A PRACTITIONERS VIEW OF MODERN DEVELOPMENTS IN LIMNOLOGY

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Abstract

With the great advances in process understanding, sensor and instrumentation technology and modelling capability it is important to ask what if any practical benefits can the lake manager and operator look forward to. Here, we examine some of the more important problems facing operators of drinking reservoirs, hydro-lakes and lakes used predominantly for recreation and the environment. In drinking reservoirs the main problems originate from increased loadings of nutrients leading to increased biomass and biomass that may give rise to toxins, of anthropogenic chemicals such as metals and synthetic organics and of pathogens of different types. Hydro-lakes are predominantly plagued by problems arising from low oxygen levels in the hypolimnion and in recreational and environmentally sensitive lakes the biggest challenge for the operator is to maintain an existing or establish a new trophic hierarchy or protect the water body from foreign species. The control variables that are at an operator's disposal are the choice of lake water level, the modification of the water column stratification via a de-stratification system, the modification of the lake flow path with flow intervention-curtains, intervention in the catchments to modify the loadings flowing into a lake, manipulation of the trophic chain with introduction of new species and chemical dosing, the latter being of marginal use in a large lake. Each of these options is cost effective under certain-circumstances. We endeavour to provide a users guide for their application and show how, especially new instrumentation and modelling methodologies may be used to achieve an effective intervention.

INTRODUCTION

The last ten years has seen enormous improvements in the understanding of limnological processes, instrument reliability and sensor availability as well as model capability. Previously lake physics was simplified to a study of the evolution of the thermal regimes, lakes were probed with fortnightly or monthly routine chemical monitoring programmes and models were, by an large, viewed with great scepticism by aquatic biologist and certainly rarely used by lake manager. The emphasis was mostly on gaining an understanding of the basin wide response of the lake as a whole to bulk inputs of nutrients, chemicals, pathogens and particles.

In the last ten years this situation has changed to where lakes are now seen as complicated water bodies with a cascade of energy from the sun and wind to the thermal structure, to basin scale waves, to high frequency waves and mid frequency gyres and

finally to slow gravitational motions sustained by the vertical mixing induced by the turbulence in the water column overcoming the density stratification. These latter motions are known to be responsible for formation, preservation and redistribution of biological and chemical patches throughout the lake. These patches have now been shown to control the bulk or average response of a lake ecosystem to river and atmospheric inputs.

Instrumentation has seen a greatly increased availability of sensor types, sensor sensitivity and the ability of sensors to function successfully in-situ. Advances range from the increase accuracy of temperature and conductivity sensors, to the availability of flourescence dependent sensors capable of measuring not only total fluorescence, but also the emission from different species of algae. The automatic sample has reached a level of maturity where it can be relied on to collect samples routinely and even carry out a large range of analyses based by flow injection. However, probably the change with the largest potential is the emergence of both in-situ Lake Diagnostic Systems and actively controlled Lagragian drogues that can carry a range of these new sensors. Togther these instruments make it possible to continuously probe a lake and view the data in real time. The real time aspect has now also been applied to practically all forms of the data inventory and we are seeing data appear on the web, available for download by real time models or observers, as it is being collected.

The modelling capability has seen two major advances. First, the one-dimensional models have gained greatly in their process descriptions of the physics, the biology, the chemistry and most recently the behaviour of pathogens entering a lake via stream and overland flows. Second, three dimensional models have emerged, which not only have the computational efficiency to make them a practical tool for a consultant, but have also recently been endowed with algorithms that negate the effects of numerical diffusion so making them useful for longer runs.

Most recently these three dimensional models have been coupled with the real time data streams coming in from both manual and in-situ monitoring programs allowing these models to become self checking and so aligning the output from such models to the data. This means that such models are now secure against drifting off track and are thus useable over long periods of time, even making them suitable for scenario testing. Most recently the models have, in turn, been used to update the sampling program of the Lagrangian drogues bring us to the point where the data gathering, the data analysis and our predictive capabilities have all been integrated into a "self learning" methodology.

Clearly, with all these improvements in understanding, monitoring and modelling it is important to pause and take stock to see how these advance may be used to aid the day to day management and operation of a large lake.