SCUM USER MANUAL

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Introduction

Cyanobacterial (blue-green algal) blooms in freshwater lakes and reservoirs have become a common nuisance in recent years. Many cases have been reported throughout the world of illness to people and death to animals coming into contact with water containing cyanobacterial toxins. In 1989, 15 dogs died after drinking contaminated water in Rutland Water, Leicestershire.

One of the most common management strategies is to close water-bodies affected by problem blooms of cyanobacteria. This action is uneconomic and causes much agitation to landowners and to the general public. A better way to manage the problem may come from the development of computer simulation models of cyanobacterial dynamics.

If under certain hydro-environmental conditions the water manager can predict that a problem bloom will develop at point X in a lake, and is likely to migrate to a point Y then management action can be focused upon that specific area of the lake. This may involve attempting to kill or prevent the growth of the cyanobacteria, or restricting access to the affected area of the lake without having to close the whole facility. This presents a much more economical

solution and would reduce complaints from interested parties.

SCUM (Simulation of Cyanobacterial Underwater Movement) is a program which models the processes of cyanobacterial movement. Cyanobacteria are able to regulate their position vertically within a water column by changing their density state in response to changing photosynthetic rates. When the cyanobacteria are buoyant, they can rise to the lake surface and become entrained within weak, wind-induced, turbulent currents. Their pattern of movement is dependent upon many factors including wind velocity, sunlight, lake morphology and colony size. These processes and how different parameters affect cyanobacterial behaviour can be investigated by using SCUM. This short paper presents instructions for the use of the SCUM software. For details of model equations and processes, consult Howard (1992a,b).

System Requirements and Installation

SCUM was programmed on an Elonex 433-PC using Microsoft QuickBASIC. A compiled version is supplied which may be used on any IBM compatible machine with the following system characteristics:

- DOS version 2.1 or higher
- an EGA or VGA card
- a colour monitor
- an hard disk
- a mouse

Although programmed on a machine with a 486-chip, the software may be run on machines with a 386-chip and maths co-processor. On less powerful machines the software runs slowly. For example, a 24 hour simulation on a 486 takes 14 seconds but on a 386 takes over two minutes.

The SCUM disk contains the following files:

- SCUM.EXE
- RUTOV3.DAT
- RUTOPAI.DAT
- GRAFPAI.DAT
- GRAFHAM.DAT

- RES.RES
- SUM.RES
- CONVERT.EXE
- 1.DAT
- 2.DAT
- 3.DAT
- 4.DAT

Briefly, the files 1.DAT to 4.DAT hold wind velocity data. The user is able to add extra data files from field records. Instructions for doing this, using CONVERT.EXE, are given below. The other four .DAT files contain data for the drawing and shading of two example lakes. SUM.RES and RES.RES are example result files and are described later. SCUM.EXE is the main program coding.

These files should be copied from the floppy disk to a directory, either on the hard disk, or to a RAM-disk created in the computer's extended memory. For details on how to create a RAM-drive a DOS manual should be consulted. The RAM-drive normally known as the D or E drive should be a minimum of 500K in size. The advantage with using the RAM-drive is that it speeds up transfer of data from disk to program. The disadvantage, however, is that all files are deleted from the directory when the computer is switched off. It is therefore necessary to re-copy the files from

the floppy disk at the beginning of each session.

Once the files have been copied the program is started by changing to the directory holding the SCUM files, typing **SCUM** at the DOS prompt and pressing return.

For users not familiar with DOS, the following DOS commands would copy the SCUM files from a floppy disk (eg A drive) to a new directory created on the hard disk (eg c:\scum). Text in brackets is not entered into the computer and the DOS prompt is written in italics:

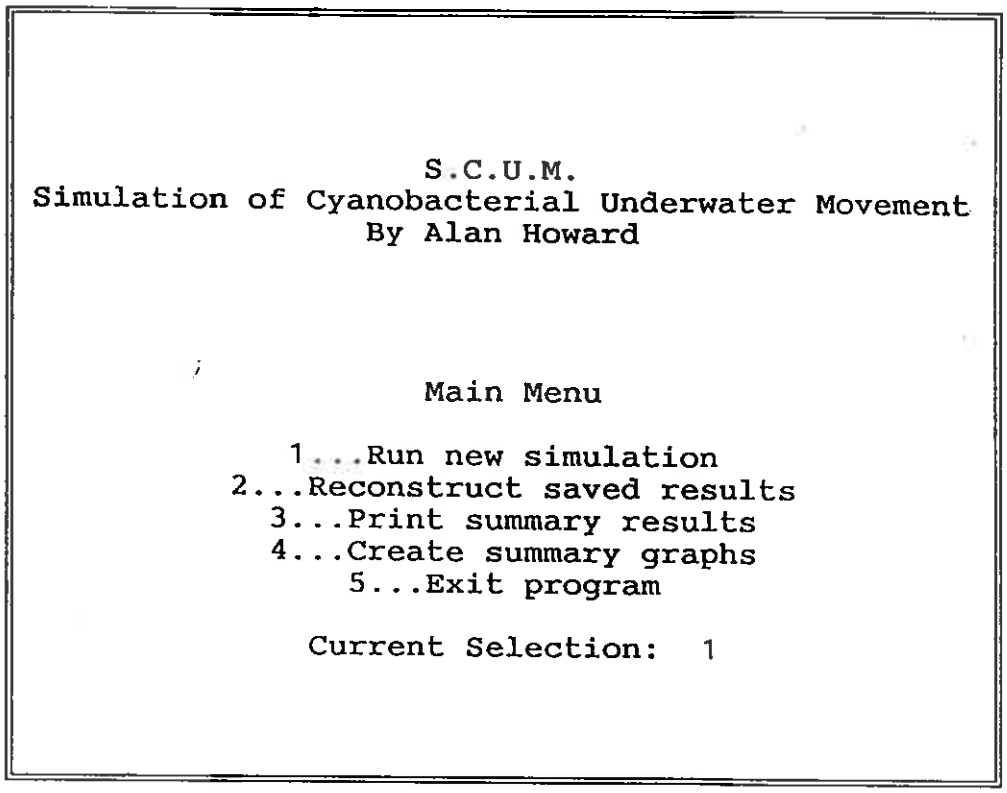
c: md scum	(makes directory)
c: cd scum	(change directory)
c:\scum copy a: *.*	(copy files to c:\scum)
c:\scum SCUM	(starts scum)

Creating additional wind data files

Four wind velocity data files are provided with the software (1.DAT - 4.DAT). Additional files may be added by saving new data as an ASCII text file or as a QuickBASIC sequential data file. The data should be in time steps of one hour.

Once the text file has been saved, the program CONVERT.EXE should be run by typing convert at the DOS prompt. This will convert the file to the necessary format for the SCUM software. When asked to give a name for this new data file then the user must call it by a number greater than 4 (eg 9.DAT or 5.dat). During the simulation, at the appropriate prompt, the user may select this file by typing the number used to name the file. Only the four example files are listed, but if additional files have been added then these may also be selected.

After entering SCUM from DOS a screen is displayed showing the main menu:

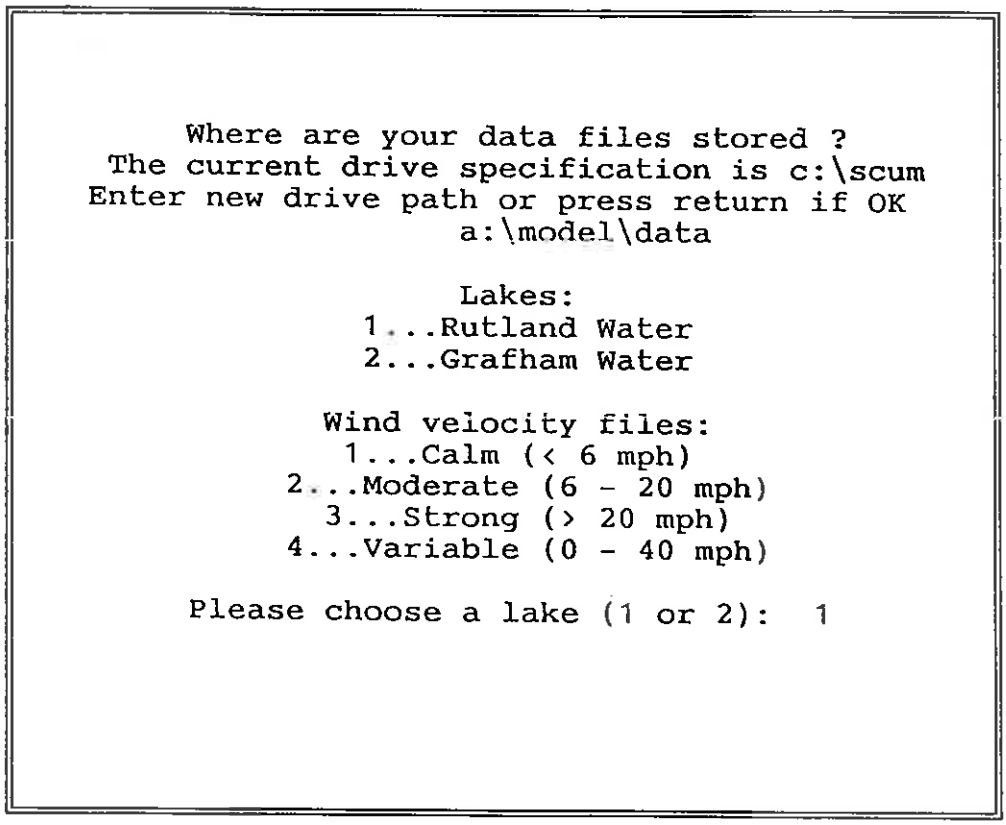


At this stage it is important to check that the Num Lock keyboard function is on and that Caps Lock and Scroll Lock are off. This is necessary for the program to recognise keyboard input.

From the main menu the user may choose one of the five options by typing the number and pressing return. Once the user is familiar with operating the first option, options 2 to 4 are self-explanatory.

Running a New Simulation

This selection starts a new SCUM simulation. It is important to check that the current drive specification is set correctly. The default specification is c:\scum. This must be changed by typing a new specification if your SCUM files are in a different directory (e.g. d:\scumdata). The user is then asked to select a water-body, to which the simulation is applied, and then a wind velocity file. Four different wind environments are available.



The next screen displays various model parameters and their starting values. These values may be edited using the keyboard, or accepted by pressing return:

```
                Model Parameters:

          Initial Density of Colony: 1000
            Initial Depth of Colony: 2
Maximum surface irradiance at noon (0-1800): 1000
          Number of daylight hours: 12
       Number of days for simulation: 10
    Radius of cyanobacteria colony (m): .002
          Extinction coefficient: 2

       Enter summary file name ? sum
```

The user is then asked to enter the name of the results file. This file stores data on the movement of a colony over an entire simulation. These results may be reviewed at a later date by selecting number 2 from the main menu or can be analyzed during the current simulation. The results file is saved to the current drive specification. The SCUM disk contains res.RES as an example of a results file. The user also has the option of creating a summary data file. This saves general simulation information which can be reviewed by selecting option number 3 or 4 from the main menu. An example summary file (sum.RES) is supplied.

When naming result and summary data files the

filename extension, .RES, is automatically added. The user should not therefore add any extension. In the example, the filename 'sum' or 'SUM' would be saved to disk as 'SUM.RES'.

A map of the water-body selected is now drawn and shaded according to water depth contours (Figure 1) using MIGS (Miscellaneous Image Generation System). For information on this simple graphics utility program and details of how to obtain a copy of the MIGS software, refer to Howard (1993).

From the lake displayed, the user is asked to select a profile using the mouse. This is done by selecting two points. The first point is selected by moving the cursor to the desired position and clicking the left mouse button. The second point is selected by clicking the right mouse button. A line is then drawn between these two points and the water profile calculated from it. When choosing the two points it is essential to click on black areas of the screen and not the lake itself.

The simulation now begins. The simulation screen is divided into three windows (Figure 2). The top window shows the lake profile and the movement of the cyanobacteria represented by cyan coloured dots.

Figure 1: Rutland Water

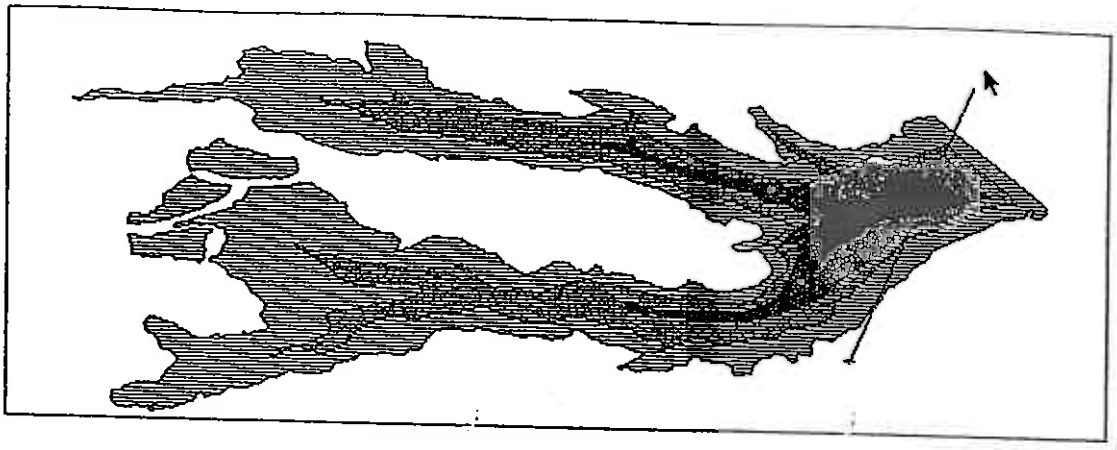
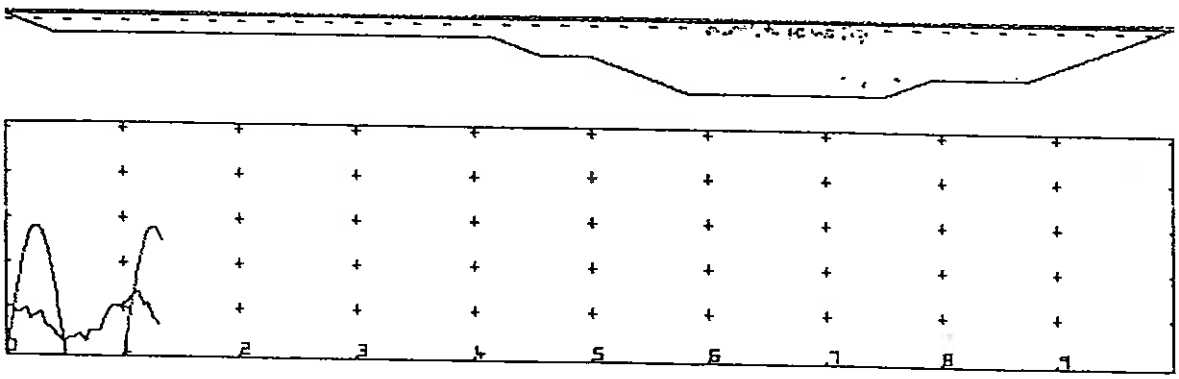


Figure 2: Main simulation screen dump



The dashed line, which relocates its position after each hour of simulation, represents the depth of the mixed layer (see Howard, 1992). The middle window shows, graphically, surface irradiance and wind velocity, and the lower text window presents information on the current simulation status. During the simulation the following function keys are activated:

ESC - pressing the escape key ends the simulation and returns the user to the main menu. Results and summary files are closed and saved to disk.

F1 - this key switches the text screen on and off. Not displaying the text speeds up the simulation rate by approximately 30%.

SPACE-BAR - this key switches to the review of the results file. Various characteristics of a single colony in the current simulation are shown graphically. This option can also be accessed from the main menu by selecting number 2.

As noted, these keys only work if Num Lock is ON, and Caps Lock and Scroll Lock are OFF.

Problems with the simulation

Under certain conditions the program may crash and an error message will be reported. This is often caused by an incorrect drive specification or because the disk is full. Results and summary files tend to be large and may use up space on a RAM-drive very quickly. If using a RAM-drive it is wise to copy such files to the hard disk between simulations and then to delete the RAM-drive files to create space for further results. Results and summary files are always stored with the *.RES extension.

On rare occasions, however, the program may fail because of a more serious problem. Such problems tend to be related to the mathematical restraints of the computer and are difficult to overcome. As with all program faults, an error message is reported and the telephone number of the author given. If an error reoccurs persistently then the author should be contacted for advice.

Ending your session

By selecting number 5 from the main menu SCUM ends and you are returned to DOS. When you have finished running SCUM simulations it is important to

back-up results files before switching the computer off. This is particularly vital if your results are saved on the RAM-drive since they will be lost when the computer is switched off. In this case they should be copied to a directory on the hard disk and as a wise precaution to a floppy disk as well.

Obtaining the software

A copy of the SCUM software can be obtained by sending a formatted $3\frac{1}{2}$ inch or $5\frac{1}{4}$ inch disk to:

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Those ordering the software will automatically receive information about improved new versions of SCUM and associated models in the future.

References

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Howard, A. (1993) MIGS - A simple graphics utility program. *Computer Applications in the Biosciences*, 9, No. 1.