Chesapeake Bay Water Quality Data Visualization

Abhishek Abhishek, James Guan, and John Wolf

Abstract—The purpose of our visualization is to display Chesapeake bay water quality data that will include wildlife habitat requirements and to improve on current visualization capabilities in the same area. The implementation contains a Google Maps style interface to display the different water quality stations scattered throughout the bay. A selection of different points of the map yields charts and other interactive visual elements to provide further details on water quality parameters. Taking this approach for visualization will yield the least amount of clutter and an easily understandable interface to make the data easier to understand.

Index Terms— Chesapeake Bay, visualization, water quality

Introduction and Motivation

The Chesapeake Bay is one of the most studied ecosystems in the world. The Chesapeake Bay Program (CBP)[1], which oversees the Chesapeake restoration effort, maintains over 30 years of water quality monitoring data that has been collected throughout 3D space and time. This water quality monitoring data is routinely used in scientific investigations as well as communicating water quality conditions for regulatory purposes.

However, the water quality data is currently accessed from a website with minimal visualization capabilities. It is up to the user to download data and then bring it into software of their choice to process and visualize. In addition, the website does not currently provide the option to interpret conditions relative to fish and shellfish habitat requirements. These habitat requirements relate to various water quality parameters such as dissolved oxygen (DO), salinity, and chlorophyll a.[2]

1 Goals and Research Questions

The overall goal of this project is to provide a visual representation of water quality data at user-specified locations and time periods. For this proof of concept, water quality data from the Chesapeake Bay monitoring program's sample locations for the year 2015 will be utilized.

The approach will leverage the Shneiderman mantra of "overview first, zoom and filter, and details on demand"[3]. This project will serve as a proof of concept for visualizing the water quality data in a manner that is directly relatable to habitat requirements. The application will provide the capability to explore water quality data through a geographic interface that enables the user to select a (1) water quality parameter of interest, (2) geographic location, and (3) time period of interest. Finally, the user will be able to relate or associate water quality conditions to habitat requirements of Chesapeake Bay living resources.

2 Proposed Methods

Requirements and sample data have been gathered by Chesapeake Bay Program data managers. The authors propose to develop a Google Maps front end with sample locations identified by visual marks on top of one or more Google base map choices. JavaScript will be used to provide interactivity with the symbols on the base map. Once a sample location is selected, charts and/or other interactive visual elements will provide detailed information on water quality parameter (DO, salinity, and chlorophyll a) at that site for a time period defined by the user. The charts will be coded using the D3 JavaScript library or other suitable development tool.

For the proof of concept, 2015 data was downloaded in csv format from the Chesapeake Bay Data Hub. Data abstraction is as follows:

Item → Station ID
Attribute → Date (temporal)
Attribute → Layer (categorical)
Attribute → Parameter (categorical)
Attribute → Value (quantitative)
Attribute → Species (categorical)
Spatial → Latitude
Spatial → Longitude
Spatial → Depth

3 Literature Review

Attempts at three-dimensional visualization of water quality data are not new. Forgang et al (1996) developed a visualization system for the comparison of simulated and measured water quality (SCIRT)[4]. This was followed by a more robust tool that visualized output from the Chesapeake Bay Program's three-dimensional eutrophication model[5] These efforts, however, focused on visualizing 3D model output as opposed to monitoring data.

Estuary monitoring data is typically four dimensional (3D space and time), but is collected at discrete sample location (as opposed to water quality model output that is frequently continuous). The depth and temporal dimensions of monitoring data present challenges for 2D or 2.5D space. Shisko et al (2010)[6] presented IGODS, a "complete software solution to support studies of ocean, coastal and inland waters". IGODS allows for the visualization of water quality

[1] Chesapeake Bay Program Overview. Accessed November 4, 2016 from http://www.chesapeakebay.net/about.
[2] S. Funderburk, J. Mihursky, S. Jordan, and D. Riley (eds). Habitat Requirements of Chesapeake Bay Living Resources. Chesapeake Bay Program Habitat Objectives Workgroup, Living Resources Subcommittee. June 1991.
[3] B. Shneiderman. The Eyes Have It: A Task by Data Type Taxonomy for Information Visualizations. IEEE 1996.
[4] A. Forgang, B Hamann, and C. Cerco. Visualization of Water Quality Data for the Chesapeake Bay. Proceedings of the 7th IEEE Visualization Conference (VIS96). 1996.
[5] R. Stein, A. Shih, M. Baker, C. Cerco, and M Noel. Scientific Visualization of Water Quality in the Chesapeake Bay. Proceedings of the IEEE Conference on Visualization 2000.
[6] J. Shisko, A. Steele, and M. Mengel. IGODS: An important New Tool for Managing and Visualizing Spatial Data.

parameters along depth profiles at multiple locations. Since it focuses on monitoring data as opposed to modeling data, the Shisko paper provided much of the inspiration for the current project, which customizes the IGODS approach for the unique ecological characteristics of the Chesapeake Bay.

Visualizing living resource habitat in estuaries and river system hasn't progressed as far as water quality. An interesting application that combines fish species requirements with a virtual reality game engine is presented by Chen et al (2014)[7]. The ability to simulate and visualize actual fish ecology through virtual reality holds much progress in the future integration of water quality and fish habitat visualization efforts.

Leveraging Google Maps as an interactive locator tool has been used in a number of environmental applications. One example that is closely aligned with the intent of this project is the HydroQual application developed by Accorsi et al (2014)[8].

The integration of water resource visualization systems and geographic information systems has also been a focus of recent research and development. Kim and Park (2012) demonstrate how environmental changes can be visualized through a GIS-based visual analytics tool. Their application of this tool for location-based oceanographic data demonstrates the values of various visual encoding approaches and user-specified filters[9].

[7] M. Chen, S. Lai, Y. Hung and J. Yang. A Virtual Education Assistance System in Simulated River Ecosystems with 3D Visualization. Proceedings of the IEEE Visualization Conference 2014.
[8] P. Accorsi, M. Fabregue, A. Sallaberry, F. Cernesson, N. Lalande, A. Braud, S. Bringay, F. Le Bar, P. Poncelet, and M. Teisseire. HydroQual: Visual Analysis of River Water Quality. IEEE Symposium on Visual Analytics Science and Technology 2014.
[9] J. Kim and J. Park. Visualizing Marine Environmental Changes to the Saemangeum Coast. IEEE Computer Society. November/December 2012.

Conclusion

Utilizing a visualization that displays water quality data and habitat requirements in terms of maps and expandable charts serves to bring those 30 years of water quality data for the Chesapeake bay into an easily understandable interface. Further improving upon current visualization tools available for the Chesapeake bay data that we have today.

References

Shisko, J. F., Steele, A., & Mengel, M. J. (2010, December 10). IGODS: An important new tool for managing and visualizing spatial data. Retrieved October 20, 2016, from http://ieeexplore.ieee.org/document/5664599/