

STAC Independent Scientific Peer Review Panel Questions for the Generalized Additive Model (GAM) Approach for Water Quality Trends in Tidal Waters 9/20/2016- Final

CBP Groups: [Scientific and Technical Analysis and Reporting \(STAR\) Team's](#)
[Integrated Trends Analysis Team \(ITAT\)](#)
[Water Quality Goal Implementation Team \(WQGIT\)](#)

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Introduction

Water quality data have been collected at over 160 long-term monitoring stations in Chesapeake Bay since the mid-1980s. Since the mid-1990s, analysts at the Maryland Department of Natural Resources (MDDNR), Virginia Department of Environmental Quality (VADEQ) and the Chesapeake Bay Program Office (CBPO) have been using the Seasonal Kendall (SK) nonparametric trend technique to identify significant degrading or improving trends in these data. Soon after the SK approach was implemented, it became clear that many of the long-term patterns were not monotonic, and an additional quadratic test was added to the analysis in order to identify those types of patterns. Since then, these analyses have been conducted for a suite of water quality parameters¹ at multiple depths and seasons annually, and have been used by the state agencies as well as the Chesapeake Bay Program partnership (CBP) for visualization of changes in estuarine water quality.

In March 2014, with an eye towards incorporating more monitoring data analysis into the TMDL mid-point assessment and beyond, the “Estimating Land Management Effects on Water Quality Status and Trends” (MEOWQT) STAC workshop was held to generate recommendations on techniques for trend detection and analysis from a group of scientific experts. Generalized Additive Models (GAMs) were presented as a statistical technique with the flexibility to represent the long-term patterns now being observed with 30 years of water quality data in Chesapeake Bay, and to explore environmental factors that may affect those trends. The recommendation from the workshop was for the CBP to continue to develop and apply GAMs to the appropriate response variables in tidal waters.

GAM Approach to be reviewed by the Panel

Development of the GAM approach for use in Chesapeake Bay tidal waters has progressed since the March 2014 MEOWQT workshop, and a draft R package (“the R package”) for applying GAMs to Chesapeake Bay has been created. In the process, several different options have been tested and implemented to account for challenges such as changes in sampling and laboratory methods, censoring

¹ Such as total nitrogen (TN), dissolved inorganic nitrogen (DIN), total phosphorus (TP), dissolved organic phosphorus (PO₄), total suspended solids (TSS), active chlorophyll a (CHLA), secchi depth (SECCHI), summer bottom dissolved oxygen (DO), salinity, and water temperature (WTEMP)

of data, and determination of statistical significance. The approach to be reviewed consists of the methods developed and assumptions made in this process. Panel members will be provided with comprehensive documentation of the GAM approach as implemented in the referenced R package, as well as more general reference materials on GAMs and links to additional optional references.

Resource and Reference Materials for the Panel

The Panel members are encouraged to consult the accompanying resource materials for background and insights into the process of developing the GAM approach for analysis of trends in tidal water quality. A brief description is provided here in advance of the full submission to enable advance planning on the part of STAC.

- Documentation of the GAM approach for Chesapeake Bay tidal trends will be provided in the form of a written report with chapters summarizing the necessary information relating to each Review Question. Appendices with additional mathematical and methodological details will be included as necessary.
- “Estimating Land Management Effects on Water Quality Status and Trends: Proceedings of the March 25-26, 2014 workshop. STAC Publication Number 15-002, Edgewater, MD. 33 p.
- Additional reference materials as needed, and links to additional optional reference materials.

Expertise needed for the review team

An effective review team will have members familiar with:

1. Time series analysis, applied environmental statistics
2. Generalized Additive Models and/or similar approaches for nonlinear temporal analysis
3. The dynamics of estuarine water quality including the complex nature of water quality responses to river flow, nutrient loads, and other factors.
4. An understanding of long-term water quality monitoring challenges including detection limit changes and laboratory and method changes.

GAM Approach for Tidal Trends Review Questions:

The CBP, through the STAR Team and the ITAT, requests an independent scientific peer review that directly addresses the questions outlined below. The scope of this request is constrained to the GAM approach implemented in the referenced R package, with the goal of providing a temporally and spatially consistent standardized method for annual reporting of trends in tidal water quality. The review panel is also encouraged to make recommendations for future work by the CBP that would further strengthen this approach, or that are related to the scientific or management issues raised in the review. The review panel will be provided with the relevant documentation and will be given direct access to the GAM development team to facilitate the review. The review panel will generate a written report addressing the questions. The partnership will then produce a written response to the review.

1. Please comment on whether the resource materials and references provided are adequate for conducting this review.

2. Please comment on whether the choice to build the R package around the 'mgcv' package raises any concerns and on whether the functionality contained within the R package addresses the STAC MEOWQT workshop recommendation to implement a process for automating the GAM application.
3. Please comment on whether the three model options (i.e., gam0 – linear trend with seasonality; gam1 – nonlinear trend with seasonality; and gam2 – nonlinear trend with seasonality and interactions) for temporal analysis built into the R package are appropriate for representing the patterns over time and whether the conclusion to generally select the gam2 model is scientifically sound.
4. Please comment on whether the Percent Change calculation applied to the GAM results is sufficient for generating conclusions as to whether the long- or short-term trends are up or down.
5. Please comment on whether the decision to derive conclusions based on log-transformed results without conducting any back-transformation are problematic for any of the conclusions we are trying to draw from the GAM model results.
6. Please comment on whether the choice of the Maximum Likelihood method via the Expectation Maximization algorithm is a reasonable approach to account for censored data in the historical record as compared to other options, including the Monte Carlo sampling approach tested.
7. Please comment on the importance of developing an intervention analysis approach to account for changes in lab and sampling methods, as opposed to implementing the adjustment factors approach used previously for these issues.
8. Please comment on the continuing research and development toward a comprehensive flow-adjustment procedure.
9. At this time, are there any issues that you recommend the CBP investigate over the longer term (i.e. post-2017) regarding the application of GAMs for water quality trend analysis? The importance of these analyses for reporting changes in Chesapeake Bay water quality will continue to increase as we approach 2025 and beyond.
10. Are there other technical approaches that we should investigate that can supplement the GAM approach in order to identify and analyze the effects of management actions on water quality in the estuary?

Proposed Peer Review Schedule and CBP Partnership Response

The CBP partnership requests that the STAC-convened independent scientific peer review panel complete their review and deliver a panel report reflecting the Panel's collective written responses to above questions by December 20, 2016.

The CBP partnership is committed to providing written responses to the Panel's collective responses to above questions by February 17, 2017.