Table 5 – Limits for Microbiological Parameters in Bathing Water Directive and Regulations.

Parameters	Irish Standard	EEC 'G'	EEC 'I'
Total Coliforms cfu/100ml	≤5,000[1]	500[1]	10,000[2]
Faecal Coliforms cfu/100ml	≤1,000[1]	100[1]	2,000[2]
Faecal Streptococci /100ml	≤300[2]	100[3]	----
Salmonella /1 litre	0[2]	----	0[2]
Entero viruses PFU/10 litres	0[2]	----	0[2]
Dissolved Oxygen % Saturation	70 - 120[2]	80 - 120	
pH	6 - 9	6 - 9	
Transparency (m)	≥ 1[2]	2[3]	1[2]

Notes: 1. to be conformed with by 80% of samples and not to be exceeded by any two consecutive samples.

2. to be conformed with by 95% of samples and not to be exceeded by any two consecutive samples.

3. to be conformed with by 90% of samples and not to be exceeded by any two consecutive samples.

4.1 Eutrophication

The OSPAR definition of eutrophication is 'the enrichment of water by nutrients causing accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned and therefore refers to the undesirable effects resulting from anthropogenic enrichment by nutrients as described in the Common Procedure.'

The EC definition of eutrophication is
'the enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus causing accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and to the quality of the water concerned'.

Eutrophication, by definition, is a biological effect, not merely increased concentrations of nutrients. Elevated concentrations of nutrients are known as hypernutrification but does not necessarily mean that an area is eutrophic.

The first effect in the eutrophication process is hypernutrification accompanied by increased duration of phytoplankton blooms. This is followed by changes in plant community structure and loss in diversity of species. The tertiary effects of eutrophication are changes in the faunal community and in extreme cases deoxygenation and mortality.

To summarise eutrophication is a natural process, but can be greatly accelerated by human activities that increase the rate at which nutrients enter the water. The growth of algae is limited by the available supply of phosphorus or nitrogen, so if excessive amounts of these nutrients are added to the water, they can promote the growth of algae in large quantities. When the algae dies, they are decomposed by bacteria, which use dissolved oxygen. Dissolved oxygen concentrations can drop too low for fish to breathe, leading to fish kills. In freshwater lakes and rivers, phosphorus is often the growth limiting nutrient, because it occurs in the least amount relative to the needs of plants. In estuaries and coastal waters, nitrogen is generally the growth limiting nutrient.

5. The Importance of Nitrogen and Dublin Bay

Eutrophication in Dublin Bay is manifested by macro-algal growths, which severely affect the amenity value of the Bay during summer time. Within the last fifteen years two major studies have been carried out on the algal problem. These were:

1. *A Study of Algal Growth and Foreshore Quality' (Jeffery et al)* which was undertaken between May 1989 and October 1990 during the preparation of the Water Quality Management Plan (WQPM) for Dublin Bay and

2. '*Particulate Nutrient Inputs and their Role in Macro-Algal Development in Dublin Bay*' (*Wilson, Jeffery, Dowley et al)* which was carried out in 1993 under the Stride Operational Programme.

The two macro-algal problems identified were:

1. the development of filamentous green macro-algal mats on the inter-tidal flats of the Bull Island lagoons and to a lesser extent in the Tolka Basin and
2. the stranding and subsequent decay of brown macro-algae mainly *Ectocarpus* on Dollymount and to a lesser extent Sandymount strands.

The following working hypothesis was suggested in the DBWQMP -Technical Report No. 7 to explain the beach fouling phenomenon in Dublin Bay:

The *Ectocarpus* is linked to the occurrence of the polychaete *Lanice conchilega* (sand mason) which is a deposit and filter feeder and is benefiting from the high organic loading to the Bay. The alga is dependent on the tubes of *Lanice* for anchorage in its early growth stages. When the *Ectocarpus* attaches itself to its host, it may avail of the nutrients mineralised by *Lanice* as well as the plentiful nutrient supply in the water column. As the ectocarpus grows it becomes detached and may be deposited on the beaches. The size of the annual crop is determined by meteorological conditions, the most favourable being high temperatures, high light intensity and low winds.

One of the main concerns of the Dublin Bay Water Quality Management Plan (DB WQMP) was to achieve a reduction in the occurrence of macro-algae - *Ectocarpus* and green algal mats. Both the DB WQMP and the Stride report (1993) indicated that this will be achieved by a reduction in the particulate nitrogen, rather than by a reduction in dissolved nutrients (ammonia, nitrate and nitrite and phosphate).

6. Survey Parameters

An emphasis has been placed on the determination of nutrients and other parameters used to detect the presence of organic biodegradable wastes in both the Liffey Estuary and the Bay. The following parameters were determined:

6.1 Ammoniacal Nitrogen

Ammoniacal nitrogen arises from the breakdown of proteinaceous and other nitrogen containing substances in waste. It is also excreted directly by animals together with urea and peptides. Raised concentrations in waters are a clear indication of the presence of sewage or similar wastes.

The Dublin Bay Water Quality Management Plan quotes standards for ammoniacal nitrogen of not more than 0.8 mg/l for the Estuary, and 0.3 mg/l for the coastal waters (both in 95% of samples). These standards were set primarily to protect migratory fish and also because ammonia in its unoxidised form is considered to be generally toxic to aquatic life when it occurs above certain levels. It should be noted that water quality surveys carried out for the Dublin Bay WQMP indicated that ammonia levels in both the Liffey Estuary and the Bay were below the standard set in the plan. However, the John B. Barry & Partners Ltd. report entitled '*Review of Effluent Quality Standards*' stated a waste water treatment plant incorporating carbonaceous secondary treatment only, would convert organic nitrogen to ammonia thereby increasing the ammonia load discharging into the Plan area. This level of treatment would not be sufficient to result in compliance with the ammonia levels which are set in the plan.

Ammonium concentrations in the sea show considerable variations and can change rapidly. The amounts rarely exceed 0.07 mgN/l in oxygenated, unpolluted waters, but in anoxic deep stagnant water such as the Black Sea, the concentration of ammonium can be as high as 1.4 mgN/l.

Ammonium is often the most abundant form of inorganic nitrogen in the surface layers after phytoplankton blooms have removed the greater part of the nitrate and phosphate. Growing microorganisms (phytoplankton, bacteria) incorporate dissolved nutrients into their biomass; this conversion from non-living to living (and from dissolved to particulate) material is called assimilation. In the assimilation processes of phytoplankton, ammonium is preferentially used for synthesising proteins. When nitrate is incorporated it must first be reduced to ammonia before it can be transferred into amino acid compounds. However, there is no indication that growth rates are particularly increased by either form.

6.2 Total Oxidised Nitrogen TON (Nitrate and Nitrite)

Nitrate is the final oxidation product of nitrogen compounds in seawater. As stated above it can be taken up by plants and therefore nitrate concentrations usually show a marked seasonal variation, being highest in late winter and early spring when plant growth is minimal and lowest in early summer after the first main growth of plants.

Nitrite occurs in seawater as an intermediate product in microbial processes of nitrate (denitrification) at low oxygen levels. In addition, nitrite may be excreted by phytoplankton.

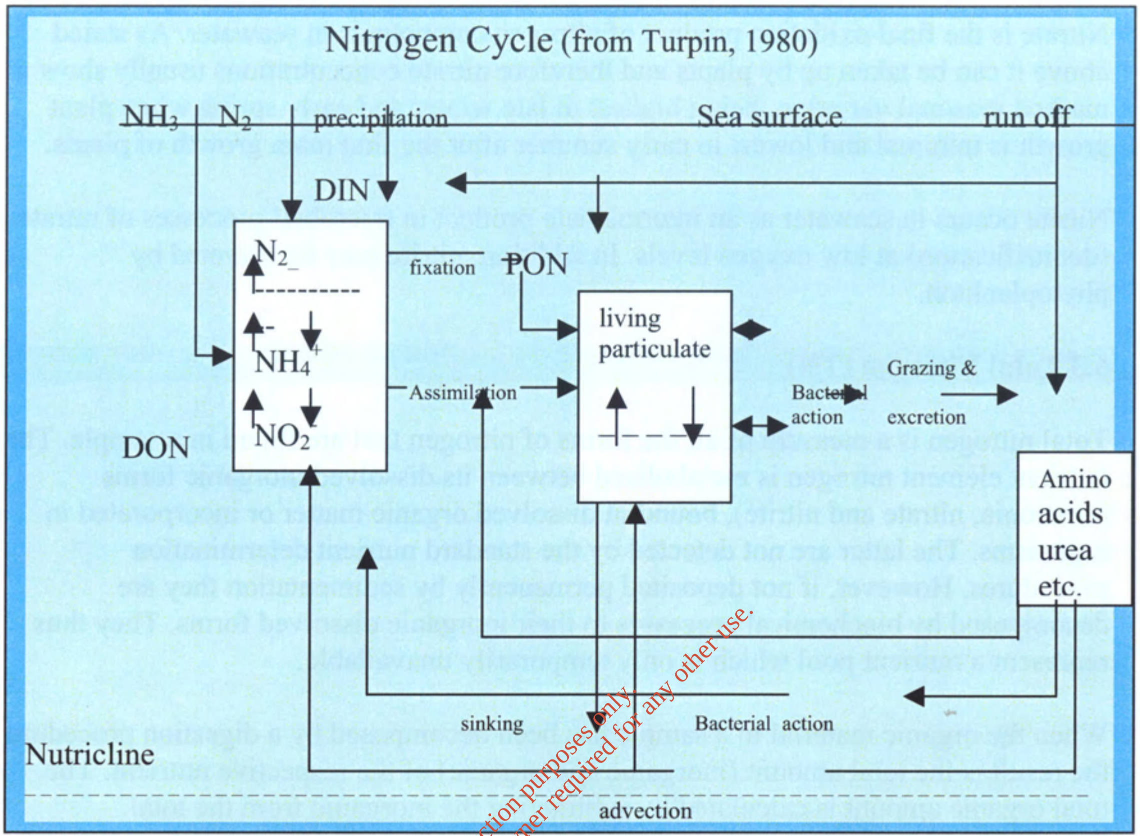
6.3 Total Nitrogen (TN)

Total nitrogen is a measure of all the forms of nitrogen that are found in a sample. The nutrient element nitrogen is metabolised between its dissolved inorganic forms (ammonia, nitrate and nitrite), bound in dissolved organic matter or incorporated in organisms. The latter are not detected by the standard nutrient determination procedures. However, if not deposited permanently by sedimentation they are decomposed by biochemical processes to their inorganic dissolved forms. They thus represent a nutrient pool which is only temporarily unavailable.

When the organic material in a sample has been decomposed by a digestion procedure the result is the total amount (inorganic and organic) of the respective nutrient. The total organic amount is calculated by subtracting the inorganic from the total. Dissolved and particulate organic forms may be discriminated by parallel analysis of filtered and unfiltered samples. It is also possible to measure the particulate nitrogen content directly by filtering a sample and determining the nitrogen concentration of the particulates retained on the filter paper.

Nitrogen in the atmosphere or in the soil can go through many complex chemical and biological changes, be combined into living and non-living material and return back to the soil or air in a continuing cycle. This is called the nitrogen cycle and is depicted in Figure 3 below.

Figure 3 - Nitrogen Cycle



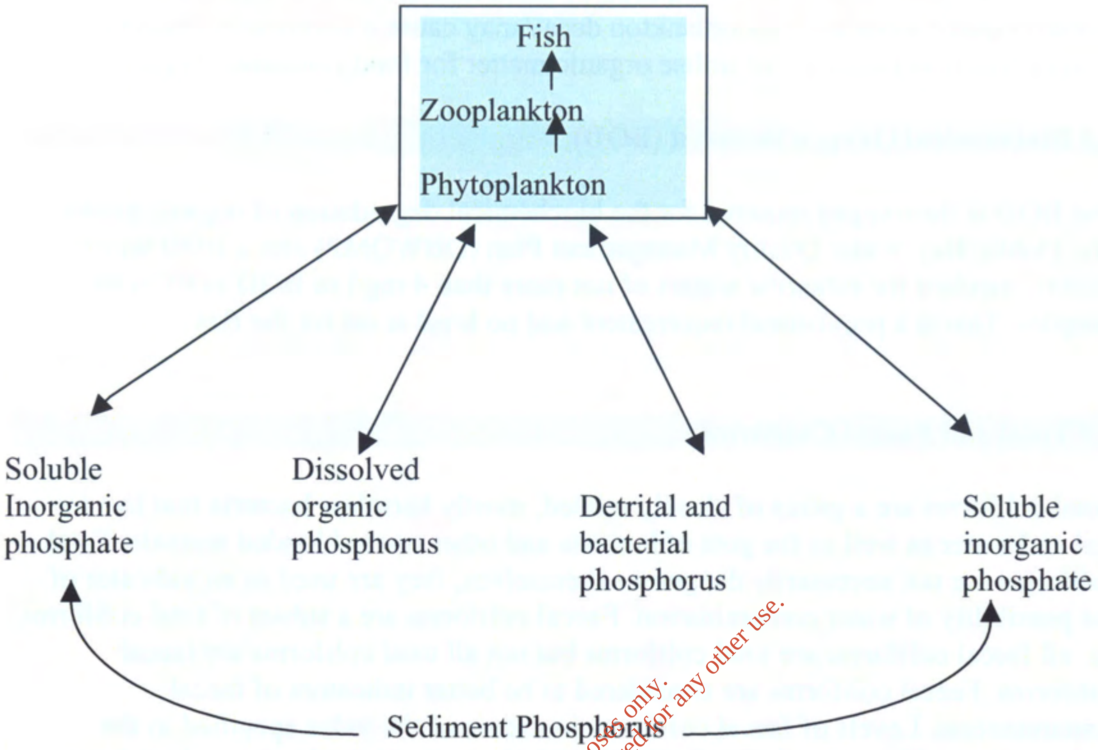
6.4 Orthophosphate (Reactive Phosphate)

Orthophosphate (often referred to as 'reactive phosphate') is the most stable form of phosphate and is the form used by plants. It is present in sewage and can also be found in detergents.

6.5 Total Phosphorus

Total phosphorus is a measure of all the forms of phosphorus that are found in a sample. Phosphorus exists in water in either a particulate phase or a dissolved phase. Particulate matter includes living and dead plankton, precipitates of phosphorus, phosphorus adsorbed to particulates and amorphous phosphorus. Figure 4 describes the major pathways for phosphorus in the sea.

Figure 4 - Major Pathways for Phosphorus in the Sea



6.6 Chlorophyll a and Phaeopigments

Chlorophyll a is the principal pigment in plants both in terrestrial and marine environments. In converting light energy to chemical energy, it allows photosynthesis, i.e. light-induced carbon fixation (primary production) to take place. The concentration of the pigment in water, therefore, is a measure of the biomass of planktonic algae present. The floating microscopic marine plant populations, known as phytoplankton (phyto = plant; planktos = wandering) contribute to over 25% of the total vegetation of the planet. Because chlorophyll's photosynthetic function makes it a unique indicator of oceanic plant biomass and productivity, it is probably the most frequently measured biochemical parameter in oceanography. Measurements of chlorophyll distribution in the oceans have revealed areas of contrasting fertility, from the oligotrophic ocean gyres with their low concentrations of chlorophyll in surface waters (<0.05 mg/m^3) to the chlorophyll-rich waters found in upwelling areas, and along continental shelf fronts and coastal seas and estuaries (chlorophyll = 1-10 mg/m^3).

Phaeopigments - chlorophyll is the primary algal pigment required for photosynthesis while phaeopigment is a chlorophyll degradation product (i.e. dead material) often found in high quantities during and after an algal bloom occurs. Phaeopigments may be an indicator of the past history of the phytoplankton population in the water column. Phaeopigments can be formed when phytoplankton cells remain in dark conditions, by bacterial action and the passage of phytoplankton cells through the gut of zooplankton organisms.

6.7 Dissolved Oxygen

Well oxygenated conditions are required by most fish and other organic organisms. Anthropogenic input and phytoplankton decay may cause a decrease in dissolved oxygen levels as bacteria that utilise organic matter for food consume oxygen.

6.8 Biochemical Oxygen Demand (BOD)

The BOD is the oxygen required for the biochemical degradation of organic matter. The Dublin Bay Water Quality Management Plan (DBWQMP) sets a BOD water quality standard for estuarine waters of not more than 4 mg/l of BOD in 95 % of samples. This is a provisional requirement and no level is set for the Bay.

6.9 Total and Faecal Coliforms

Total coliforms are a group of closely related, mostly harmless bacteria that live in soil and water as well as the guts of humans and other warm-blooded animals. Total coliforms are not necessarily dangerous themselves, they are used as an indicator of the possibility of water contamination. Faecal coliforms are a subset of total coliforms i.e. all faecal coliforms are total coliforms but not all total coliforms are faecal coliforms. Faecal coliforms are considered to be better indicators of faecal contamination. Levels of faecal coliforms in excess of the value specified in the Bathing Water Directive (2000cfu/100ml) may be indicative of waters which have received volumes of sewage which has been inadequately treated. Agricultural run-off (livestock slurries and manure) may also give rise to the presence of coliforms in bathing waters. The bacteria and viruses present in sewage and animal excreta may lead to illness as a result of ingestion or infection through wounds or cuts.

6.10 Transparency

Transparency (or water clarity) is measured to determine the depth to which enough light penetrates to support plant growth. Factors affecting transparency include the amount of suspended silt and soil particles and the amount of phytoplankton and zooplankton in the water column. Freshwater input particularly after storms and wave action also influence transparency. Low transparency over an extended period of time can degrade the health of a waterbody as the decreased amount of light penetration reduces the area for aquatic plants and primary producers to grow. In addition many marine organisms feed by filtering water and large amounts of suspended matter may foul their filter feeding systems. In offshore marine waters transparency usually exceeds 4 m and may be greater than 10 m. Nearer the shore, the water may be more turbid but the transparency is usually greater than 2 m.

7. Results and Discussion

7.1 Liffey Estuary

7.1.1 Dissolved Oxygen (DO)

As in the first three years of the monitoring programme the dissolved oxygen regimes within the estuary were generally satisfactory (70 – 120 % saturation). However, the surface sample taken from the Dodder/GCB outfall to the Liffey on 27/05/04 and a number of depth samples from the Toll Bridge, Alexandra Basin, Ocean Pier, Tanker Pier, the Old Treatment Works outfall, the New Treatment Works outfall, Half Moon Poolbeg, X15 and X16 had dissolved oxygen values slightly greater than 120%. The maximum DO value of 143% saturation was recorded off Tanker Pier on 10/12/03. None of the dissolved oxygen values measured at any location (surface or depth) were less than 70% saturation. The lowest dissolved oxygen values recorded during the third year of the monitoring programme were in depth samples taken from Butt Bridge (59 & 60% on 14/08/02 and 09/10/02 respectively) and the Custom House (60% on 09/10/02).

None of the DO values recorded during the first three years of the monitoring programme were as low those recorded from depth samples taken at the New Treatment Works and Matt Talbot Bridge (49 and 51 % saturation respectively) when sampling was carried out for the Dublin Bay WQMP June to August 1986.

7.1.2 Biochemical Oxygen Demand (BOD)

During the fourth year of the monitoring programme the median BOD values for all sampling stations (surface and depth) were less than 2 mgO_2/l. Upstream of the Ringsend Treatment Works BODs greater than 4 were recorded for samples taken from a number of sampling stations. The dates, sampling stations and BOD values are listed below:

Date	Sample Station	BOD mgO_2/l
04/09/03	Butt Bridge (S)	5
04/09/03	Butt Bridge (D)	5
04/09/03	Custom House (S)	>6
27/05/04	Dodder/GCB outfall (S)	>8
10/06/04	Cardiff Lane (D)	>7

It is not clear what caused the elevated BOD levels upstream of Ringsend. The discharges from Ringsend ceased in May 2004 and therefore they cannot be responsible for the elevated results at Cardiff Lane and the Dodder/GCB outfall. There are a number of combined sewer overflows into the river Liffey upstream of Ringsend and these require further investigation.

During the fourth year of the monitoring programme there has been a significant improvement in the BOD results for samples taken from the Liffey downstream of the Ringsend effluent. A total of 147 samples (surface and depth) were taken from ‘off the NTW O/F' down to the Poolbeg Lighthouse and only four samples (2.7%) had BOD values greater than 4 mgO_2/l. Three of these samples were taken on 18/02/04 and the third sample was taken on 11/03/04. There were discharges from Ringsend on both dates. The sampling stations with the elevated BOD values are listed below:

Date	Sample Station	BOD mgO_2/l
18/02/04	Off NTW Outfall (S)	5
18/02/04	Off Old R & P Outfall (S)	>6
18/02/04	Half Moon (S)	6
11/03/04	Off NTW Outfall (S)	6

The percentage of BOD results that exceeded 4 mgO_2/l for each of the four years of the monitoring programme are summarised in Table 6 below. The secondary treatment process commenced during the second half of 2002/3 and from April to June 2003 the BOD results for all samples taken from the New Treatment Works outfall down to the Poolbeg station were satisfactory i.e. less than or equal to 4 $mgO_2.l$.

Table 6 - Summary of BOD Results for samples taken in Vicinity of Ringsend Treatment Works 2000/1, 2001/2, 2002/3 and 2003/4

	2000/1	2001/2	2002/3	2003/4
No. of Samples	115	124	133	147
No. of BOD values >4 mgO_2/l	28	27	18	4
% BOD results exceeding 4mgO_2/l	24.3	21.8	13.5	2.7

7.1.3 Transparency/pH

All pH values were within the expected limits.

The maximum transparency during the fourth year of the monitoring programme was 3.25m and the minimum 0.25m compared with a maximum transparency of 3m and the minimum 0. 5m during the third year of the monitoring programme. The transparency of 0.25m was recorded at the NTW Outfall on 11/03/04. There was a discharge from Ringsend on this date and that probably affected the clarity of the water. In the Dublin Bay WQMP values for transparency are given for four locations during the period September 1987 to August 1988. During this period the minimum transparency was 0.8m at the site off the Ringsend Treatment works outfall. The maximum transparency was 2.7m at the site off the Old treatment Works outfall.

7.1.4 Total and Faecal Coliforms

Total and faecal coliforms determinations were carried out on the surface samples only. The range of median total and faecal coliform counts recorded in 2000/2001, 2001/2002, 2002/2003 and 2003/2004 are displayed in Table 7 below. There was a significant improvement in the bacteriological quality of the samples taken from Tanker Pier and off the Old Treatment Works during the fourth year of the monitoring programme when compared to the third years data. The highest total and faecal coliform counts at both locations were recorded on 11/03/04 (>20,000 total coliforms & 9,100 faecal coliforms per 100 mls off Old Treatment Works and 15,200 total coliforms & 6,900 faecal coliforms per 100 ml off Tanker Pier). Total and faecal coliform counts greater than 50,000 and 20,000 cfu per 100 ml respectively were recorded for five samples taken from Tanker Pier during the third year of the monitoring programme. These elevated results were associated with discharges from Ringsend.

Table 7 - Range of Median Coliform Counts for Samples Upstream of Ringsend Treatment Works

	Median Total Coliform Counts cfu/100mls			
	2000/1	2001/2	2002/3	2003/4
Upstream of Ringsend TW	3,100 – 8,000	2,950 – 12,925	3,350 – 36,475	1,400 – 8,000

	Median Faecal Coliforms Counts cfu/100mls			
	2000/1	2001/2	2002/3	2003/4
Upstream of Ringsend TW	890 – 3,400	854 – 4,900	1,182 – 12,050	310 – 2,850

During the fourth year of the programme the bacteriological quality of the surface samples taken during the bathing season months, with a few exceptions, complied with the EU mandatory limit values for total and faecal coliforms. Outside of the bathing season there were a large number of elevated bacteriological results for samples taken from 'off NTW Outfall' down to the Poolbeg lighthouse. These results were probably associated with discharges from Ringsend. It is hard to accurately assess the impact of the secondary treatment process in this region of the Liffey estuary due to the discharges from Ringsend which ceased in May 2004. It should be possible to make a more accurate assessment after the fifth year of the monitoring programme.

7.1.5 Chlorophyll a and Phaeopigments

As in the previous three years of the monitoring programme the highest values for chlorophyll a/phaeopigments were recorded for samples taken in the upper reaches of the Liffey estuary i.e. Butt Bridge to the Dodder/Grand Canal Basin sampling stations Due to tidal conditions it was only possible to sample the Butt Bridge and Custom House sampling stations on 14/09/03, 11/03/04 and 10/06/04. During the fourth year of the programme the highest value for chlorophyll a/phaeopigments of 15.1 and 99mg/m^3 was recorded for a surface sample taken from 'the Dodder/GCB outfall to the Liffey' on 27/05/04. The phytoplankton were identified as cryptomonas. To date the highest chlorophyll a value of 121.6 mg/m^3 was recorded for a sample taken from 'off Matt Talbot Bridge' on 01/05/03. The phytoplankton were also identified as cryptomonas.

During the 1986 survey the maximum value of 14.3 mg/m^3 was recorded at Cardiff Lane whereas in 1987-88 the highest value of 13.5 mg/m^3 was from a sample taken from downstream of the Toll Bridge.

7.1.6 Nutrients

7.1.6.1 Total Oxidised Nitrogen TON (Nitrate and Nitrite)

In the upper reaches of the Liffey estuary (Matt Talbot Bridge down to the Toll Bridge) the median TON values recorded during the fourth year of the monitoring programme were similar to those recorded during the first year. This would be expected as the salinities of the samples in both surveys were similar. In the lower reaches of the estuary ('off NTW Outfall down to the Poolbeg) the total oxidised nitrogen values were slightly elevated as a result of the increased levels of TON in the Ringsend effluent. Prior to the upgrading of the Treatment Works the TON levels in the Ringsend effluent were generally less than 0.32 mgN/l. During the fourth year of the monitoring programme the mean TON result for the Ringsend effluent was 7.77 mgN/l. These increased TON levels were due to nitrification of the sewage. The median TON values are depicted alongside the corresponding values recorded for the surveys carried out in 2000/1, 2001/2 and 2002/3 in Figures 5 and 6 below.

The median salinity values recorded during the first and fourth years of the programme were similar whereas the salinity values for the second year were similar to the third years values. It should be noted that the median salinity values recorded during the second and third years of the programme were similar, yet the median TON values recorded during the third year of the programme are similar to the values recorded during the first year of the programme when the lower median salinity values indicated that there was a greater contribution from the Liffey. Figure 7 below is a plot of the winter TON versus salinity values (2001/2, 2002/3 and 2003/4). The R^2 value of 0.8861 indicates an almost linear correlation between salinity and TON. A linear relationship between nutrient concentration and salinity indicates that mixing (dilution) is the dominant process that transports nutrients away from coastal regions.

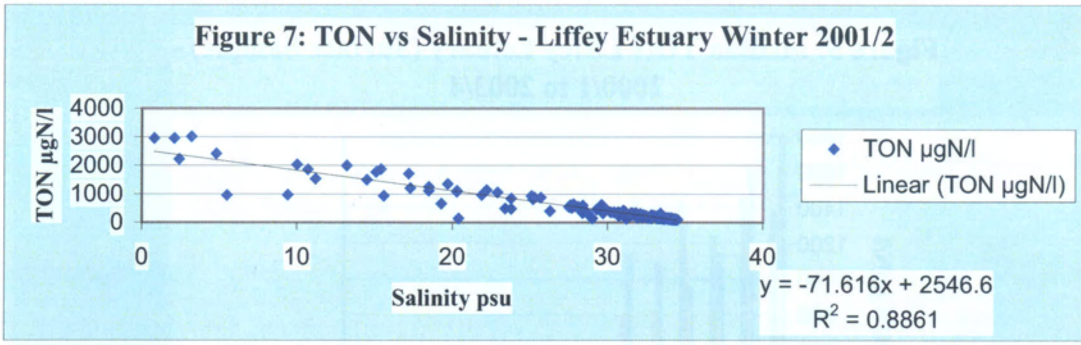


Figure 7: TON vs Salinity - Liffey Estuary Winter 2001/2

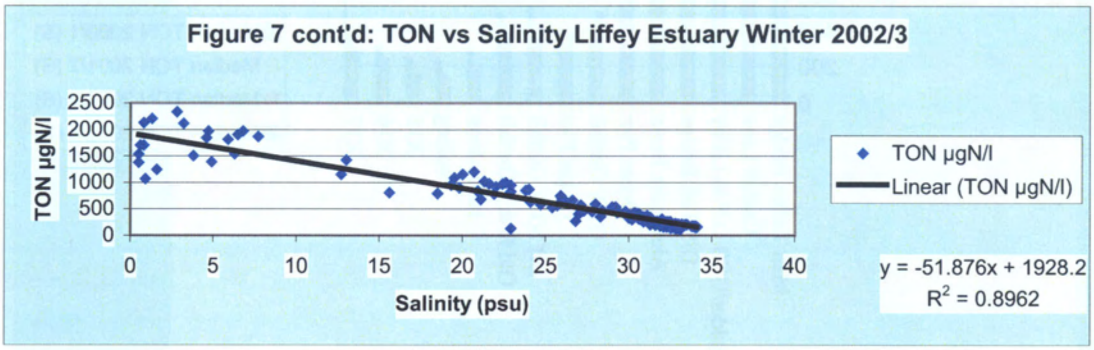


Figure 7 cont'd: TON vs Salinity Liffey Estuary Winter 2002/3

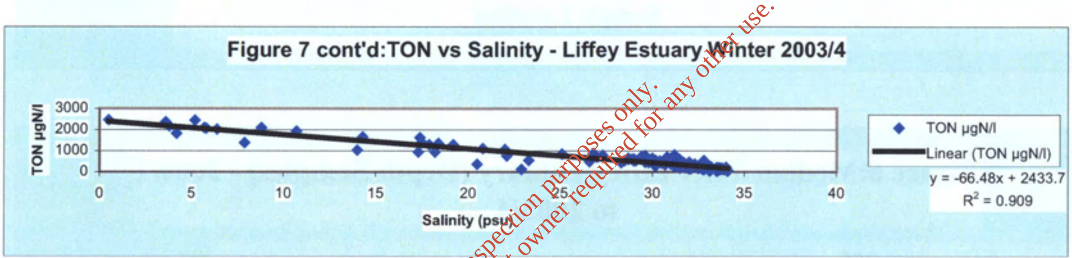


Figure 7 cont'd:TON vs Salinity - Liffey Estuary Winter 2003/4

The 2001/2, 2002/3 and 2003/4 winter nutrient versus salinity plots for TN, ammoniacal nitrogen and phosphate and TP are displayed in Figure 8. The high nutrient values at salinities of approx. 25 to 32 psu (2001/2) are associated with the effluent from Ringsend, whereas, the very high values for ammoniacal nitrogen, total nitrogen, phosphate and total phosphorus (winter 2002/3) are associated with results for samples taken from off the Old Treatment Works, Tanker and to a lesser extent the New Treatment Works and Rathmines and Pembroke sampling stations.

Figure 5: Median TON Liffey Estuary (Surface Sample) - 2000/1 to 2003/4

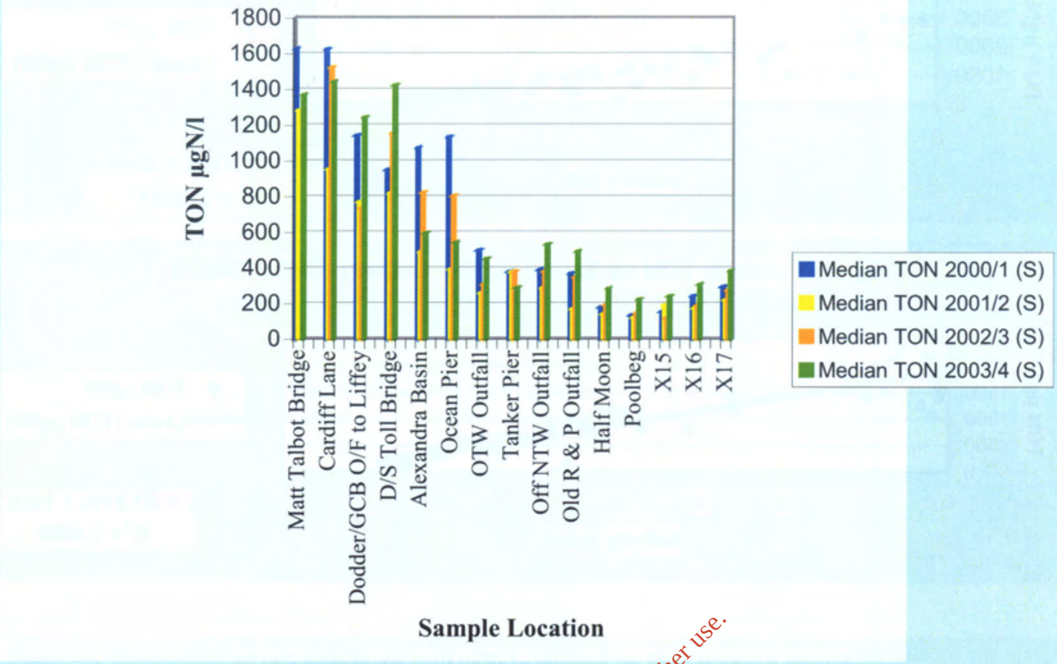
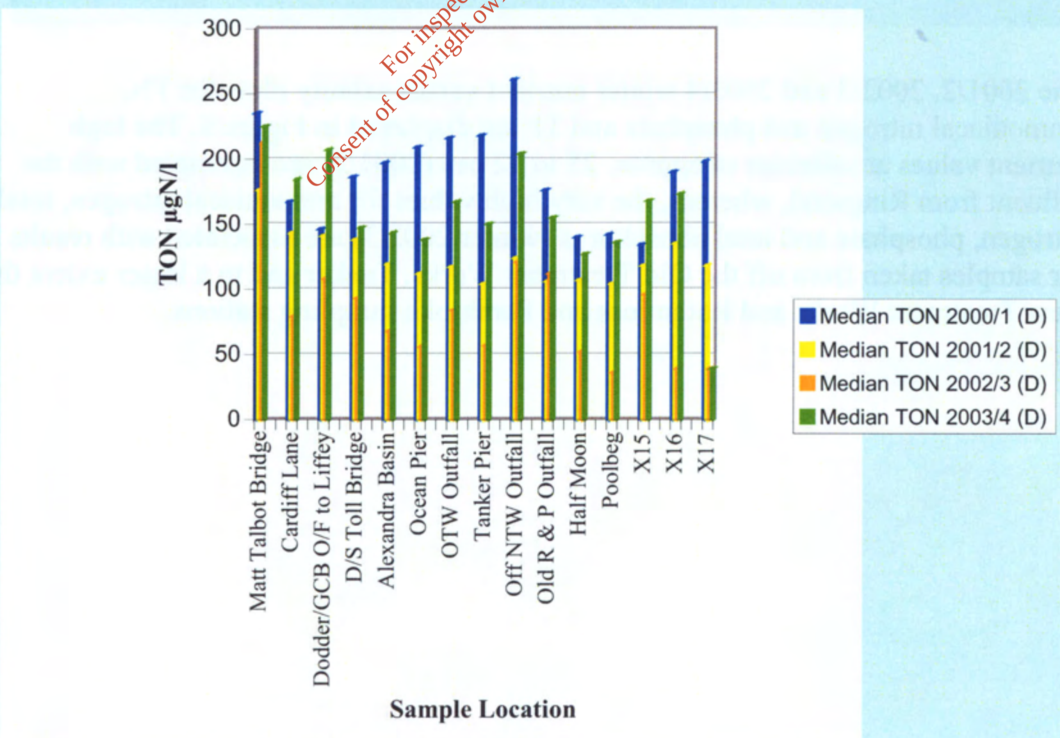


Figure 6:Median TON Liffey Estuary (Depth Samples) - 2000/1 to 2003/4



As in the first three years of the monitoring programme the TON values recorded during the winter months were higher than the values recorded during the summer months. The yearly, winter and summer ranges of median TON values are tabulated alongside the corresponding values recorded during 2000/1, 2001/2 and 2003/4 in Table 8a and b below.

Table 8a – Comparison of Median TON & Salinity Values – Liffey Estuary (Surface Samples) 2000/1, 2001/2, 2002/3 & 2003/4

	Range of Median TON & Salinity values Surface Samples			
	2000/2001	2001/2002	2002/2003	2003/2004
July - June TON µgN/l	134 - 1625	122 - 1283	115 - 1524	223 - 1443
Salinity psu	7.6 – 32.4	11.4 – 32.5	11.4 – 32.7	7.6 – 32.8
Summer TON µgN/l	113 - 923	74 - 952	54 - 1050	118 - 1443
Salinity psu	12.2 – 33.1	13.2 – 33.2	15.7 – 33.1	9.1 – 33.1
Winter TON µgN/l	456 - 1872	197 - 1626	269 - 1841	322 - 2005
Salinity psu	0.4 – 31.9	10.3 – 32.7	1.1 – 31.9	4.2 – 31.7

Table 8b – Comparison of Median TON & Salinity Values – Liffey Estuary (Depth Samples) 2000/1, 2001/2, 2002/3 & 2003/4

	Range of Median TON & Salinity values Depth Samples			
	2000/2001	2001/2002	2002/2003	2003/2004
July - June TON µgN/l	134 - 275	104 - 176	36 - 212	39 - 225
Salinity psu	31.3 – 33.8	32.4 – 34.1	31.1 – 33.8	31.8 – 33.7
Summer TON µgN/l	14 - 93	21 - 83	17 - 151	26 - 136
Salinity psu	30.8 – 34.0	32.7 – 34.1	31.5 – 34.0	32.4 – 33.7
Winter TON µgN/l	200 - 331	130 - 266	178 – 443	155 - 323
Salinity psu	31.0 – 33.6	31.7 – 34.1	29 – 32.9	30.1 – 33.8

7.1.6.2 Total Nitrogen

As in the previous three years of the monitoring programme, the highest total nitrogen values were recorded for surface water samples taken from the upper reaches of the Liffey estuary and in the vicinity of the Ringsend Treatment Works. The yearly, winter and summer range of median TN values for surface and depth samples are tabulated alongside the corresponding values recorded for 2000/1, 2001/2 and 2002/3 in Tables 9a and b below. The median As in 2000/1, 2001/2 and 2002/3 the total nitrogen consisted mainly of TON in the upper reaches of the estuary. Ammoniacal nitrogen and particulate plus dissolved organic nitrogen were the largest contributors to the total nitrogen value in the vicinity of the Ringsend Treatment Works outfall. There is some evidence that the TN levels have decreased in the immediate vicinity of the Ringsend Treatment Works outfall however further surveys are required in order to assess the impact of upgrading the Ringsend Sewage Treatment Works on the level of nutrients in the estuary. The median values for each of the individual sites are displayed alongside the corresponding values recorded during the first three years of the programme in Figures 9 and 10 below. Total Nitrogen was not determined for the Dublin Bay WQMP.

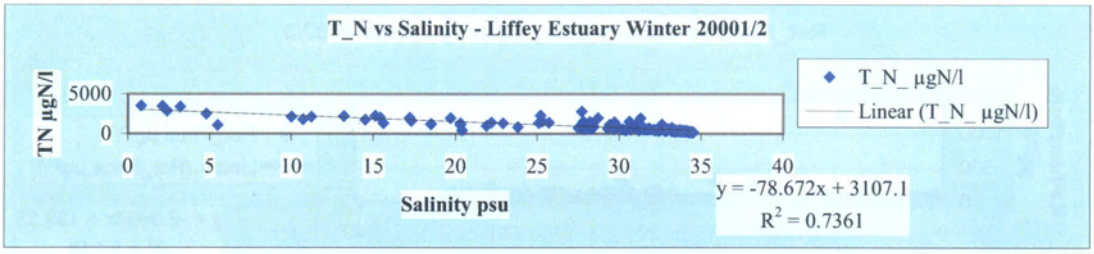
Table 9a – Comparison of Median TN Values – Liffey Estuary (Surface Samples) 2000/1, 2001/2, 2002/3 & 2003/4

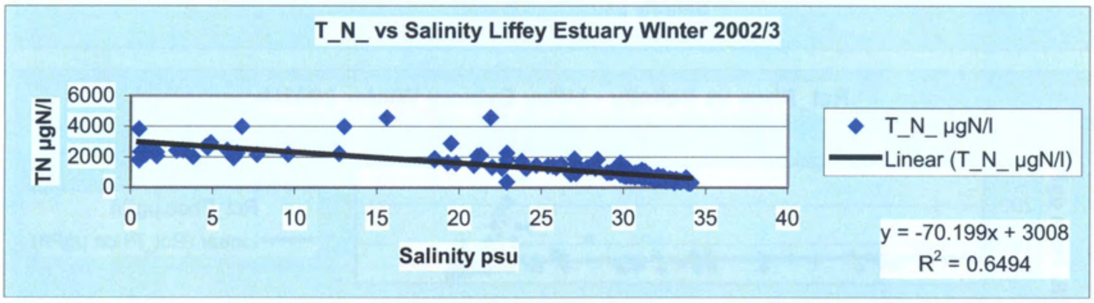
	Range of Median TN & Salinity values Surface Samples			
	2000/2001	2001/2002	2002/2003	2003/2004
July - June TN µgN/l	534 - 2377	472 - 1988	530 - 2241	496 - 2037
Salinity psu	7.6 – 32.4	11.4 – 32.5	11.4 – 32.7	7.6 – 32.8
Summer TN µgN/l	434 - 2339	459 - 1872	397 -1732	371 - 2037
Salinity psu	12.2 – 33.1	13.2 – 33.2	15.7 – 33.1	9.1 – 33.1
Winter TN µgN/l	534 - 2813	544 - 2168	674 - >4,000	589 - 2076
Salinity psu	0.4 – 31.9	10.3 – 32.7	1.1 – 31.9	4.2 – 31.7

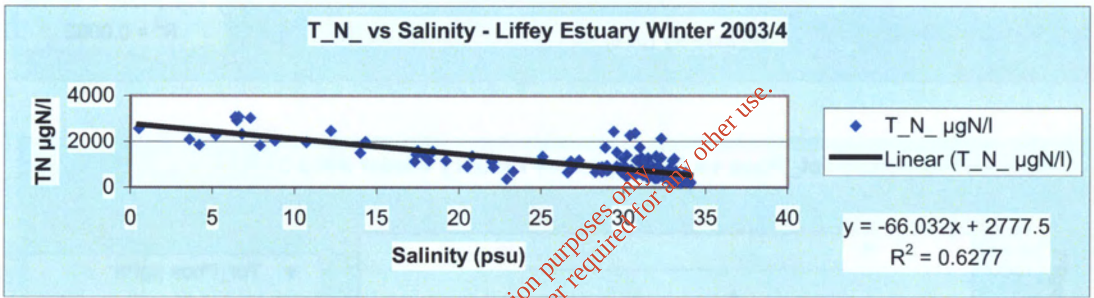
Table 9b – Comparison of Median TN Values – Liffey Estuary (Depth Samples) 2000/1, 2001/2, 2002/3 & 2003/4

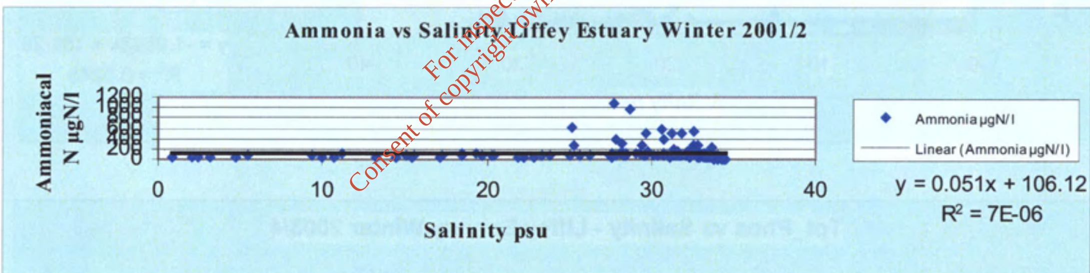
	Range of Median TN & Salinity values Depth Samples			
	2000/2001	2001/2002	2002/2003	2003/2004
July - June TN µgN/l	333 - 899	255 - 553	366 - 739	315 - 552
Salinity psu	31.3 – 33.8	32.4 – 34.1	31.1 – 33.8	31.8 – 33.7
Summer TN µgN/l	258 - 627	252 - 542	267 - 690	267 - 739
Salinity psu	30.8 – 34.0	32.7 – 34.1	31.5 – 34.0	32.4 – 33.7
Winter TN µgN/l	399 - 965	299 - 683	477 - 793	303 - 691
Salinity psu	31.0 – 33.6	31.7 – 34.1	29 – 32.9	30.1 – 33.8

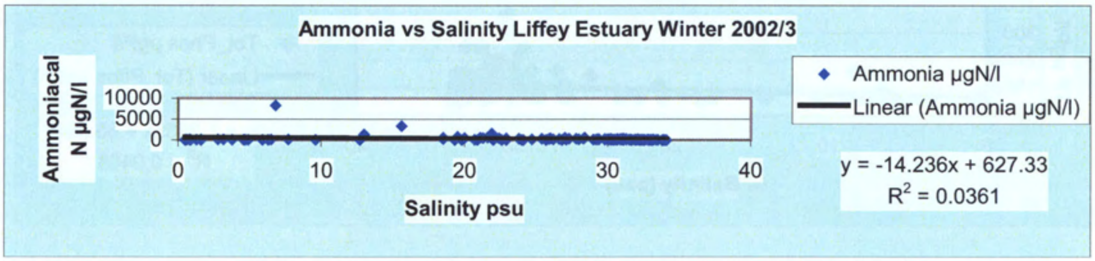
Figure 8 – Nutrient versus Salinity Plots for data recorded during the winter months in the Liffey Estuary











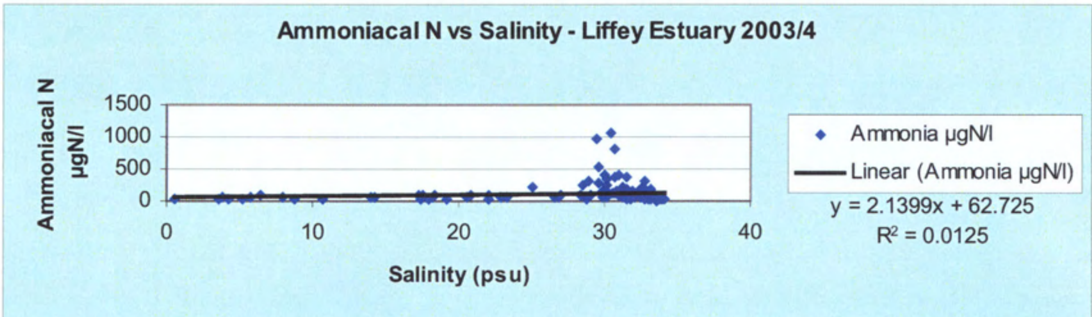
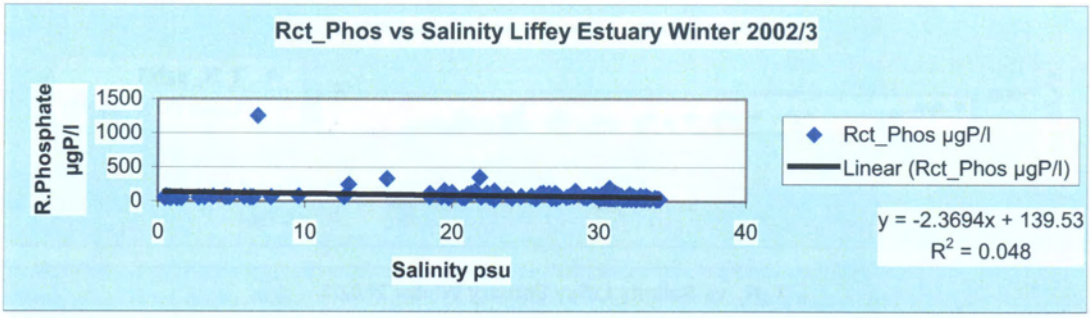
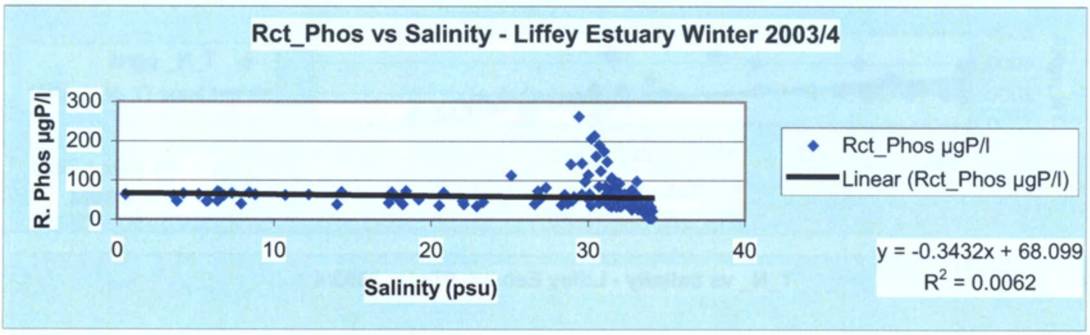
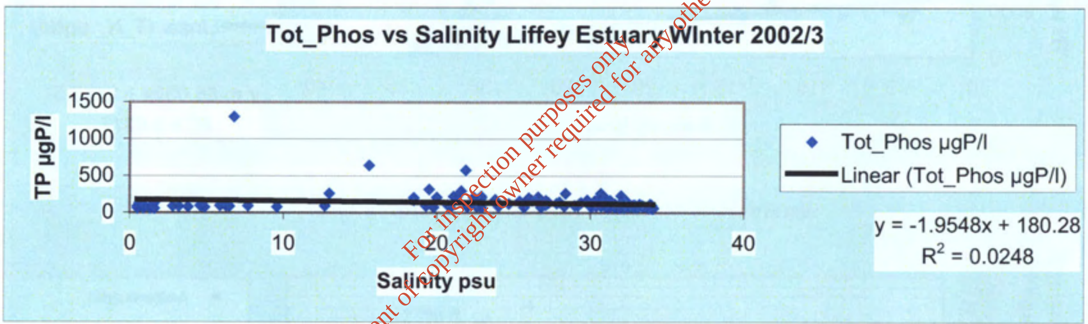


Figure 8 cont'd– Nutrient versus Salinity Plots for data recorded during the winter months in the Liffey Estuary







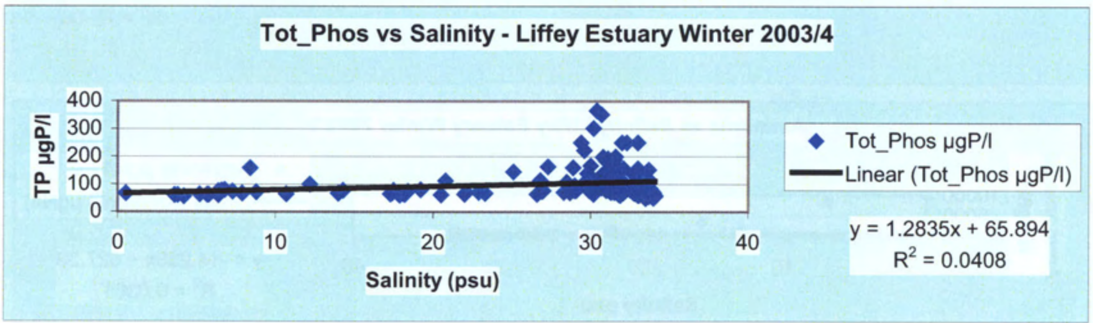


Figure 9: Median TN Liffey Estuary (Surface Samples) - 2000/1 to 2003/4

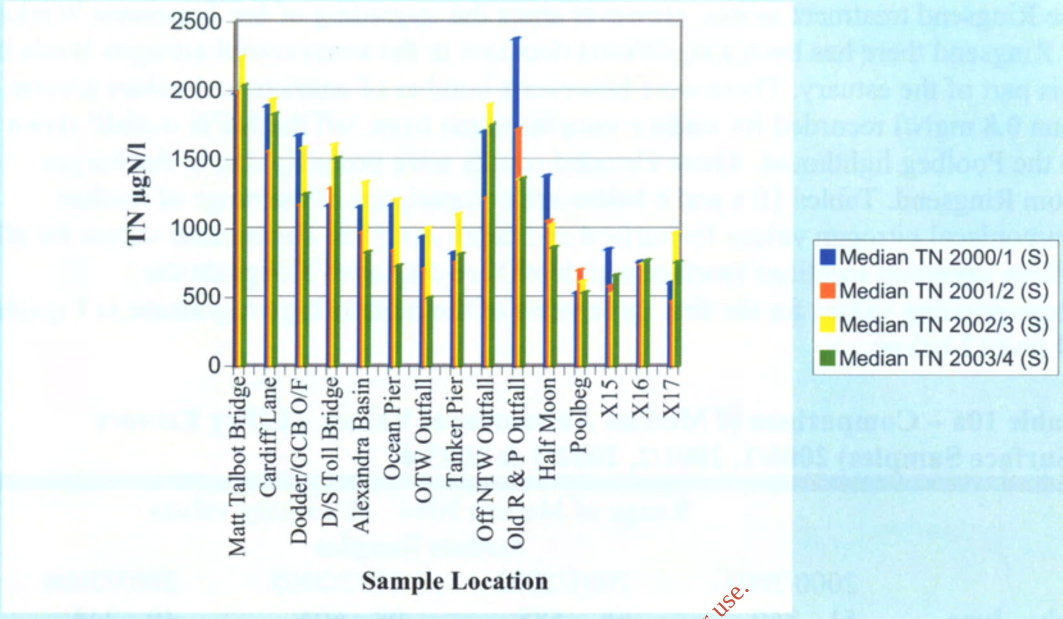
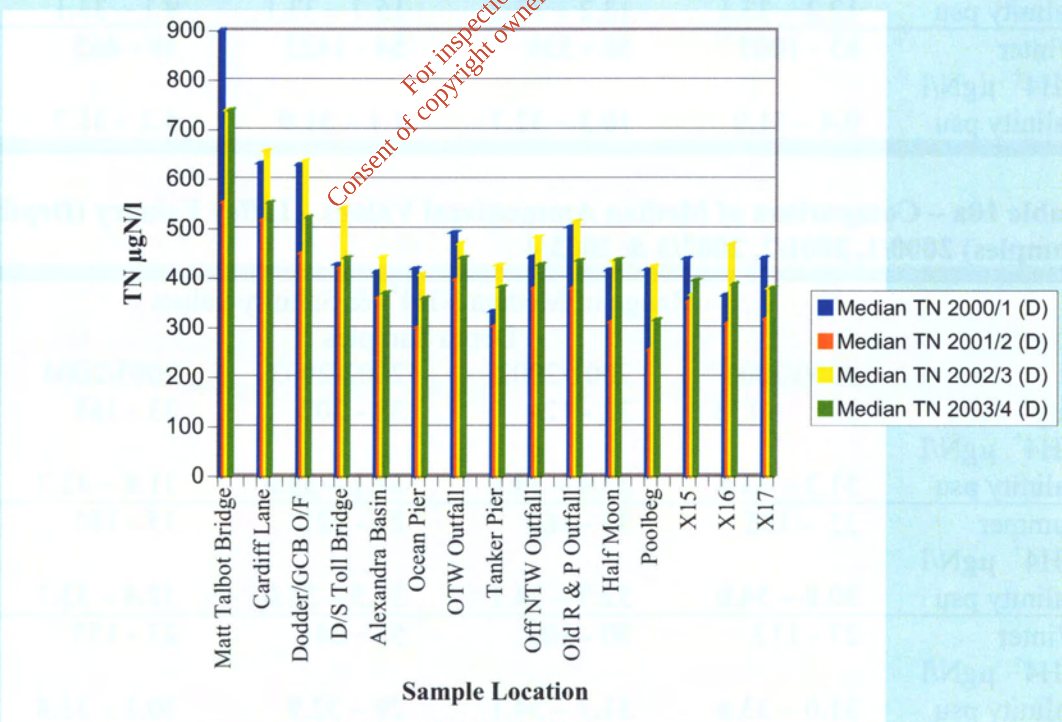


Figure 10: Median TN Liffey Estuary (Depth Samples) - 2000/1 to 2003/4



7.1.6.3 Ammoniacal Nitrogen

As in the first three years of the monitoring programme, the maximum levels of ammoniacal nitrogen were recorded for surface water samples taken in the vicinity of the Ringsend treatment works. However since the upgrading of the Treatment Works at Ringsend there has been a significant decrease in the ammoniacal nitrogen levels in this part of the estuary. There were however a number of ammoniacal values greater than 0.8 mgN/l recorded for surface samples taken from 'off the NTW outfall' down to the Poolbeg lighthouse. These elevated results were probably due to discharges from Ringsend. Tables 10 a and b below are comparisons of the range of median ammoniacal nitrogen values for surface and depth samples. The median values for all fifteen sampling locations (surface and depth) are displayed alongside the corresponding values for the first three years of the monitoring programme in Figures 11 and 12 below.

Table 10a – Comparison of Median Ammoniacal Values – Liffey Estuary (Surface Samples) 2000/1, 2001/2, 2002/3 & 2003/4

	Range of Median $NH4^+$ & Salinity values Surface Samples			
	2000/2001	2001/2002	2002/2003	2003/2004
July - June $NH4^+$ µgN/l	51 - 860	68 - 585	98 - 604	49 - 244
Salinity psu	7.6 – 32.4	11.4 – 32.5	11.4 – 32.7	7.6 – 32.8
Summer $NH4^+$ µgN/l	61 - >500	85 - 740	43 - 373	44 - 188
Salinity psu	12.2 – 33.1	13.2 – 33.2	15.7 – 33.1	9.1 – 33.1
Winter $NH4^+$ µgN/l	83 - 1005	58 - 538	54 - 1422	49 - 465
Salinity psu	0.4 – 31.9	10.3 – 32.7	1.1 – 31.9	4.2 – 31.7

Table 10a – Comparison of Median Ammoniacal Values – Liffey Estuary (Depth Samples) 2000/1, 2001/2, 2002/3 & 2003/4

	Range of Median $NH4^+$ & Salinity values Depth Samples			
	2000/2001	2001/2002	2002/2003	2003/2004
July - June $NH4^+$ µgN/l	39 - 133	32 - 124	38 - 207	33 - 168
Salinity psu	31.3 – 33.8	32.4 – 34.1	31.1 – 33.8	31.8 – 33.7
Summer $NH4^+$ µgN/l	35 - 155	32 - 160	21 - 221	35 - 180
Salinity psu	30.8 – 34.0	32.7 – 34.1	31.5 – 34.0	32.4 – 33.7
Winter $NH4^+$ µgN/l	27 - 113	30 - 103	55 - 241	27 - 153
Salinity psu	31.0 – 33.6	31.7 – 34.1	29 – 32.9	30.1 – 33.8

During 1986 (Dublin Bay WQMP) the median concentrations recorded for ammoniacal nitrogen varied from 100 to 320 µgN/l and from 80 to 160 µgN/l in the surveys of 1987-88 when samples were taken from four locations only.

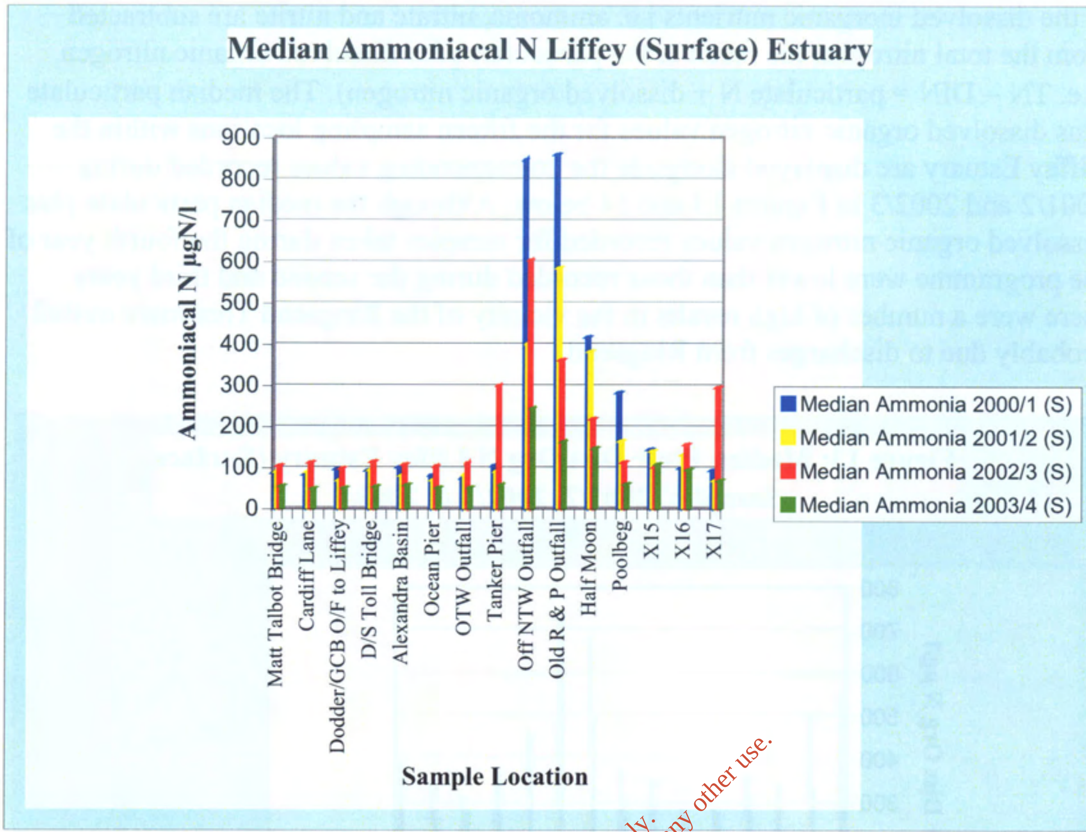
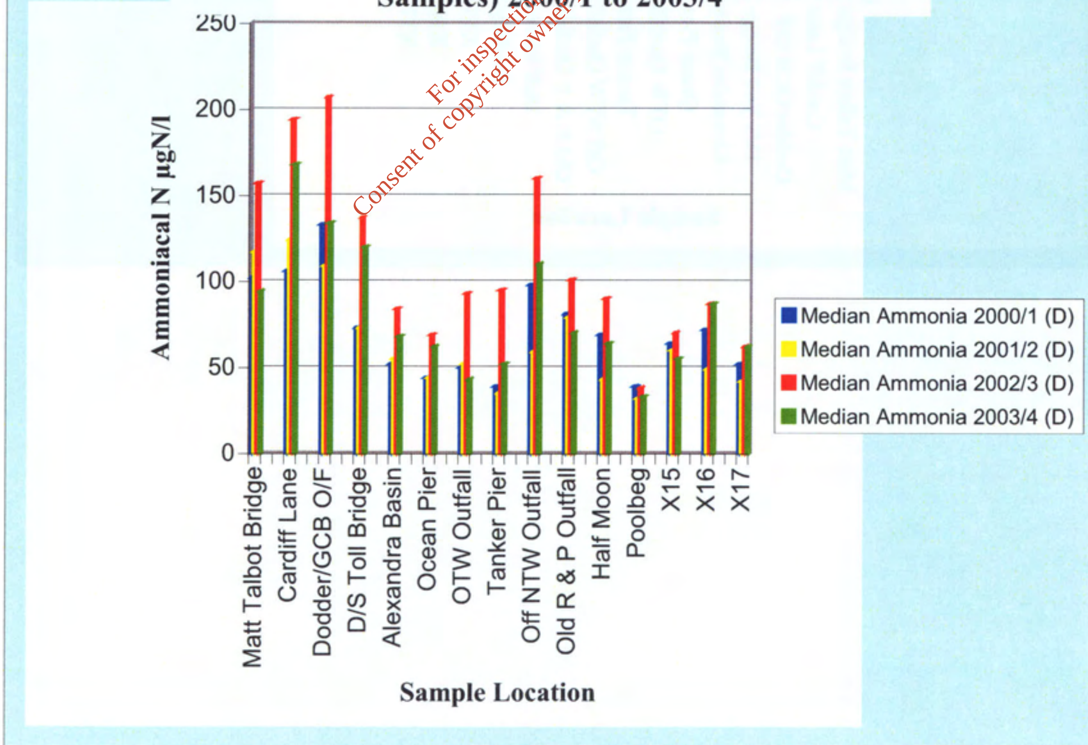


Figure 12: Median Ammoniacal N Liffey Estuary (Depth Samples) 2000/1 to 2003/4



If the dissolved inorganic nutrients i.e. ammonia, nitrate and nitrite are subtracted from the total nitrogen, the result is the particulate plus dissolved organic nitrogen (i.e. TN – DIN = particulate N + dissolved organic nitrogen). The median particulate plus dissolved organic nitrogen values for the fifteen sampling locations within the Liffey Estuary are displayed alongside the corresponding values recorded during 2001/2 and 2002/3 in Figures 13 and 14 below. Although the median particulate plus dissolved organic nitrogen values recorded for samples taken during the fourth year of the programme were lower than those recorded during the second and third years there were a number of high results in the vicinity of the Ringsend Treatment outfall probably due to discharges from Ringsend.

Figure 13: Median Ptc + Diss Org N Liffey Estuary (Surface Samples) 2001/2, 2002/3 & 2003/4

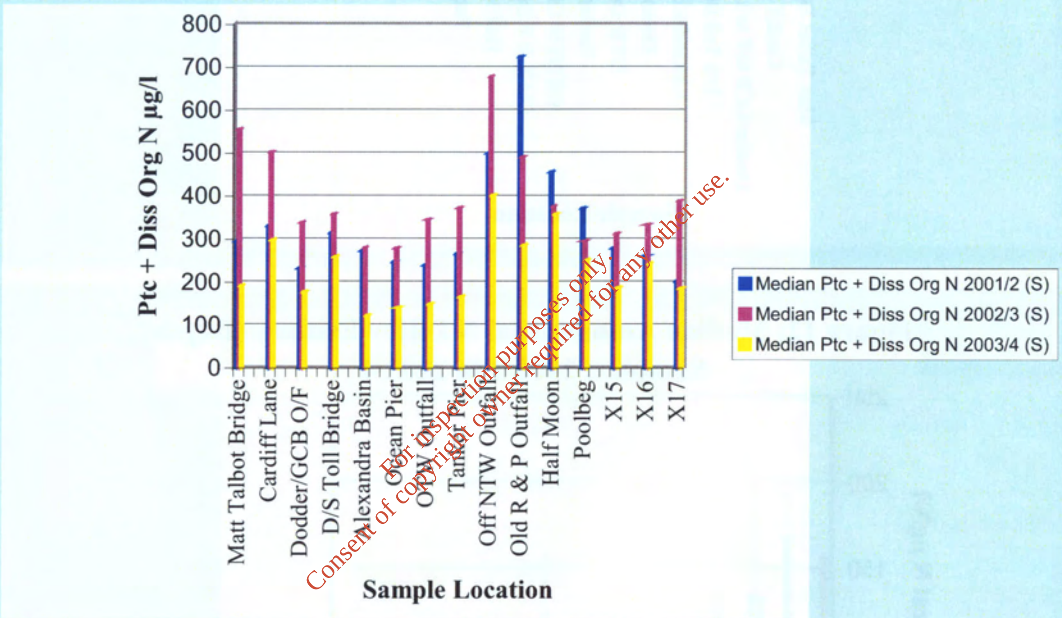
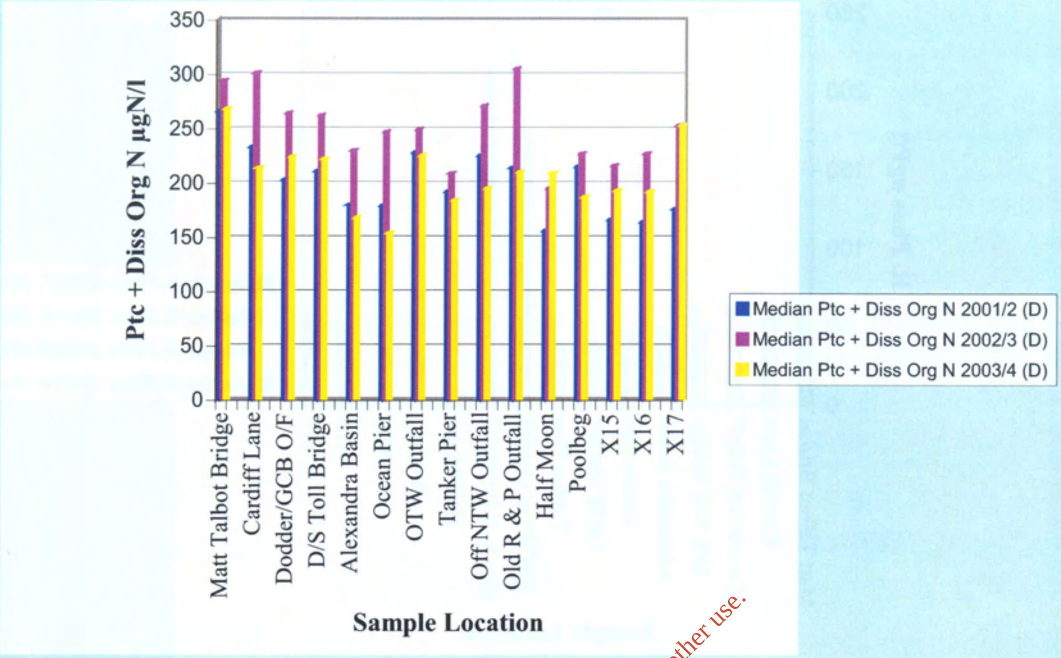


Figure 14: Median Ptc + Diss Org N Liffey Estuary (Depth Samples) 2001/2, 2002/3 & 2003/4



7.1.6.4 Phosphate

As in 2000/2001, 2001/2 and 2002/3 the highest levels of phosphate were recorded for surface samples taken in the vicinity of the Ringsend Treatment Works outfall. The median phosphate values recorded during 2002/3 are displayed alongside the corresponding values for the first two years of the monitoring programme in Figures 15 and 16 below. The results were generally similar to those recorded during the first three of the monitoring programme. The yearly, winter and summer range of median reactive phosphate values for surface and depth samples are tabulated alongside the corresponding values recorded during 2000/1, 2001/2 and 2002/3 in Tables 11 a and b below.

During the 1986 surveys for the Dublin Bay WQMP median phosphate concentrations ranged from 50 to 180µgP/l. When surveys were carried out during 1987-1988 only four locations were sampled and the median phosphate concentrations in surface samples ranged from 50 to 80µgP/l. During this period median values for depth samples ranged from 30 to 60µgP/l.

Figure 15: Median R. Phos Liffey Estuary (Surface Samples) - 2000/1 to 2003/4

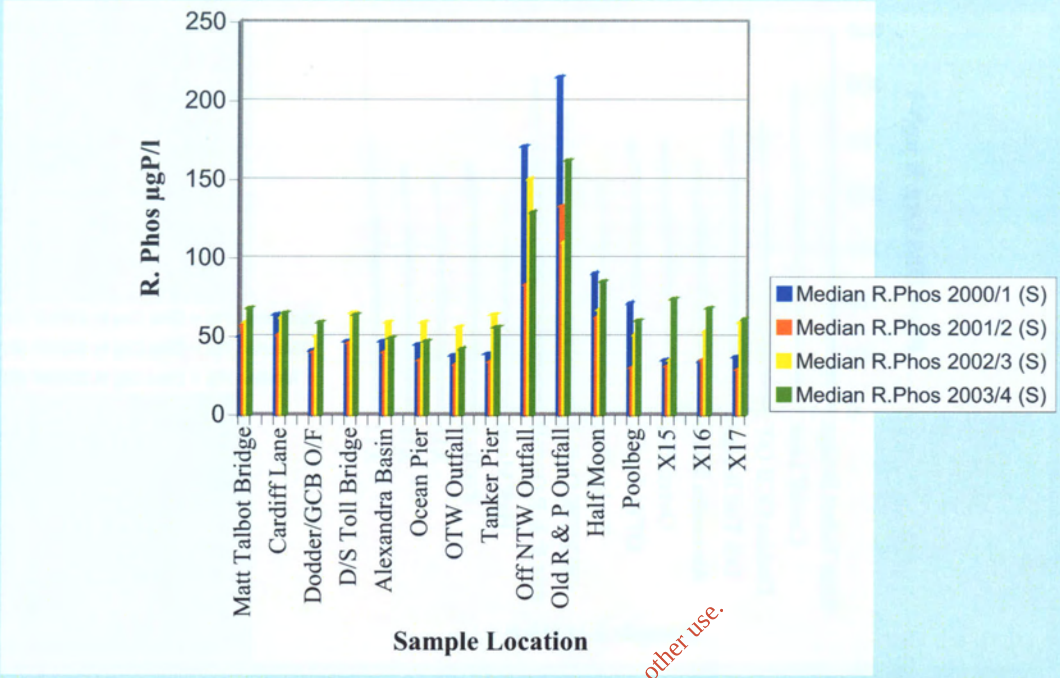


Figure 16: Median R. Phos Liffey Estuary (Depth Samples) 2000/1 to 2003/4