Wilson Inlet 9

Report to the Community

MAY 2007

Department of Water
Government of Western Australia

Water Quality in Wilson Inlet from 2002 to 2006

Photo: Wilson Inlet bar opening October 2006 (H. van Wees & J. King)

CONTENTS

Introduction

This newsletter is the ninth in the series of community reports on Wilson Inlet, and the first produced under the umbrella of the Department of Water (previous publications in the series were produced by the Water and Rivers Commission). It summarises the results between January 2002 and April 2006 of the estuarine monitoring program carried out by the Department of Water. The water quality parameters measured and reported on here include salinity, temperature, dissolved oxygen, pH, nutrients (phosphorus and nitrogen) and phytoplankton (chlorophyll *a*, abundance and composition).

Water quality monitoring in Wilson Inlet started in the early 1990s and was undertaken in an effort to understand its estuarine processes. Sampling has been undertaken on monthly and fortnightly intervals depending on the year, season and whether the bar has been open or closed to the ocean. The first of this information was reported in the second Wilson Inlet Report to the community which described the data collected between 1995 and 1998 ('*Wilson Inlet Report to the Community No 2 – Summary of the Estuarine Monitoring Programme Conducted in Wilson Inlet 1995 to 1998*'). In 2002 another report was published which along with data collected between 1995 and 2002 also contributed some important fundamentals that aid the understanding of water quality data, as well as a historical account of events in the Inlet ('*Wilson Inlet Report to the Community No 5 – Water Quality in Wilson Inlet 1995 to 2002*').

These reports show that for most of the year water quality in the Inlet is good, and that it follows a relatively predictable sequence of events that reflect the annual cycles of rainfall and river flow, ocean water levels and wave conditions, wind, temperature and pressure. The main cause for concern over the years has been the occurrence of algal blooms. Major algal blooms to date have all been linked to events initiated by bar opening which corresponds to salinity stratification, deoxygenation and increases in sediment nutrient recycling. The health of the Inlet was shown to be in a fine balance between managing the nutrient losses from the catchment which

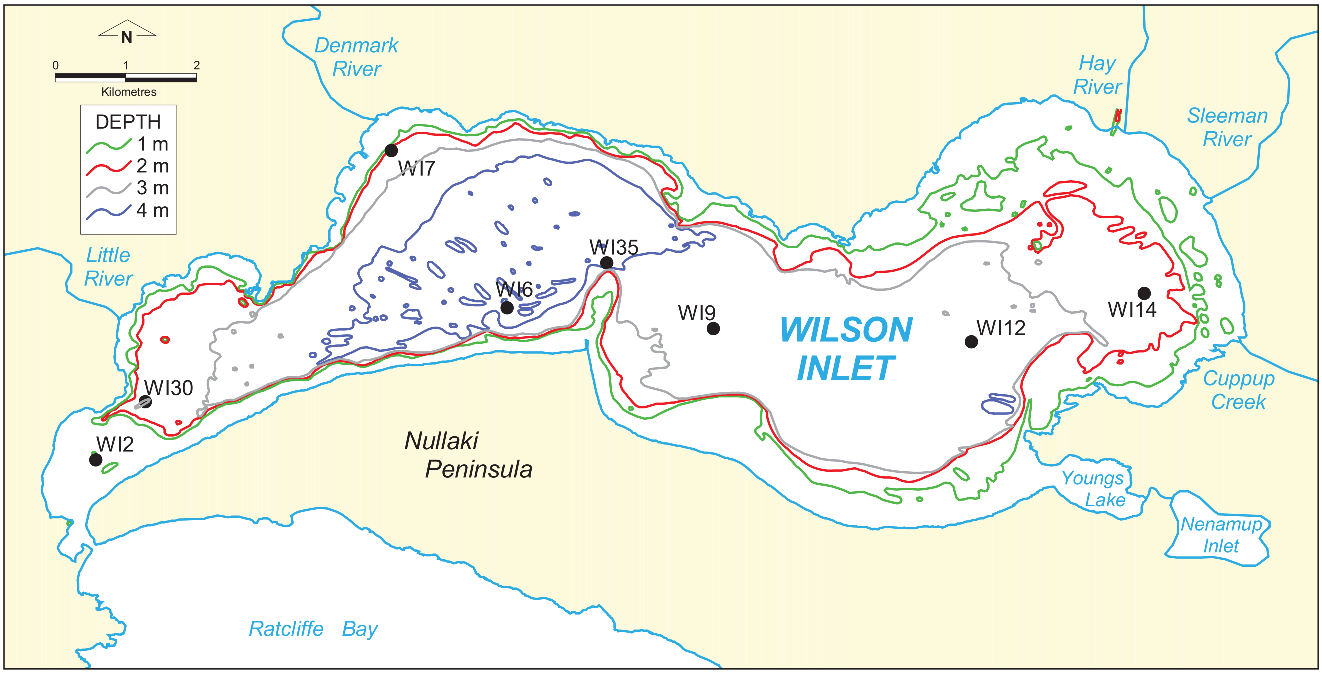

Figure 1: Map of Wilson Inlet in Western Australia showing water depths below mean sea level and the location of the 8 commonly used water quality monitoring sites: WI2, WI30, WI6, WI7, WI9, WI35, WI12, WI14.

support algal growth, and maintaining adequate oxygen concentrations in bottom waters to prevent sediment nutrient recycling.

This newsletter follows on from these initial water quality reports by the Water and Rivers Commission updating the information to include the water quality data gathered between 2002 and 2006. Overall recent data suggests that there has been little change in the sequence of events that occur within the Inlet compared to previous years. The most significant event during this period was the persistence of the harmful algal species *Dinophysis acuminata* which prompted health warnings against the consumption of shellfish from the Inlet for a period in 2005.

'Wilson Inlet Report to the Community No 5 – Water Quality in Wilson Inlet 1995 to 2002' is a useful reference when considering the data in this report.

Data in this report was collected from 8 water quality monitoring sites in Wilson Inlet (Figure 1).

Bar opening

Wilson Inlet is a periodically open estuary, meaning that the entrance channel of the estuary is typically open only for short periods in the year before sand deposition cuts it off from tidal exchange with the ocean. Current practise is to open the bar every year. This is primarily carried out to prevent flooding in the low lying areas around the Inlet and to improve drainage from the farmlands on the eastern shore, but also allows for exchange between Inlet and ocean waters.

Inlet water levels combined with rainfall and river flow conditions influence the duration that the bar remains open. High rainfall and flow help to maintain the entrance channel (2003 and 2005 openings), with the bar closing more quickly under low flow conditions (2001 and 2002 openings) (Table 1). Higher water levels in the Inlet at the time of bar breaching have over the years also resulted in longer openings. Openings that have occurred when water levels are low (below 1.01 Australian Height Datum or AHD), and in particular openings that occur late in the year, have been shorter.

Rainfall and runoff

The south coast experiences a Mediterranean climate characterised by high winter rainfall and dry hot summers. Highest rainfall generally occur in June and the lowest rainfall in January. Rainfall isohyets representing average annual rainfall range from 1200 in the west to 600 mm in the east.

Year	Opened	Closed	Duration open (days)	Rainfall (mm)	River flow (GL)
2001–02	03 October 01	15 February 02	135	930	-
2002–03	06 September 02	07 January 03	120	650	143
2003–04	20 August 03	02 April 04	227	1689	854
2004–05	11 August 04	no record	-	-	-
2005–06	03 June 05	28 February 06	271	1082 (up to 16 Oct 05)	504 (up to 16 Oct 05)

Table 1: Dates of bar opening and closing; duration of opening (days); the rainfall for the Denmark catchment (mm); and the gauged flows from the catchment (GL) to the Inlet when the bar was open.

The Denmark catchment recorded an average monthly rainfall of 237 mm between 2002 and 2005 (Figure 2 & Figure 3). The highest rainfall years in that period were 2003 which recorded a monthly average of 269 mm and 2005 on average 369 mm per month. The highest rainfall month over the four year period was April 2005 which experienced a total of 966 mm, and the lowest in January 2002 which received only 15 mm for that month. Both 2003 and 2005 experienced an early start to the rainfall season with high falls in February and March which then continued right through to September. This was in contrast to 2002 and 2004 which only experienced similar rainfalls in April and May which also continued into September.

Inflow volume to the Inlet reflects the seasonality of the rainfall to the Denmark catchments. Peak flow occurs in the months of August to October, winter and spring, the highest rainfall period. As with rainfall the highest flows occurring during 2003 (14 GL/month) and 2005 (19 GL/month) (Figure 3). Average flow into Wilson Inlet from the catchment is 10 GL/month (10 × 10^6 m^3/month). The highest total daily discharge measured between January 2002 and present, of over 17.4 GL (17.4 × 10^6 m^3), was measured 3 April 2005. On average the Hay River accounts for 43% of the Wilson Inlet inflow volume, the Denmark River 33 % and the Sleeman River 11%. The remaining 13% of discharge to the Inlet arrives from Cuppup Creek and Little River (Figure 3).

Relative to previous wet seasons measured during this period, the freshwater flows recorded in 2003 were high and late, while those in 2005 were early with an extended opening time for the Inlet.

Water colour and clarity

Gilvin is a measure of the yellow-brown colour of the water that comes from catchment derived tannins and humic compounds. The most striking feature is that gilvin concentrations increase with river flow (Figure 4). For 2003 this was in the high rainfall and flow period that occurred in September and for 2005 in the early rainfall and flow period that occurred from April to June. An increase in Gilvin is also evident in the winter/spring of 2004. During exceptionally high flow Gilvin concentrations were two-fold the 'normal' flow years.

Salinity and oxygen

Salinities in Wilson Inlet range between 4 ppt and 35 ppt (Figure 5). The Inlet is periodically disconnected from tidal exchange so its salinities are coupled to freshwater flows from the catchment and the closing of the bar which allows seawater in. These two processes often coincide as high flow into the Inlet prompts the opening of the bar to avoid

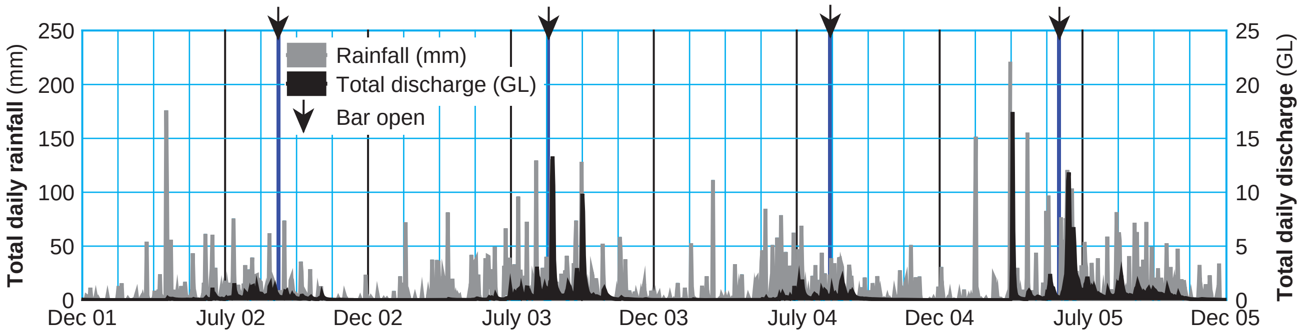

Figure 2: Total daily rainfall (mm) in the Denmark catchment and total daily river flow (GL) from the catchment into Wilson Inlet measured between January 2002 and December 2005.

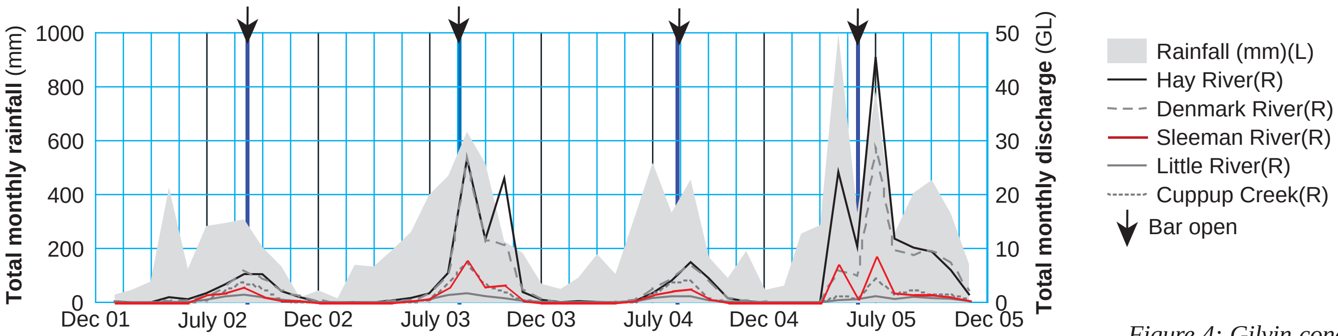

Figure 3: Total monthly rainfall (mm) in the Denmark catchment and monthly river flows (GL) from the catchment into Wilson Inlet measured between January 2002 and December 2005.

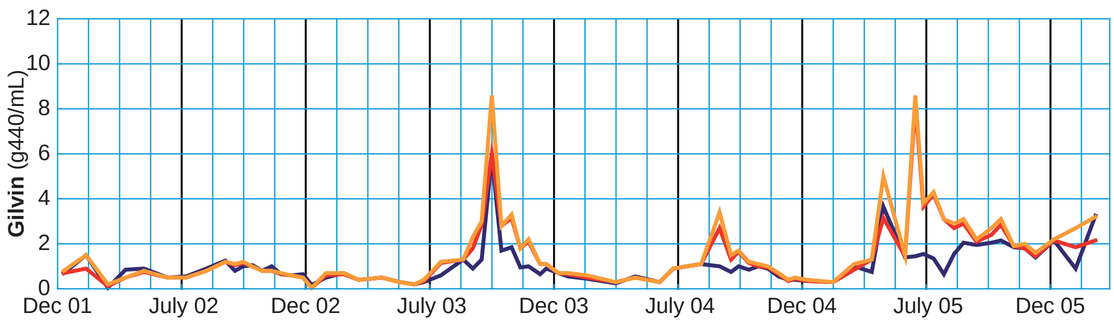

Figure 4: Gilvin concentration (as absorbance at 440 nm) measured in Wilson Inlet between January 2002 and April 2006. The red line is the median surface water gilvin concentration, the blue line is the bottom water and the orange line is the maximum surface water gilvin concentration for sites WI6, WI12, WI35, WI14 and WI9.

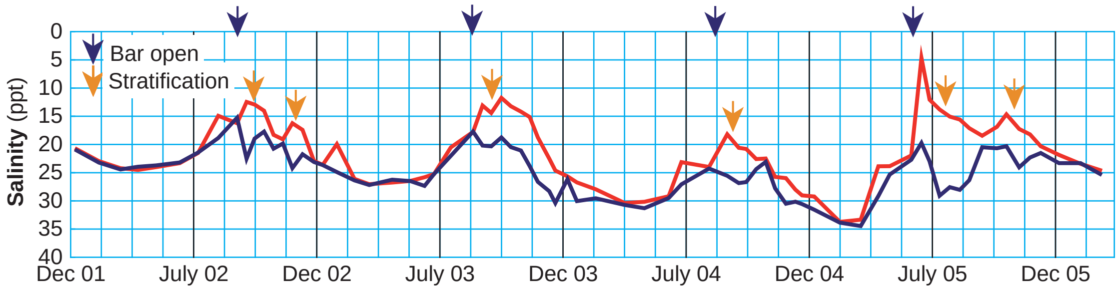

Figure 5: Time-series plots of salinity (in ppt) in Wilson Inlet between January 2002 and April 2006. The red line is the average surface and the blue line the average bottom salinity for sites WI6, WI12, WI35, WI14 and WI9. Salinities of freshwater (0 ppt) and seawater (35 ppt) are shown by the aquamarine gridlines.

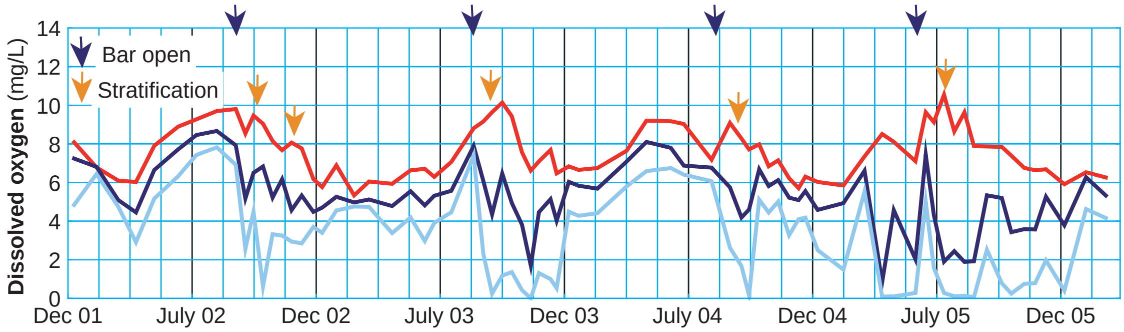

Figure 6: Time series plots of dissolved oxygen concentrations (mg/L) in Wilson Inlet between January 2002 and April 2006. The red line is the average surface, the dark blue line the average bottom and the light blue line the minimum bottom water dissolved oxygen concentration for sites WI6, WI12, WI35, WI14 and WI9.

flooding. It is during these times that bottom and surface water salinities diverge and the water stratifies. Generally, this occurs between the end of winter and the beginning of summer.

Surface waters were well oxygenated throughout the Inlet (Figure 6). Periods of deoxygenation are coupled to salinity stratification when exchange between the two layers is restricted by the strong differences in salinity. These can be seen where lines indicating bottom and surface water dissolved oxygen concentrations diverge (Figure 6). It is clear from this plot that to date the longer 2003 and 2005 bar openings (Table 1) have resulted in greater deoxygenation than in previous years: most likely the result of persistent stratification from high river flows and prolonged oceanic exchange.

Nutrients

Ammonium concentrations peak in 2003 and 2005 in response to the occurrence of stratification and deoxygenation (Figure 7). In the absence of oxygen, denitrification is reduced promoting the release of ammonium from the sediments. As with previous years (refer to Wilson Inlet Report to the Community No. 5), ammonium levels became elevated as oxygen concentrations dropped below 4 mg/L, but this was not the case before December 2002 or after December 2003. Wind mixing of the surface waters is likely to have contributed to the increase in surface water ammonium concentrations in May and June of 2005.

Nitrate/nitrite (NOx) concentrations generally reflected the patterns of rainfall and river flow with elevated levels during the wetter months of June, July and August (Figure 8, note scale). A dramatic increase in NOx concentrations was recorded in 2005. Rainfall in 2005 was high and early in the year (April). Given the temporal nature of NOx concentrations, it is likely the bulk of nitrate is provided to the Inlet via river inflow. Median concentrations of NOx are generally within the limits of the ANZECC guidelines for estuarine waters (0.045 mg/L) for approximately 70% of all samples.

Total nitrogen (TN) includes dissolved organic nitrogen (DON, e.g. urea), particulate organic nitrogen (PON, e.g. phytoplankton), NOx and ammonium. There are large spikes in total nitrogen in 2003 and 2005. In 2003 these peaks in nitrogen correspond to ammonium concentrations and phytoplankton densities (PON). In 2005 it was likely that the largest contribution consisted of dissolved organic nitrogen derived from the catchment, NOx and ammonium contributed little to the TN recorded in that period (Figure 9, note scale).

Filterable reactive phosphorus concentrations (FRP, also referred to as Soluble Reactive Phosphorus and Orthophosphate) measured in the Inlet have remained reasonably consistent and low over the monitoring period, with little evidence of strong seasonality in measured concentrations (Figure 10). In June 2005 high FRP concentrations in the surface waters correspond to a heavy river flow period (Figure 2, Figure 3 & Figure 10). In contrast October/November 2005 concentrations in the bottom waters reflect sediment nutrient cycling as a result of deoxygenation. FRP concentrations in response to deoxygenation appear to be haphazard. There was no significant release of FRP in 2003 as was the case with ammonium when oxygen levels decreased. This may reflect differences in the form of organic matter stored in the sediments and being recycled. FRP constitutes only a small fraction of the total phosphorus in the system (Figure 11), but it is soluble and bioavailable and readily used by primary producers such as the seagrass *Ruppia*, algal

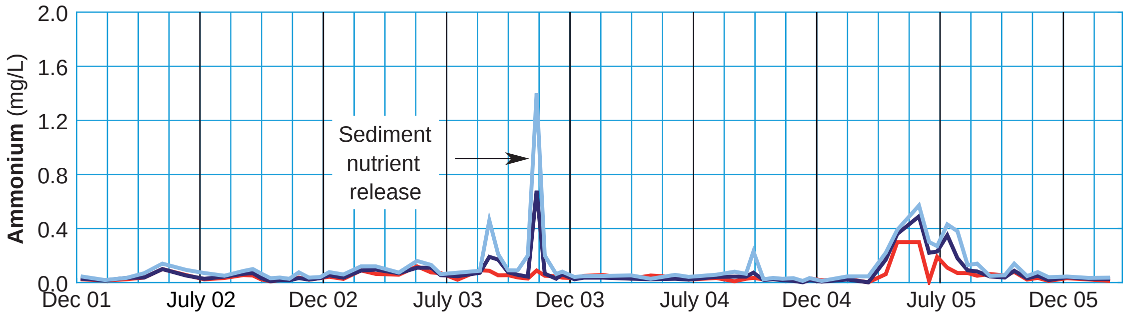

Figure 7: Ammonium concentrations (in mg/L) measured in surface and bottom waters of Wilson Inlet between January 2002 and April 2006. The red line is the surface water, the dark blue line the bottom water and the light blue line the maximum bottom water ammonia concentration for sites WI6, WI12, WI35, WI14 and WI9.

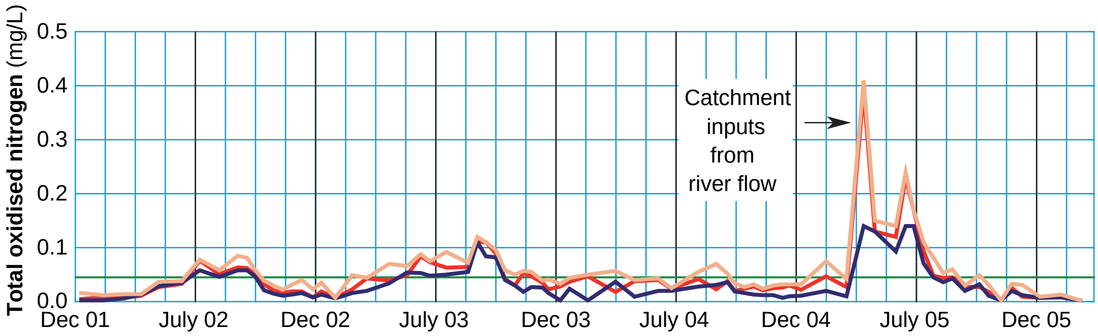

Figure 8: Total oxidised nitrogen (NOx) concentrations (in mg/L) measured in surface and bottom waters of Wilson Inlet between January 2002 and April 2006. The red line is the median surface water, the blue line is the bottom water and the orange line is the maximum surface water NOx concentrations for sites WI6, WI12, WI35, WI14 and WI9. The green line represents the ANZECC guideline for nitrate concentrations in estuarine waters.

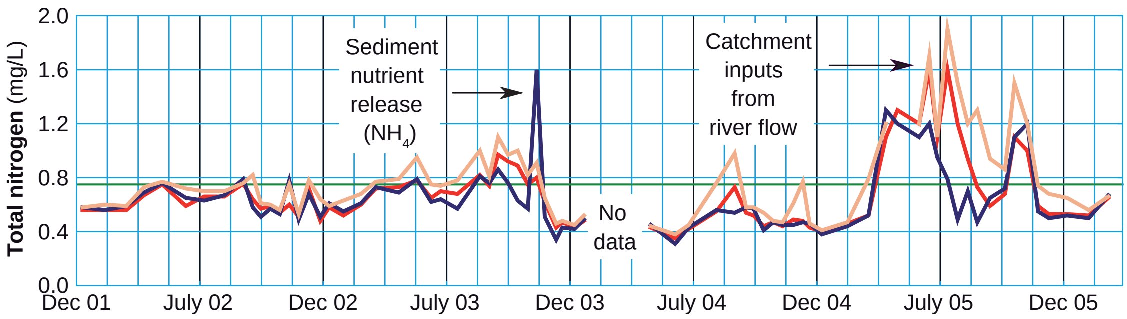

Figure 9: Total nitrogen (TN) concentrations (in mg/L) measured in Wilson Inlet between January 2002 and April 2006. The red line is the median surface water, the blue line is the bottom water and the orange line is the maximum surface water TN concentrations for sites WI6, WI12, WI35, WI14 and WI9. The green line represents the ANZECC guideline for TN concentrations in estuarine waters.

epiphytes and phytoplankton for growth. This may reflect differences in the type of organic matter stored in the sediments and being recycled.

As with the nitrate and ammonium contribution to total nitrogen, the dissolved inorganic phosphorus concentrations contribute little to total phosphorus concentrations (Figure 10, Figure 11). This is likely to be the result of high particulate, or dissolved organic phosphorus loading to the Inlet from the catchment or resuspended from the sediments. Forms of particulate organic phosphorus would include macrophytes, algae and phytoplankton and in various stages of growth and senescence, and their accompanying detritus.

Phytoplankton (microalgae)

Assessments of phytoplankton communities include biomass (measured as total chlorophyll *a*), density (cells/mL) and community composition (cell counts of phytoplankton groups).

Chlorophyll *a* concentrations in Wilson Inlet have generally been low (less than 0.004 $mg.L^{-1}$, Figure 12), with occasional peaks, and some seasonal variation. Chlorophyll *a* concentrations tend to be higher in winter to early spring. This corresponds to the high phytoplankton cell counts in Figure 13, but also to strong flow events which transport plant materials (containing chlorophyll) into the Inlet. Flow related increases in Chlorophyll *a* are particularly obvious between May and September in 2005: Chlorophyll *a* concentrations are high but cell densities are low.

Cell densities also track closely to nutrient availability. In particular the availability of oxidised nitrogen from surface run-off, and ammonium and soluble phosphorus which are released from the sediments during periods of deoxygenation. These are the most bioavailable (easily used) nutrients to primary producers.

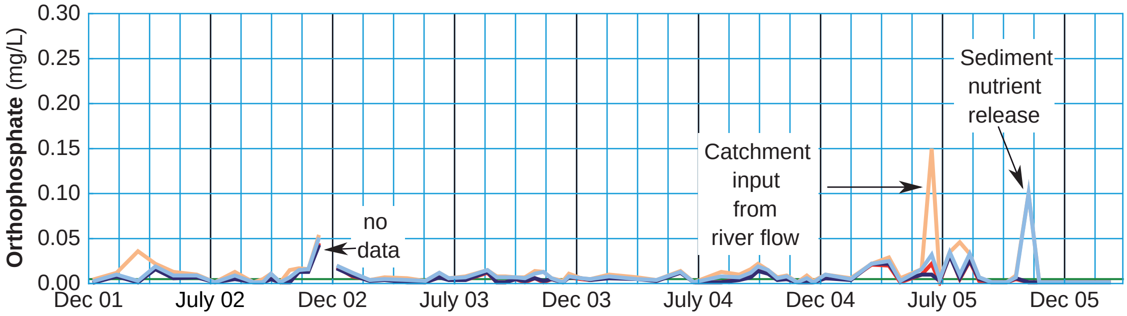

Figure 10: Soluble phosphorus (FRP/Orthophosphate) concentrations (in mg/L) measured in Wilson Inlet between January 2002 and April 2006. The red line is the median surface, the dark blue line the bottom water, the light blue line the maximum bottom water, and the light orange line is the maximum surface water FRP concentration for sites WI6, WI12, WI35, WI14 and WI9.

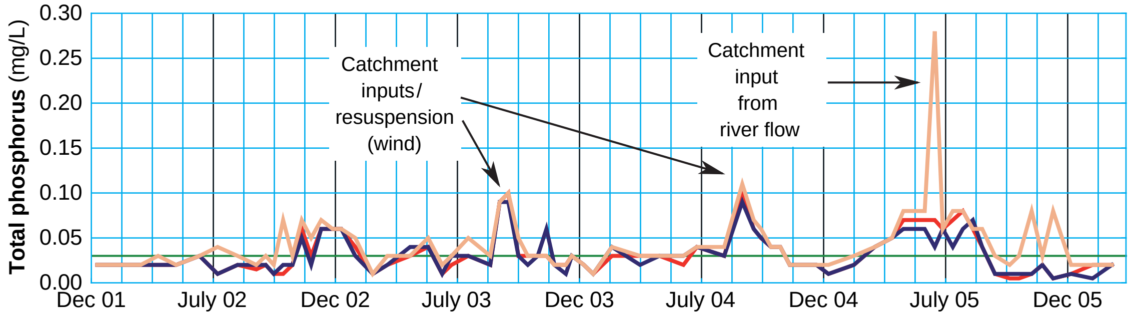

Figure 11: Total phosphorus (TP) concentrations (in mg/L) measured in Wilson Inlet between January 2002 and April 2006. The red line is the median surface water, the blue line is the bottom water and the orange line is the maximum surface water TP concentrations for sites WI6, WI12, WI35, WI14 and WI9. The green line represents the ANZECC guideline for TP concentrations in estuarine waters.

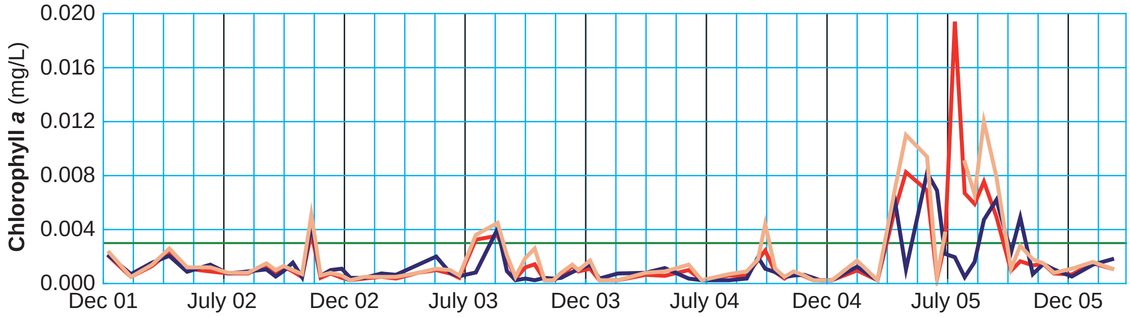

Figure 12: Chlorophyll a *concentrations (in mg/L) measured in Wilson Inlet between January 2002 and April 2006. The red line is the median surface water, the blue line bottom water and the orange line is the maximum surface water Chl* a *concentrations for sites WI6, WI12, WI35, WI14 and WI9. The green line represents the ANZECC guideline for Chl a concentrations in estuarine waters.*

Phytoplankton assemblages in Wilson Inlet mainly consist of diatoms (orange), cryptophytes (blue) and dinoflagellates (light green) (Figure 14). Except for August and September 2003, Chlorophytes (dark green) make up a small proportion of the phytoplankton assemblage. Chrysophytes (red) occur less frequently.

Spring blooms (sharp increases in cell densities) are evident in all four years (Figure 13). These were particularly intense in 2003 and 2004 dominated by small diatoms *Chaetoceros minimus* (2003–04) and *Cyclotella* (2003), and the dinoflagellate *Prorocentrum cordatum* (2003). Spring diatom blooms are common and are usually a result of silica and nutrient input. Dinoflagellate blooms seem to have appeared after the bar opening, when stratification, deoxygenation and release of bioavailable nutrients from the sediments occurs. Bioavailable inorganic fractions of nitrogen and phosphorus were low at this time suggesting that, in this case cell numbers were supported by the availability of organic nitrogen and phosphorus. A cryptophyte bloom followed some heavy April rainfall in 2003 when nitrogen and phosphorus levels were slightly elevated.

Two exceedences of potentially harmful algal species were recorded in the Inlet in 2005 prompting a health warning prohibiting the collection and consumption of shellfish from the Inlet. In early April, significant rainfall lead to large river flows into Wilson Inlet. These freshwater flows carried sediment and associated nutrients from the catchment and stirred up sediments in the Inlet, creating ideal conditions for algal growth. *Dinophysis acuminata* was recorded in the lower inlet between April and August 2005. *Dinophysis acuminata*, while predominantly a marine species, thrived in the sheltered, stratified and nutrient rich conditions present at the time. *Karenia*/*Karlodinium*/*Gymnodinium* Group dinoflagellates were recorded in the inlet from July 2005 into the warmer months.

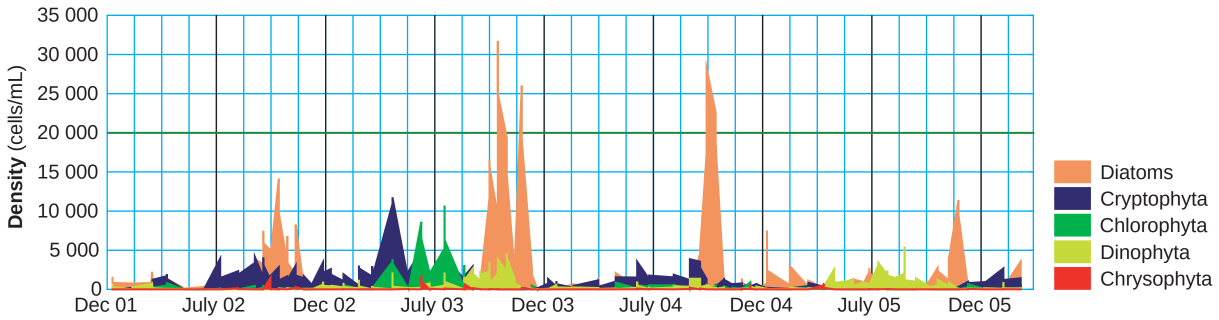

Figure 13: Phytoplankton density (cells/mL) measured in Wilson Inlet between January 2002 and April 2006.

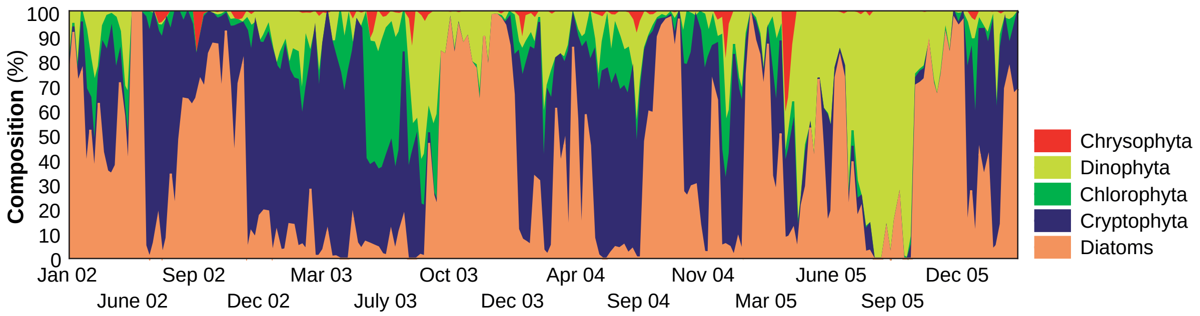

Figure 14: Phytoplankton composition (as % abundance) measured in the lower reaches of Wilson Inlet between January 2002 and April 2006.

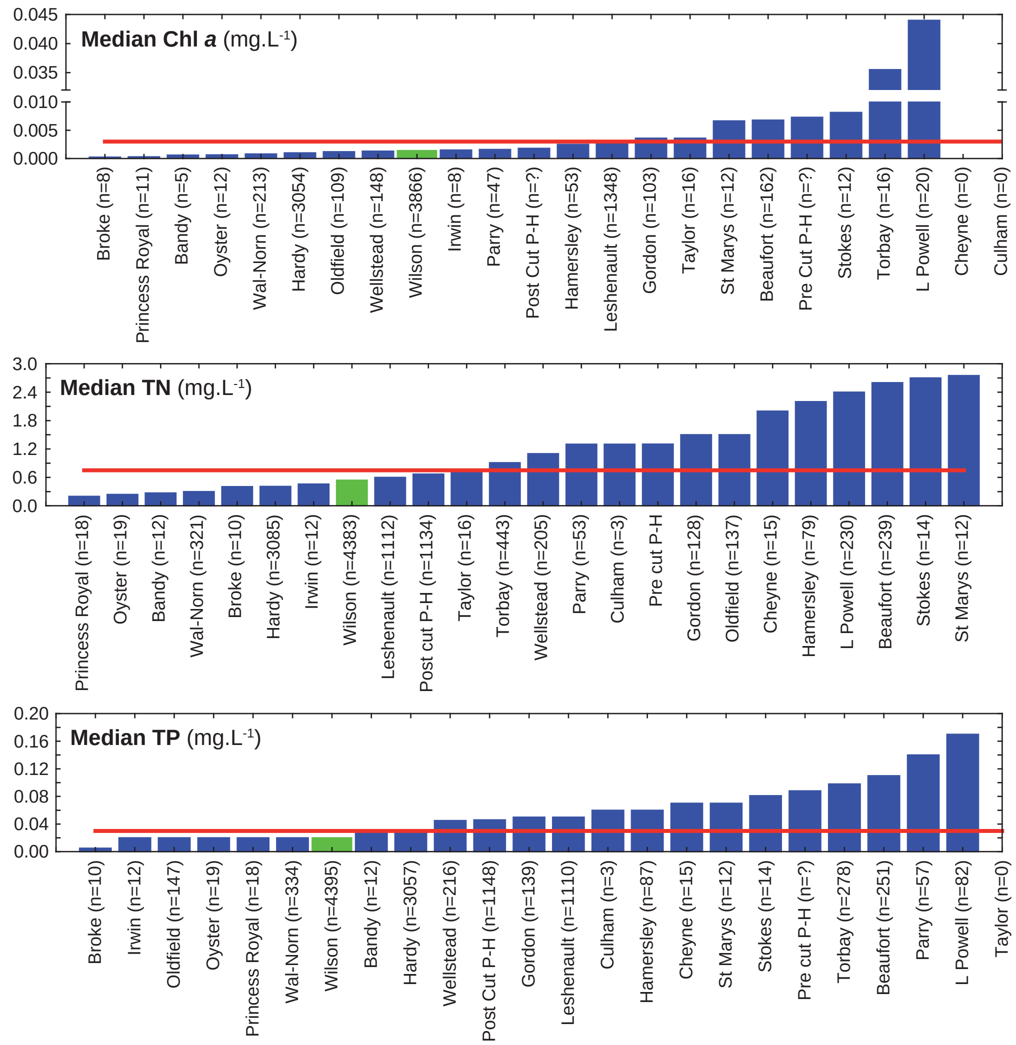

Figure 15: Comparison of Wilson Inlet chlorophyll a (Chl a), total nitrogen (TN) and total phosphorus (TP) data to other Inlets in the south west of Western Australia. This data represents the median value of all data points for all Inlets between 1997 and 2006, except for the 'Pre-cut P-H' which represents the data for Peel-Harvey between 1980 and 1993 prior to the Dawesville Cut. The red line represents the ANZECC guideline (ANZECC 2000).

Comparison to other Inlets

The median values for Chlorophyll *a*, TN and TP of Wilson Inlet compares quite well to other south-western Australian estuaries (Figure 15).

Water quality in Wilson Inlet is generally better than the water quality of Inlets to the East, namely Torbay Taylor, Cheyne, Beaufort, Wellstead, Gordon, Hamersley, Culham and Stokes Inlets. Wilson Inlet's water quality was comparable to the Hardy Inlet and Walpole-Nornalup Inlets

(Wal-Norn). These estuaries are typically open to ocean exchange for longer periods of time to estuaries in the East. Though water quality parameters in Wilson Inlet are within the recommended ANZECC guidelines for estuaries on the southwest coast, management of the Inlet should work towards minimizing the seasonal input of nutrients from the surrounding catchment.

Summary of findings

- Water quality is responding to the same influences as previously identified, namely river flow, bar opening, stratification and nutrient availability.
- There has been no significant improvement or deterioration in the condition of the water quality of Wilson Inlet between 2002 and 2006 compared to the years between 1995 and 2002.
- The highest river flows were recorded in 2003 and 2005 corresponding to similar high rainfalls in those years. Timing of the flows appear to be more variable, occurring relatively late in 2003 (September/October) and early in 2005 (April). Flow was previously greatest in July/August.
- Following the high and persistent river flows in 2003 and 2005, the bar remained open for longer periods.
- Salinity and oxygen stratification following heavy river flow in 2003 and 2005 were widespread and persistent. Once river flows abated, stratification gradually broke down through factors including winds and tidal mixing.
- Bioavailable nutrients were released from the sediments during these periods of stratification. Under the right conditions (e.g. optimal light and temperature) these nutrients can support primary producers such as phytoplankton, algae and macrophytes. For example, in 2003 high numbers of diatoms corresponded to a benthic (sediment) flux in ammonium brought about by deoxygenation. In contrast, high levels of nutrients in 2005 did not correspond to an increase in cell densities.
- The contribution of nutrients from the catchment are highlighted by the high total phosphorus, total nitrogen and gilvin concentrations measured in 2003 and 2005 which correspond to high river flow at those times.
- Except for two exceedences of potentially harmful algal species the main phytoplankton community consists of harmless diatoms. The harmful algal species (*Dinophysis acuminata* and the *Karenia*/*Karlodinium*/*Gymnodinium* Group dinoflagellates) were recorded in the Inlet in 2005. These are known to cause diarrhetic shellfish poisoning (DSP) and potential neurotoxic shellfish poisoning (NSP) in humans. Warnings about the collection and consumption of shellfish were put in place around the Inlet at that time. Though the presence of toxin producing algae in Wilson Inlet is of concern, it is likely these species flourished following significant rainfall and were a direct result of the *in situ* conditions present at the time. It is not uncommon for these species to disappear as quickly as they appear, particularly after rainfall or a change in weather conditions.
- In conclusion, resources should remain focused on the successful implementation of the Nutrient Reduction Action Plan to lower inputs to the Inlet from the catchment. This, in addition to minimizing the periods of stratification and deoxygenation, is essential to managing the ecology of the Inlet.

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Acknowledgements

We would like to thank Malcolm Robb, Petra Ringeltaube, Alana Kidd, Kieryn Kilminster, Steve May, Andrew Maughan and Chris Gunby for their editorial comments. We would also like to acknowledge the efforts of Geoff Bastyan for undertaking the field sampling.

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ISSN 1444-6200