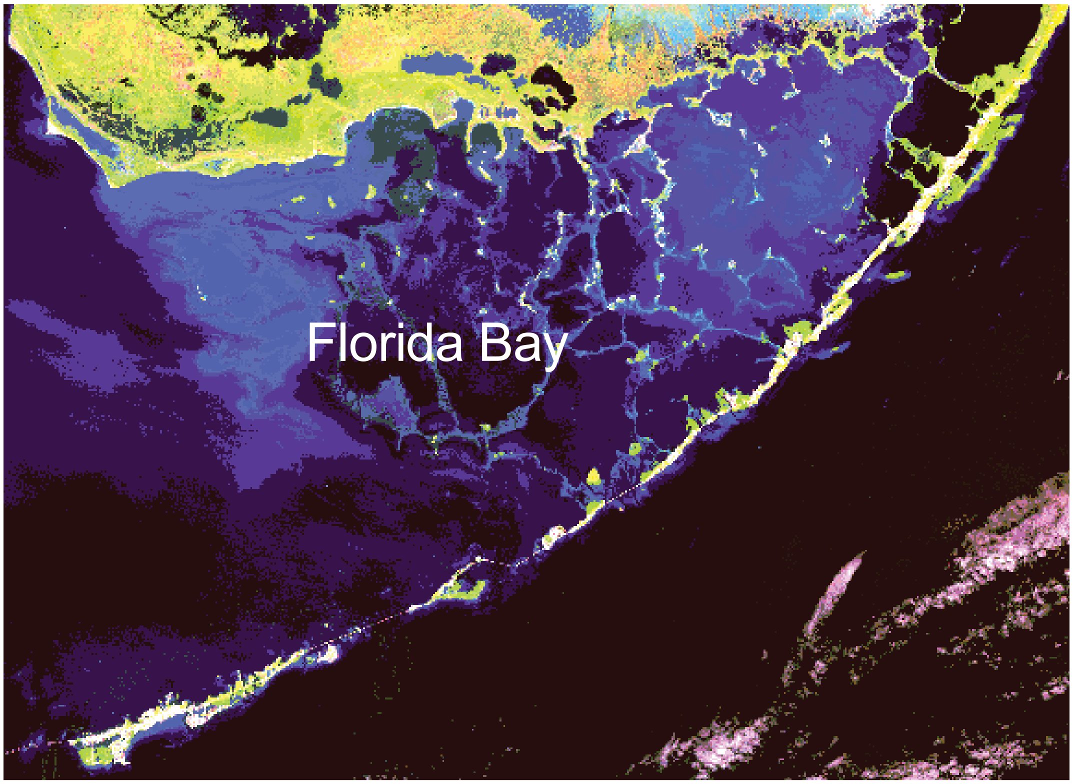
Southern Coastal Systems Performance Measure

Salinity in Florida Bay



Last Date Revised: September 2008
Acceptance Status: Revised Draft September 2011

1.0 Justification

Florida Bay is a complex, heterogeneous coastal environment that, prior to human intervention, varied due to natural factors, including hurricanes, climatic variation and changing sea level (Nuttle 2003). Paleosalinity records indicate oligohaline to mesohaline conditions (5 to 18 parts per thousand [ppt]) existed in the nearshore embayments of Florida Bay around the turn of the last century, which could be considered to be a reasonable pre-water-management or pre-drainage time period (http://pubs.usgs.gov/pdf/of/ofr97736.html). During that same time period, polyhaline (22-30 ppt) conditions existed in Whipray Basin within central Florida Bay (Trappe and Brewster-Wingard 2001). The main effect of water management has been to interfere with the natural relationship between rainfall throughout the Everglades system and runoff patterns (Smith et al. 1989), alter the seasonal inflow deliveries, and make salinity fluctuations more extreme in the northern and eastern part of the bay (Dwyer and Cronin 2001, Brewster-Wingard and Ishman 1999).

The greatest fluctuations in salinity occur in eastern Florida Bay where both extreme low salinity and hypersalinity occurs (Kelble et al. 2007). This part of the bay receives diverted flow from water released into the C-111 Canal, primarily during the wet season (June-November). The limited inflow in the dry season often creates high salinity conditions, including hypersaline conditions, particularly if the wet season rains are delayed in the area drained by the canal. Declines in diversity and increases in dominance of euryhaline species in several benthic invertebrate groups since the 1980s are evident in several parts of Florida Bay (Wingard et al. 2003), which is a change likely cause by of water management.

Zones of hypersalinity that develop in the north central bay sometimes expand to cover most of the bay (Kelble et al. 2007). Model output of salinity under a pre-water management scenario indicates that hypersalinity occurs more frequently today and lasts longer since the freshwater levels driving flow to the coast have been lowered by the upstream management of the canals, levees and water conservation areas. For example, in the past decade, observed salinity has occasionally reached 70 practical salinity units (psu) and frequently reaches 50 psu in the north central bay. Hypersaline conditions often start in the dry season, following a wet season of below normal rainfall. Hypersaline conditions can persist into the wet season when the dry season also has low rainfall, and are exacerbated when another wet season of low rainfall follows. In the mid-1970's and 1980's, hypersaline conditions persisted for several years.

Water management changes that result in meeting the targets for Florida Bay (described below) are expected to reduce the intensity, frequency, duration and spatial extent of hypersaline events in Florida Bay and establish a persistent and resilient estuarine zone that extends further into the bay than current conditions. This is expected to improve the production of bay flora and fauna and increase biomass and diversity in the bay at large. The seagrass species *Halodule wrightii* and *Ruppia maritima* should expand their current spatial coverage in these areas and, with persistent estuarine conditions, mature into rich forage habitat providing food and shelter to associated fauna (Madden et al. 2009).

Salinity in Whipray Basin and the Everglades National Park's (ENP) Marine Monitoring Network (MMN) stations in central Florida Bay is significantly related to salinity in the coastal embayments (Marshall et al. 2003). These results were analyzed in conjunction with paleo-salinity data, which suggested flows into Florida Bay are 2 to 4 times below their pre-drainage levels (Marshall et al. 2009). For initial evaluation, Whipray Basin salinity can be assumed to be an indicator for overall Bay salinity distribution. Reducing hypersaline conditions and increasing polyhaline conditions in the central and western parts of the bay will favor the production of the ecologically and economically important pink shrimp (Browder et al. 2002), spotted seatrout (Kelble et al. 2011), and forage species such as bay anchovy, clown goby, mojarras, pinfish, dwarf seahorse and Gulf pipefish (Johnson et al. 2002a, 2002b) that support game fish and wading birds. Other game fish species expected to benefit include life stages of common snook, gray snapper, and crevalle jack. The smalltooth sawfish, recently listed under the Endangered Species Act by the National Marine Fisheries Service, may also benefit in expanded available habitat.

2.0 Desired Restoration Condition

The desired restoration condition in Florida Bay is to:

- Reduce the frequency, duration, magnitude, and extent of hypersaline (>37 psu) conditions throughout the bay;
- Lower the average salinity in the bay;
- Restore oligohaline to mesohaline salinity patterns in the nearshore environment, including coastal lakes;
- Restore seasonal deliveries of freshwater that were more typical of the undisturbed system; and

3.0 Metric and Target

Salinity targets (also known as "paleo-adjusted NSM salinity") are derived using simulated historical hydrologic conditions with the Natural System Model (NSM) Version 4.6.2 and Multiple Variable Linear Regression (MLR) statistical models to estimate salinity response at all MMN stations in Florida Bay (Marshall et al. 2003, 2004). The NSM salinity time series values at each MMN station are then adjusted based on paleosalinity information provided by USGS studies in Florida Bay (Wingard et al. 2007a, Wingard et al. 2007b, Marshall et al. 2009). These adjustments provide a more accurate pre-water management salinity condition than the unadjusted NSM provides. See Figure 8 for locations of all MMN stations in Florida Bay for which paleo-adjusted NSM salinity targets are available.

The paleo-adjusted NSM targets are generally consistent with the former salinity target envelopes that were based on the salinity optima and preferences of plant and animal species common to historical (i.e., desired) communities in the various basins. It is worth noting that the set of available cores from which to make the paleosalinity adjustments are clustered in the central region of the bay and are certainly appropriate for making adjustments to MMN stations in that region. It would be preferable to make paleo adjustments to NSM time series at MMN stations located in other regions of the bay using cores from those regions; however, those cores are not available at this time.

For **evaluation** purposes, simulated hydrology produced by the South Florida Water Management Model (SFWMM) for each CERP alternative is post-processed using the MLR statistical models to predict the salinities at the MMN stations. The CERP alternative time series are then compared to the target using the metrics described below. As indicated, the desire is for the salinity at each station to reflect the condition provided by the paleo-adjusted NSM targets. This approach is used to compare among various restoration scenarios.

For **assessment** purposes, the observed salinity data from the MMN stations in Florida Bay are compared to the targets. Salinity data at other monitoring stations within the zones may be added to this evaluation in the future to enhance the overall assessment. The assessment period data are compared to the target using the metrics described below. The desire is for the salinity at each station to reflect the condition provided by the paleo-adjusted NSM targets.

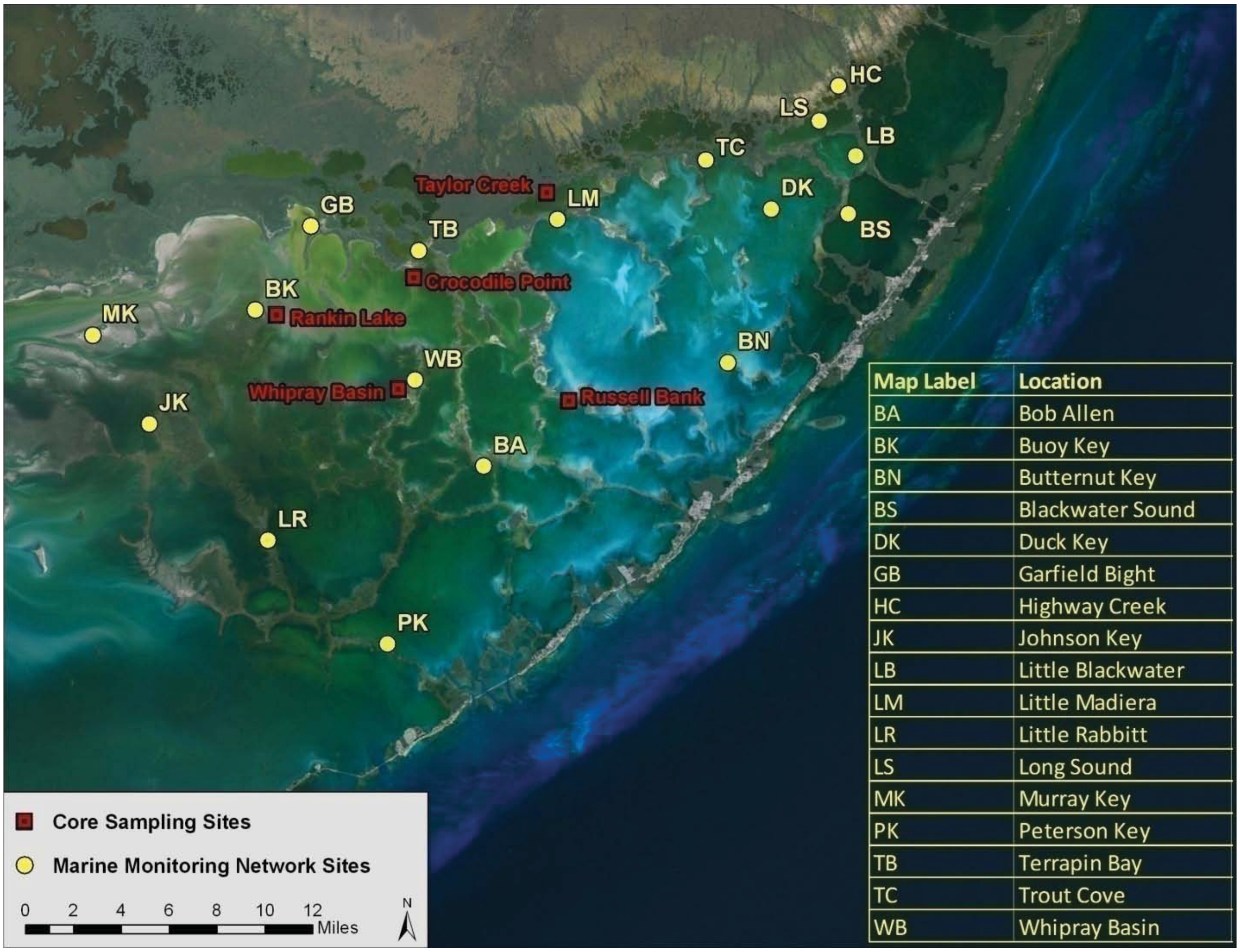


Figure 8. Map figure showing locations of MMN stations in Florida Bay (yellow dots) and the USGS core sites used for paleo-salinity adjustments.

The observed (assessment) and predicted (alternative evaluation) data are compared against the target using three metrics, as follows:

1. **Regime metric** – The distribution of salinities in the paleo-adjusted NSM record (target) is compared to the observed or predicted distribution of results between the 25th and 75th percentiles (hereafter referred to as the "mid-range"). Using values between the 1st and 3rd quartiles tends to minimize the confounding effects of outliers that are caused by ephemeral events such as tropical storms. The mid-range distribution of paleo-adjusted NSM salinities in the period of record (POR; currently 1965-2000, but will likely be extended in the future) is evaluated on a cumulative monthly basis to determine the target for this metric.

   a. **For assessment purposes**, the mid-range distribution is determined for yearly empirical data at each MMN site and compared to the target distribution. The overlap between the mid-range distributions is determined on a monthly basis and reported as a proportion of the mid-range values of the observed data that fall within the mid-range of the target, and is calculated as follows for a given month:

$$\text{Mid-range}_{overlap} = (\text{\# of days Mid-range}_{observed} \text{ falling within Mid-range}_{target)} \div \text{(1/2 the total \# days in the month)},$$

where Mid-range$_{observed}$ is the average daily salinity values for days in a given month when daily average salinity values fall within the 25th to 75th percentiles and the Mid-range$_{target}$ is the 25th and 75th percentile values of the target.

For example, if the assessed month is June, there are 15 values in the observed data set (1/2 the total # of days in the month of June) that would comprise the observed mid-range subset. If 7 of those values (i.e., days) fall within the target mid-range, then the score for that month would be 7 ÷ 15 = 0.46. This provides a 0-1 “overlap score” for each month, and allows calculation of an overall 0-1 annual overlap score by averaging the monthly scores.

b. **For evaluation purposes**, the method described above (1a) will be performed using the model output time series for alternatives of interest and comparing against the target.

2. **Mean Offset metric** – A measure of the magnitude that the observed data or predicted (CERP alternative) output may deviate from the target is determined by calculating the difference between the target annual salinity mean and the observed or predicted annual salinity mean and reporting the difference as the “mean salinity offset.” This metric is most useful when the regime metric score (i.e., mid-range overlap) is zero.

$$\textit{Mean Offset Metric} = \textit{Annual Mean}_{\textit{Observed or Predicted}} - \textit{Annual Mean}_{\textit{Target}}$$

Illustrations and examples of how the regime and mean offset metrics are calculated are shown in the figures, tables, and text below. Figure 9 shows ribbon plots of the mid-range (25th to 75th percentile) salinity distributions for the paleo-adjusted NSM output and observed salinity data from 2003 for Whipray Basin. Note that the target distribution is significantly wider than the 2003 observed data distribution due to the fact that the target is a POR average distribution, i.e. currently 36 years, versus only 1 year of observed data. In this example, the distributions show no overlap for the months of Jan-Mar and Jul-Oct, so the scores for those months are zero (see monthly scores just above the X-axis). The months of June, November, and December show the mid-range distribution of the observed data falls completely within the mid-range distribution of the target, so the scores for those months is 1.0. The months of April and May show partial overlap. The average regime metric score for all months for 2003 is 0.309, compared to a perfect 1.0 score if all months overlap completely. The average of the monthly differences between the target mean and the observed mean (i.e., mean offset score) is 4.9. The best condition (i.e., desired) is a mean offset score of 0.0.

Figure 10 shows an example when the mean salinity offset score is most useful. The left panel shows ribbon plots of mid-range distributions of the target and 2005 observed data from Whipray Basin; the right panel shows the same except for 2006 observed data. The distribution overlap with the target for both observed data sets is essentially zero. However, 2005 exhibits an overall worse condition than 2006 because the mean salinity offset is 3.6 higher in 2005 than in 2006 (9.8 versus 6.2).

Figure 11 shows an example of the regime metric used for CERP alternative evaluations. The right panel shows 2050 Base (i.e., future without project) compared to the target for Whipray Basin; the

right panel shows CERP0 versus the target for Whipray Basin. Note that CERP0 provides a 3-fold increase in the mid-range overlap compared to the future without project condition. However, the desired condition is an overlap score of 1.0.

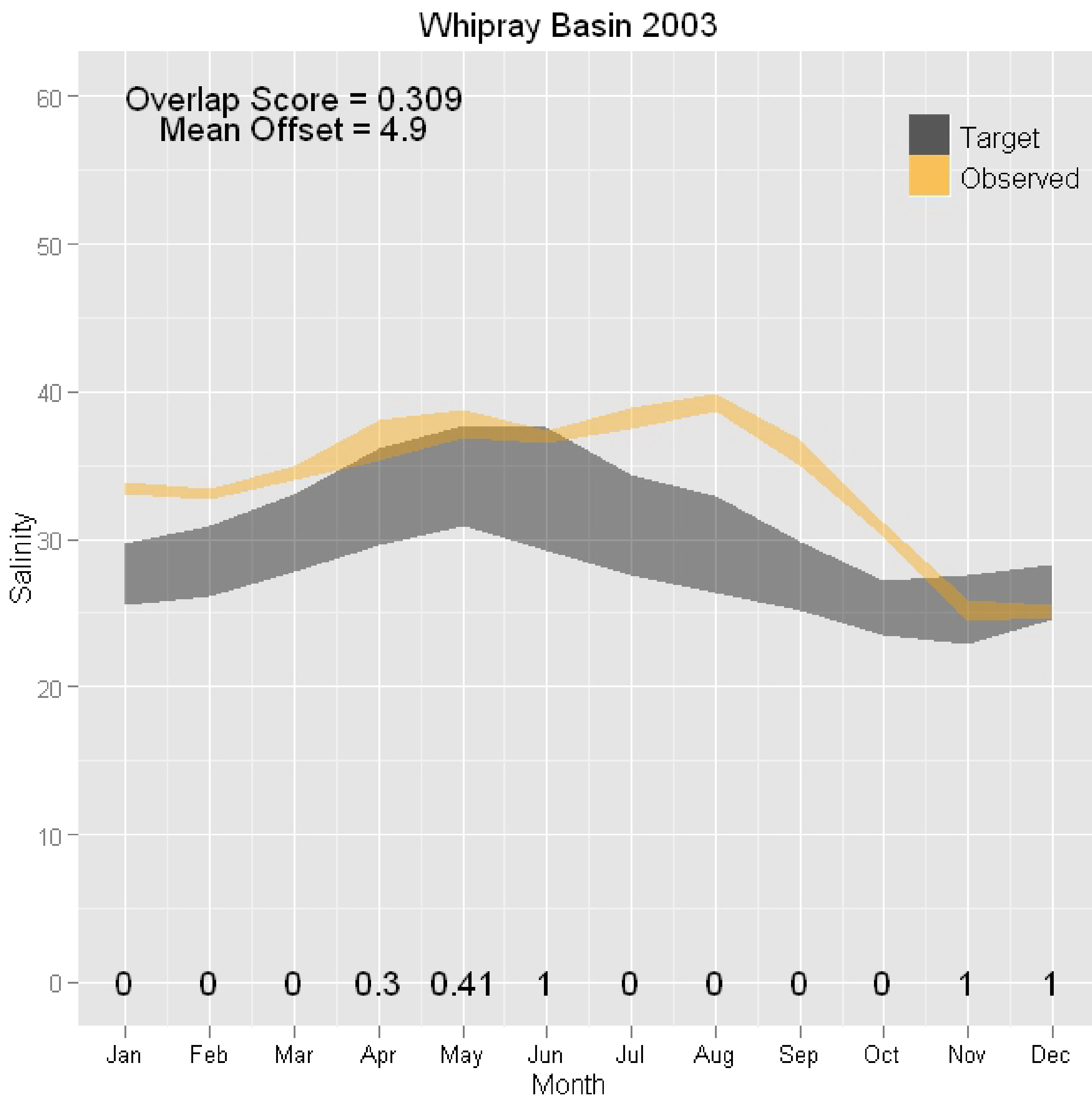


Figure 9. An example showing salinity distributions, regime metric, and overlap metric scores for Whipray Basin. The gray ribbon shows the mid-range (25^{th} to 75 percentile) distribution of the paleo-adjusted NSM target and the orange ribbon shows the mid-range of the 2003 observed data. The monthly overlap score is provided near the bottom of the plot, the 12-month average overlap score and the mean offset are shown in the upper left corner.

Figure 10. Example regime and offset metric plots showing where the mean offset metric is most useful.

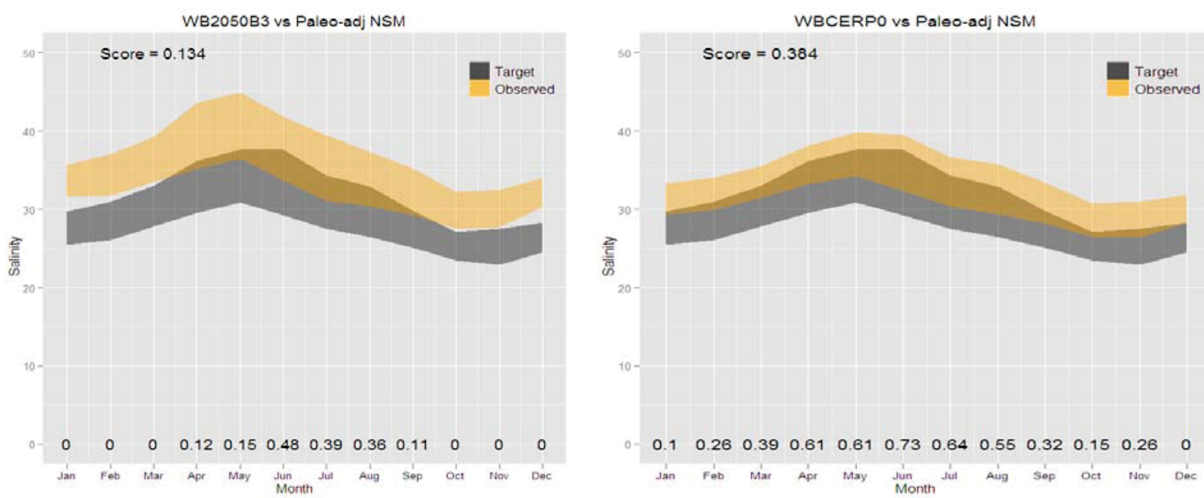


Figure 11. Example of the regime metric used for CERP alternative evaluations. The right panel shows 2050 Base (i.e., future without project) compared to the target for Whipray Basin; the right panel shows CERP0 versus the target for Whipray Basin. Offset scores are not available for this example.

3. **Hypersalinity metric** – This metric compares the frequency of occurrence (FO) of hypersalinity between the target and the assessment data (observed data) or evaluation output (CERP alternative) using 37 psu as the threshold. The target is calculated by summing all the days in a given month in the paleo-adjusted NSM salinity record where the daily average

exceeds the 37 salinity unit threshold, then dividing by 36 (currently the number of years in the POR) to obtain a monthly average hypersalinity FO. For example, to obtain the target for July, all the days for the 36 Julys in the current paleo-adjusted NSM salinity POR that exceed the threshold are summed and then the sum is divided by 36. The same procedure would be performed for model output for any CERP alternative. The FO score is obtained by dividing the FO of the target (annual average) by the observed or predicted FO for the period of record.

$$HypersalinityMetric = \frac{FO_{TARGET}}{FO_{OBSERVED\,or\,PREDICTED}}$$

Annual scores are used in place of monthly scores because for some months the observed or predicted hypersalinity FO in the equation is zero. Figure 13 shows an example of this metric for Whipray Basin where the observed data for 2004 was compared to the target. In this example, the salinity in April of 2004 was above 37 psu for 18 days, compared to the target of only about 6 days. Again, the April target for Whipray Basin is the average number of days in April over the 36-year POR when salinity was above 37 psu. In this example, hypersalinity at this location during 2004 was most prevalent during the wet season.

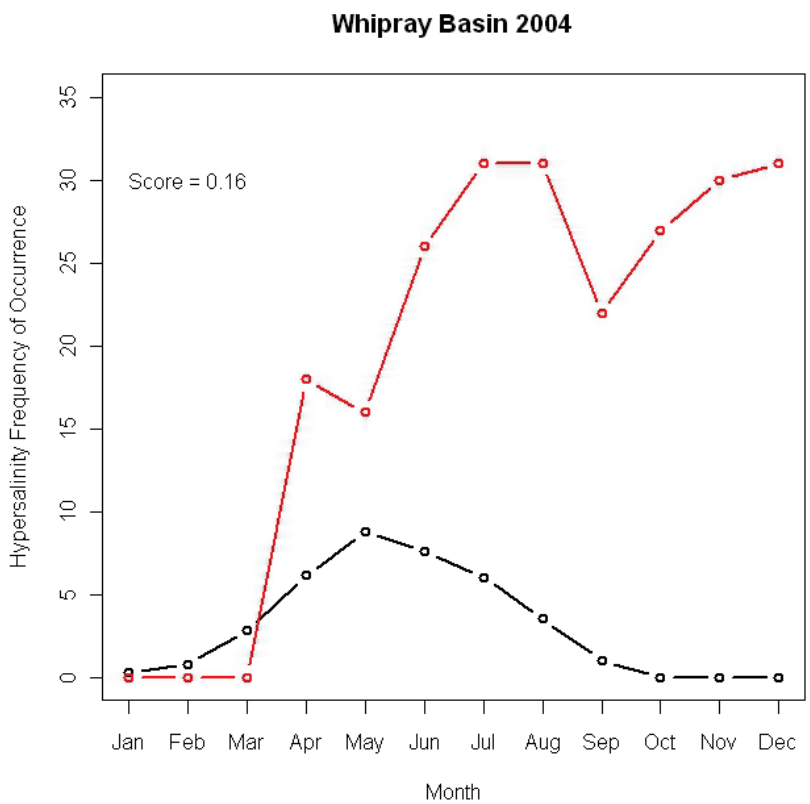


Figure 13. Example of hypersalinity frequency of occurrence metric showing the monthly average of the paleo-adjusted NSM target from Whipray Basin (black line) and 2004 observed

data from Whipray Basin (red line). The hypersalinity threshold value is 37 psu. The metric score is provided in upper left corner.

4.0 Metric Summarization and Reporting

Scores for each of the salinity PM metrics will be compiled into a table, examples of which are shown below (Tables 7 and 8). The information generated 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" approach. For the regime overlap and hypersalinity metrics, the stoplight scale shown in the panel below left will be used; for the mean offset metric the stoplight scale at below right will be used.

Score **(regime overlap and hypersalinity metrics)**	**Stoplight Evaluation**
0-0.30	**Red**
0.31-0.60	**Yellow**
0.61-1.0	**Green**

Score **(mean offset metric)**	**Stoplight Evaluation**
3.0 <	**Red**
1.0-3.0	**Yellow**
0-1.0	**Green**

Because two of the metrics are normalized and the other is not, an overall score cannot be obtained by aggregating metric scores. Instead, the overall stoplight score is generated by initially assigning an integer value for each stoplight color (red=0, yellow=1, green=2). Then, the stoplight color value for each metric is converted to the corresponding integer value. The three integer values for each metric for a given MMN station are then multiplied and the geometric mean is calculated, which becomes the overall stoplight numeric score. Assigning zero to a red score and using the geometric mean forces an overall stoplight score of red for any MMN station that has even one metric that is red. This is justified because red is supposed to mean substantial deviations from restoration targets creating severe negative condition that merits action. The overall score is then applied to the stoplight scale in the panel below. For example, according to Table 7, the Highway Creek assessment for 2003 resulted in yellow scores for two metrics and a green score for one metric, for a product of 2 (1 x 1 x 2) using the integer assignments described above. The overall stoplight score is then 1.26 (the cube root of 2), which results in an overall stoplight color value of yellow.

Overall Stoplight Score	**Stoplight Evaluation**
0	**Red**
1.0-1.26	**Yellow**
1.59-2.0	**Green**

Table 7. Summary of metric scores and stop evaluation for each MMN station within Florida Bay for 2003 (a relatively wet year) and averages of the scores within each zone (Figure 16). MMN stations have been grouped according to zones as determined by Nuttle et al. 2000, Boyer et al. 2007, Madden et al. 2009, Briceno and Boyer 2011 (see Future Tool Development and Data Needs section below), and zone averages have been calculated.

MMN Station	Mid-range Overlap	Mean Offset	Hypersalinity Frequency of Occurrence	Overall Stoplight Score
Highway Creek (HC)	**0.392**	**2.5**	**1.0**	**1.26**
Long Sound (LS)	**0.358**	**2.0**	**1.0**	**1.26**
Joe Bay (TC)	**0.263**	**1.7**	**1.0**	**0**
Taylor River (TR)	**0.710**	**0.5**	**NA**	**NA**
Little Madeira Bay (LM)	**0.711**	**1.3**	**1.0**	**1.59**
Terrapin Bay (TB)	**0.563**	**2.6**	**1.0**	**1.26**
Garfield Bight (GB)	**0.323**	**3.1**	**0.972**	**0**
Blackwater Sound (BS)	**0.048**	**4.8**	**NA**	**NA**
Little Blackwater Sound (LB)	**0.246**	**7.3**	**1.0**	**0**
Transition average	**0.402**	**2.9**	**0.996**	**1.26**
Middle Key (MD)	**NA**	**NA**	**NA**	**NA**
Manatee Bay (MB) Flow	**NA**	**NA**	**NA**	**NA**
Manatee Bay (MB) Stage	**NA**	**NA**	**NA**	**NA**
Florida Bay Northeastern average	**NA**	**NA**	**NA**	**NA**
Duck Key (DK)	**0.220**	**5.0**	**1.0**	**0**
Butternut Key (BN)	**0.087**	**5.1**	**0.542**	**0**
Florida Bay East Central average	**0.154**	**5.1**	**0.771**	**0**
Buoy Key (BK)	**0.503**	**1.1**	**0.921**	**1.26**
Whipray Basin (WB)	**0.309**	**4.9**	**0.331**	**0**
Florida Bay Central average	**0.406**	**3.0**	**0.626**	**1.26**
Bob Allen Key (BA)	**0.396**	**3.4**	**1.0**	**0**
Peterson Key (PK)	**0.219**	**2.1**	**0.327**	**0**
Florida Bay Southern average	**0.308**	**2.8**	**0.664**	**1.26**
Murray Key (MK)	**0.360**	**2.5**	**0.512**	**1.0**
Johnson Key (JK)	**0.424**	**1.1**	**0.717**	**1.26**
Little Rabbit Key (LR)	**0.386**	**2.0**	**0.289**	**0**
Florida Bay Western average	**0.390**	**1.9**	**0.506**	**1.0**

Table 8. Same as Table 7 except 2007 (a dry year) is used as the evaluation year.

MMN Station	Mid-range Overlap	Mean Offset	Hypersalinity Frequency of Occurrence	Overall Stoplight Score
Highway Creek (HC)	0.308	6.4	1.0	0
Long Sound (LS)	0.086	2.0	1.0	0
Joe Bay (TC)	0.132	1.7	1.0	0
Taylor River (TR)	0.675	0.5	NA	NA
Little Madeira Bay (LM)	0.178	1.3	1.0	0
Terrapin Bay (TB)	0.279	2.6	1.0	0
Garfield Bight (GB)	0.264	3.1	0.262	0
Blackwater Sound (BS)	0.000	4.8	NA	NA
Little Blackwater Sound (LB)	0.167	7.3	0.022	0
Transition average	0.232	2.9	0.661	0
Middle Key (MD)	NA	NA	NA	NA
Manatee Bay (MB) Flow	NA	NA	NA	NA
Manatee Bay (MB) Stage	NA	NA	NA	NA
Florida Bay Northeastern average	NA	NA	NA	NA
Duck Key (DK)	0.107	7.4	0.228	0
Butternut Key (BN)	0.000	6.7	0.750	0
Florida Bay East Central average	0.054	7.1	0.489	0
Buoy Key (BK)	0.053	6.1	0.200	0
Whipray Basin (WB)	0.161	5.7	0.304	0
Florida Bay Central average	0.107	5.9	0.252	0
Bob Allen Key (BA)	0.000	5.6	0.208	0
Peterson Key (PK)	0.063	2.8	0.149	0
Florida Bay Southern average	0.032	4.2	0.179	0
Murray Key (MK)	0.024	4.4	0.142	0
Johnson Key (JK)	0.355	2.7	0.350	2.00
Little Rabbit Key (LR)	0.211	2.8	0.272	0
Florida Bay Western average	0.197	3.3	0.255	0

5.0 Uncertainty

It is uncertain if the volume of water that is identified as needed for restoration can be delivered from upstream. It is also unclear if CERP projects (e.g., C-111 Spreader Canal and Biscayne Bay Coastal Wetlands) will perform as anticipated.

It is also understood that the SFWMM does not perform well at the southern end of the model grid (2 to 3 cells from the edge). Most selected gage/grid locations used in the MLR salinity models are

located in areas where the SFWMM has been shown to be reliable from calibration/verification analysis. The ability of the MLR salinity models to simulate the observed conditions can be evaluated using a number of error statistics. Uncertainty will be continually reevaluated by comparison with assessment data. The error statistics for the MLR salinity models are presented in Table 8 and defined below.

Table 8. Error statistics (in psu) for the MLR salinity models, and include root mean square error (Root MSE), adjusted R^2 (Adj R-sq), mean error, maximum absolute error, mean absolute error, and Nash-Sutcliffe Efficiency (NSE).

MMN Station	Root MSE, psu	Adj R-sq	Mean Error, psu	Maximum Absolute Error	Mean Absolute Error	NSE
Transition						
Highway Creek (HC)	4.3	0.81	-0.95	17.7	3.7	0.76
Long Sound (LS)	3.9	0.8	0.31	18.9	2.7	0.81
Joe Bay (TC)	5.1	0.75	-0.14	20.6	3.7	0.76
Taylor River (TR)	4.6	0.78	-0.49	22.9	3.6	0.78
Little Madeira Bay (LM)	6.4	0.65	-0.66	22.6	5.1	0.62
Terrapin Bay (TB)	5.7	0.75	-0.99	5.4	5.4	0.67
Garfield Bight (GB)	6.15	0.68	-0.36	21.1	4.75	0.89
Little Blackwater Sound (LB)	3.75	0.75	-0.14	15.7	2.9	0.76
Florida Bay Northeastern						
Middle Key (MD)	2.60	0.74	-0.22	11.33	2.19	0.71
Manatee Bay (MB) Flow	2.6	0.77	0.25	10.70	2.1	0.7
Manatee Bay (MB) Stage	3.10	0.69	0.02	12.9	1.99	0.76
Florida Bay East Central						
Duck Key (DK)	3.1	0.71	-0.18	14.4	2.27	0.71
Butternut Key (BN)	3.3	0.65	0.1	11.3	2.7	0.66
Florida Bay Central						
Buoy Key (BK)	2.65	0.79	0	7.76	2.14	0.79
Whipray Basin (WB)	2.7	0.80	0.11	10.1	2.2	0.77
Florida Bay Southern						
Bob Allen Key (BA)	2.7	0.79	0.3	9.2	2.1	0.81
Peterson Key (PK)	1.98	0.55	-0.01	5.79	1.58	0.55
Florida Bay Western						
Murray Key (MK)	2.9	0.62	0.02	11.97	2.34	0.51
Johnson Key (JK)	2.68	0.55	0.05	9.72	2.21	0.55
Little Rabbit Key (LR)	2.41	0.59	0.09	8.58	1.92	0.45

Root Mean Square Error - The Root Mean Square Error is a weighted measure of the error where the largest deviations between observed and predicted values contribute most to this uncertainty statistic. This statistic has units that are the same as the observed and predicted values. It is thought to be the most rigorous tests of absolute error.

Adjusted – R^2 - The Coefficient of Multiple Determination (R^2) is the most common measure of the explanatory capability of a model. R^2 measures the percentage reduction in the total variation of the dependent variable associated with the use of the set of independent variables that comprise the model. When there are many variables in the model, it is common to use the Adjusted Coefficient of Multiple Determination, which is R^2 divided by the associated degrees of freedom.

Mean Error - The Mean Error is another measure of model uncertainty. Positive values of the mean error indicate that the model tends to over-predict and negative values indicate that the model tends to under-predict.

Maximum Absolute Error – The Maximum Absolute Error is the largest deviation between observed and predicted values.

Mean Absolute Error - The mean of the absolute values of the residual values. It is a measure of the expected magnitude of difference between forecast and measures values of salinity at a particular location and time reported in the units of the simulated variable.

Nash-Sutcliffe Efficiency (NSE) – The NSE is a measure of model performance that is similar to R^2. The value of the NSE roughly corresponds to the percentage of variation that is explained by the model.

6.0 Sustainability

Continued salinity monitoring at the MMN sites and the USGS flow monitoring sites are essential for being able to use this approach for the salinity PM. Also, the C-111 Spreader Canal Project and other new water management features are likely to change the flow-to-salinity relationships, hence the need to also retain the USGS flow monitoring network in Florida Bay and the southwest Florida coast.

7.0 Future Tool Development and Data Needs

The MLR models may be improved over time using improvements in statistical relationships for salinity, stage, sea level, and wind parameters, and knowledge gained through development of 37 statistical models. However, it may be more beneficial to complete the development of a hydrodynamic model that can relate salinity to upstream flow. Models being developed by the USGS, ENP, and others are being considered for IMC review and implementation. The FATHOM model shows particular promise. This model divides Florida Bay into over 50 individual basins or embayments (Fig.16). Also, recent studies have shown that Florida Bay can be divided into six zones based upon water quality/salinity characteristics (Nuttle et al. 2000, Boyer et al. 2007, Madden et al. 2009, Briceno and Boyer 2011)(Fig.16). At least two MMN stations exist within each zone. The stations, basins, and zones provides options to expand the evaluation using these basins and zones to better interpret the influence of the project upon the area. The zones and basins closest to the transition zone, e.g. northeastern, east central and central) should have the greatest influence from restoration resulting in salinity reduction. Analyzing results by these basins and zones is useful for interpretation.

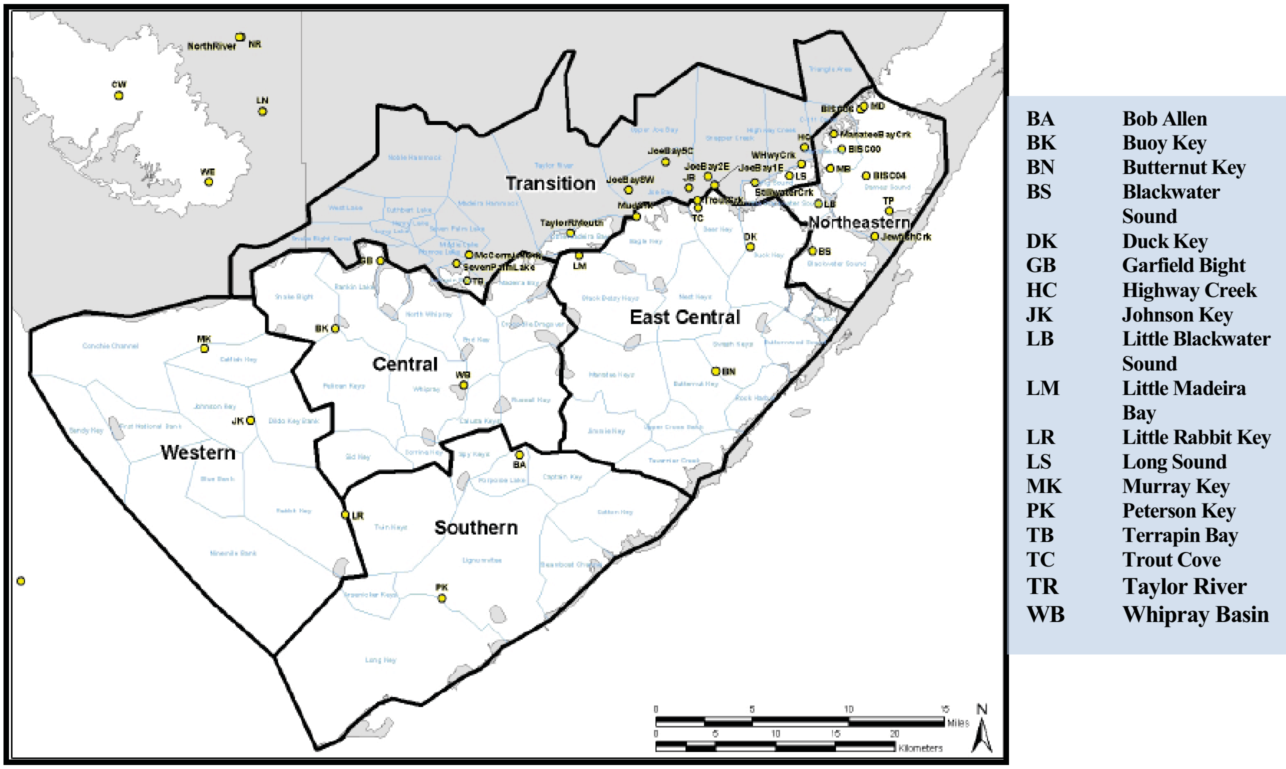


Figure 16. Map showing the six zones in Florida Bay as determined by water quality characteristics and FATHOM basins. Location of the Marine Monitoring Network stations are indicated. Additional stations that have been used in assessment are also indicated.

8.0 References

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