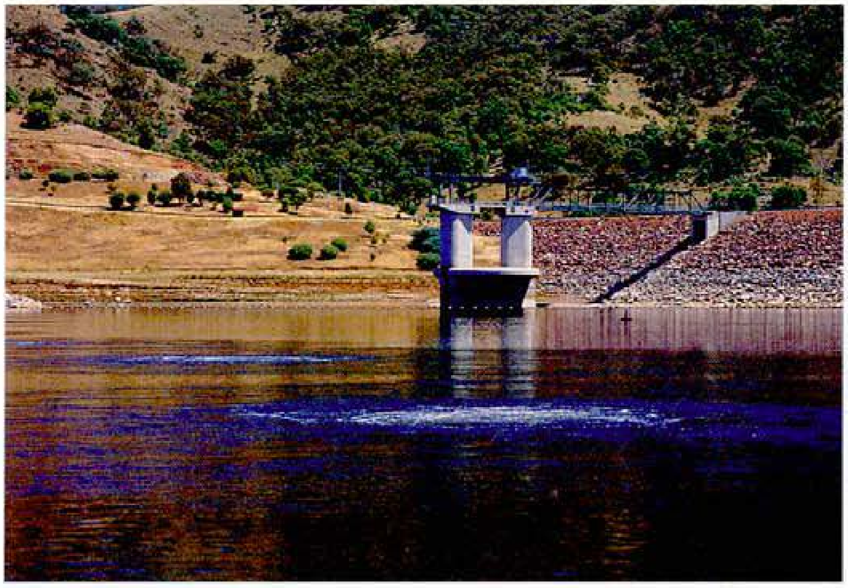


Above: Patrick Hatton and Bruce Hindmarsh prepare to measure a profile of temperature, dissolved oxygen and chlorophyll fluorescence at Chaffey Dam.
Left: A bubble plume hits the surface.

Still waters cause a stir at Chaffey

Tamworth's Chaffey Dam is the focus of a three-year, cooperative effort to unravel, understand, and devise ways of managing the mechanisms that cause blue-green algal blooms in warm-climate water storages.

The project is sponsored by the Cooperative Research Centre for Freshwater Ecology and led by Dr Bradford Sherman and Dr Phillip Ford from CSIRO's Centre for Environmental Mechanics. It draws together scientists and technicians from a range of organisations.

Through a series of experiments at Chaffey Dam the researchers aim to discover why attempts to control algal blooms by mixing the water in lakes using a technique called artificial destratification have been largely unsuccessful. They believe the answer may lie in the interplay between physical processes controlling light availability to algae and chemical processes controlling the bioavailability of nutrients.

When freshwater algae die they gradually sink to the bottom of the lake or reservoir, mixing with clay particles, plant detritus and waste carried in by the water flow. In the bottom sediment, huge populations of bacteria derive energy and new cell materials from this rain of food while consuming oxygen and breaking the old cells down into simpler molecules. As a result, the oxygen content of the water closest to the bottom decreases, and nutrients are released to the water column.

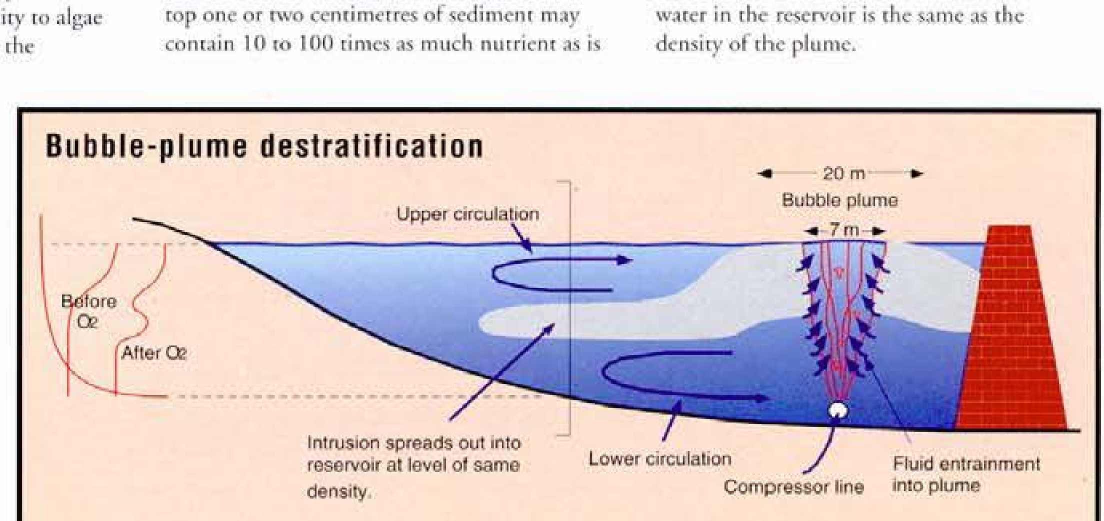
If the rate of oxygen supplied to the bottom waters is equal to or greater than the rate of oxygen consumed, the sediments remain oxic (containing oxygen). Most of the phosphate released by the breakdown of the algal cells is adsorbed by iron hydroxide, with only a small portion returning to the surface where it can support further algal growth.

But if the rate of supply of dead algae is high (eutrophic systems), or the rate of oxygen supply is low (deep lakes or low winds), or the organic matter is rapidly digested (such as with sewage), the bottom sediments may become anoxic.

Under anoxic conditions, other varieties of bacteria take over. The sediment pores fill up with phosphate and soluble iron and manganese, and the water develops a strong smell of hydrogen sulfide (rotten egg gas). The top one or two centimetres of sediment may contain 10 to 100 times as much nutrient as is needed to support a large algal crop in the water column. Thus water managers attempt to keep the sediments oxic.

One way of keeping the sediments oxygenated is to mix the water by releasing compressed air at the bottom of the lake (see diagram). The compressed air forms a conical plume of bubbles. The water surrounding the plume is mixed in and carried up to the surface.

When the bubble plume reaches the surface, the bubbles escape to the atmosphere while the water in the plume spreads out along the surface for a short distance, then plunges to a depth where the temperature in the lake away from the plume is the same as the temperature of the plume. This depth is called the level of neutral buoyancy and is simply the depth at which the density of the water in the reservoir is the same as the density of the plume.



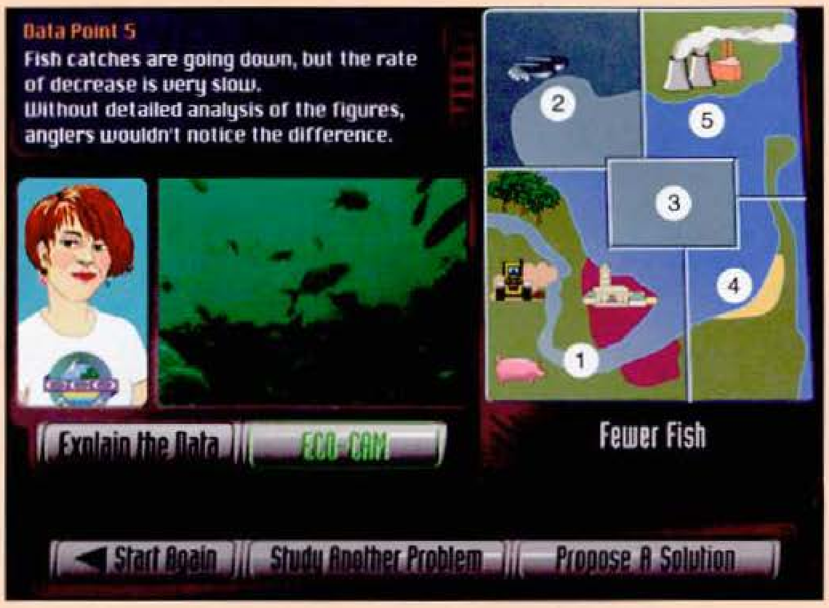
Troubleshooting with Ecotrekker

Imagine taking charge of an environmental disaster area: a coastal bay where the water is murky, fish catches are falling and algal blooms appear way too often. It's your job to track down the source of the problems, and then to select a viable solution.

This scenario is presented in Ecotrekker, a computer adventure that presents anecdotal and scientific 'evidence' about environmental factors affecting the fictitious Illusion Bay. Based on this information, decisions can be made about how the area should be managed.

Users are introduced to the various human activities affecting Illusion Bay by an animated guide called Wanda, and a few of the 'locals' describe the bay's present state. Is it the sewage treatment plant, the power station or upstream land-use practices that are to blame?

Data relating to the environmental impact of each activity are presented as videos, maps, graphs and illustrations. Once the true culprit is revealed and a solution decided upon, 'TV news broadcasts' explain the future consequences of each decision. Should we have created a marine park, dug a canal or taken community action?



Ecotrekker was developed jointly by CSIRO Division of Fisheries and CSIRO Information Services. Their aim was to provide a fun way of acquainting people with marine management issues.

The program was unveiled in March at the opening of the Bunbury Dolphin Discovery Centre at Koombana Bay in Western Australia. Ecotrekker is one of three activities being started there by the Division of Fisheries as part of its Coastal Impact Assessment Project.

Craig Manning, a marine ecologist with the division, says the project's aim is to involve the community in collecting data relevant to managing human impacts on marine ecosystems, while at the same time enhancing public education.

The second activity is an educational exercise for centre visitors. It involves sampling from the bay to determine temperature and salinity, recording these data on an interactive computer spreadsheet, and comparing them with daily, weekly and monthly means.

In addition, a marine environment monitoring program for Koombana Bay, to be operated by volunteers from the Dolphin Discovery Centre, is being designed by the division. Dr Charles Jacoby, who heads the three projects, says this is a pilot trial for a plan to implement similar programs along the Western Australian coast, and perhaps eventually the entire Australian coastline. These programs are meant to generate data for use by environmental managers.

Ecotrekker is likely to find its way into other community centres and museums in the future. In the meantime, the possibility of making the program available on CD-ROM is being investigated.

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Having reached the level of neutral buoyancy, the plume moves towards the far boundaries of the reservoir and generates a return flow back towards the bubble plume along both the bottom and the surface of the reservoir.

In effect, the circulation pattern that has been established acts as a conveyor belt, carrying water from all parts of the reservoir, especially the bottom, through the bubble plume, where it mixes with the water that lies above. Slowly the temperature difference between top and bottom decreases as the colder bottom water is lifted upwards and replaced with warmer, more oxygenated water from the return flow.

As the top-to-bottom temperature difference decreases, the wind has a better chance of mixing the reservoir over its entire surface. Bubble-plume destratification cannot completely remove the temperature difference by itself.

In warm climates, however, such as at Chaffey Dam, a side-effect of destratification is that the temperature at the bottom can increase by as much as 10°C. This can double the rates of cellular degradation, oxygen consumption and the release of nutrients. Nutrients and iron which have accumulated at the bottom are also carried up into the surface layer, where iron is oxidised to iron hydroxide. The algae in the surface layer then compete with the iron hydroxide for the phosphate.

The consequences of destratification are thus more far-reaching than merely keeping the sediments oxygenated. There are positive and negative impacts. The Chaffey Dam project aims to characterise and quantify these interactions, and work out ways to take advantage of this knowledge to improve water quality management.

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Project partners include: Dr Ron Beckett and Mr Jason van Berkel, Monash University; Dr Rod Oliver, Mark Fink and Damien Green, Murray Darling Freshwater Research Centre; Professor Graham Harris, CSIRO Institute of Natural Resources and Environment Project Office, University of Canberra; and Dr Bill Maher, University of Canberra. Michelle Price and Bruce Hindmarsh of the NSW Department of Land and Water Conservation are also contributing.