Analysis of Long-Term Summer Water Quality Data

Background

Thirteen years of continuous summer water quality monitoring in the vicinity of Perth's three metropolitan ocean outlets have produced a valuable long-term data set. These data are, to the author's knowledge, the most extensive continuous water quality data set for Perth's coastal waters. The data, encompassing measures of chlorophyll *a*, total nitrogen, ammonia (NH_3), nitrate & nitrite (NO_X), dissolved inorganic nitrogen (DIN) and filterable reactive phosphorus (FRP), were collected over a number of spatial scales including:

- Appropriate reference locations (beyond the influence of the plume);
- Directly above the ocean outlets (direct influence of the plume); and
- At a number of fixed locations north of outlets (graded influence of the plume).

This level of spatial and temporal differentiation has enabled scientists to make statistical comparisons of water quality characteristics between potentially-impacted and non-impacted regions of Perth's costal waters. Also of interest to water quality scientists was the effect of major wastewater treatment plant (WWTP) upgrades conducted in the early to mid 2000's. Technological upgrades to the WWTPs have had the effect of significantly reducing the concentrations (and loads) of nitrogen discharged to the Ocean. Managing the load of nitrogen reaching the ocean is desirable from an environmental management perspective, as excess nitrogen may lead to the interruption and degradation of marine trophic processes.

An analysis of the long term summer data set, incorporating over 1,860 individual water quality measures, was recently conducted to examine:

- The effect of wastewater treatment plant upgrades on ocean water quality;
- The extent of nutrient dilution downstream of the outlets; and
- The distance downstream of the outlets at which nutrient concentrations reach background levels

The preliminary results of this analysis were presented to the joint Australian Marine Science Association and the New Zealand Marine Science Society Conference, Christchurch in July 2008, and to the Western Australian Marine Parks and Reserves Authority in May 2008.

Preliminary Results

Preliminary results based on a graphical representation of average (±SE) ammonia, FRP, NO_X and DIN concentrations are presented in Figure 1. Note, that for the purposes of this summary, data have been pooled by year. Although helping to highlight the 'before v after' trends, this style of presentation acts to mask the degree of inter-annual variability - which was considerable for most analytes. Further analysis using permutational analysis of variance (PERMANOVA) is presently incomplete. These analyses are expected to reveal the extent of spatial and temporal change in more detail, including the effect of changing nitrogen concentrations on concentrations of chlorophyll *a*.

Results of the analysis have yielded striking results with respect to (a) the level of dilution achieved (downstream of the outlets) and (b) the effect of WWTP upgrades on ocean water quality. Clear dilution gradients for all nitrogen and phosphorus based compounds were apparent between the outlet (0 km) and distances north of the outlets; the steepest gradients were detected between the outlet and the 0.97-1 km mark, with distances further north (3.8/4.9 km & 7.8/13.8 km) yielding concentrations closer to background (but note the possible exception at Sepia Depression).

Two notable results were revealed with regard to the effect of WWTP upgrades. Preliminary analysis has indicated that prior to the WWTP upgrades at Ocean Reef and Swanbourne, nitrogen based compounds DIN and NO_X reach background concentrations at the 3.8 km mark, but post upgrade, this distances reduces to 1 km. These results are indicative of the

effect of the technological upgrades at each of these WWTP, both of which upgraded to advanced nitrogen removal technologies.

The effect of the upgrade at Sepia depression is less distinct from those at Swanbourne and Ocean Reef, but nevertheless marked. In January 2002, the Woodman Point WWTP was upgraded from primary to secondary treatment status. This is manifested in the results as a switch in the dominant type of nitrogen detected in the ocean, from ammonia to nitrite and nitrate (measured here as NO_X). The switch from ammonia to NO_X as the dominant type of nitrogen detected in the ocean at Sepia Depression is clearly visible in Figure 1.

Further analysis to determine patterns of chlorophyll *a* in relation to changing nutrient concentrations are presently underway. These data together with the results described above are presently the focus of a manuscript. It is envisaged that these data, along with a full justification of the methods and experimental design, will be submitted for publication sometime in 2010.

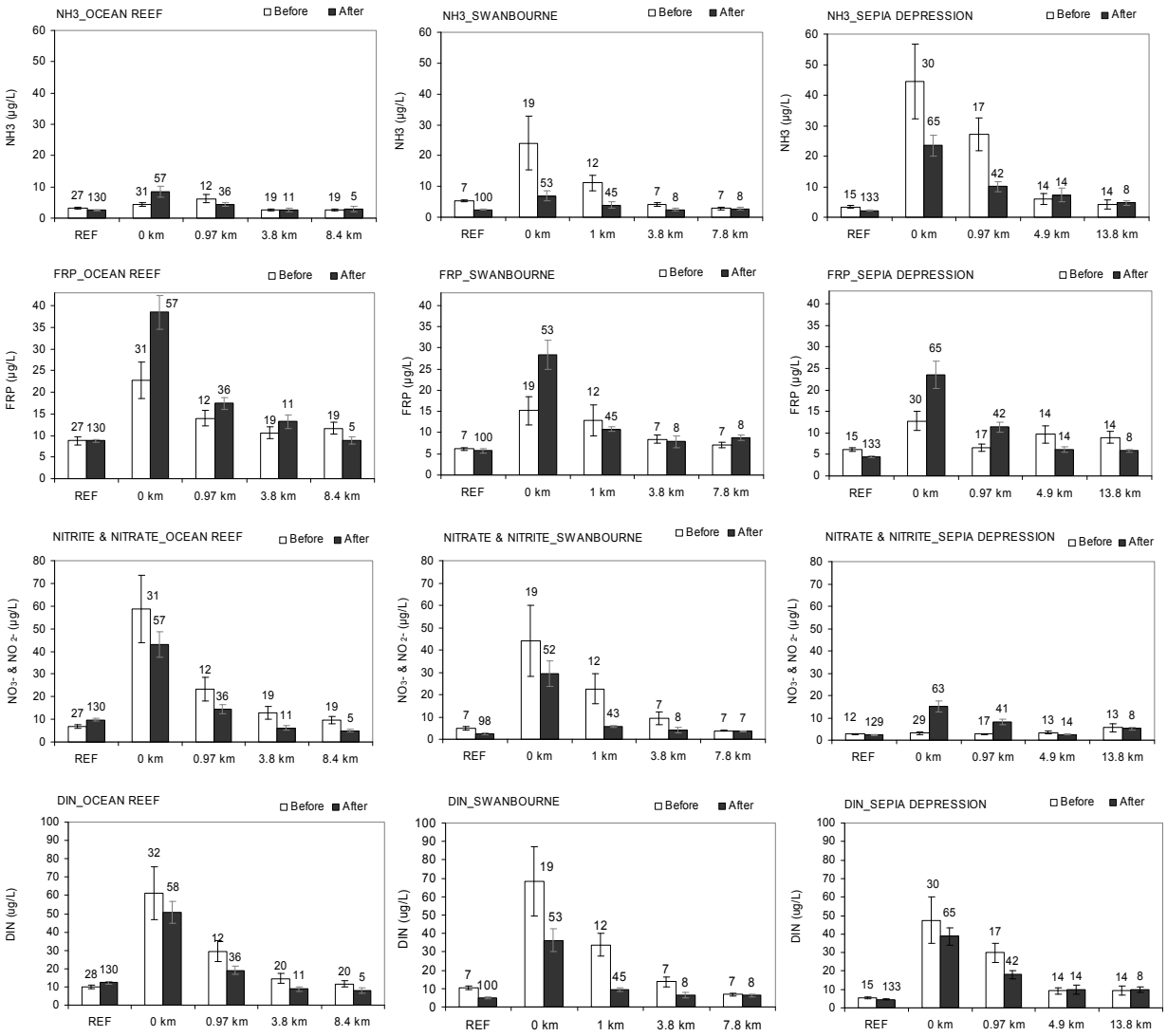

Figure 1 Mean nutrient concentrations (± SE) before and after major WWTP upgrades based on data collected between 1996 and 2009. Numbers above histograms are the number of data points used to calculate means.