PROPOSED SOUTHERN SEAWATER DESALINATION PLANT

SEDIMENT OXYGEN DEMAND

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by

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Aims:

1. To determine the existing and potential Sediment Oxygen Demand (SOD) of the coastal sediments off Binningup, at KBR sites BY-500N, BY-0 and BY-500S;

2. To determine the Chemical Oxygen Demand (COD) of the surface waters off Binningup, at KBR sites BY-500N, BY-0 and BY-500S

Methods:

Retrieval of Cores
Three sites, BY-500N, BY-0 and BY-500S were sampled on December 3rd 2007.

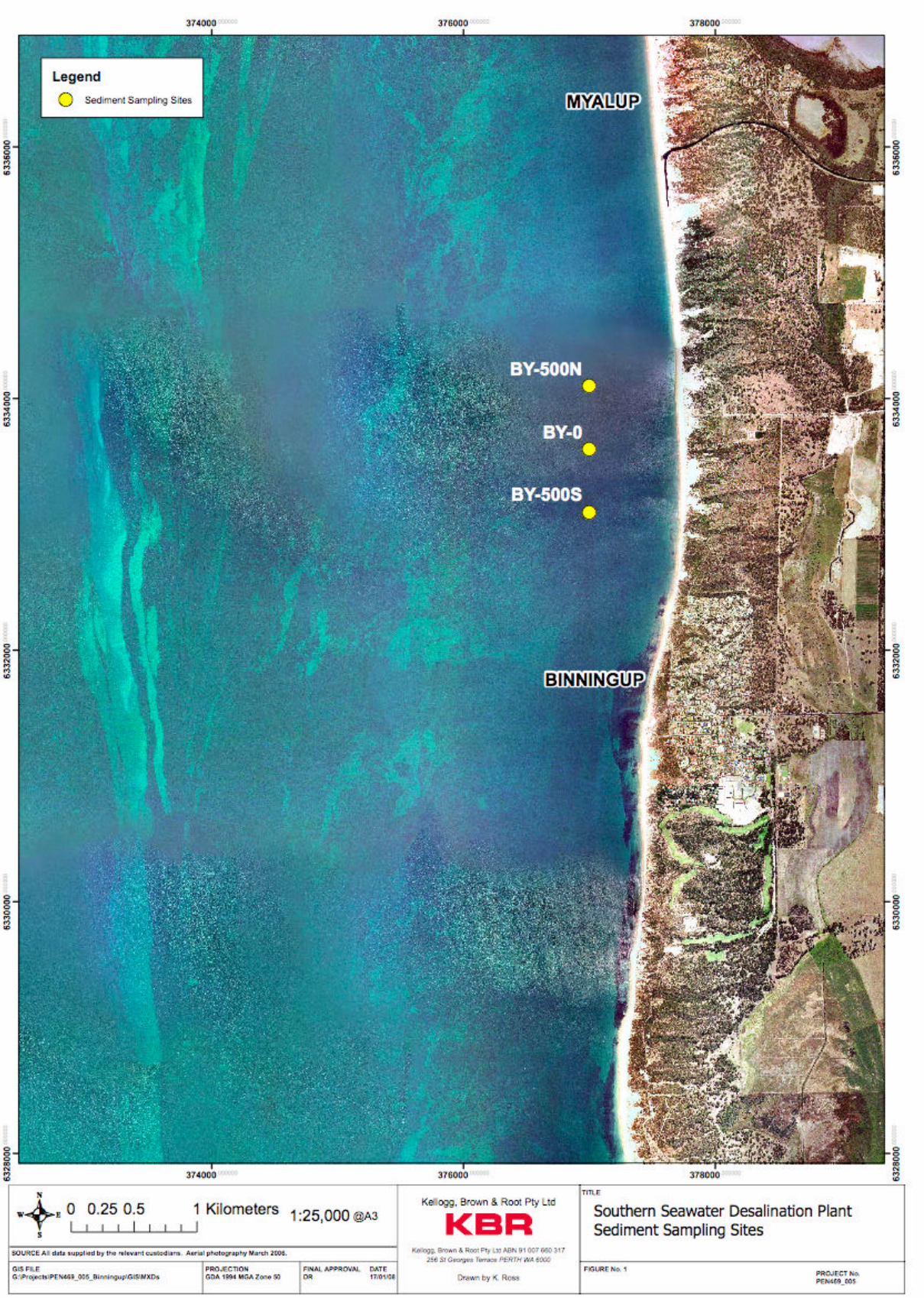
Sediment samples from each site were collected using small push corers; the sediment in these corers were used in the *batch experiments.* Small samples of these sediments were sent for XRD and XRF analysis.

In addition, 6 intact sediment plus overlying water cores were collected from each site; these intact corers were used for the *column experiments.* The corers were made from polycarbonate tubing (ID 95mm and OD 100mm, height approx. 0.5 m). All corers were acid washed and rinsed with DI water prior to sampling. The corers were sealed with rubber bungs, which had been pre-soaked in marine salinity water for 3 days prior to use, rinsing every day.

GPS coordinates were taken at each site and are given in Table 1 with the location of the sites shown on the map below.

Table 1 Coordinates of the three sample sites

Site	Latitude	Longitude	Easting	Northing	Water Depth (m)
BY-500N	-33° 07’ 29.42”	115° 40’ 53.90”	376,998.03	6,334,102.70	12
BY-0	-33° 07’ 45.65”	115° 40’ 53.14”	376,994.73	6,333,599.94	12
BY-500S	-33° 08’ 01.61”	115° 40’ 53.11”	376,991.42	6,333,107.11	12


374000
376000
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Legend
Sediment Sampling Sites
MYALUP
BY-500N
BY-0
BY-500S
BINNINGUP
0 0.25 0.5 1 Kilometers
1:25,000 @A3
SOURCE All data supplied by the relevant custodians. Aerial photography March 2006.
GIS FILE G:\Projects\PEN469_005_Binningup\GIS\MXDs
PROJECTION GDA 1994 MGA Zone 50
FINAL APPROVAL DR
DATE 17/01/08
Kellogg, Brown & Root Pty Ltd
KBR
Kellogg, Brown & Root Pty Ltd ABN 91 007 660 317
256 St Georges Terrace PERTH WA 6000
Drawn by K. Ross
TITLE
Southern Seawater Desalination Plant
Sediment Sampling Sites
FIGURE No. 1
PROJECT No. PEN469_005

Each core was pushed approximately halfway into the sediment and the bottom was sealed using a rubber plug. The top of the core was then sealed using a second rubber plug. Cores were transported to the surface and stored vertically in the dark, on ice for the journey back to the lab. A 50 L water sample was also collected at mid water depth at each site. This water will be referred to as site water.

Incubation

On arrival at the lab the rubber plug sealing the top of the cores was loosened and cores were stored overnight in a constant temperature (19°C) room to allow them to equilibrate with their surroundings. The site water was also stored at 19°C. The cores and water was stored throughout the experiments in the dark. While the light climate around Binningup may allow some photosynthesis at depth, such activity would only increase production of oxygen. A precautionary principle was therefore adopted, where we assumed that under dark conditions any measured changes in oxygen were due to respiration only and would therefore provide a maximum rate of sediment oxygen demand.

On December 4th initial water samples (130 ml, for nutrient and metal analysis) were taken from each of the site water containers. The water in the cores was aerated for 5 minutes using a small air pump (Hailipai) to saturate the water column with oxygen and therefore ensure that all sediment cores started from as close as possible to the same dissolved oxygen concentrations. Initial water column DO measurements were then completed in each core. Aeration was **not** performed at any other time during the experiment and every effort was made to minimize future exposure to air. For all DO measurements a TPS^{TM} Aqua-D DO meter with a TPS^{TM} ED1 sensor was used.

Water column DO was measured and water samples collected in all columns, according to the schedule shown in Table 2. Water removed during sample collection was replaced with the appropriate site water to ensure minimal air space above the water in the columns. DO concentrations were monitored before and after sampling to quantify any introduction of DO that occurred during the replenishment of the water.

The experiment continued for 32 days and was completed on January 3rd 2008.

Results:

A. Chemical Oxygen Demand (mg /L /day) was calculated from the batch experiment data as:

$$COD = \frac{dO}{dt} = \frac{O_2 - O_1}{t_2 - t_1}$$

The batch experiments indicated that the water alone, consumed negligible dissolved oxygen (0.1 mg/L/day, Figure 1). When a small mass of sediment was added, there was a significant increase in consumption of dissolved oxygen, though the scatter was significant across sites and replicates. When sediment and DOC were added to the water, again, there was a significant increase in the consumption of dissolved oxygen, though again the scatter across sites and replicated was large.

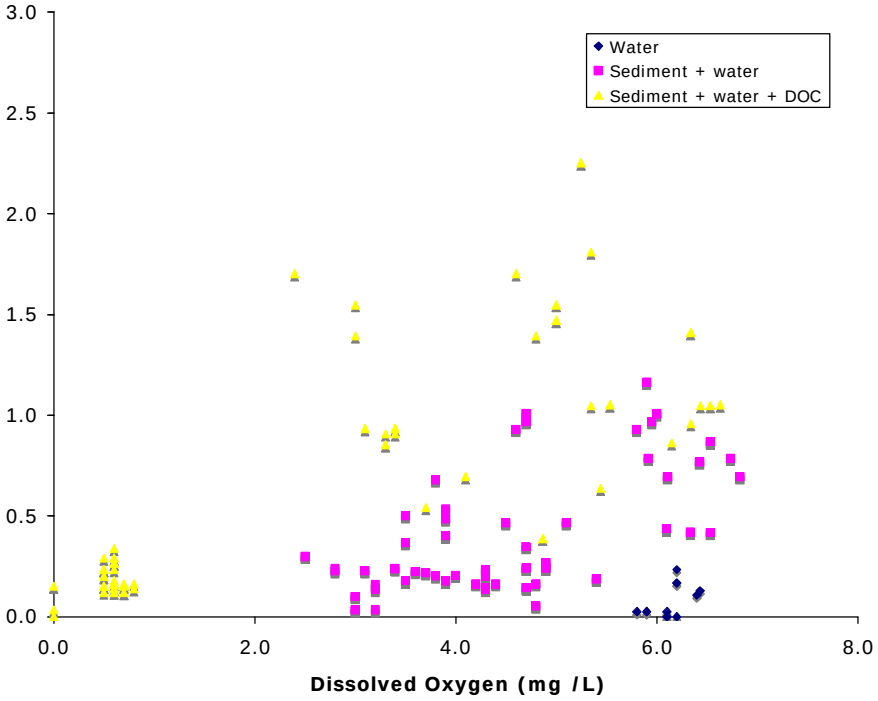

Figure 1: Batch experimental data showing increasing water column oxygen demand, or chemical oxygen demand, with the addition of sediment (yellow symbols) and sediment plus DOC (pink symbols). Note that the relationship between DO and COD was not significant ($r^2 < 0.3$)

B. Sediment Incubations

By about day 10 the dissolved oxygen concentrations in the water overlying the intact sediments decreased to below 2 mg /L in all cores and at all sites (Fig 1, 2 and 3). Once dissolved oxygen concentrations decrease below this level, negative ecologically impacts should be expected.

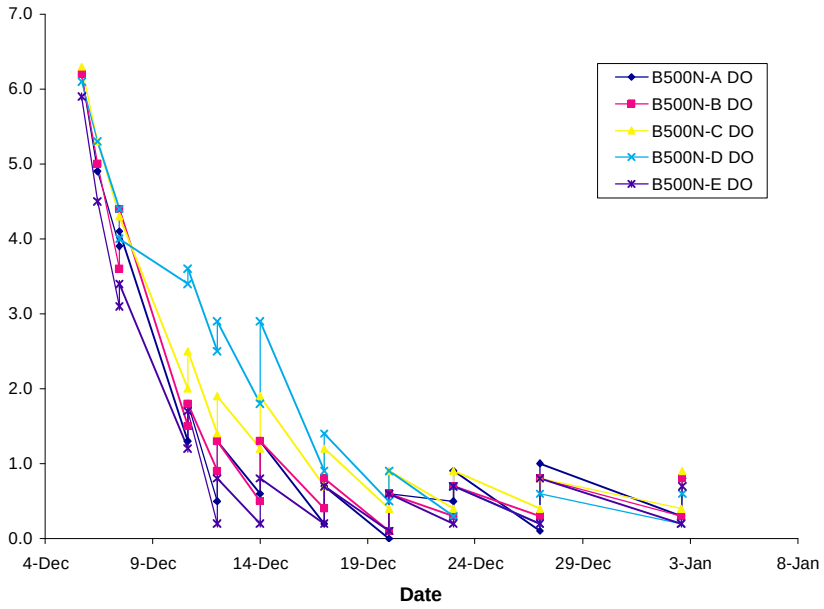

Figure 2: Decreasing dissolved oxygen concentrations in the overlying water, with time. Sediment was collected from Site B500N.

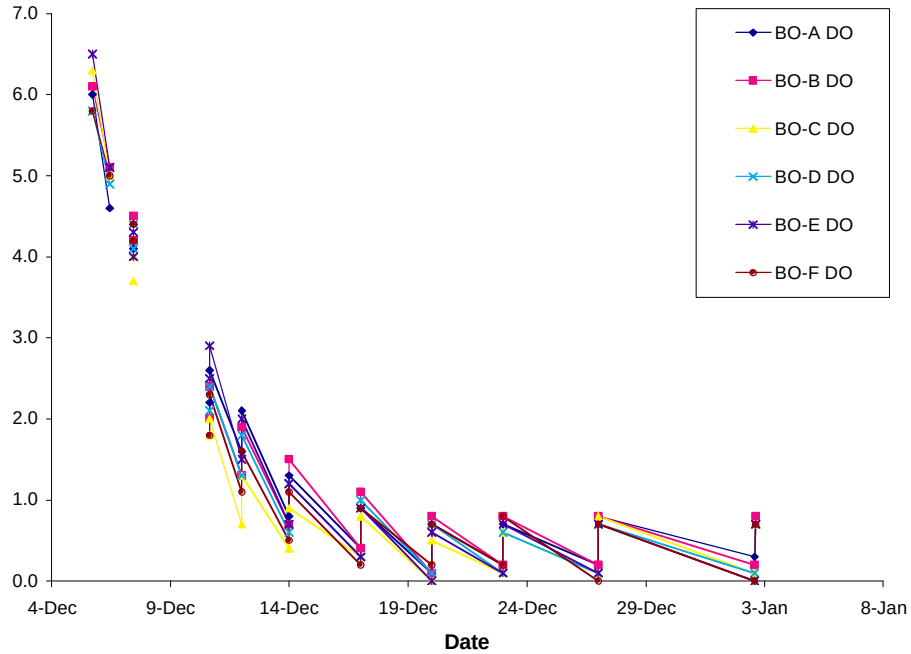

Figure 3: Decreasing dissolved oxygen concentrations in the overlying water, with time. Sediment was collected from Site B0.

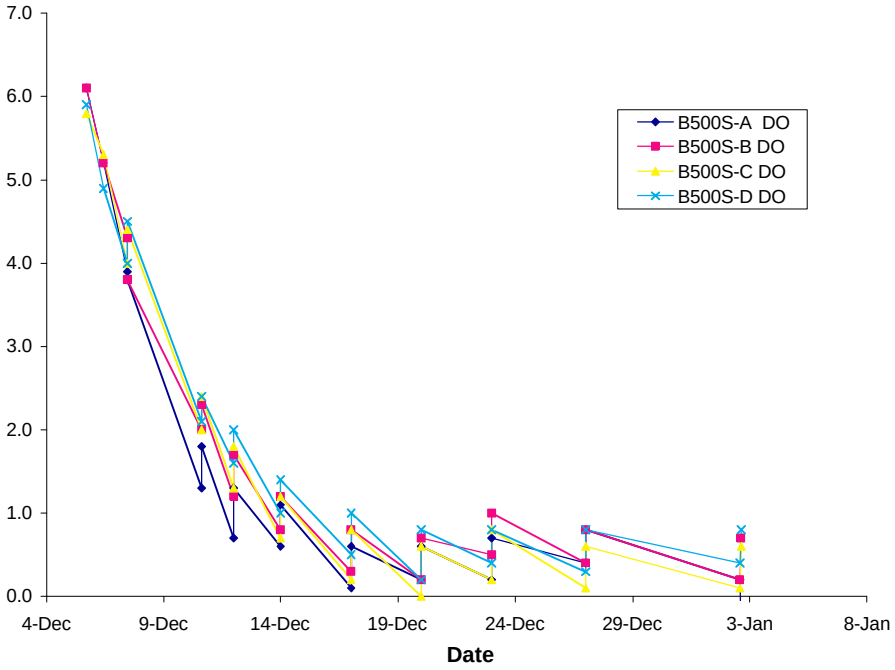

Figure 4: Decreasing dissolved oxygen concentrations in the overlying water, with time. Sediment was collected from Site B500S.

Sediment Oxygen Demand (g /m2 /day) was calculated from the incubated sediment experiment data as:

$$SOD = \frac{dO}{dt} \times H = \frac{O_2 - O_1}{t_2 - t_1} \times \frac{V}{A}$$

where H was the measured height of water above the sediments, V was the volume of overlying sediments and A was the cross-sectional area of sediment (approximated as the cross-sectional area of the tubes).

All sediment cores showed strong correlations between dissolved oxygen concentration and sediment oxygen demand (Figs 5 and 6). While there was significant variation between replicates, there was little variation between the three sites.

The relationship between dissolved oxygen concentration and SOD could be parameterized as:

$SOD = 0.0578 \times [DO]$ ($R^2 = 0.91$).

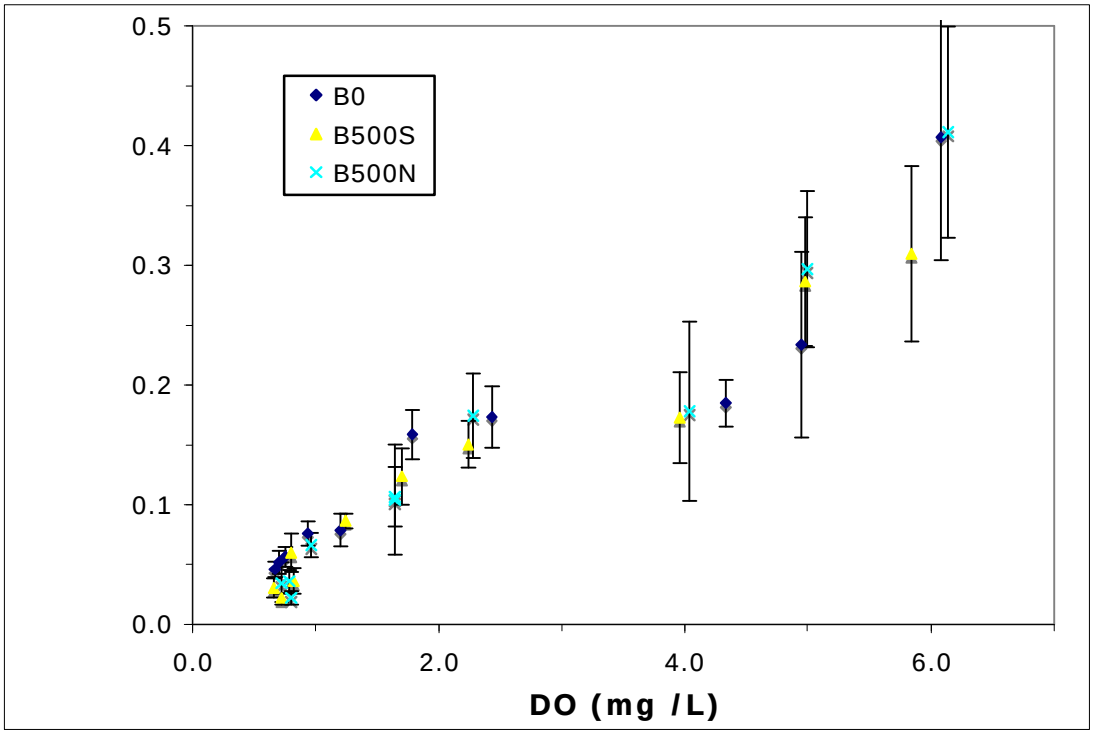

Figure 5: Sediment oxygen demand correlated strongly with dissolved oxygen concentrations. While there was some scatter between replicates, there was little significant difference between sites.

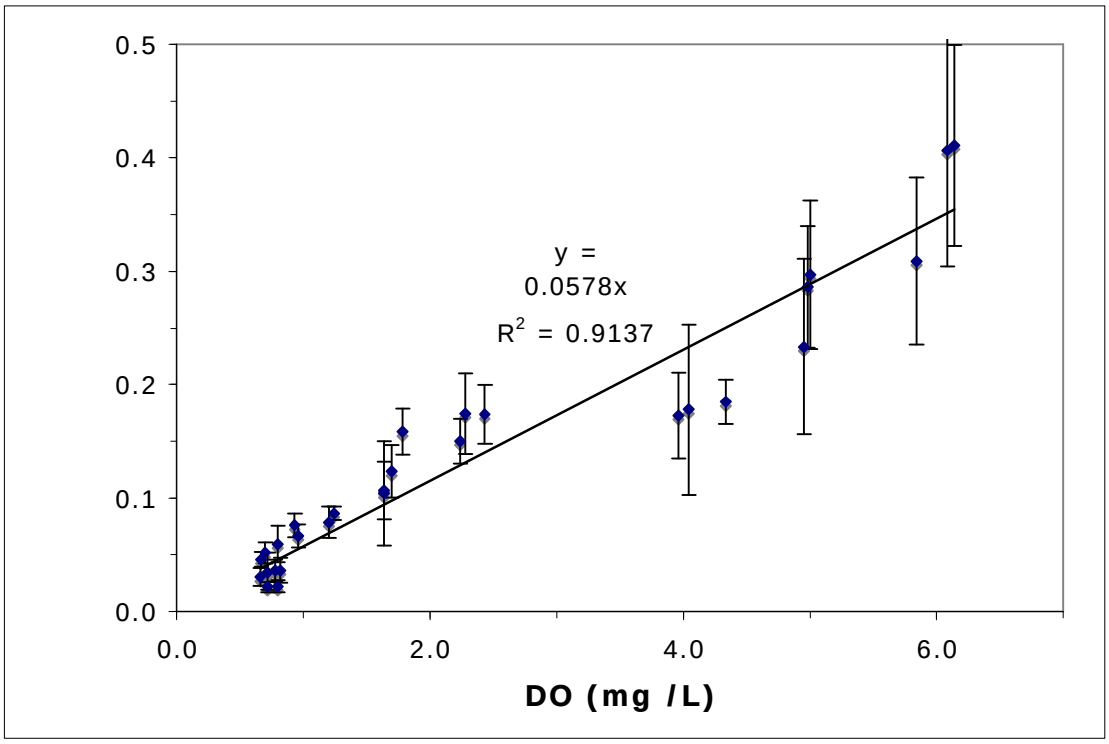

Figure 6: Using all data across all three sites, we could parameterise SOD as a function of DO.

Discussion:

Interestingly, at the equivalent dissolved concentration, the SOD measured from sediment collected at the Binningup sites was approximately two to three times the SOD measured from sediment collected from Cockburn Sound.

For example, at a DO concentration of 6 mg/L, at Binningup an SOD was measured of approximately 0.35 g /m2 /day (Figure 6) whereas in Cockburn Sound a SOD of approximately 0.1 g /m2 /day was measured (Figure 7).

This suggests a larger source of labile POC/DOC was contained in Binningup sediments. Close inspection of the cores at the end of the experiments showed evidence of distinct layers (2 – 5 cm thick) what at this stage we propose are seagrass root fibres. The presence of this source of POC/DOC in Binningup sediments would accelerate consumption of oxygen from the overlying water column, if a density stratification was established for a reasonable period of time. A comparison of stratification timescales and timescales of oxygen depletion is essential.

Numerical modeling is required of density stratification set up and breakdown, coupled to sediment oxygen demand (which must be a function of the actual dissolved oxygen concentration) to establish whether the organic carbon consumes oxygen at a rate that would be ecologically significant.

If so, it would be important to determine whether the sediment around Binningup is loaded with organic carbon at all times of the year, or only at times after e.g. seagrass wrack deposition

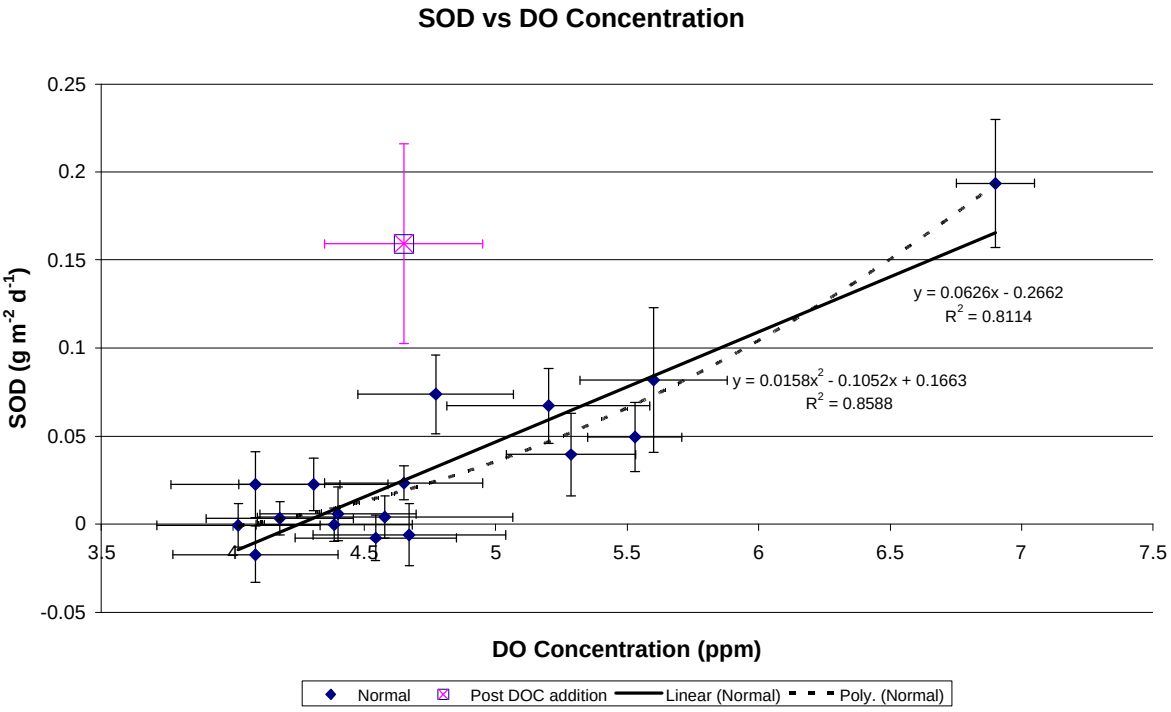

Figure 7: The measured relationship between SOD and dissolved oxygen concentrations in Cockburn Sound (taken from Read and Oldham, Report to Water Corporation 2006).