ASSESSMENT OF NUTRIENT LOADING AND EUTROPHICATION IN BARNEGAT BAY-LITTLE EGG HARBOR, NEW JERSEY IN SUPPORT OF NUTRIENT MANAGEMENT PLANNING

Prepared for:

New England Interstate Water Pollution Control Commission

By:

Michael J. Kennish and Benjamin M. Fertig
Institute of Marine and Coastal Sciences
Rutgers University
New Brunswick, NJ 08901

Richard G. Lathrop
Center for Remote Sensing and Spatial Analysis
Rutgers University
New Brunswick, NJ 08901

KEY FINDINGS

- Barnegat Bay-Little Egg Harbor (BB-LEH) is highly eutrophic and is susceptible to nutrient loading. It is shallow, poorly flushed, and affected by a developed watershed (34% developed, 25% urban, 10% impervious surface). The estimated range of annual total nitrogen loads from the watershed is 448,000 – 851,000 kg N yr^{-1}.

- Concentrations, loads and yields of total nitrogen and total phosphorus were quantified on annual and seasonal timescales and on 3 spatial scales: whole watershed, watershed segments corresponding to estuary segmentation, and 14-digit hydrologic unit code.

- This study confirmed that surface-water concentrations of nutrients (nitrogen and phosphorus) in the BB-LEH estuary are strongly related to land use. Total nitrogen and phosphorus are highest in areas with the highest percentages of urban and agricultural land, and with the lowest percentages of forested and undeveloped land.

- Urban development has steadily increased in the watershed since the 1970s, and this is strongly correlated with the observed increase in total nitrogen concentration in BB-LEH watershed streams. Development (and corresponding increases in total nitrogen concentrations and loads) is more intense in the north segment than elsewhere.

- Concentrations, loads and yields of phosphorus and nitrogen are generally higher during the growing season than during the nongrowing season.

- Nitrogen loads from areas covered with turf are about twice those of non-turf urban areas. Phosphorus loads from turf areas are more than eight times those from non-turf areas. Phosphorus concentrations, loads and yields are generally higher in areas with more development, and higher during runoff than in baseflow.

- Baseflow contributes more than 80% of the total nitrogen loading from streams, however, runoff contributes a higher percentage of nitrogen loading in developed areas than in undeveloped areas owing to the greater percentage of streamflow from runoff for streams in developed areas.

- From 1989 to 2010, BB-LEH experienced low dissolved oxygen (82 times $\leq$4 mg L^{-1}), high total suspended solids (max >200 mg L^{-1}) and chlorophyll *a* (max >40 $\mu g\ L^{-1}$), harmful algal blooms ($\geq$200,000 cells mL^{-1}), epiphytic loading (mean values up to 38.3% cover of seagrass), macroalgae blooms (80-100% cover 36 times, 70-80% cover 19 times, 60-70% cover 10 times), habitat loss, >67% fewer clams, and degraded seagrass biomass (to 2.7±8.0 g m^{-2} aboveground; 17.9±37.5 g m^{-2} belowground).

- The Index of Eutrophication is the most comprehensive and holistic assessment of BB-LEH, integrating 74,400 observations among 85 variables for ~20 indicators in 6 components: (1) Ecosystem Pressures, (2) Water Quality, (3) Light Availability, (4) Seagrass Response, (5) Harmful Algal Blooms, and (6) Benthic Invertebrate Response.

Outputs are quantitative annual assessments for 3 areas on a scale of 0-100 (0 is Highly Degraded, 100 is Excellent). Index scores assess condition and its consistency. Increased availability of data would improve its resolution, though would not likely significantly change the conclusions of this report. Though monitoring intensified over time and the number of indicators monitoring are increasing, spatio-temporal alignment of data collection and increased sampling frequency will improve future assessments.

- Index of Eutrophication values declined 34% and 36% in the central and south segments, from 73 and 71 in the 1990s to 48 and 45 in 2010, respectively, indicating these segments are currently undergoing eutrophication. The north segment has already undergone eutrophication. Eutrophication condition was worst in the north segment despite modest improvements, in contrast to stages and trends in the south and central segments. Scores in the north segment declined sharply in 2010 (to 37), but the highest score there (50) was in 2009, 3.5 times its low score (14, in 1991).

- Nutrient loading severely impacted Index of Eutrophication values in BB-LEH, particularly in 2003-2010, degrading condition from 73 to 45 and 37. Initial rapid declines highlight sensitivity to loading. Beyond ~2,000 kg total nitrogen km^{-2} yr^{-1} or ~100 kg total phosphorus km^{-2} yr^{-1}, condition plateaued yet variability increased (ranging 2 to 50), suggesting a switch in dominant factors.

- Total nutrient loadings in the north were very low (7), but were 60 and 55 in the central and south segments respectively. During 1989-1997, low dissolved oxygen countered favorable temperatures leading to a Water Quality Index score of 57. Favorable temperatures continued in 1998-1999, but total phosphorus increased in 2000-2003. In 1998-2003, total suspended solids scores ranged 21 to 45, epiphytic loading scores were 16 to 40, available surface light scores were 7 to 32 declining in 1998-2002 in the north and south segments. In 2004-2010, total phosphorus condition in BB-LEH fell from 32 to 7. Total suspended solids improved steadily in the north segment, variably in the south segment, and temporarily declined in 2004-2007 in the central segment. Similar temporary declines in condition during 2004-2009 in the central segment was seen in epiphytic load scores (44 to 1) and available surface light scores (41 to 0). Seagrass cover and length scores decreased over 2004-2010 from 34 to 14 and from 30 to 18, respectively.

- Increasing eutrophication of the central and south segments since the 1990s and even worse condition in the north segment was observed throughout the study period. The condition of BB-LEH progressively worsened over time for both nitrogen and phosphorus. Periods of improvement (1989-1992, 1996-2002, and 2006-2008) did not outpace shorter but detrimental periods, thus leading to overall poorer condition.

- Collectively, the direct relationship between nutrient loading from the watershed and estuarine nutrient concentrations, the degradation of an array of biotic indicators, and the relationship between nutrient loading and the Index of Eutrophication supports the conclusion that BB-LEH is an estuary that has undergone significant ecological decline.