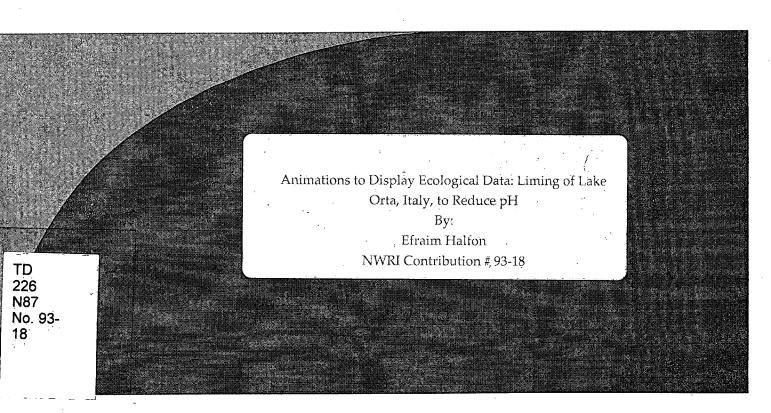# Environment Canada
Water Science and Technology Directorate

Direction générale des sciences et de la technologie, eau
Environnement Canada

Animations to Display Ecological Data: Liming of Lake
Orta, Italy, to Reduce pH

By:

Efraim Halfon

NWRI Contribution # 93-18

ANIMATIONS TO DISPLAY ECOLOGICAL DATA: LIMING OF LAKE ORTA, ITALY, TO REDUCE pH.

by

Efraim Halfon

Lakes Research Branch
National Water Research Institute
Canada Centre for Inland Waters
Burlington, Ontario
Canada L7R 4A6

Gianni Tartari
Istituto di Ricerca sulle Acque
CNR
via Occhiate
I-20047 Brugherio (Milano)
Italy

and

David Brendon
Wastewater Technology Centre
Canada Centre for Inland Waters
Burlington, Ontario
Canada L7R 4A6

January, 1993

MANAGEMENT PERSPECTIVE

This report presents methodology on how to develop animations of ecological data. Animations are an important tool to display data collected at different times at many stations. The animation can give the researcher a clear view of dynamical processes. This animation was developed using commercial programs, shareware programs and custom programs on an MS-DOS platform. The animation disk is available on floppy disks.

ABSTRACT

Lake Orta, in northern Italy, is an acid lake. The average pH in 1988 was 4.5. 14,000 tons of calcium carbonate (lime) were introduced into the lake between Feb. 1989 and May 1990. The average pH of the lake increased to 4.91. Calcium carbonate was added at different locations over 14 months. The animation shows the change in lake water pH when calcium carbonate was added. A colour scale quantifies observed pH values. Two windows at the bottom show the total amount of calcium carbonate added and the date, each frame is updated weekly; at the bottom right a smaller window shows the lake temperature. Animations were created using commercial programs (ANIMATOR, DELUXE PAINT II ENHANCED, and a C compiler), shareware programs (VGACAP, GWS) and custom programs written in C on an MS–DOS platform. The animation is available on floppy disks.

INTRODUCTION

The field of computer animation is quite large and under development. Magnenat–Thalmann and Thalmann (1985) have written an excellent textbook. Recently (in 1991) a large conference took place at the Media Laboratory of MIT: the topic was Visualization of Physical Phenomena. Most applications have been in the physical fields, for example to show current movements. As far as we know not many applications have been developed to display ecological data collected in time and space. This paper shows such an application.

The computer used for development is a MS–DOS platform based on an Intel 286 chip. Even if MS–DOS machines are usually used on business applications, with some effort it is possible to develop acceptable simulations. The time to complete the project from the moment data were made available was 18 programmer days. This was our first project and the time includes learning time.

Lake Orta, in northern Italy, is an acid lake. The acidity has originated industries located on its shores that over several decades have discharged chemicals into the lake. The average pH in 1988 was 4.5. To try to remedy this problem and to study the effects of direct lake manipulation, 14,000 tons of calcium carbonate (lime) were introduced into the lake between Feb. 1989 and May 1990. The average pH of the lake increased to 4.91. Calcium carbonate was added at many stations over the 14 months of this study. Data were collected at various times, usually monthly. The animation shows the change in lake water pH when calcium carbonate was added. The animation is available on floppy disks. Requirements are a colour monitor and a graphic card able to display 320 x 200 lines with 256 colours.

METHODS

Lake Orta is 14 km long, it is located in a deep long valley at an elevation of 290 over m.s.l. The lake has a maximum depth of 143 meters, an average depth of 70 m, an area of 18.2 square kilometres and a volume of 1.3 cubic kilometres. The watershed area is 116 square kilometres.

In 1989 and 1990 a total of 14,798 tons of calcium carbonate were added to the lake with the purpose of increasing the pH in the lake. This effort was successful since pH increased from an average of 4.5 in February 1989 to an average of 4.91 in May 1990. During the fourteen months of this project pH and temperature data were collected every half meter at eight stations with an electronic probe. Ten cruises, not equally spaced in time, were organized to collect samples while a barge added the lime to the lake. Data were recorded in real time and later transferred to a spreadsheet[1] (in this effort we used Quattro Pro but others, such as Lotus 1-2-3 could have been used instead).

Missing data

A first analysis was performed in the spreadsheet. Data manipulation was done to prepare the data for use in a graphical animation. The important point was to have a uniform set of data for all ten sampling periods. One problem was the fact that some data were missing, some were collected at slightly different depths (in different cruises) and to different depths; this last problem was due to the change in water levels . Missing data were created by linear interpolation. A total of ten spreadsheets with dimensions 8 x 144

---

[1]The naming of commercial and shareware programs in this paper is for information only to allow duplication of results. The use of these programs is not endorsed by Environment Canada.

were created. Eight was the number of stations and 143 is the maximum depth of Lake Orta. Since not all samples reached the bottom, some of the matrix entries are blank. Data were then exported from the spreadsheet to an ASCII file.

Interpolation

The first step was to convert the raw data from a matrix of data, 8 x 144, to a matrix of pixels, 144 x 144. One hundred forty four pixels were chosen for several reasons: one is that the lake is approximately 14 km long, thus each pixel corresponds to 100 metres, the second reason is that space was required to display the pH colour legend. The choice of 144 pixels in the vertical direction was also convenient since the lake is 143 meters deep at maximum depth. In this matrix the bottom of the lake is indicated by a − 1 entry.

The second step was to interpolate the data for each sampling period among all eight stations. A C program was written for this purpose. A major problem was to decide how to evaluate the boundary conditions at the shore and at the bottom of the lake where data were not collected. This problem was solved with the assumption that the data at the shore and at the bottom had the same values as sampled at the same depth at the nearest station. Two other procedures could have been followed, one was not to show values at the boundaries, and the second would have been to use other interpolation schemes and extrapolate the data at the boundaries. The first procedure was discarded because the graphic display would not have looked well without the boundaries and the second procedure was not used because extrapolation might have created data that did not exist and therefore might have confused the viewer.

Colour palette

Each matrix contained either pH or temperature data. The next step was to convert the data to colour. A program was written in C to convert each temperature and pH value to a colour. Since we chose to display the data using 128 colours, a new matrix was computed with values between 0 and 127.

Key frames

The matrices of data with the interpolated data and information about colours are called key frames. Key frames are at the basis of animation. Key frames can not be changed arbitrarily since they contain the original information collected in the lake. Other frames can be added in between key frames. A program was written to show each key frame on the screen. The screen resolution was 320 x 200 with 256 colours. This format is called MCGA since CGA is 320 x 200 with 4 colours. The resolution of 320 x 200 was mandated by the version of the ANIMATOR we were going to use to develop the animation. A more recent version of the ANIMATOR program allows higher resolutions.

Animations

An animation is produced by creating many frames in between key frames. These interpolated frames show the evolution of events taking place in the water in between observations. Because of limitations of the program VGACAP (described later) much work had to be done manually and could not be automated. Thus, we decided to create in-between frames with a period of one week. This interpolation in between key frames was

linear. Since our animation lasts 14 months with a time step of one week, the total animation has 60 frames, eight of which are key frames. The interpolation was used to find out the colour of each pixel in the in-between frames.

Each frame was displayed on the screen. Each screen was manually grabbed with VGACAP, a shareware program (1987). This effort was time consuming: each frame was displayed on the screen, the screen was grabbed by VGACAP, stored on disk, and finally converted to GIF format using BLD2GIF, another shareware program. The GIF files were imported into the ANIMATOR. VGACAP is a resident utility that captures pictures in 320x200x256 VGA/MCGA mode, any 640x480x256 SVGA mode or any 800x600x256 SVGA mode. The GIF format is a standard graphics file. Graphics Interchange Format and GIF are trademarks (tm) of CompuServe Inc. an H&R Block Company.

Use of the ANIMATOR to create the final animations

The screens we developed displayed the information in an unsophisticated manner. The ANIMATOR program was used to create the finished product. The first effort was to adjust the colour palette to make it interesting. The advantage here is that it is possible to change the colour palette quite easily if a user is not happy with the one initially chosen.

ANIMATOR was also used to create all the boxes, show the amount of lime added, and specify the date each week. One interesting aspect was to show the location the location and the timing of each application of calcium carbonate. This problem was solved by adding a green arrow on the surface of the lake. This arrow appears only when an application of lime was made. Thus, it does not appear in all frames. An analysis of the animation shows that this green arrow moves from left to right over time. Initially

applications were made in the south part of the lake, near station one, and moved northward during the next 14 months.

To create the finished product, ANIMATOR was also used to create all the screens at the beginning and at the end of the animation.

Other graphics devices

To show the location of the lake, a map of Italy was scanned from an atlas with a Scanjet Plus with 8 bit resolution. Colours were added with Deluxe Paint II Enhanced. Conversion from a PCX format used by Deluxe paint II Enhanced to GIF was done with a shareware program, GWS. To create an outline of the lake, geographic co-ordinates of the shoreline were entered in a spreadsheet. Lake Orta was displayed on the screen, captured with VGACAP and coloured in ANIMATOR.

RESULTS

The complete animation lasts two minutes and 48 seconds. Six title pages present information about the authors, the purpose of the animation and data about the lake. A chart of Italy shows the location of the lake. Another frame shows the station locations. The animation proper follows, and all sixty frames are shown. A colour scale is presented at the right to relate pH and temperature values with those shown on the screen. Two windows at the bottom show the total amount of calcium carbonate added and the date, each frame is updated weekly; at the bottom right a smaller window shows the lake temperature. The green arrow at the top shows the location of the liming. When the arrow is present it means that calcium carbonate was added that particular week. Note the change in colour

in the lake: this colour shows an increase in pH when calcium carbonate is added. Also note the lowering of pH in winter when liming was stopped. A final screen shows information about completion of the field work.

Some notes to run the demo. The playback speed of the animation may be adjusted using the function keys.

F1 = runs at the fastest speed.

F2 – F8 = speeds in between.

F9 = runs at the slowest speed.

F10 = returns to the original speed.

The animation is made up of four parts, so the function key adjustments only apply to the current part. The backspace key will pause the animation, any key, when pressed, will continue the playback. The right arrow key will advance to the next part of the animation. This is very useful for skipping the introduction. ESC will break the animation.

DISCUSSION

This project allowed us the explore the application of animations to display scientific data. As described above, even if the animation only lasts for about three minutes, it requires a large amount of work to develop. The field program had to be organized, data had to be retrieved, analyzed, converted to the proper format, colours had to be chosen, key frames had to be created, in–between frames had to be created and displayed, screens had to be grabbed, colour palettes changed, additional screens added, atlas scanned, etc. The fact that this effort could be completed in just over three weeks could not have been completed without commercial and shareware programs. Even so, a large amount of custom

programming had to be developed to integrate these packages.

One of the major drawbacks was the fact that each of the 60 frames had to be displayed on the screen before it could be grabbed by the program VGACAP, saved and converted to GIF. Each step had to be done manually and therefore it was time consuming. VGACAP had to be manually started (VGACAP is a memory resident program) to store each screen. Since only 60 frames are present the animation is not as smooth as we would have like it to be. To be smooth an animation has to be displayed at 24 frames per second. Thus, a two minute animation would have required 24 x 120 or 2880 frames. To capture 2880 frames manually it would have taken a long time. We are now completing a computer program that will run on Commodore Amiga computers. This program renders automatically animations from data. This program will be able to render a two minute animation in about 15 hours CPU time. This program will be available at the time of publication of this paper.

Animation is an interesting field of research and more ecologists should try to show their data in this fashion. Organization is needed to collect data in a format suitable for animation, however, once information is available, animations are now easily created. In this effort we used 127 colours. Comments received from other scientists indicate that 127 colours are too many. Agreement seems to be that three to 12 colours are very so that boundaries are easily discerned. Two-dimensional interpolation is also a major problem. In this effort we have used a linear interpolation. Other two dimensional interpolation schemes, for example using splines, might give more realistic results. We are now analyzing seven such schemes to find out which is better. The problem of interpolation is also related to the display of events at the boundary where data are not available. This problem is also

being investigated numerically.

REFERENCES

ANIMATOR, Autodesk, Inc.

DELUXE PAINT II Enhanced, Electronic Arts, P.O. Box 7578, San Mateo, California 94403-7578, U.S.A.

GWS, Alchemy Mindworks Inc., P.O. Box 500, Beeton, Ontario, L0G 1A0, Canada.

Magnenat-Thalmann, N. and Thalmann, D. 1985. Computer Animation: Theory and Practice, Springer-Verlag, New York, 240 pp.

VGACAP available from Dr. Marvin Gozum, 2 Independence Place, Apt. 303-2, 6th & Locust Street, Philadelphia, Pennsylvania 19106, U.S.A.

Additional deliverables:

Page 1. In Toxic chemical impacts we can add NOI participation. This relfects the theoretical development being done with Bruggemann. Ranking.

Page 8. We should add the work being done on computer animations in 2D and three D. Also interface of computer grapgics and video to approach the public.

We can write it up as: Within two years, complete major demonstration on video, using computer animations in 2D and 3D, of data collected in RAPs, mainly Hamilton Harbour.