

An integrated observation network for the Gippsland Lakes, Victoria, Australia: Balancing the needs of science and management

W.R. Davies and G. Martinez

Centre for Environmental Science

EPA Victoria

Ernest Jones Drive,

Macleod 3085 VIC

Australia

Warren.davies@epa.vic.gov.au

Guillaume.martinez@epa.vic.gov.au



ABSTRACT

Davies, W.R. and Martinez, G., 2007. An integrated observation network for Gippsland Lakes: Balancing the needs of science and management. *Journal of Coastal Research*, SI 50 (Proceedings of the 9th International Coastal Symposium), 57 – 61. Gold Coast, Australia, ISSN 0749.0208

The Gippsland Lakes region in eastern Victoria is a partially flushed coastal lake system within a diverse catchment of rural and urban communities. Pressure from lakeside developments, re-occurring blue-green algal blooms, declining fisheries, sedimentation and infilling of the ocean entrance, has borne several decades of focussed studies and routine monitoring programs, along with a variety of engineering and management solutions. A recent review recommended that these disparate studies should be enhanced to formulate a coordinated monitoring network that could improve both spatial and temporal coverage, develop a capacity to trigger responsive investigations and was able to serve the needs of system management. Through a series of partnerships an integrated network was developed that comprises event and baseline monitoring of catchment loads, local meteorological forcing and an array of water quality sampling sites within the lakes system. A majority of these sites are incorporated with real-time telemetry that provides up to the minute information to stakeholders via a web-based information management system and vital operational status to technical system management.

ADDITIONAL INDEX WORDS: *Gippsland Lakes, time series analysis, Real time monitoring*

INTRODUCTION

The Gippsland Lakes are a series of large estuarine lakes situated in the south-eastern corner of Australia about 200 km east of the capital city of Melbourne, in the state of Victoria. These coastal lakes are approximately 69 km in length and 10 km wide at their broadest point and separated from Bass Strait by a system of sandy barriers. Three major lakes with surface areas of 148, 75 and 98 km² respectively, constitute to the majority of the total area of the Gippsland Lakes (364 km²). The lakes are generally shallow with Lake Wellington in the west having an average depth of 2.6 m, Lake Victoria 4.8 m and Lake King 5.4 m (WEBSTER, 2001). At the eastern end of the Gippsland Lakes is a man-made channel (Lakes Entrance), which has been maintained open since its construction in 1889, therefore maintaining a strong salinity gradient running east to west along the Gippsland Lakes system. Flow from 5 major rivers drain 20,600 km² of catchment and represent about 9% of the total land area of Victoria (WEBSTER et al., 2001).

The Gippsland Lakes are an important ecosystem in regards to environmental, economic, cultural and social values. Its wetlands are listed under a number of international convention treaties including, the RAMSAR convention, the Japan-Australia Migratory Bird Agreement (JAMBA) and the China - Australia Migratory Bird Agreement (CAMBA) (HERON, 1989). It is recognised as an important nursery for a diverse array of aquatic

species, some with commercial importance (COUTIN et al., 1996; RAMM, 1983; RIGBY, 1982) and has been identified as an important tourist destination that brings economic and employment benefit to local communities in the region (GIPPSLAND COASTAL BOARD STAFF, 2000).

A number of reviews have identified major environmental pressures and associated problems that pose a threat to the integrity of the Gippsland Lakes ecosystem (WEBSTER et al., 2001; HARRIS et al., 1998). Of these pressures, eutrophication from river loads (GRAYSON, 2006) has been identified as a major contributor to toxic blue green algal blooms from the species *Nodularia spumigena* (GIPPSLAND COASTAL BOARD STAFF, 2000).

Several decades of disparate studies and monitoring have provided insight into the health of the Gippsland Lakes. An environmental audit of the Gippsland Lakes (HARRIS et al., 1998), initiated government commitment to a coordinated monitoring network as a cornerstone theme (GIPPSLAND COASTAL BOARD, 2002). A focus of the monitoring network was to provide improved spatial and temporal coverage over current monitoring programs, with the capacity to enable a responsive system to meet transient events.

In this paper, the technical aspects of designing and maintaining a low cost, robust monitoring system in a productive, shallow coastal estuarine system are discussed. Further to this are comparisons to other current Gippsland Lakes monitoring

programs and examination of integrating datasets to provide information for management needs.

METHODS

Eight Gippsland Lakes monitoring stations were spatially distributed along the main water bodies of Lake King and Victoria (Figure 1). Gippsland Ports have in place a range of navigation markers located throughout the Gippsland Lakes which provide an opportunistic and secure sampling platform for the installation of monitoring hardware. Most of these locations are also strategically placed in areas where algal blooms, fish kills and bottom water oxygen depletion have been reported.

In operation the sondes perform hourly measures of water parameters, although a higher instrument sampling rate is possible. Hourly monitoring was regarded as an adequate temporal scale to investigate fine scale changes generated by wind, tide and floods and also accords with other estuarine monitoring networks.

Recorded data from the sondes and instructional data from the user is transferred via cabling with a RS232 connection. Prior to water quality monitoring the external dataloggers must be preprogrammed with a log file specifying the monitoring parameters, frequency and monitoring period. Once the Log files are enabled, the sondes are

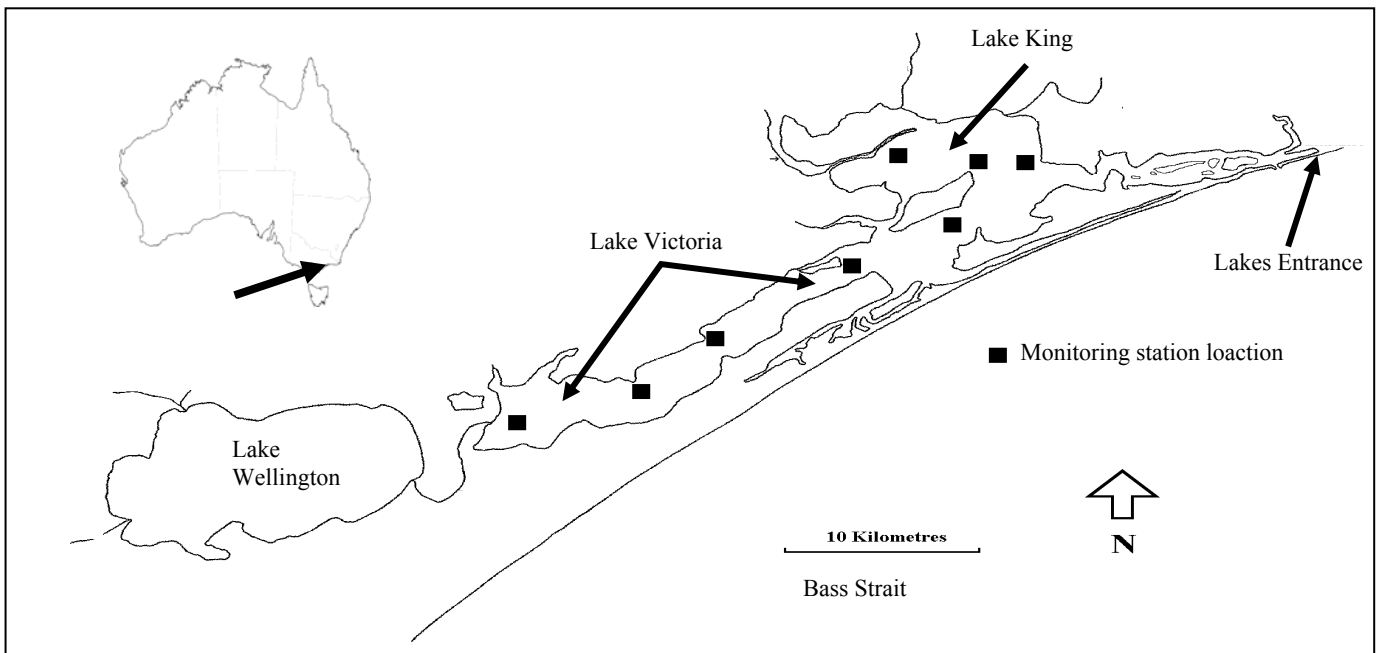


Figure 1. Location of Gippsland Lakes and monitoring stations

Monitoring equipment in the form of Hydrolab datasondes DS5X water quality multiprobes were fitted to monitoring stations 0.5 m under the water surface (surface sonde) by securing rigid PVC pipes to the navigational marker pylon. Previous monitoring (EPA Victoria unpublished data) has demonstrated that a strong halocline can exist below depths of 5 m and therefore the monitoring design incorporated a bottom sonde at the six most easterly sites. As navigational markers generally resided in shallow water (< 5 m), a submerged buoy arrangement was deployed nearby in deeper water to accommodate the bottom sonde (Figure 2). The submerged buoy usually lay at a distance between 30 to 60 m from the navigational marker and surface sonde. Also secured to the navigational marker above the water is a waterproof housing containing a telemetry unit with a CDMA modem and flush antenna, datalogger (Campbell CR10X-2M) and battery unit. Power was supplied to the instrumentation via a 40 W solar panel secured above the housing.

The in situ DS5X sondes have been fitted with a range of water quality probes and include a conductivity sensor with graphite electrodes, a standard pH electrode with separate reference, Turner, Cyclops 7 Chlorophyll-*a* sensor, HACH LDO luminescent dissolved oxygen probe and a temperature and depth sensor. Two further sondes were fitted with sensors to measure the blue-green algal pigment phycocyanin and deployed specifically in Lake King where *N. spumigena* blooms have historically been

deployed into the environment and water quality monitoring commences upon the specific settings in the Log file. Monitored water conditions are transferred and stored into the external datalogger until a remote request for a download is made at the EPA Centre for Environmental Science in Melbourne, Victoria approximately 350 km away. An automated polling of data is currently requested every two days by dialling into the telemetry system and transferring the raw data to databases, although real time monitoring is possible. Downloaded data is transferred to the EPA Victoria database containing pre-programmed quality checks to filter and reject spurious data. The manipulated data is sent to a web page after execution of a code producing an ASCII formatted file.

A web-based information system is being developed for online usage, providing time series analysis of water quality parameters, trends and the ability to incorporate up to the minute information to stakeholders. Navigation is possible by a clickable map of the monitoring network superimposed over the Gippsland Lakes and the user can select a particular monitoring station and be directed to a new HTML file showing images of the site, measurements and data interpretation (Figure 3).

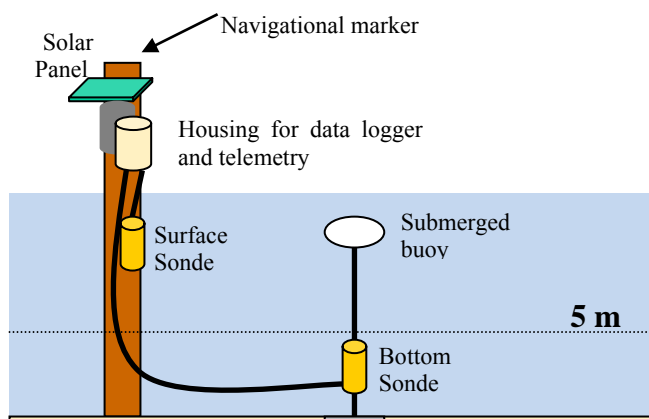


Figure 2. Monitoring site design: Each sonde is connected to the main housing via a waterproof, underwater cable that provides power and transfer collected data.

Maintenance and calibration of field sondes is accomplished by monthly visits to the monitoring stations where retrieval is undertaken. Calibrated handheld field meters are profiled over the sites during the visit to duplicate water quality measures for later crosschecking with sonde data to quality check sensor drift. Sondes are returned to the laboratory for cleaning and recalibration and redeployed the following day, minimising monitoring downtime. During the routine visit and every following two weeks, water samples are also taken for nutrient monitoring at the sites. Nutrients that are currently monitored are total phosphates (TP), total nitrogen (TN), reactive phosphate (PO₄), ammonium (NH₄) and nitrite and nitrate as NO_x and are analysed by an external NATA certified laboratory. Algal samples are also collected at each monitoring site visit for laboratory derived Chlorophyll *a* measurements that are correlated with the Chlorophyll *a* readings from the sondes.

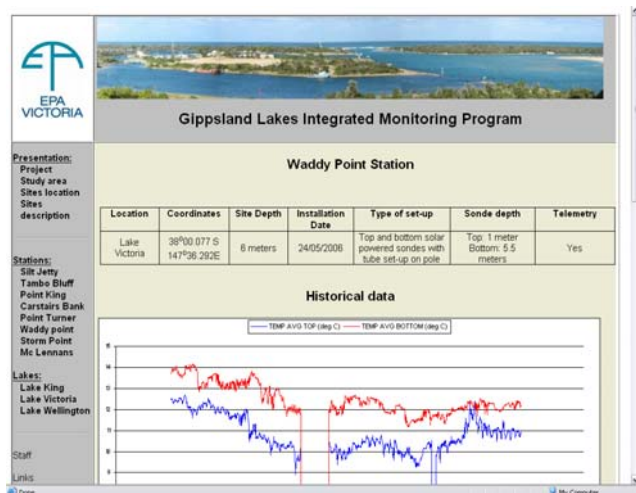


Figure 3. Web site displaying Gippsland Lakes monitoring site and data

RESULTS AND DISCUSSION

The monitoring network system has been successfully operating for nearly 10 months at some sites, since February 2006. High temporal resolution of chemical and biological water quality can be ascertained at the eight network stations in the Gippsland Lakes. This high temporal frequency for surface and bottom waters is similar in frequencies to other monitoring strategies around the world (SPRINGER et al., 2005) and is important because the confidence intervals of estimates are a function of the number of samples taken (DIXON and CHISELL, 1996). The EPA also has a boat sampling monitoring program (Fixed Sites Program) to measure long term changes in the Gippsland Lakes and is undertaken approximately monthly. This may miss small scale changes in time. Figure 4 comparatively demonstrates the temporal advantage the in situ sondes have over the Fixed Sites Program where a highly intensive monitoring program should be able to characterise fine temporal shifts in water quality parameters such as the diurnal dissolved oxygen cycle (Figure 5) and give indication of potential causes and understanding of fish kills and algal blooms. Indeed, this is evident in Figure 6 where rapid decreases in dissolved oxygen and pH, accompanied by increases in salinity, were observed for a period of just a few days in February, 2006. Changes to dissolved oxygen at this bottom sonde suggests that oxygen, at least for short periods, falls to dangerous levels for life. Other obtainable data such as river flow volumes, tidal movements and wind data are also now being incorporated into the monitoring program and should give explanation to such brief phenomena.

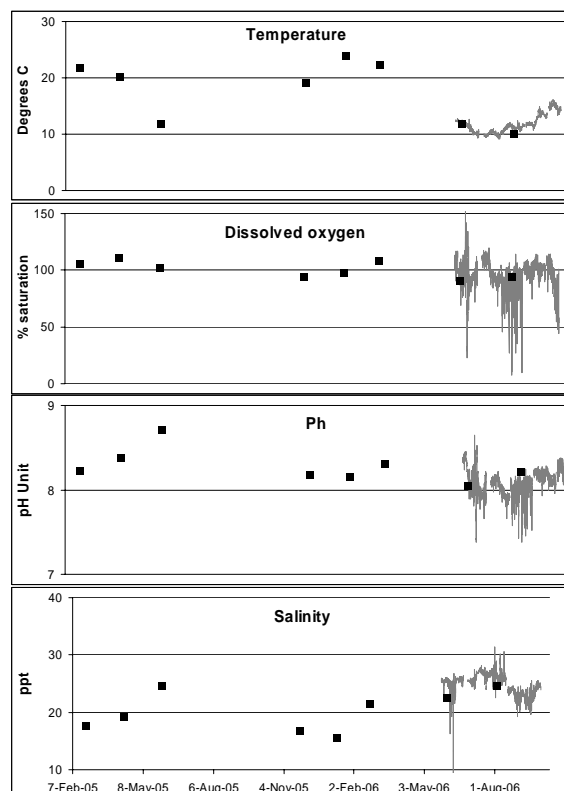


Figure 4. EPA Monitoring frequency from Storm Point, Lake Victoria (■ Fixed Sites Program, - Remote telemetry network)

This ability to intensely monitor key water quality parameters during transient events can provide a powerful early warning system which may ultimately lead to strengthening an understanding of fish kills or algal blooms in the Gippsland Lakes. The usefulness of telemetry system networks to provide real-time remote monitoring (RTRM) has been reviewed (GLASGOW *et al.*, 2004) and has been used effectively in other parts of the world to detect and characterise toxic algal blooms (LEE *et al.*, 2005; SPRINGER *et al.*, 2005) and water quality indicators (LEE and LEE, 1995). The current Gippsland Lakes monitoring network only polls data every two days but has the ability to become real-time during specific periods when algal blooms or fish kills are expected (summer months). Building from the experience of SPRINGER *et al.* (2005) it is proposed that the Gippsland Lakes monitoring network also be used as an early response tool to direct manual sampling efforts to affected sites.

Future considerations for the program would be to augment the telemetry network with shipborne underway sampling to aid in interpolation between monitoring sites. The Gippsland Lakes has a number of government and commercial fishing and tourist vessels that may provide ships of opportunity to increase both spatial and temporal resolution of water quality and algal dynamics.

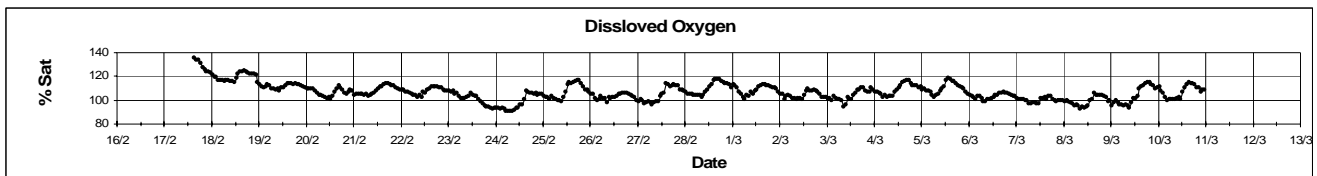


Figure 5. Daily oxygen cycle measured at Lake King north, surface water

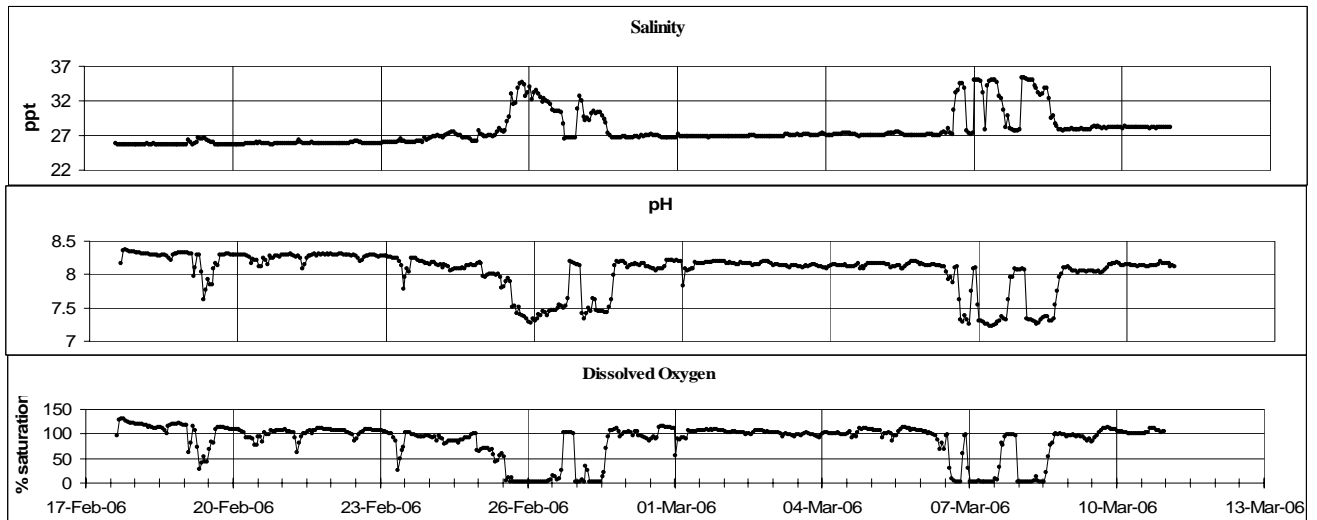


Figure 6. Lake King North bottom surface waters. Transient temporal changes in salinity, pH and dissolved oxygen

ACKNOWLEDGEMENTS

Funding support for this research was provided by the Victorian State Government through the Gippsland Lakes Rescue Package (RCIP 06-07 095). Use of navigational markers was made possible through Gippsland Ports and assistance with installation, field collection and preparation of field samples was supported by Jonathon Smith and Mark Bird at RMIT university and Ron Stott at South Eastern Maritime Education Centre (SEAMEC).

LITERATURE CITED

- COUTIN, P., WALKER, S. and MORRISON, A. (ed), 1996. *Black bream 1996. Assessment Report Number 14. Bay and Inlet Fisheries and Stock Assessment Group*. Marine and Freshwater Resources Institute, Queenscliff, Fisheries Victoria.
- DIXON, W. and CHISWELL, B., 1996. Review of aquatic monitoring program design. *Water Research* 30, 1935-1948.
- GLASGOW, H. B.; BURKHOLDER, J. M.; REED, R. E.; LEWITUS, A. J. and KLEINMAN, J. E., 2004. Real-time remote monitoring of water quality: a review of current applications, and advancements in sensor, telemetry, and computing technologies. *Journal of Experimental Marine Biology and Ecology* 300, 409-448.
- GRAYSON, R., 2006. *Prioritising nutrient reduction for the Gippsland Lakes and catchments Part 1 Loads and sources*. Catchment to Sea Pty. Ltd., Victoria.
- HARRIS, G., BATLEY, G., WEBSTER, I, MOLLO, R AND FOX, D., 1998. *Review of Water Quality and Status of the Aquatic Ecosystems of the Gippsland Lakes*. In CSIRO Gippsland Lakes Environmental Audit, prepared for the Gippsland Coastal Board.
- HERON, J., 1989. *Conservation values of wetlands and estuaries in South-east Victoria*, Department of Water Resources Victoria, Report 52. 62 p.
- GIPPSLAND COASTAL BOARD STAFF, 2000. *Gippsland Lakes coastal action plan*. , 38 p.
- GIPPSLAND COASTAL BOARD STAFF, 2002. *Gippsland Lakes future directions and action plan*, DNRE, 38 p.
- LEE, J. H. W.; HODGKISS, I. J.; WONG, K. T. M. AND LAM, I. H. Y., 2005. Real time observations of coastal algal blooms by an early warning system. *Estuarine, Coastal and Shelf Science* 65, 172-190.
- LEE, H. S. AND LEE, J. H. W., 1995. Continuous monitoring of short term dissolved oxygen and algal dynamics. *Water Research* 29, 2789-2796.
- RAMM, D., 1983. *An ecological survey of postlarval and juvenile fish in the Gippsland Lakes (Victoria)*, Gippsland Regional Environmental Study Ministry for Conservation, Victoria Report.
- RIGBY, B. A., 1982. *An ecological study of the Estuarine Fish Assemblage in the Gippsland Lakes*. Internal Report No. 3. Marine Science Laboratories, Ministry for Conservation.
- SPRINGER, J. J.; BURKHOLDER, J. M.; GILBERT, P. M. AND REED, R. E., 2005. Use of a real-time remote monitoring network (RTRM) and shipboard sampling to characterise a dinoflagellate bloom in the Neuse Estuary, North Carolina, USA, *Harmful Algae* 4, 533-551.
- WEBSTER, I. T.; PARSLAW, J. S.; GRAYSON, R. B.; MOLLOY, R. P.; ANDREWARTHA, J.; SAKOV, P.; TAN, K. S.; WALKER, S. J. AND WALLACE, B. B., 2001. *Gippsland Lakes Environmental study*. CSIRO, , 84 p.