Report on the 1999/2000 Swan barge oxygenation trial

A brief outline

This project is part of the Swan-Canning Cleanup Program, and is supported by the Coasts & Clean Seas program. Oxygenation is one of several river remediation techniques being evaluated in the program. The aim of these techniques is to remediate and manipulate river conditions to reduce phytoplankton blooms.

River Science Issue 13 describes how oxygenation works and why it is being used as a river remediation technique.

This project aims to test the capability of a prototype mobile oxygenation vessel to oxygenate sections of the Swan River. The vessel is an existing Swan River Trust barge, the 'Seagull', which has been fitted with oxygenation equipment. The design of the barge is the result of a collaborative research agreement between the Water and Rivers Commission and BOC Gases.

Over the 1999/00 summer the barge operated at Maylands, Ron Courtney Island and Success Hill. These initial trials will be followed up with further trials next summer.

The Situation in the Swan River

The Swan River is an estuary with fresh water flowing downstream in winter and salt water moving upstream in summer as the fresh water flow subsides. Low dissolved oxygen conditions in the Swan River upstream of Maylands are closely related to the movement and presence of this 'wedge' of saline water (see Figure 1 on page 3). There are several mechanisms by which the saline water may induce anoxia. The different chemical properties of salt water decrease the solubility of oxygen in water and increase the coagulation and settling of suspended particles. As these settled particles decompose they consume oxygen. The increased density of saline water also has important effects. Denser saline water will not mix well with lighter fresh water, and thus tends to form a bottom layer that is not replenished with oxygen and becomes anoxic. Dense saline water also 'flushes' oxygen poor and nutrient rich fresh water from surface sediments.

Anoxic water may also be pushed upstream from anoxic areas further downstream particularly, for example, the large body of poorly oxygenated water often located just upstream of the Narrows bridge.

The consequences of this anoxia may include fish mortality, hydrogen sulfide gas production, and nutrient releases that fuel algal blooms.

The salt wedge is highly mobile and moves with the tides and gradients in atmospheric pressure. Strong winter flows will push the salt wedge downstream. Thus, the salt wedge may disappear as winter flows peak, and then as they ebb it will reform and advance upstream. Although the salt wedge may

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travel as far upstream as the Ellen Brook confluence (60 km from river mouth) it is on average located near Ron Courtney Island (about 40 km from the river mouth) during summer. The movement of the 'nose' of the wedge is also very dynamic, as it may travel 8 km upstream in a single day.

Oxygenation barge design and construction a major achievement

The main achievement of the first year of the project was to design and build the barge. As this was the first time an oxygenation barge had been attempted in Australia there were several design issues that required solving. The barge was designed in conjunction with BOC Gases and is shown in the picture on page 4.

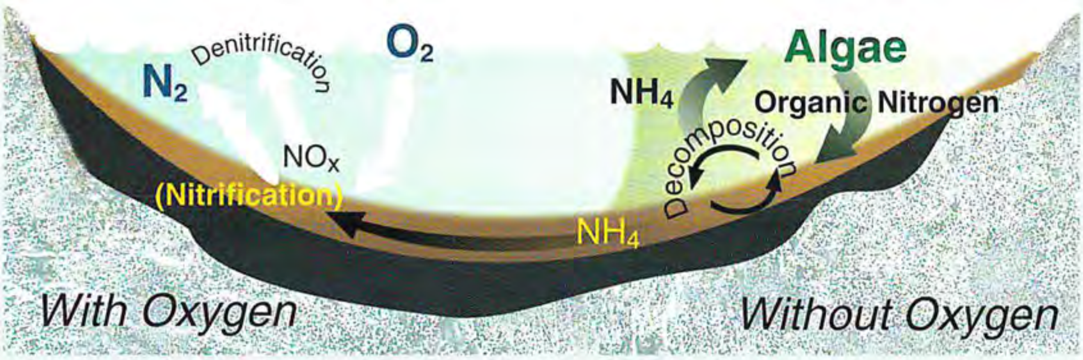
The barge operated for six weeks

The barge operated for six weeks over March and April. Several minor adjustments had to be made as the trial progressed but in general the oxygenation equipment worked reliably and efficiently. Because the oxygenated water is returned below the river surface, and the dissolver is efficient, there were few visible signs of the oxygenation process.

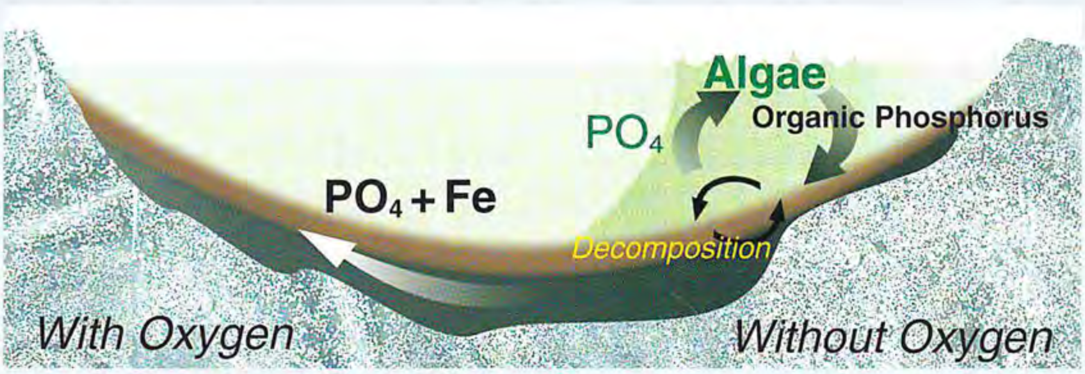
Care was taken to ensure that the barge would operate safely and not obstruct recreational river users. The main features of the barges operation were:

- The barge was anchored when in operation.
- The barge did not block navigation channels and thus did not obstruct other recreational river users.

How oxygenation affects nutrient cycling



An important pathway by which nitrogen is removed from the aquatic system is via the different but complementary processes of nitrification and denitrification. Nitrification (a process that requires oxygen) converts ammonium to nitrate. Denitrification, for which oxygen is not essential, then converts the nitrate to nitrogen gas.



In the presence of oxygen, soluble phosphates rapidly bind with other minerals, typically iron oxide, and are then no longer available to plants. When oxygen is not present, iron oxides become more soluble, and the bound phosphorus also enters solution.

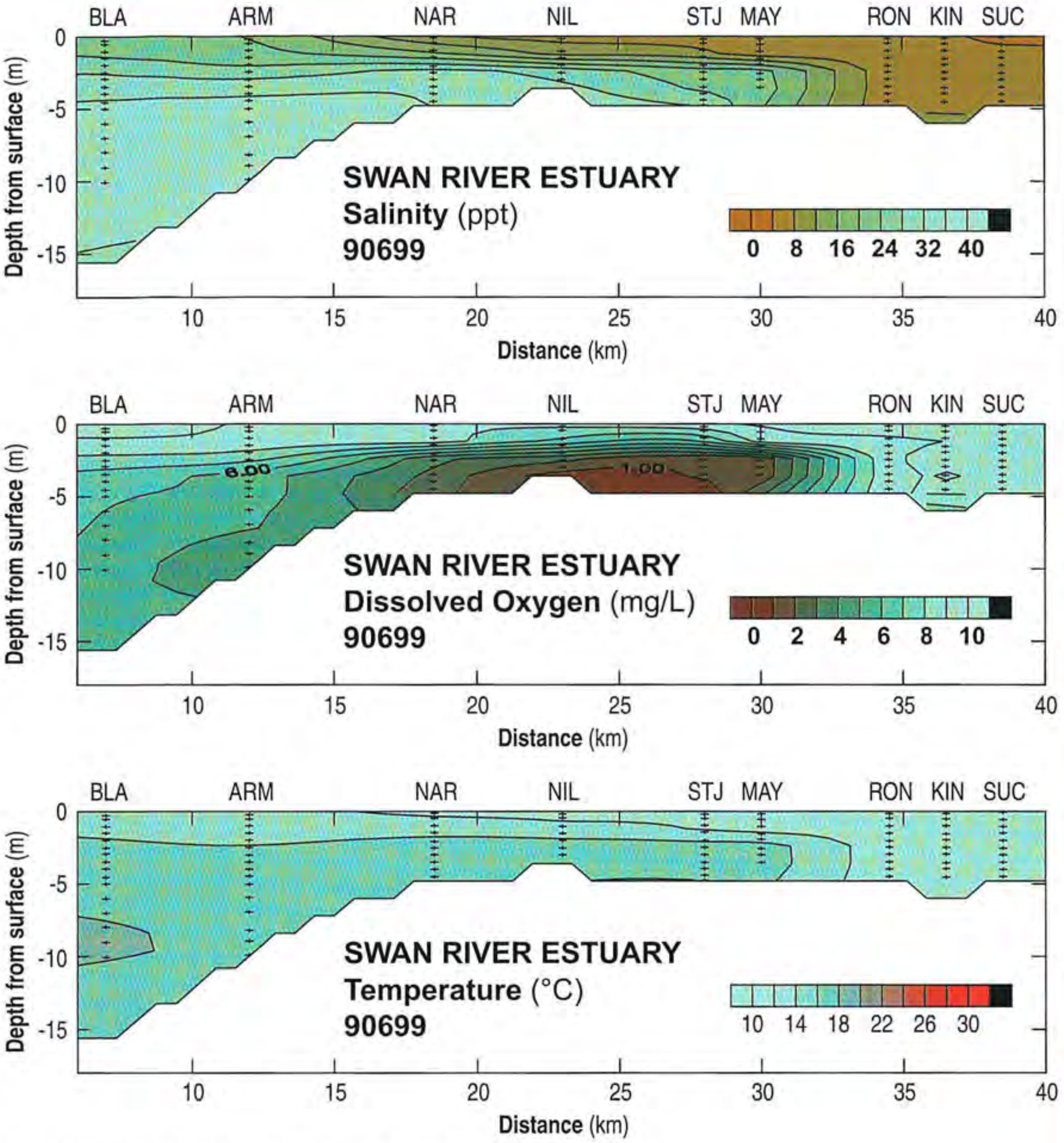


***Figure 1:** Longitudinal Sections of Swan River, showing salt wedge*

Figure 1 shows a longitudinal section of the Swan River in which the salt wedge is clearly apparent. The abbreviations at the top of the plot denote sampling sites: BLA is in Blackwall Reach, ARM is in Melville Water, NAR at Narrows Bridge, RON at Ron Courtney Island and SUC at Success Hill. The first plot shows the lighter blue saline water underlying the darker fresh water. Where these layers meet there is a series of contour lines indicating a rapid change in salinity from salt to fresh. The second plot shows very clearly how the oxygen level is much lower in the bottom saline layer. The third plot shows that water temperature is also influenced by the salt wedge. The fact that the warmer saline water is underlying the colder fresh water (which would normally be unstable) highlights the extent to which the saline water resists mixing.

There were no incidents involving other boats or members of the public.

- The barge was operated round the clock when on site. Normally the operational period was from Monday to Friday but longer periods of operation were experimented with towards the end of the trial.

- The barge was always manned when on the river to minimise the risk of the barge being stolen or vandalised. A pontoon was moored to the barge to provide accommodation for the operator.

The pump was fitted with sound-proofing that substantially reduced the noise it made. This enabled round the clock operation without affecting river-side residents.

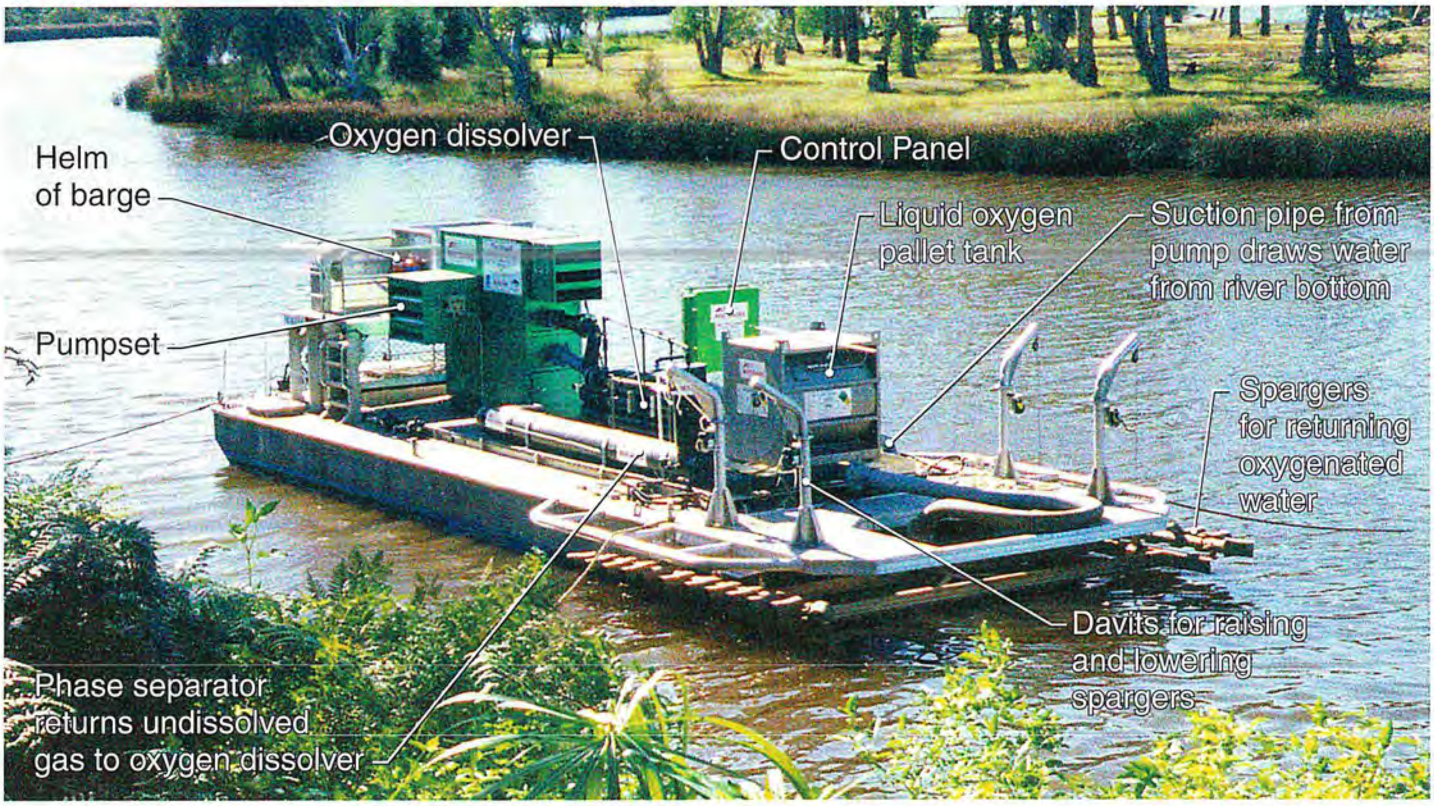


***Figure 2:** Diagram and description of how the oxygenation barge works.*

Water is drawn from the bottom of the river by the pump and pumped into the oxygen dissolver. Here oxygen gas from the front of the vessel is mixed with the water so it dissolves. The second stage of the dissolver system, the phase separator, collects any undissolved gas and feeds it back into the dissolver. The oxygenated water is fed from the phase separator into a sparger system that returns the water to the bottom of the river.

Results of monitoring program

The main objective of the oxygenation process was to raise dissolved oxygen levels in the saline bottom waters. The oxygenation barge was most successful at doing this near Guildford Road, where a plume of water with elevated dissolved oxygen concentrations up to 50 m downstream and 15 m either side of the barge was measured.

During the year 2001 a more detailed sampling program will be in place to properly evaluate the impact of the barge.

Acknowledgments

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For more information

More information on the Swan barge Project and the Swan-Canning Cleanup Program is available from the Swan River Trust.

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