Interactive Visualization of Ecosystem Change for Public Education

Tanyoung Kim, Hwajung Hong, Brian Magerko

Georgia Institute of Technology

ABSTRACT

We present an interactive visualization system named 'VisCoral' which represents the ecosystem changes in the Pacific Ocean. Our system allows users to explore the temporal changes of environmental data such as temperature, CO_2 level, sea level and precipitation and their impact on the health of coral reefs and neighbor marine species such as coral fish. VisCoral is composed of multi-view interactive visualization, which features a timeline of environmental data, a table view of species data, and the simulation of ecosystem generated according to the data. We hope this InfoVis system will help students or the general public learn about how environmental changes are directly connected to the living condition of ocean creatures.

KEYWORDS: Eco-Visualization, Educational System, Interactive Visualization

INDEX TERMS: H.5.1 [Information Interfaces and Presentation]: Miscellaneous

1 INTRODUCTION

In order to collect data for the changes in the ecosystem triggered by global warming, geoscientists and biologists estimate the environmental changes such as CO_2 level, precipitation and temperature through they study of the chemical changes of long-living creatures. Among them, coral reefs are considered a primary indicator of ocean climate change such as temperature rise and acidification since the environmental change trigger coral bleaching and weakening skeletons [3, 4].

Although there is a myriad of data about the undergoing environmental changes and the danger of coral reefs, it is not easily accessible by ordinary people. Even if research results and observation data are open to public over the Internet, the raw data are typically in a dense spreadsheet format and hard for laymen to understand. However, those data can serve as a valuable source for young students to learn about science and environment and for furthering public awareness of environmental change and its impact on living creatures. Here arises the importance of the easily accessible and understandable representation of the scientific data. Certainly one promising way is the scientific visualization or information visualization (InfoVis) of coral reef data related to climate change for educational purposes [2].

In this poster, we present an InfoVis system named 'VisCoral' that represents how the environmental change such as temperature, precipitation, CO_2 level affects the status of coral reefs and other related ocean fauna in the Pacific Ocean. It is composed of several visual components which can be controlled by a user and changed interactively.

Email: {tanykim | hhong31 | magerko}@gatech.edu

2 RELATED WORKS

Amongst many visualization researches pertaining to the environmental changes, MacEachren et al.'s project which aims at solely simulating geographic data virtually [6]. Due to the nature of environmental research, which needs collaboration from many different fields, some of the virtual visualization research focuses on supporting the collaboration dealing with large-scale data provided by different researchers [7, 8]. However the users of these visualization systems are scientists and researchers rather than that the general population making the visualization is more scientific than graphically aesthetic and accessible.

Beyond the scientific visualization for professional works, there are several visualization projects whose style and goal are close to ours: CyArk's *The Hazard Map* is an interactive map which visualizes the history of earthquakes and its impact on heritage sites [9]. *State of Salmon* visualizes the health of coastal ecosystem and its impact on the salmon fisheries [14].

3 REPRESENTED DATA

3.1 Range of Location and Time

We focused on a small specific area of the Pacific Ocean, called the Palmyra Atoll, since it is one of the most important unprotected marine wilderness areas in the U.S. tropics [1]. There is ongoing active research on the relation between the climate change and the coral reefs around the area by the National Oceanic and Atmospheric Administration [1], from which we were able to collect part of the necessary data.

The data that we collected suffered from varying formats to different duration and frequencies. The duration of the data ranged from a single observation to that collected over centuries while the frequency ranged from daily to yearly. While trimming out isolated data and balancing the frequencies, we narrowed down the duration to the last ten years and the then organized the data monthly.

3.2 Environmental Data

Some of the factors leading to the change in the oceanic environment are the fossil gas emission (mostly CO_2) are temperature, sea level, and precipitation. We chose these four categories and gathered the data from many sources such as [10, 11, 13]. Since the lack of data or the difficulty in data collection did not let us complete the four categories by monthly for ten years, some missing parts were estimated and accordingly marked on the visualization.

3.3 Ocean Animals Data

There are at least 125 different marine species in the Palmyra Atoll, including many different kinds of coral [12]. In addition to coral species, we added two other categories - 'reef fish' and 'other species' (e.g. turtles, clams, shells and whales) because the changes of coral reefs affect the living conditions of other species [3]. We enumerated several species under each category. Each specific coral reef has the data for population, bleaching status and kinds of disease. For reef fish and other kinds, we included population and conservation level.

4 VISUALIZATION

The layout of VisCoral is largely divided into three parts: 1) a timeline at the bottom, 2) a list of marine animals on the left, 3) and a simulation screen, which is the largest feature (Figure 1).

4.1 Timeline with Environmental Data

We use timelines, a conventional way of temporal data visualization, to represent the ten-year data collected by monthly. We put all four environmental data onto the timeline and integrated one slider for a single month view, and a pair of sliders for multi-months view.

The sliders on this timeline are the central points for users to control the system. For the investigation of a single month, a user can move the slider to view the values of the categories on this timeline for that selected month. It also prompts the changes of other visualization elements: it changes the values of each ocean animal properties on the left side – this visualizes the impact of environmental factors on the marine animals' status. Also the simulation screen reflects the ecosystem represented according to the changed data. In a similar manner, the user can control two sliders to set the duration for multiple months.

4.2 List of Marine Animals

This is a basic table-look list that includes three categories divided into their specific kinds. Users can choose what species will be visible on the simulation screen. They can also choose which properties of each species will be presented.

4.3 Simulation Screen

The simulation screen is a place for both Environmental data that are numerical in nature and Marine Animals data that can be directly visualized. Amongst the four invisible Environmental data, we represent the sea level as the tint of the background (i.e. high sea level is seen as darker blue). Plus, the selected animals on the left tables are displayed in the simulation screen, the number of which is decided according to the population. The appearance, which stands for the colour and texture of coral reefs, look different based on their bleaching and disease status.

We assumed that our users namely students or general public would not be capable of matching the name of the animal to its look, for which we included a clue: if a user clicks on one of the simulated animals, a detailed explanation is overlaid and the matching row of the animal on the left tables is highlighted.

For the investigation of multiple months, the initial visualization of the simulation screen and value of ocean animals is the first month of the duration. Next, the user can easily click previous and next button on the left and right side respectively.

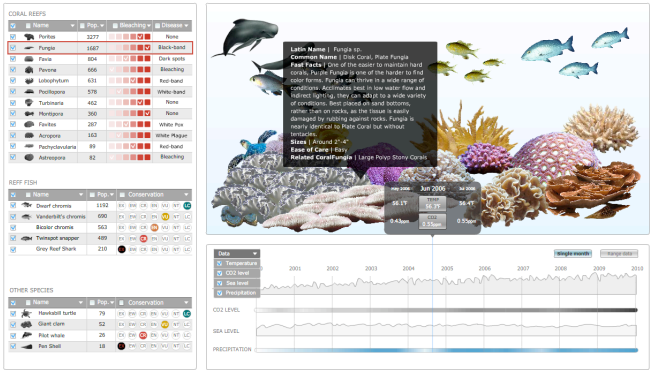

Figure 1. Screenshot of VisCoral: Single Month View

5 DISCUSSION AND FUTURE WORKS

In contrast to scientific visualization of virtual environments for professional researchers, we aimed to design an information visualization system that integrated complex data, but one that is easily understandable by ordinary people. We hope that users of this system will learn the impact of environmental change on the population, bleaching and disease of coral reefs and the living condition of other species. Our other work has focused on communicating how energy consumption in our daily lives is part of this global process [5].

VisCoral, while an effective prototype, could further benefit from additional data collaboration with marine biologists or environment engineers along with a longer time span than ten years which would help our users obtain more educated understanding of the temporal changes. In addition to this, including a bigger area would allow our users to track the regional changes too.

We so far simulated static images of the visible animals. For the future enhancement, we may adopt an animation approach that would depict the liveliness of marine animals.

6 CONCLUSION

We presented an interactive information visualization system which represented 1) numerical climate and ocean environment data and their impact on 2) the population and health of coral reefs and their effect on fauna through 3) a simulation of an underwater ecosystem. In conclusion, this system may be used a teaching aid or self-learning tool for environmental science for middle or high school students. Further, if our system is introduced in a relevant place such as aquarium, general public can learn about the ecosystem interacting with our system, otherwise sightsee passively.

REFERENCES

[1] Rusty Brainard et al., The State of Coral Reef Ecosystems of the U.S. Pacific Remote Island Areas, Accessed at http://ccma.nos.noaa.gov/ecosystems/coralreef/coral2008/pdf/PRIAs.pdf

[2] Douglas N. Gordin and Roy D. Pea, Prospects for Scientific Visualization as an Educational Technology, *The Journal of the Learning Sciences*, 4(3), 249-279, 1995

[3] O. Hoegh-Guldberg, et al. Coral Reefs Under Rapid Climate Change and Ocean Acidification. *Science*, 318, 1737-1742, 2007

[4] T.P. Hughes, et al., Climate Change, Human Impacts, and the Resilience of Coral Reefs, *Science* Vol 31, 929-933, 2003

[5] Tanyoung Kim, et al., Coralog: use-aware visualization connecting human micro-activities to environmental change, *In proceedings of CHI EA'09*, 4303-4308, 2009

[6] Alan M. MacEachren, et al., Virtual Environments for Geographic Visualization: Potential and Challenges, *In Proceedings of NPIVM 99*, 35-40, 1999

[7] Robert Stein, et al., Scientific Visualization of Water Quality in the Chesapeake Bay, *In proceedings of the conference on Visualization '00*, 509-512, 2000

[8] Glen H. Wheless, et al., Virtual Chesapeake Bay: Interacting with a Coupled Physical/Biological Model, *IEEE Computer Graphics and Applications*, 52-57, 1996

[9] http://archive.cyark.org/hazard-map

[10] http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=1619000

[11] http://www.esrl.noaa.gov/

[12] http://www.nature.org/wherewework/asiapacific/palmyra/animals/

[13] http://www.palmyraresearch.org/research/publications?sortby=YA

[14] http://www.stateofthesalmon.org/msc/tool/index.html