EA - South West Box 5

L119.

ENVIRONMENT AGENCY

WATER QUALITY SECTION
CORNWALL AREA

FINAL DRAFT REPORT

UPPER FAL ESTUARY URBAN WASTE WATER TREATMENT DIRECTIVE SENSITIVE AREA (EUTROPHIC) DESIGNATION

February 1997
COR/97/004

Executive author: Tim Geatches
Investigations Officer

Geoff Boyd
Area Manager

UPPER FAL ESTUARY URBAN WASTE WATER TREATMENT DIRECTIVE SENSITIVE AREA (EUTROPHIC) DESIGNATION

EXECUTIVE SUMMARY

The Upper Fal Estuary has been proposed as a sensitive area under the EC Urban Waste Water Treatment Directive. Data collected since 1994 has shown that the estuary is prone to significant algal blooms under certain conditions during the summer. Modelling of the system has shown Newham STW discharge to be a significant source of nutrients under these conditions.

Of the bloom forming algae *Alexandrium tamarense* is of most concern due to its toxin production and link with Paralytic Shellfish Poisoning (PSP). PSP was shown by MAFF to be a problem within the proposed sensitive area during 1995.

Nutrient stripping at Newham STW during the summer months would significantly decrease the total inorganic nitrogen (TIN) loading to the estuary and by that reduce eutrophication.

UPPER FAL ESTUARY URBAN WASTE WATER TREATMENT DIRECTIVE SENSITIVE AREA (EUTROPHIC) DESIGNATION

1. BACKGROUND

1.1. Location

The upper Fal Estuary receives the drainage of the Rivers Fal, Tresillian, Allen, Kenwyn and Calenick Stream. The area is bounded by the tidal limits of the rivers and to the south by the lower Fal Estuary (known as the Carrick Roads). Chemical and biological monitoring points together with the proposed sensitive area are shown in appendix 1.1. E19B is a designated site under the EC Shellfish Waters directive. WSTW0240C is a designated EC Dangerous Substances directive assessment site for Newham STW.

1.2. Description

The Fal Estuary is a ria, a river valley drowned by rising sea levels. A deep water channel runs from the boundary with the Carrick Roads to the junction of the Tresillian River and the Truro River at Malpas. Above this point the estuary is mainly sediment-filled, with mud flats exposed at low water backed by low rocky cliffs.

1.2.1. River Catchment Characteristics

In the upper reaches of the River Fal catchment china clay extraction, the dominant activity, greatly affects the area. Historic mineral mining has left a legacy of old mines, particularly in the Calenick Stream. The remainder is rural in character, ranging from moorland around the headwaters, farm land (mostly put to dairying), meadowland and extensive woodland in the lower reaches of the Rivers Fal and Tresillian.

The Fal Estuary lies within the Cornwall Area of Outstanding Natural Beauty (AONB). The landscape is of national significance and is afforded special protection from development by Planning Authorities.

1.2.2. Wildlife

This catchment contains a range of habitats of great national and international importance. The marine and intertidal areas of the Fal Estuary are of great nature conservation value. The whole of the upper Fal Estuary is designated a Site of Special Scientific Interest (SSSI) (see Appendix 1.2.). Several organisms are found here at their only sites in the country, and various species of wader and waterfowl use the estuaries as feeding sites. There are many Red Data Book species (Nationally rare, vulnerable or threatened species) within the proposed area. The whole of the Fal Estuary is also proposed as a special area of conservation (SAC).

The area contains a variety of fisheries, with most watercourses supporting populations of coarse fish and brown trout, and some supporting migratory sea trout and salmon. The estuaries and coastal waters contain a variety of fish and shellfish.

1.2.3. Geology

The geology of this catchment can be divided roughly into two main sections: the Carnmenellis and St. Austell granites and the Devonian sediments.

The Devonian sediments within the catchment consist of the fossiliferous slates of the Meadfoot Beds in the north, the interbedded grey slate and light brown sandstone of the Grampound Grit, and over most of the southern section, the slates and sandstones of the Veryan, Portscatho, Falmouth and Mylor Series. All these sediments have been subjected to low-grade metamorphism and varying degrees of folding.

Within the catchment boundaries there are parts of two granite intrusions: the St. Austell granite in the northeast and the Carnmenellis granite in the west. Metamorphic aureoles are found associated with both these bodies and their shape reflects the subsurface shape of the plutons. The aureoles are characterised by spotting of some slates. The southern portion of the St. Austell granite has undergone extreme weathering and the resultant china clays are extensively mined. Small amounts of low-grade china clay were formerly worked from quarries on the margin of the Carnmenellis pluton but no traces of these workings now remain.

1.2.4. Hydrogeology

None of the rocks within the catchment have been classified by the Environment Agency as 'major aquifers' with highly productive strata of regional importance. All the rocks have, however, been classified as 'minor aquifers' and, as such, have sufficient groundwater resources in the weathered zone and in fissures in the bedrock to support locally important abstractions. The weathered zone on the granites is variable in thickness. It is generally absent on the hilltops and up to a few metres thick in the valleys. The weathered zone is generally less than 15m thick. Beneath the weathered zone, groundwater flow is predominantly along the major joints. The depth of water abstraction boreholes in the catchment does not bear any direct relationship to the depth of the water table but simply reflects the depth necessary to intersect sufficient water-bearing fissures.

2. DATA ANALYSIS AND PRESENTATION TO DEMONSTRATE THE PROPOSED STRETCH IS EUTROPHIC

2.1. Chemical data

2.1.1. Methods

Chemical data from January 1994 to August 1996 has been used for this report. Since 1995 additional data from six of the estuary sites have been collected specifically for UWWT (E19B7 to E19B12). All sites are shown in appendix 1.1. and sampling methodologies are detailed below.

Quarterly surveys are conducted on a seasonal basis as follows:

December to February - Winter
March to May - Spring
June to August - Summer
September to November - Autumn

Two of the surveys are undertaken on neap tides and two under spring tides. For each survey surface samples at high and low water are taken. All sites were sampled on the same day. In the winter season three additional surveys were carried out including bottom samples.

In addition, intensive tidal cycle surveys on a spring (winter season) and neap (summer season) were conducted at three of the sites. This entailed taking hourly samples from both bottom and surface.

Monthly samples for chlorophyll a and phytoplankton from all six sites were taken from April to October for 1995 and 1996. Theses were taken at the surface at high and low water.

A Hydrolab Datasonde 3 water quality monitor was installed at Malpas in June and July 1995 (see Appendix 1.1. for location). This was used to continuously monitor dissolved oxygen concentrations at the surface.

2.1.2. Results

All sample results for each site have been split into surface and depth samples and analysed separately.

Summary statistics for total inorganic nitrogen, orthophosphate and chlorophyll a at all estuary sites are shown in appendices 2.1. to 2.3.

Seasonal plots for the combined estuary sites were done to identify evidence of significant sources of nutrients. If no significant sources were present the relationship between salinity and nutrients would be linear showing simple dilution. The plots are shown in appendices 2.4. to 2.7. for the following pairs of determinands:

Salinity v total inorganic nitrogen
Salinity v total oxidised nitrogen
Salinity v total ammonia
Salinity v orthophosphate
Salinity v chlorophyll a
Total inorganic nitrogen v chlorophyll a

Continuous dissolved oxygen readings for June and July 1995 at Malpas are shown in appendix 2.8.

Total inorganic nitrogen (TIN)

Surface TIN concentrations show simple dilution in the winter season. This is evident by the steady decline in concentrations with increasing salinity (appendix 2.4.). However, in the summer season this is not so. Most of the scatter is due to total ammonia samples taken at E19B9 during June and July 1995. This is evidence of a significant input of nitrogen, Newham STW being the most likely source.

Chlorophyll a

Surface chlorophyll a concentrations tended to be low during the winter season with only the uppermost sites of the Truro River and Tresillian River occasionally exceeding the 10 µg/l standard. E19B9 and E19B11 exceeded the standard approximately 30% of the time. This indicates the eutrophic state of this part of the estuary probably because of the proximity to Newham STW and estuarine conditions.

In the summer the 10 µg/l standard for Chlorophyll a was exceeded regularly at most surface sites. In general the mean concentration increased from the Carrick Roads to the tidal limits. The two sites on the River Fal branch of the estuary (E19B5 and E19B6) had the lowest means of all the sites and the least exceedences of the standard. This suggests that this branch of the estuary is less eutrophic than the rest of the estuary.

Dissolved oxygen

Dissolved oxygen concentrations at Malpas showed a marked increase in variation towards the end of June which persisted through July. Variation was due to a combination of tidal and diurnal factors. Algal bloom activity and die off were likely to have been the prime cause of both the peaks and troughs of dissolved oxygen.

2.2. Biological data

2.2.1. Methods

A sample for algae was taken on each occasion a chlorophyll a sample was taken (see section 2.1.1.). If the chlorophyll a sample was found to exceed the threshold level of 10 ug/l, the algal sample was sent to an external contractor for algal analysis and enumeration. In 1995 these samples were analysed by Southern Science and in 1996 by MENTEC of North Wales. In addition, ad-hoc samples taken by the National Rivers Authority (NRA) in response to algal boom events were analysed by SAHFOS based in Plymouth. More information on the work carried out in 1995 is contained in the report by SAHFOS (see Reference 1).

MAFF was also involved in the monitoring of the Fal Estuary. Their sampling and analysis were primarily concerned with the identification of toxic algae and toxin levels within shellfish species. E19B9, E19B2 and Ruan were regularly monitored (see Appendix 1.1. for location).

2.2.2. Results

Alexandrium tamarense blooms

The *Alexandrium tamarense* blooms of 1995 and 1996 were the most significant biological event to have occurred within the Upper Fal Estuary which may be attributed to eutrophication. Appendix 2.9. describes the blooms of *A. tamarense* that have occurred at three sites (E19B9, E19B2 and Ruan) within the designated area in 1995 and 1996.

At the end of June 1995, reports were received by the NRA of red coloured water within the middle reaches of the Fal estuary. On the 3rd July 1995, *A.tamarense* was the dominant alga in the River Fal between E19B9 and E19B2. E19B2 was found to have a cell count of 1261 cells / ml and E19B9 a count of 970 cells / ml. It is generally accepted that a cell count of 1000 cells / ml is the threshold for ' Red tide ' conditions. A maximum cell count of 3130 cells / ml was observed at E19B2 on the 7th July 1995. Over the following two week period *A. tamarense* began to decline in abundance and was absent at all sites by the 21 July 1995. The 1995 bloom had developed during a long period of calm weather with bright sunshine that led to a rapid rise in sea surface temperature. The development of the bloom was also linked to the spring / neap tidal cycle, with the bloom coinciding with neap tides (see Reference 1).

Analysis of sediment samples from the Fal Estuary in the autumn of 1995 confirmed the encystment of *A. tamarense* into a dormant wintering phase. It was therefore anticipated that the algae would reappear within 1996. This proved to be the case, and on the 11 June 1996 *A. tamarense* was found in small numbers at Ruan (12 cells / ml). The timing of the 1996 bloom was earlier than in 1995 and a maximum cell count of 800 cells / ml was obtained just one week later at Ruan. The maximum counts achieved at E19B2 (50 cells / ml) and E19B9 (1.1 cells / ml) was much lower than those attained in 1995, although the presence alone of this species was still significant.

Depth profiles

During the NRA ad-hoc sampling of the *A. tamarense* bloom events water column profiling analysis was undertaken. Appendices 2.10. and 2.11. display the results of water profile sampling at the Truro / Fal confluence site (Near Ruan) in 1995 and 1996 respectively, at the time of the annual bloom maxima of *A. tamarense*. Appendix 2.10. suggests that in 1995 the greatest density of *A. tamarense* was actually at a depth of two metres and counts more than the surface cell count were observed throughout the water column until a depth of ten metres. The graph also provides evidence for a thin layer of low salinity water, as distinguished by the relatively lower conductivity, at the surface. This indicates the presence of water stability that may promote bloom conditions. This observed stratification of the water column may reflect the stable warm, calm weather conditions experienced in the early summer of 1995. Newham STW discharge would have contributed a significant component to the observed total summer freshwater input to the Truro river system. The significantly higher abundance of *A. tamarense* at the two metre depth would appear to reflect the optimal environmental criteria of salinity, nutrients and sunlight necessary for the proliferation of this algal species.

In contrast to 1995, the 1996 water profiling analysis did not indicate the presence of this relationship and the highest counts of *A.tamarense* were obtained at the surface. The most likely reason for this situation would appear to be the unfavourable cool, windy climatic conditions experienced in 1996. This would have interfered with the stratification of the water column and allowed for a greater degree of mixing and dilution of nutrients associated with the freshwater would otherwise have promoted a full bloom event. A. *tamarense* is likely to appear on an annual basis from the sediment cyst bank and the extent of the proliferation and attainment of red tide conditions would appear to be very much dependant upon the inter relationship between climatic and physico-chemical determinands. The sampling data suggests that the deeper areas of the Fal Estuary (Ruan to Carrick Roads) tend to hold the blooms of *A. tamarense* for a longer duration than the shallower areas. This may reflect the slower flushing ability of this area of the estuary.

Algal assemblages

At all six of the UWWTD sites high chlorophyll a levels were recorded between mid April and mid August in 1995. The analysis of the corresponding samples identified a varied assemblage of algal species within the Upper Fal. In order to appreciate the full extent of the situation it would help to illustrate graphically the total biomass of cells obtained on each sampling date (by combining low and high water cell count data) for each of the UWWTD sites in 1995.The average of high and low tide data eliminates variations in algal cell counts that may be due to tidal state and provides a total monthly phytoplankton biomass for each site. Appendix 2.12. shows that in both April and May 1995 all six of the UWWTD sites showed very similar low algal cell counts. The June sampling detected the first major change in overall phytoplankton abundance and all of the sites with the exception of E19B11 had shown a substantial increase. On the 4 July 1995, a distinct difference arose between the sites situated on the Tresillian and Truro river systems. Algal abundance on the Tresillian sites remained at a relatively low level whereas those situated on the Truro rivers experienced a substantial increase in phytoplankton numbers. This date coincided with the large bloom of *A. tamarense* within the Truro river system. In August, the exceptional cell counts observed at E19B7, E19B8 and E19B10 in July were lower and similar to those observed within the Tresillian system. However, E19B9 situated downstream of Newham STW, still maintained high cell counts. On the Autumn sampling dates of 14 September 1995 and 4 October 1995, the phytoplankton biomass at all sites within the Truro system had declined to their spring / winter levels. The highest counts were now present in the shallower parts of each river system particularly in the Tresillian river. The algal assemblage at this time was dominated by benthic diatoms. It would therefore appear that the Truro river system is more eutrophic than the Tresillian river system though the latter does exceed the threshold level for chlorophyll a on a regular basis.

The extremely high total phytoplankton cell counts observed at sites within the Truro river system during the summer months were not due to the elevated levels of just one algal species. Appendix 2.13. shows that at E19B9, situated immediately downstream of Newham STW on the Truro river system, six algal species underwent successive dominance during the summer months. Initially in April 1995, the microflora was dominated by benthic diatoms, predominantly *Melosira moniliformis and Navicula spp.* As water temperature and day length increased, so the phytoplankton biomass was found to diversify. Initially, *Skeletonema costatum* became dominant, reaching densities of 800 cells / ml. On the 4 July 1995 this species was replaced by an organic enrichment indicator species *Nitzshia closterium* that exceeded the bloom threshold (1873 cells / ml) and remained at high abundance levels until the end of August. In the interim period a 'Red tide' bloom of *A.tamarense* became established in early to mid July. This species quickly declined and *S. costatum* reached a very high bloom maxima on 21 July 1995 (4134 cells / ml) that was more than four times the bloom threshold level. On 22 August 1995, *M. moniliformis* again formed a significant component of the algal assemblage, along with *N.closterium*. On 14 September 1995 S. *costatum*, *Peridinium spp.*, *N. closterium*, *Navicula spp. and Melosira spp.* were still present within the water column although at much reduced densities. The sample taken on 4 October 1995 confirmed the reestablishment of benthic diatoms particularly, *Navicula spp.*, as the dominant microflora.

In 1996, the microflora was again initially dominated by benthic diatoms. It was not until the end of June that the phytoplankton began to emerge as the dominant floral biomass. At this time *A. tamarense* was found at a very low density with both S.costatum and *N. closterium* increasing in abundance. On the 12 July 1996 both species were present at very similar abundances just below the bloom threshold level. Within a week, *S. costatum* was found to decline in abundance with *N. closterium* increasing in abundance. On the 15 July 1996, *N. closterium* reached its highest recorded density (14 400 cells / ml) at this site well in excess of the bloom threshold level. On the final date for which data is available in 1996 (25 July 1996), the abundance of *N. closterium* had declined and was again similar to that of *S. costatum*. The observed succession of algae species at E19B9 as described above for both 1995 and 1996, indicates that blooms of algae occur on a regular basis throughout the summer months.

3. ADVERSE EFFECTS

3.1. Paralytic shellfish poisoning (PSP)

A. tamarense is known to produce toxins that can be concentrated within shellfish to form Paralytic Shellfish Poisoning (PSP). Analysis for this toxin is the responsibility of MAFF and appendix 3.1. summarises PSP results obtained from sites within the UWWTD designated area in 1995 and 1996. PSP levels are measured in mouse cell units and counts of less than 200 are below the limit of detection. Data in appendix 3.1. indicates that at Ruan, a maximum count of 906 was obtained in 1995 and a count of 652 in 1996. These counts are considered to show significantly toxicity.

Appendix 3.2. presents the *A. tamarense* cell counts / ml obtained by both the NRA and MAFF within the Upper Fal Estuary in 1995 and 1996. Appendix 3.3. indicates the relationship between the levels of *A. tamarense* and PSP toxins at the time of the bloom maxima. The observed lag between the maximum level of the *A. tamarense* and PSP represents the duration taken for the accumulation of the toxin within shellfish.

The bloom of *A. tamarense* and the subsequent detection of PSP has potentially serious implications for environmental health, recreational usage and the historical shell fishery within the River Fal. The bloom was an exceptional event and was the first confirmed record of a toxic bloom south of Flamborough Head in the UK. Because of the PSP the Port Health Authority issued a prohibition notice on the collection of shellfish in 1995 and 1996 (see Appendix 3.4.).

4. NUTRIENT REMOVAL AT QUALIFYING DISCHARGES

4.1. Modelling

4.1.1. Model

Nutrient load impacts were quantified using an estuarine modelling system, ECoS. EcoS was developed by Plymouth Marine Lab. The estuary is modelled as a branched system. The main branch is from the tidal limit at Truro and follows a line along the lowest depth to a point 15,000 metres down estuary, off Restronguet Creek in Carrick Roads (see Appendix 1.1.). The second branch is the River Tresillian, which is modelled from the confluence at Malpas to a freshwater point 5000 metres upstream.

Further details on the modelling and the outputs are contained in references 2, 3 and 4.

4.1.2. Determinands used in model

Water quality data from January 1994 to August 1996 was used for the model. Total Inorganic Nitrogen (TIN) was used for the river and STW discharge sites. Salinity was used for the estuary sites.

4.1.3. Outputs

Two simulations for the year 1995 were done; one with all the freshwater and STW loadings, and one without Newham STW. The results are shown in appendices 4.1. and 4.2. These show the distributions of TIN concentrations at the estuary monitoring points. The peak in the distributions is the mode which is closely related to and can be loosely interpreted as the mean. The width of the distribution is related to the standard deviation. The graphs show that the distributions are bimodal. This is due to the differing summer and winter loadings as calculated.

The impact of Newham can be seen by comparing the two sets of graphs (see Appendices 4.1. and 4.2.). Unfortunately the scaling (on the frequency axis) differs between the two runs. However, the decrease in the mode (~mean) is easily observable. There is substantial impact at the sites near Newham (E19B10, E19B9), with less obvious impact down the estuary.

From the findings above simulations for summer 1995 were modelled; one with all the freshwater and STW loadings, and one without Newham STW. The impact of Newham can be seen by comparing the two sets of graphs (see Appendices 4.3. and 4.4.). On the Truro branch (sites E19B10 through to E19B2), there are substantial reductions in concentration when Newham is not discharging. These were estimated to be between 30% and 50% from E19B2 to E19B10 respectively.

4.1.4. Conclusions

Newham STW has a localised impact on TIN concentrations within the upper Fal Estuary throughout the year. In the summer the impact of Newham STW on TIN concentrations extends to all sites on the Truro River and main channel to E19B2. It was estimated that in summer 1995 Newham STW contributed up to 50% of the TIN loading in the estuary.

4.2. Nutrient removal and justification for nutrient stripping at the qualifying works

4.2.1. Relative contribution from various sources

Appendix 4.5. shows the loads from January 1994. It was assumed that Newham and Ladock Valley STW's discharge at one dry weather flow. During the winter the computed loads show the riverine inputs dominate the STW discharge loads. This could explain why the model results (see Appendices 4.1. and 4.2.) showed limited impact, as they were swamped by the winter loads. In the summer the loadings from Newham begin to exceed river loads.

4.2.2. Conclusions

The TIN load from Newham STW will dominate over the river inputs in summer only. During the winter riverine inputs dominate the loading of TIN to the estuary.

5. GENERAL DISCUSSION

The *A.tamarense* bloom and PSP problem in summer 1995 highlighted the eutrophic state of the upper Fal Estuary. This resulted in the issue of a prohibition notice on the collection of shellfish. Nutrient data and modelling of the estuary have shown that under the prevalent conditions in summer 1995 Newham STW discharge is a significant source of the nutrients (principally TIN) to generate such a bloom. Even at E19B2 (the lowest site within the proposed sensitive area) Newham STW was contributing an estimated 30 to 40% of the TIN loading.

Algal densities through the summer of 1995 showed increasing phytoplankton abundance over benthic species. Chlorophyll a concentrations during the summer exceeded the 10 µg/l standard on most occasions at most sites. Even in winter only the upper estuary sites showed elevated chlorophyll a, principally in the vicinity of Newham STW discharge.

6. CONCLUSIONS

6.1. During sustained calm weather in the summer the upper Fal Estuary is prone to significant algal blooms, including *A.tamarense*.

6.2. The effect of *A.tamarense* blooms has been the manifestation of PSP.

6.3. Under the conditions necessary for bloom production Newham STW discharge is a major source of nutrients contributing up to 50% of the TIN loading.

6.4. The Upper Fal Estuary satisfactorily fulfills the criteria for nomination as a sensitive area (eutrophic) and therefore should be designated as such.

6.5. Nutrient stripping at Newham STW during the summer months would significantly decrease the TIN loading to the estuary and by that reduce eutrophication.

7. REFERENCES

1. Reid, P., Pratt, S. and Harbour D. 1995. A red tide event in the Fal Estuary, Cornwall, July 1995. SAHFOS.

2. Murdoch, N. September 1996. Truro-Tresillian water quality model.

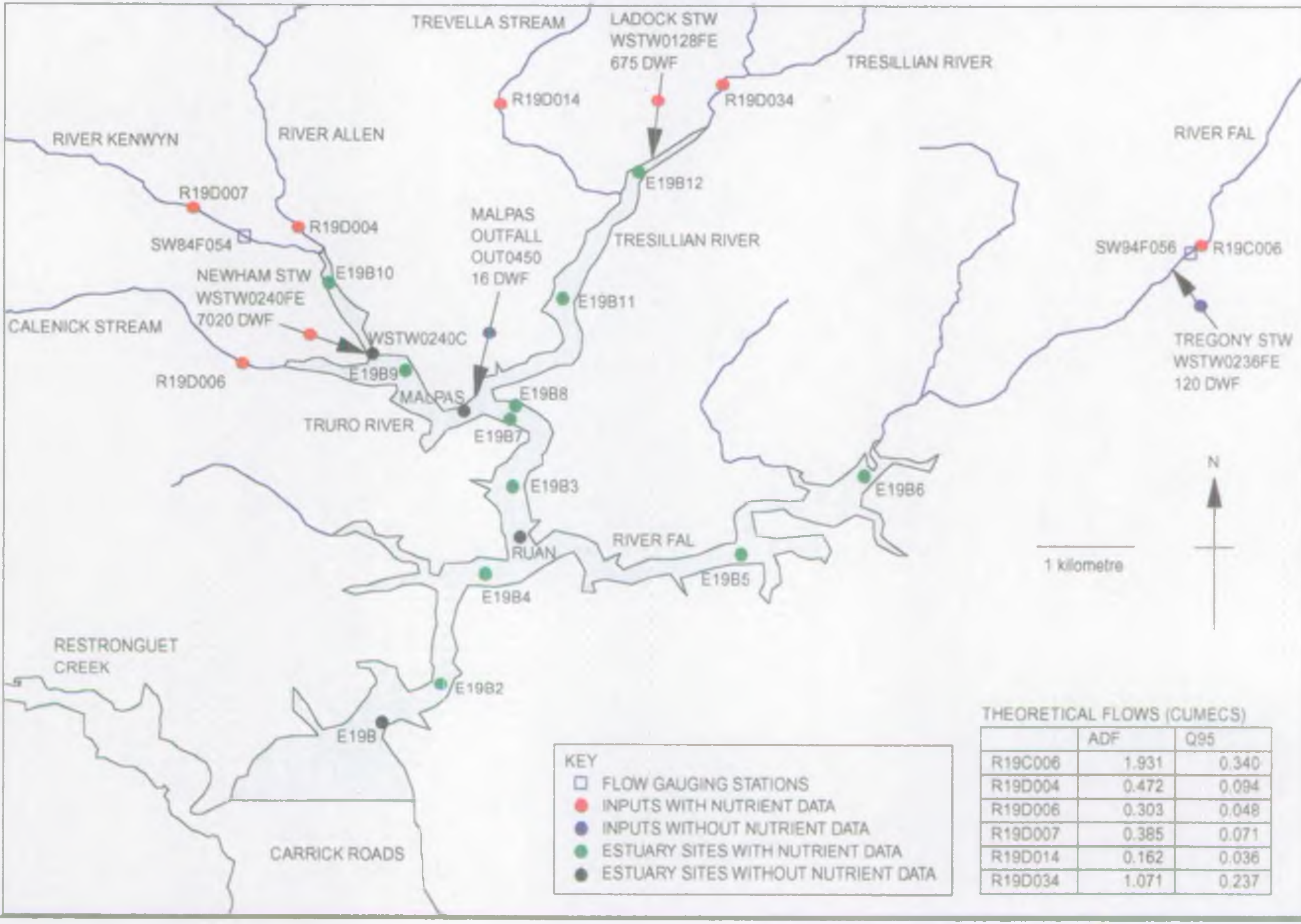
3. Murdoch, N. October 1996. Truro-Tresillian loads (brief note).

4. Murdoch, N. December 1996. Truro-Tresillian water quality model (summer simulations).

8. ACKNOWLEDGEMENTS

Simon Toms (Biologist) wrote the section on algae (section 2.2.). Neil Murdoch (Senior Modelling Officer) constructed the ECoS model and ran the scenarios (section 4.1.).

APPENDIX 1.1. PROPOSED UPPER FAL ESTUARY SENSITIVE AREA (SHADED AREA) SHOWING CURRENT MONITORING SITES



THEORETICAL FLOWS (CUMECS)

	ADF	Q95
R19C006	1.931	0.340
R19D004	0.472	0.094
R19D006	0.303	0.048
R19D007	0.385	0.071
R19D014	0.162	0.036
R19D034	1.071	0.237

Site notified to the Secretary of State on 29 March 1996

Appendix 1.2. Upper Fal Estuary site of special scientific interest (SSSI)

CITATION SHEET

COUNTY: **CORNWALL**

SITE NAME: **UPPER FAL ESTUARY AND WOODS**

DISTRICT: **CARRICK**

Status: Site of Special Scientific Interest (SSSI) notified under Section 28 of the Wildlife and Countryside Act 1981 (as amended)

Local Planning Authority: Cornwall County Council; Carrick District Council

National Grid Reference: SW850410

Area: 603.46 (ha) 1490.55 (ac)

Ordnance Survey Sheet 1:50,000:204

1:10,000:SW83NE, SW83NW
SW84SW, SW84SE
SW84NE, SW94SW

Date Notified (Under 1949 Act): 1968

Date of Last Revision:

Date Notified (Under 1981 Act): 1996

Date of Last Revision

Other Information: The site overlaps two Nature Conservation Review Sites and is mostly within the Cornwall Area of Outstanding Natural Beauty. The site boundary has been amended by extension and deletion.

Description and Reasons for Notification:

The Fal Estuary is a ria - a deeply incised river valley which has been 'drowned' by rising sea levels. The estuary, whose lower section is an important natural deep-water harbour, opens to the sea near Falmouth on the south coast of west Cornwall. The upper reaches which constitute this site are, for the most part, sediment-filled, with mudflats backed by low rocky cliffs. They are of major importance for the wintering wading birds and for the ancient semi-natural woodlands which clothe much of their banks.

Of particular importance and rarity are the relatively undisturbed transitions from tidal mud through saltmarsh and scrub to woodland at the upper limits of tidal influence. On a high proportion of estuaries, such transitions have been destroyed by drainage and subsequent agricultural activity or by development.

The mudflats within the site support nationally important numbers of Black-tailed Godwit (Limosa limosa) during autumn and winter. They are also important feeding grounds for large populations of a number of other wintering waders and wildfowl. In particular, the site supports Curlew (Numenius arquata), Dunlin (Calidris alpina), Shelduck (Tadorna tadorna), Redshank (Tringa totanus) and Golden Plover (Pluvialis apricaria). On the Tresillian River there are habitats which support Greenshank (Tringa nebularia), Spotted Redshank (Tringa erythropus), Little Grebe (Tachybaptus ruficollis) and Kingfisher (Alcedo atthis). Small but growing numbers of Little Egret (Egretta garzetta) now occur within the complex. The site is important for Grey Herons (Ardea cinerea) and there is a major heronry.

Saltmarsh communities have developed in a number of localities within the complex, most notably near the limit of tidal influence at Ruan Lanihorne and on the Tresillian River. In addition extensive beds of Common Reed (Phragmites australis) have developed in some places. Typically the saltmarshes in these upper reaches are characterised by Sea Club-rush (Scirpus maritimus) and Creeping Bent (Agrostis stolonifera), Common Saltmarsh-grass (Puccinellia maritima), Red Fescue (Festuca rubra) and Sea Rush (Juncus maritimus).

On the transitions from saltmarsh to woodland isolated young trees grow over the upper marsh and eventually, despite the area being subjected to flooding with brackish water on extreme tides, more extensive scrub invades and extends across the entire alluvial valley floor. Alder (Alnus glutinosa) is the major component of these woodlands, forming a closed canopy of well grown, characteristically multi-stemmed trees at a height of around 15 metres. In places Willow (Salix spp) forms a boundary against mature oak woodland.

This transition zone supports over 100 species of flowering plants and ferns, many not normally associated with maritime situations. These include Greater Tussock-sedge (Carex paniculata), Hemlock Water-dropwort (Oenanthe crocata), Lesser Pond-sedge (Carex acutiformis), Yellow Iris (Iris pseudocorus), Common Nettle (Urtica dioica), Hemp-agrimony (Eupatorium cannabinum) and Meadowsweet (Filipendula ulmaria). On the drier areas on the estuary sides there is a transition to oak dominated woodland.

The upper estuaries and these transitional zones are important for Otters (Lutra lutra).

Extensive stands of ancient semi-natural woodland occur within the site and on the eastern shores these are virtually continuous. They lie on steep slopes rising to 80m and upon soils which are acidic and generally free draining.

Sessile Oak (Quercus petraea) is generally the dominant tree of these valley side woodlands, although there are variations, notably on damp valley floors where Sessile Oak with Ash (Fraxinus excelsior) and Hazel (Corylus avellana) occurs and on well-drained slopes, where Silver Birch (Betula pendula) - Sessile Oak woodland is present. Pedunculate Oak (Quercus robur) also occurs within these woodlands and hybridisation between the two oak species is thought to have taken place.

Much of the oak woodland was coppiced between 40 and 90 years ago resulting in even-aged stands with a closed canopy though in inaccessible valleys areas of standard trees occur.

Two types of ground flora are widespread within the woodland:

A Bramble (Rubus fruticosus) dominated community with Honeysuckle (Lonicera periclymenum), Bluebell (Endymion non-scriptus), Dryopteris ferns and Creeping Soft-grass (Holcus mollis) occurs typically on the higher, gentler slopes which permit good soil-depth and fertility. Closer to the estuary a Bilberry (Vaccinium myrtillus), Greater Woodrush (Luzula sylvatica), Hard Fern (Blechnum spicant) community is more common. Heather (Calluna vulgaris) is frequently abundant where the lower slopes give way to low rocky cliffs. A number of notable plants are found within the woodlands including the nationally rare Wild Leek (Allium ampeloprasum) and the nationally scarce Bastard Balm (Melittis melissophyllum). Other species of note are Wild Madder (Rubia peregrina), Imperforate St. John's-wort (Hypericum maculatum), Greater Burdock (Arctium lappa) and Hard Rush (Juncus inflexus). Spindle (Euonymus europaeus), Alder Buckthorn (Frangula alnus) and Cornish Elm (Ulmus cornubiensis) occur within the underwood.

A number of mosses and liverworts typical of ancient woods in the southwest occur including Rhytidiadelphus triquetrus, Thuidium tamariscinum, Polytrichum commune and Isothecium myosuroides. The fern flora includes Common Polypody (Polypodium vulgare), Hart's Tongue Fern (Asplenium scolopendrium), Golden Male Fern (Dryopteris affinis) and an abundance of Soft Shield Fern (Polystichum setiferum). Despite the dense shade of the canopy, and the comparative youth of the coppiced stems, the trees support a range of epiphytic lichens including two nationally scarce species Opegrapha corticola and Schismatomma niveum which are found on old oak bark.

The invertebrate fauna of these woodlands is also rich. Particularly notable species include the ground-living spider Hahnia helveola and the beetle Rhizophagus nitidulus, a species confined to ancient woodlands.

The site is also of high marine interest. On the extensive area of coarse intertidal sediment at Turnaware Point, a number of interesting communities have developed largely associated with beds of Seagrass Zostera marina. A rich algal flora includes Cladosiphon zosterae, Gracilaria verrucosa and Chorda filum. Further communities of particular interest occur at Tom's Rock within the King Harry Reaches where the steep rocky shores are dominated by Ascophyllum nodosum. On the lower shores a particularly luxuriant growth of sponges has developed which includes Hymeniacidon perleve and Halichondria panicea.

Site notified to the Secretary of State on 29 March 1996

SITE NAME: UPPER FAL ESTUARY AND WOODS

COUNTY: CORNWALL

OPERATIONS LIKELY TO DAMAGE THE FEATURES OF SPECIAL INTEREST

Standard Ref No.	Type of Operation
1	Cultivation, including ploughing, rotovating, harrowing, and re-seeding.
2	The introduction of grazing and changes in the grazing regime (including type of stock or intensity or seasonal pattern of grazing and cessation of grazing).
3	The introduction of or changes in stock feeding practice.
4	The introduction of mowing and changes in the mowing or cutting regime.
5	Application of manure, fertilisers and lime.
6	Application of pesticides, including herbicides (weedkillers).
7	Dumping, spreading or discharge of any materials.
8	Burning.
9	The release into the site of any wild, feral or domestic animal*, plant or seed.
10	The killing or removal of any wild animal*, including pest control.
11	The destruction, displacement, removal or cutting of any plant or plant remains, including tree, shrub, herb, hedge, dead or decaying wood, moss, lichen, fungus, leaf-mould and turf etc.
12	The introduction of tree and/or woodland management and changes in tree and/or woodland management (Including afforestation, planting, clear and selective felling, thinning, coppicing, modification of the stand or underwood, changes in species composition).
13a	Drainage (including use of mole, tile, tunnel or artificial drains).
13b	Modification of the structure of water courses (eg. rivers, streams, springs, drains), including their banks and beds, as by re-alignment, re-grading and dredging.
13c	Management of aquatic and bank vegetation for drainage purposes.

14 The changing of water levels and tables and water utilisation (including irrigation, storage and abstraction from existing water bodies and through boreholes).

15 Infilling of ditches, drains, ponds, pools, marshes or pits.

16a The introduction of freshwater fishery production and/or management*, and changes in freshwater fishery production and/or management*. *including sporting fishing and angling.

16b The introduction of coastal fishing and changes in coastal fishing practice or fisheries management and seafood or marine life collection*

17 Reclamation of land from sea, estuary or marsh.

18 Bait digging in intertidal areas.

19 Erection of sea defences or coast protection works, including cliff or landslip drainage or stabilisation measures.

20 Extraction of minerals, including sand and gravel, topsoil, sub-soil and spoil.

21 Construction , removal or destruction of roads, tracks, walls, fences, hardstands, banks, ditches or other earthworks, or the laying, maintenance or removal of pipelines and cables, above or below ground.

22 Storage of materials.

23 Erection of permanent or temporary structures, or the undertaking of engineering works, including drilling.

24 Modification of natural or man-made features including clearance of boulders, large stones, loose rock or scree and battering, buttressing or grading rock-faces and cuttings, infilling of pits and quarries.

26 Use of vehicles or craft likely to damage or disturb features of interest.

27 Recreational or other activities likely to damage features of interest.

28 Introduction of game and waterfowl management and changes in game and waterfowl management and hunting practices.

* "animal" includes any mammal, amphibian, bird, fish or invertebrate.

Appendix 2.1. Total inorganic nitrogen (mg/l) summary statistics (January 1994 to August 1996)

SAMPLE POINT	SAMPLES TAKEN	MEAN	SD	MAX	MIN
ALL SAMPLES					
E19B2	59	0.82	0.96	4.11	0.11
E19B4	60	1.04	1.19	5.29	0.11
E19B5	42	1.58	1.69	7.36.	0.11
E19B6	35	2.35	2.05	7.55	0.23
E19B3	59	1.06	1.16	5.18	0.11
E19B7	98	1.49	1.68	6.54	0.11
E19B8	97	1.47	1.71	6.89	0.11
E19B9	80	3.12	2.62	11.10	0.12
E19B10	81	5.07	1.49	8.04	0.57
E19B11	80	3.55	2.97	9.76	0.12
E19B12	57	6.32	2.68	15.13	0.48
ALL SURFACE SAMPLES					
E19B2	27	1.14	1.27	4.11	0.11
E19B4	28	1.47	1.56	5.29	0.11
E19B5	27	1.98	1.89	7.36	0.11
E19B6	25	2.63	2.12	7.55	0.23
E19B3	27	1.52	1.46	5.18	0.11
E19B7	56	1.99	1.96	6.54	0.11
E19B8	57	1.92	1.99	6.89	0.11
E19B9	79	3.13	2.63	11.10	0.12
E19B10	78	5.07	1.50	8.04	0.57
E19B11	79	3.59	2.96	9.76	0.12
E19B12	57	6.32	2.68	15.13	0.48
SURFACE SAMPLES (WINTER SEASON)					
E19B2	8	2.98	0.58	4.11	2.40
E19B4	8	3.65	1.03	5.29	1.89
E19B5	8	3.82	1.97	7.36	0.85
E19B6	7	4.87	1.95	7.55	1.41
E19B3	7	3.59	1.11	5.18	1.60
E19B7	24	3.54	1.93	6.54	0.82
E19B8	23	3.64	1.97	6.89	0.78
E19B9	33	4.63	2.02	8.03	1.14
E19B10	32	6.17	0.98	8.04	4.29
E19B11	35	5.81	2.57	9.76	1.27
E19B12	24	7.24	1.09	8.86	5.29
SURFACE SAMPLES (SUMMER SEASON)					
E19B2	6	0.20	0.09	0.37	0.11
E19B4	6	0.29	0.17	0.61	0.11
E19B5	5	0.77	0.55	1.50	0.11
E19B6	5	1.70	1.29	3.94	0.29
E19B3	6	0.37	0.22	0.77	0.11
E19B7	19	0.41	0.33	1.48	0.11
E19B8	19	0.36	0.30	1.32	0.11
E19B9	31	1.94	2.81	11.10	0.12
E19B10	31	4.10	1.05	6.20	1.95
E19B11	30	1.36	1.43	6.02	0.12
E19B12	19	5.78	3.39	15.13	0.48
ALL DEPTH SAMPLES					
E19B2	32	0.55	0.42	1.77	0.13
E19B4	32	0.66	0.47	2.09	0.17
E19B5	15	0.85	0.88	3.85	0.28
E19B6	10	1.64	1.67	4.92	0.33
E19B3	32	0.67	0.61	3.27	0.23
E19B7	42	0.82	0.83	3.60	0.13
E19B8	40	0.81	0.83	4.03	0.12
E19B9	1	2.14	0.00	2.14	2.14
E19B10	1	4.87	0.00	4.87	4.87
DEPTH SAMPLES (WINTER SEASON)					
E19B2	8	0.87	0.32	1.49	0.56
E19B4	8	1.02	0.42	1.81	0.59
E19B5	3	2.29	1.56	3.85	0.72
E19B6	2	4.72	0.19	4.92	4.53
E19B3	9	1.13	0.88	3.27	0.48
E19B7	19	1.36	0.97	3.60	0.52
E19B8	17	1.34	0.99	4.03	0.56
E19B9	1	2.14	0.00	2.14	2.14
E19B10	1	4.87	0.00	4.87	4.87
DEPTH SAMPLES (SUMMER SEASON)					
E19B2	8	0.22	0.07	0.34	0.13
E19B4	8	0.29	0.10	0.48	0.17
E19B5	3	2.29	1.56	3.85	0.72
E19B6	3	0.51	0.25	0.86	0.33
E19B3	8	0.33	0.11	0.50	0.23
E19B7	14	0.24	0.11	0.43	0.13
E19B8	14	0.25	0.14	0.52	0.12

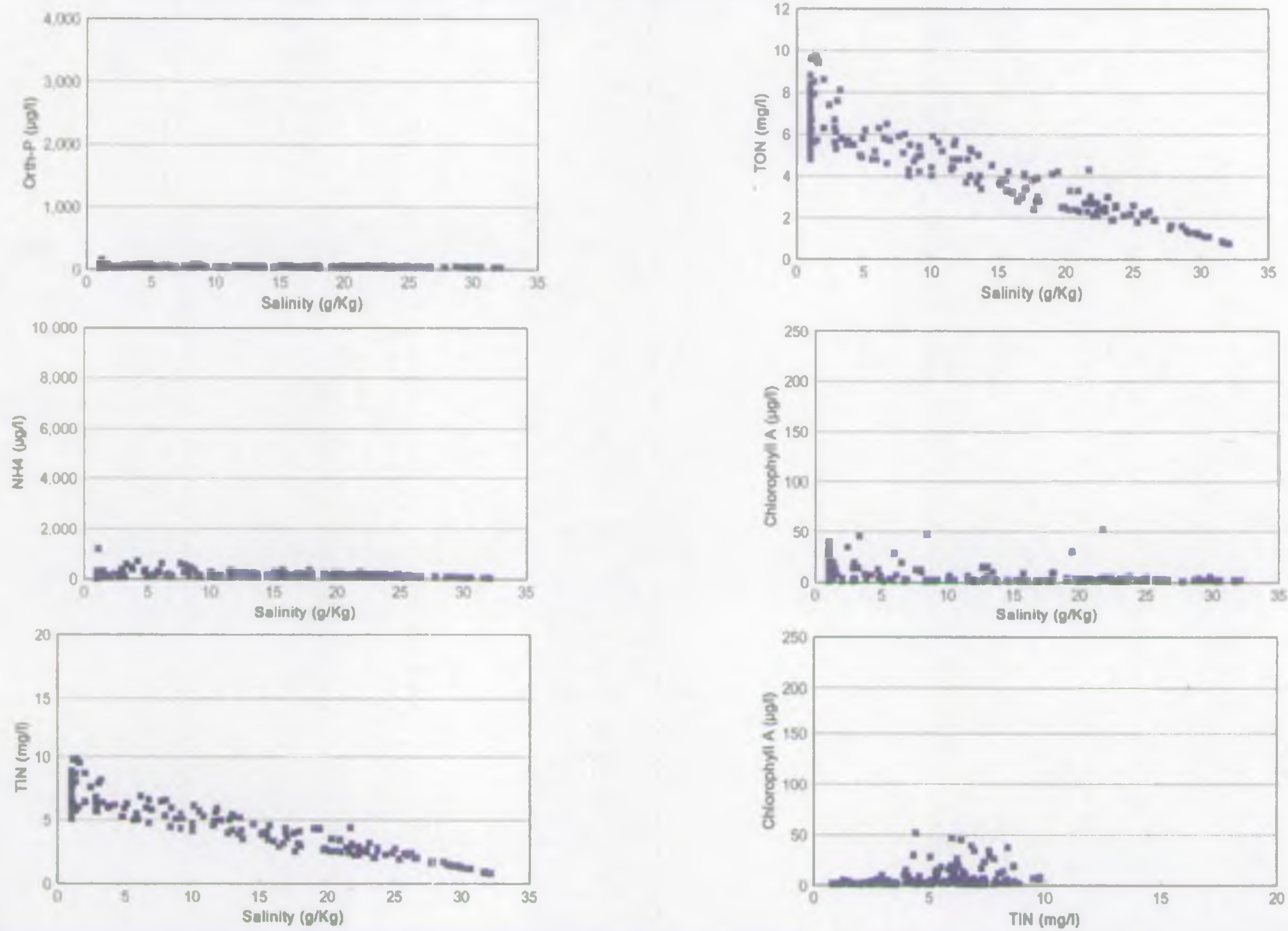
Appendix 2.2. Orthophosphate (µg/l) summary statistics (January 1994 to August 1996)

SAMPLE POINT	SAMPLES TAKEN	MEAN	SD	MAX	MIN
ALL SAMPLES					
E19B2	59	21.71	6.51	40	10
E19B4	60	24.38	7.86	47	10
E19B5	42	28.64	14.49	92	10
E19B6	35	32.26	15.91	87	10
E19B3	59	29.42	10.77	63	10
E19B7	98	32.73	17.15	91	10
E19B8	96	28.20	11.59	68	10
E19B9	80	157.44	383.74	2136	15
E19B10	79	114.35	111.61	528	18
E19B11	80	51.00	45.29	377	17
E19B12	57	288.61	708.87	3796	18
ALL SURFACE SAMPLES					
E19B2	27	22.59	8.07	40	10
E19B4	28	25.36	8.76	47	10
E19B5	27	28.44	12.55	71	10
E19B6	25	34.36	17.97	87	10
E19B3	27	33.67	12.81	63	10
E19B7	56	37.63	18.52	91	10
E19B8	57	31.00	12.53	68	10
E19B9	79	158.96	385.92	2136	15
E19B10	78	115.30	112.01	528	18
E19B11	79	51.41	45.43	377	17
E19B12	57	288.61	708.87	3796	18
SURFACE SAMPLES (WINTER SEASON)					
E19B2	8	29.75	1.71	32	27
E19B4	8	30.75	3.03	35	25
E19B5	8	26.50	4.30	32	19
E19B6	7	25.43	4.81	34	19
E19B3	7	40.71	6.84	52	31
E19B7	24	35.89	9.03	66	24
E19B8	23	34.48	7.00	50	23
E19B9	33	39.24	11.44	72	20
E19B10	32	45.38	28.46	157	18
E19B11	35	38.66	5.84	57	31
E19B12	24	35.54	6.70	49	18
SURFACE SAMPLES (SUMMER SEASON)					
E19B2	6	14.00	1.83	17	12
E19B4	6	18.00	3.96	24	14
E19B5	5	33.80	19.67	71	18
E19B6	5	53.40	23.38	87	21
E19B3	6	21.00	5.32	29	15
E19B7	19	33.84	23.33	91	10
E19B8	19	21.79	8.93	42	10
E19B9	31	329.10	574.58	2136	15
E19B10	31	205.10	121.05	528	61
E19B11	30	65.33	68.39	377	18
E19B12	19	707.42	1096.18	3796	33
ALL DEPTH SAMPLES					
E19B2	32	20.97	4.70	30	12
E19B4	32	23.53	6.87	41	13
E19B5	15	29.00	17.44	92	16
E19B6	10	27.00	6.31	40	19
E19B3	32	25.84	6.88	46	14
E19B7	42	26.19	12.43	80	10
E19B8	39	24.10	8.54	46	10
E19B9	1	37.00	0.00	37	37
E19B10	1	41.00	0.00	41	41
DEPTH SAMPLES (WINTER SEASON)					
E19B2	8	24.63	1.22	27	23
E19B4	8	26.63	2.90	32	24
E19B5	3	29.00	4.00	33	25
E19B6	6	22.50	1.50	24	21
E19B3	9	28.44	4.57	37	24
E19B7	19	28.68	7.63	49	20
E19B8	17	27.29	6.30	44	19
E19B9	1	37.00	0.00	37	37
E19B10	1	41.00	0.00	41	41
DEPTH SAMPLES (SUMMER SEASON)					
E19B2	8	14.88	1.90	18	12
E19B4	8	15.50	2.74	21	13
E19B5	2	29.00	4.00	33	25
E19B6	3	22.33	4.03	28	19
E19B3	8	19.13	4.28	27	14
E19B7	14	17.14	7.35	35	10
E19B8	14	17.00	6.60	35	10

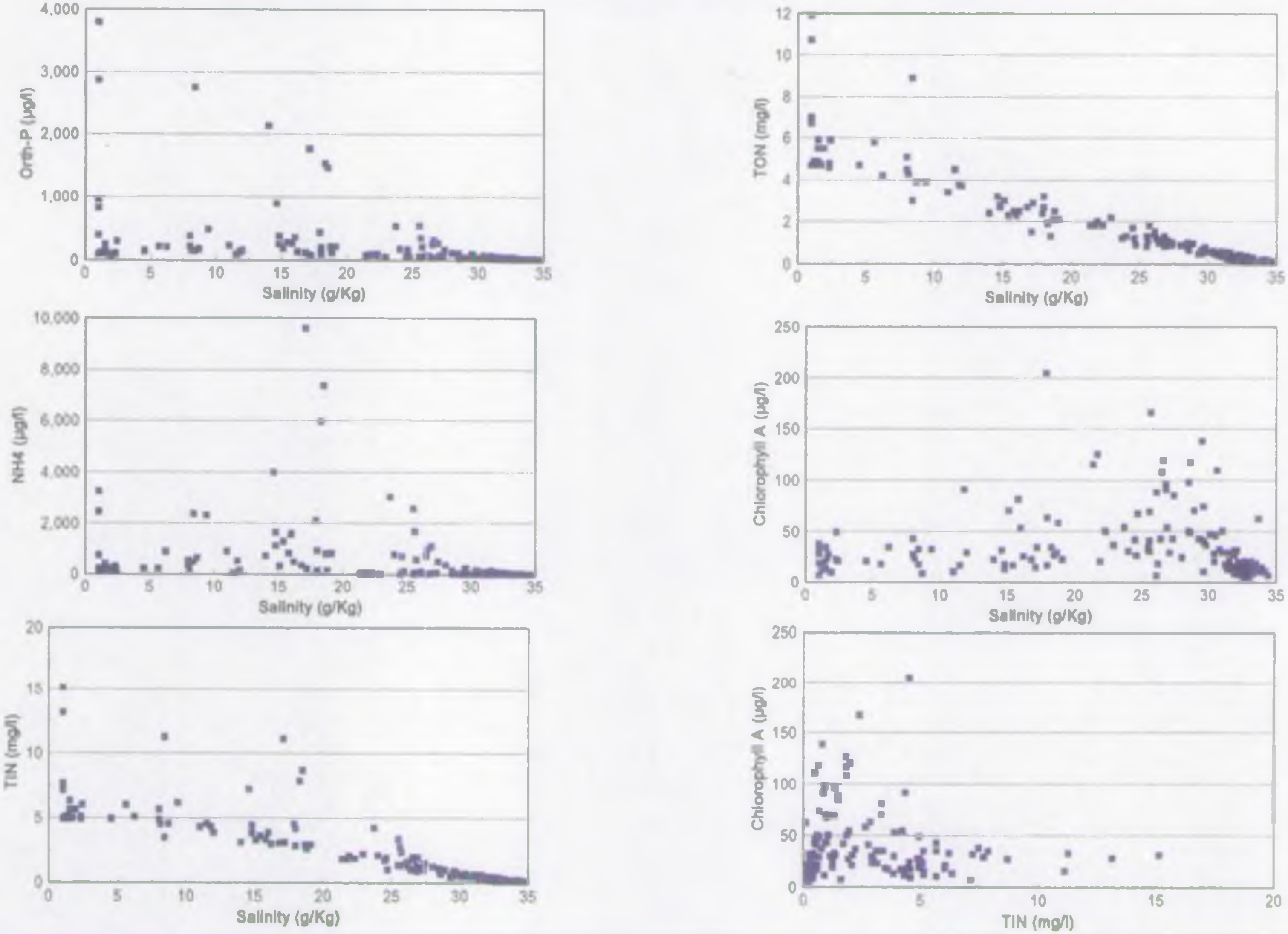
Appendix 2.3. Chlorophyll-a (µg/l) summary statistics (January 1994 to August 1996)

SAMPLE POINT	SAMPLES TAKEN	MEAN	SD	MAX	MIN	No. OF SAMPLES EXEEDING DoE CRITERIA	% OF SAMPLES EXCEEDING DoE CRITERIA
ALL SAMPLES							
E19B2	48	3.46	4.29	17	1	6	13
E19B4	48	4.48	5.75	23	1	8	17
E19B5	30	3.87	5.18	23	1	3	10
E19B6	23	3.17	4.00	21	1	1	4
E19B3	47	6.17	9.21	37	1	10	21
E19B7	111	12.51	20.58	138	1	43	39
E19B8	110	11.88	17.22	118	1	42	38
E19B9	96	16.51	19.21	108	1	45	47
E19B10	96	19.92	31.12	205	1	51	53
E19B11	96	20.66	23.25	126	1	52	54
E19B12	71	15.54	16.23	70	1	32	45
ALL SURFACE SAMPLES							
E19B2	16	3.75	4.58	15	1	3	19
E19B4	16	4.94	6.62	21	1	3	19
E19B5	15	2.73	2.49	11	1	1	7
E19B6	13	3.54	5.12	21	1	1	8
E19B3	16	7.13	11.01	37	1	4	25
E19B7	55	16.64	27.49	138	1	24	44
E19B8	57	14.74	21.98	118	1	24	42
E19B9	79	17.14	20.61	108	1	38	48
E19B10	79	20.43	33.91	205	1	38	48
E19B11	79	20.97	24.69	126	1	39	49
E19B12	57	14.30	16.59	70	1	22	39
SURFACE SAMPLES (WINTER SEASON)							
E19B2	4	1.00	0.00	1	1	0	0
E19B4	4	1.25	0.43	2	1	0	0
E19B5	4	2.00	1.22	4	1	0	0
E19B6	3	1.67	0.47	2	1	0	0
E19B3	4	1.50	0.50	2	1	0	0
E19B7	24	5.04	9.25	47	1	2	8
E19B8	23	4.09	4.02	19	1	2	9
E19B9	33	9.55	10.17	45	1	10	30
E19B10	32	4.97	4.46	18	1	4	13
E19B11	35	11.20	12.55	52	1	11	31
E19B12	24	4.67	7.32	37	1	2	8
SURFACE SAMPLES (SUMMER SEASON)							
E19B2	4	11.25	2.86	15	7	3	75
E19B4	4	15.75	4.32	21	9	3	75
E19B5	3	6.33	3.30	11	4	1	33
E19B6	3	9.33	8.26	21	3	1	33
E19B3	4	23.50	11.19	37	11	4	100
E19B7	19	38.33	37.85	138	11	18	95
E19B8	19	32.84	28.99	188	10	18	95
E19B9	31	29.42	26.45	108	5	23	74
E19B10	31	42.97	45.27	205	9	29	94
E19B11	30	35.97	30.89	126	5	23	77
E19B12	19	30.79	16.41	70	7	17	89
ALL DEPTH SAMPLES							
E19B2	32	3.31	4.13	17	1	3	9
E19B4	32	4.25	5.24	23	1	5	16
E19B5	15	5.00	6.69	23	1	2	13
E19B6	10	2.70	1.49	6	1	0	0
E19B3	31	5.68	8.08	34	1	6	19
E19B7	42	7.41	8.18	33	1	12	29
E19B8	39	7.82	9.20	31	1	11	28
E19B9	1	5.00	0.00	5	5	0	0
E19B10	1	3.00	0.00	3	3	0	0
DEPTH SAMPLES (WINTER SEASON)							
E19B2	8	1.00	0.00	1	1	0	0
E19B4	8	1.00	0.00	1	1	0	0
E19B5	3	1.00	0.00	1	1	0	0
E19B6	2	2.00	0.00	2	2	0	0
E19B3	8	1.50	0.50	2	1	0	0
E19B7	19	2.42	1.43	7	1	0	0
E19B8	17	2.24	1.26	6	1	0	0
E19B9	1	5.00	0.00	5	5	0	0
E19B10	1	3.00	0.00	3	3	0	0
DEPTH SAMPLES (SUMMER SEASON)							
E19B2	8	9.13	4.68	17	4	3	38
E19B4	8	12.13	4.78	23	6	5	63
E19B5	2	1.00	0.00	1	1	0	0
E19B6	3	3.33	1.25	5	2	0	0
E19B3	8	17.25	8.42	34	7	6	75
E19B7	14	17.29	7.04	33	10	12	86
E19B8	14	18.21	8.05	31	8	11	79

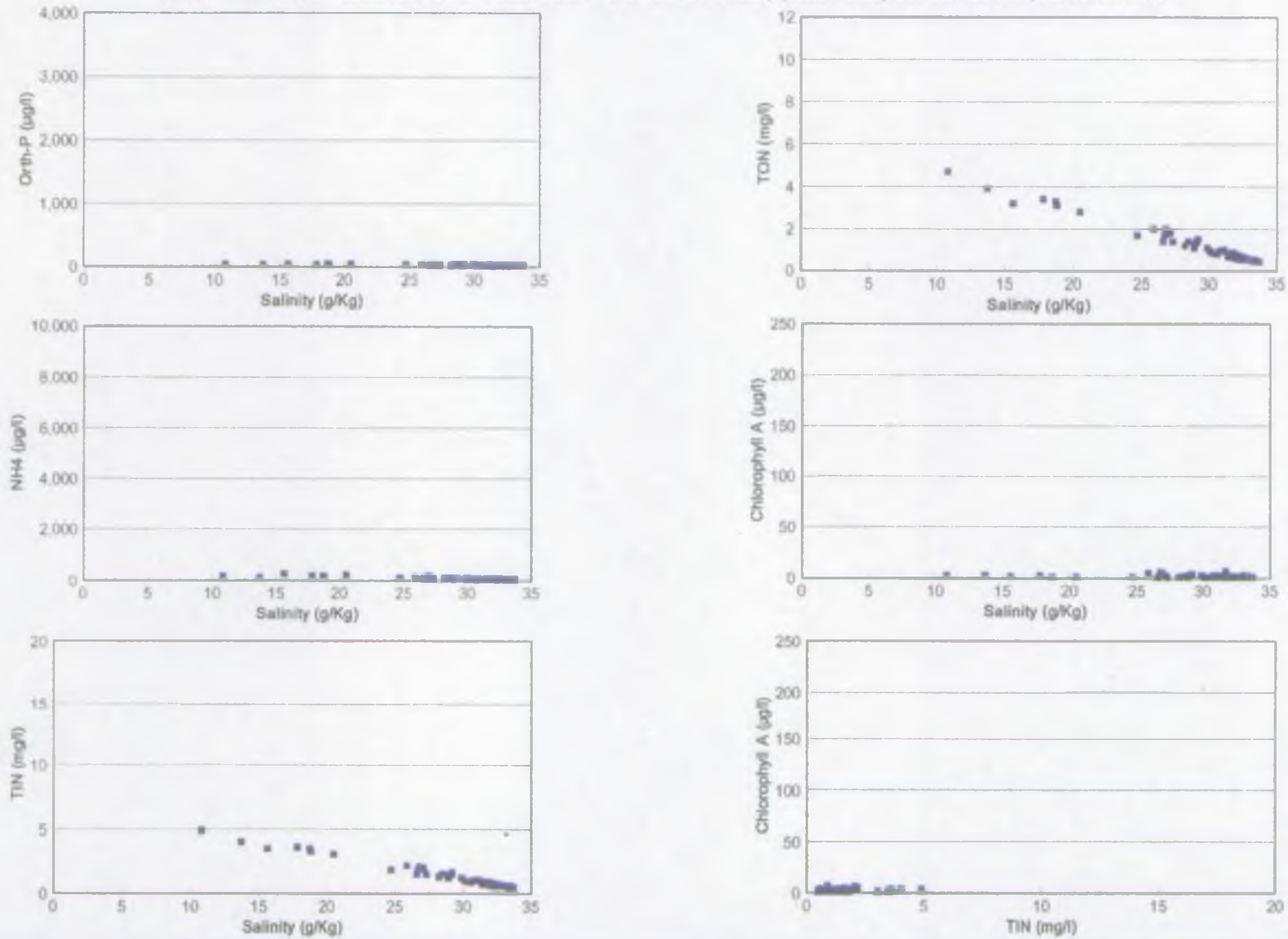
Appendix 2.4. Upper Fal Estuary Water Quality Data - December to February (1994 - 1996). Surface Samples For All Sites.



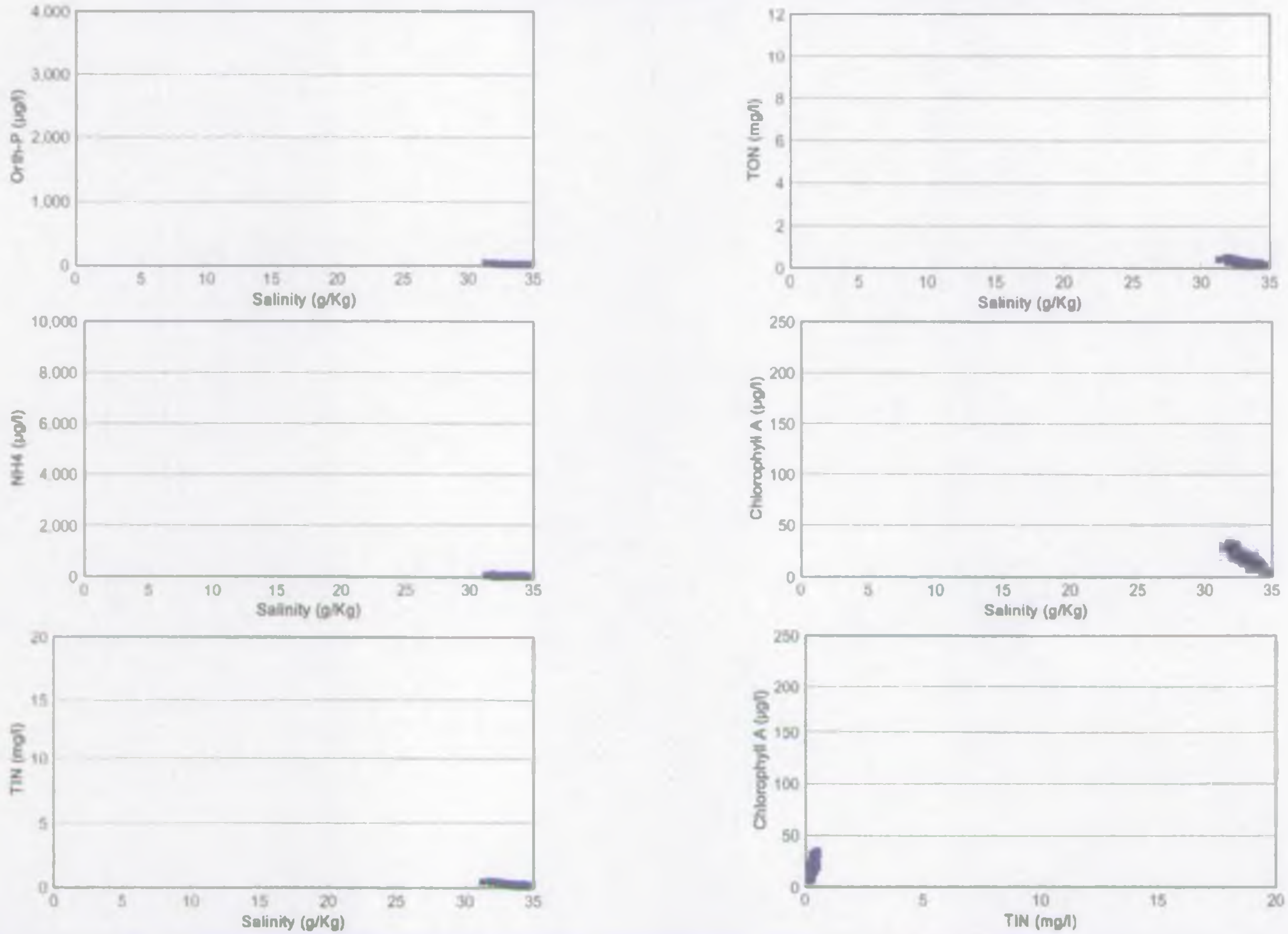
Appendix 2.5. Upper Fal Estuary Water Quality Data - June to August (1994 - 1996). Surface Samples For All Sites.



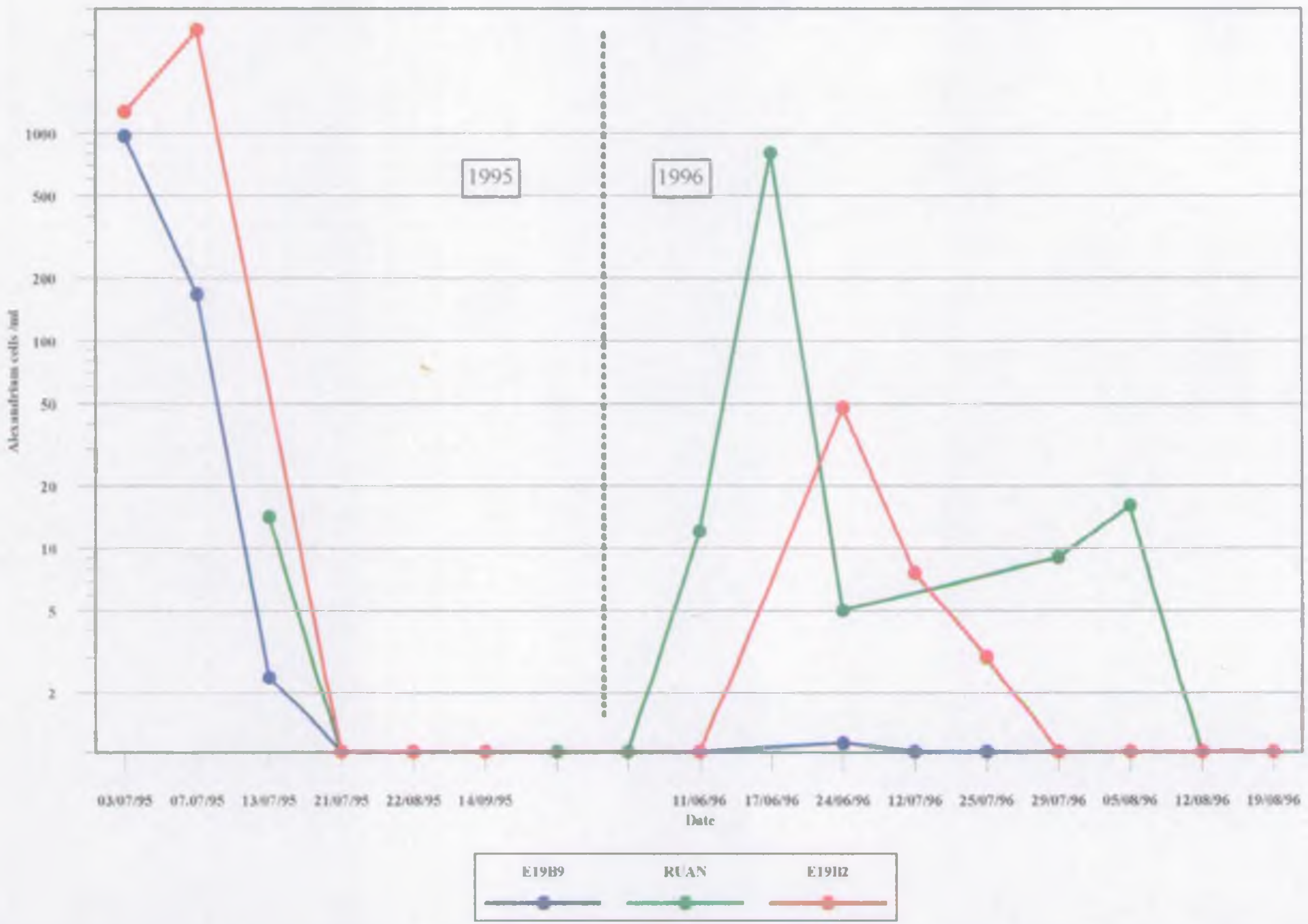
Appendix 2.6. Upper Fal Estuary Water Quality Data - December to February (1994 - 1996) Sub-surface Samples For All Sites.



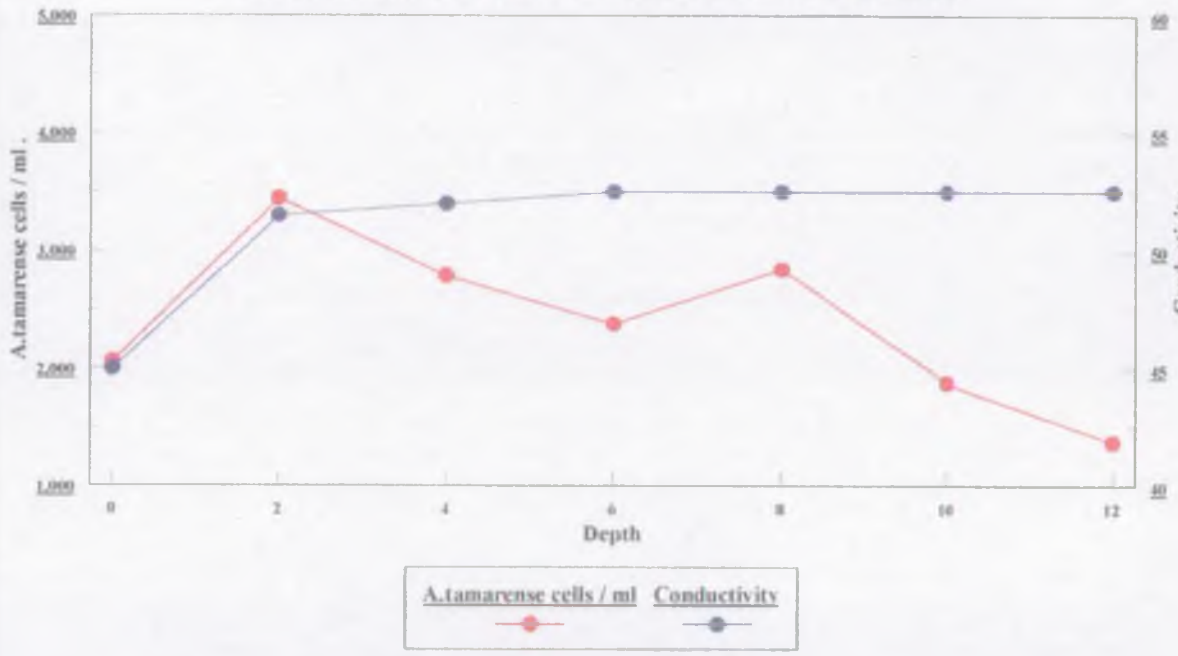
Appendix 2.7. Upper Fal Estuary Water Quality Data - June to August (1994 - 1996). Sub-surface Samples For All Sites.



Appendix 2.9. Alexandrium cell count data for 3 sites situated in the upper Fal estuary .

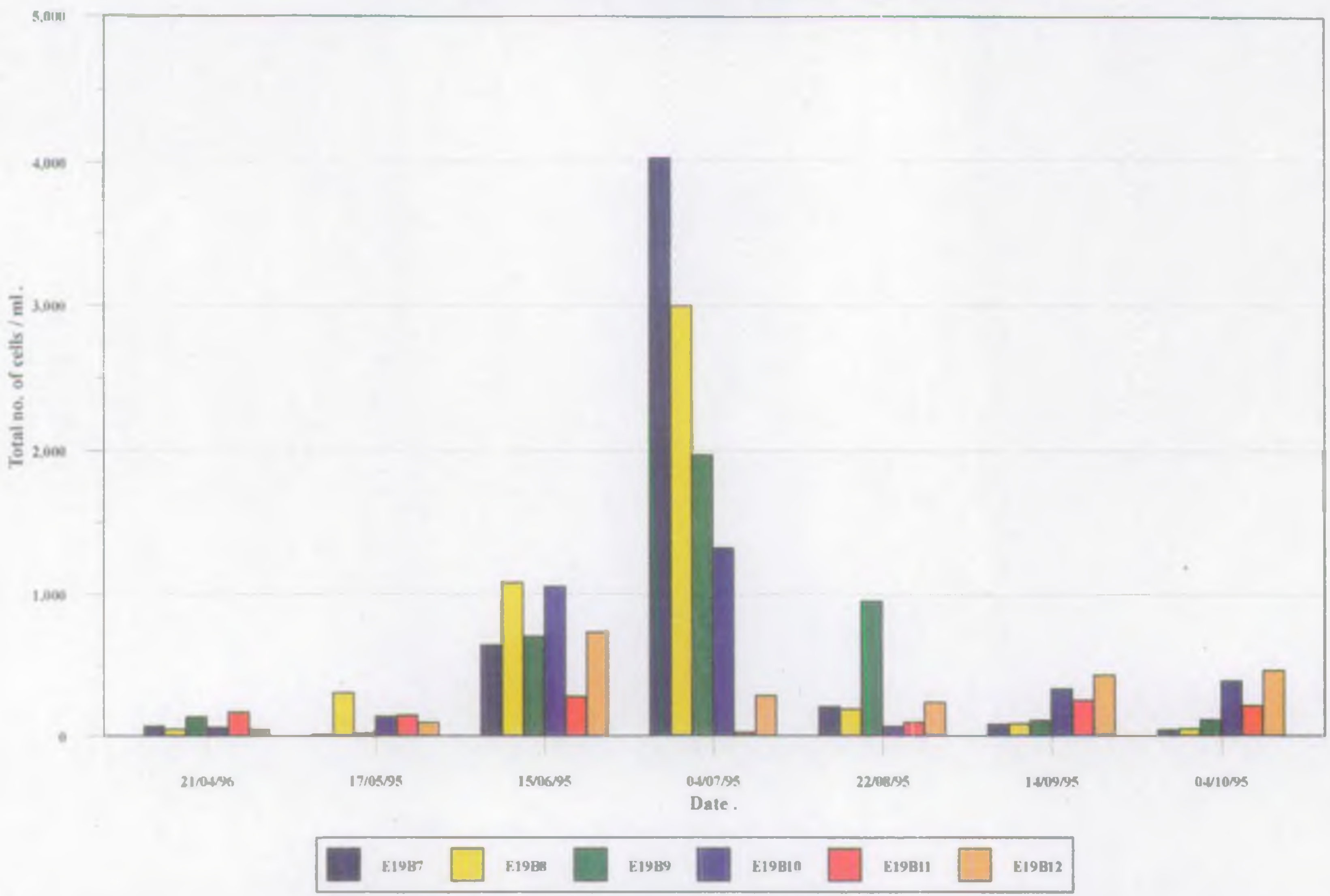


Appendix 2.10. A graph showing the relationship between A.tamarense and conductivity at the Truro /Fal confluence on 07/07/95.



Appendix 2.11. A graph showing the relationship between A.tamarense and conductivity at the Truro /Fal confluence on 24/06/96.

Appendix 2.12. A graph showing total phytoplankton biomass (combined high and low water) for each of the 6 sites sampled for the UWWTD in 1995 .



Appendix 2.13. Algal species succession at E19B9 at the confluence of the Truro and Tresilian rivers (cells per ml).

	Navicula	Skeletonema	Alexamdrium	Nitzshia	Peridinium	Melosira
21/04/95	6	0	0	2	1	103
17/05/95	6	1	1	1	1	1
15/06/95	21	430	1	1	4	1
03/07/95			965		1	1
04/07/95	10	1	1	1,873	51	1
07/07/95			167			
13/07/95			2			
21/07/95		4,134				
22/08/95	34	6	1	483	1	390
14/09/95	38	11	1	11	3	2
04/10/95	44	1	1	1	8	1
12/06/96	21		1	1	1	
24/06/96	1	9	1	130		1
12/07/96	1	483		610	1	1
15/07/96	1		1	14,400	1	1
25/07/96	0	129	1	262	1	1

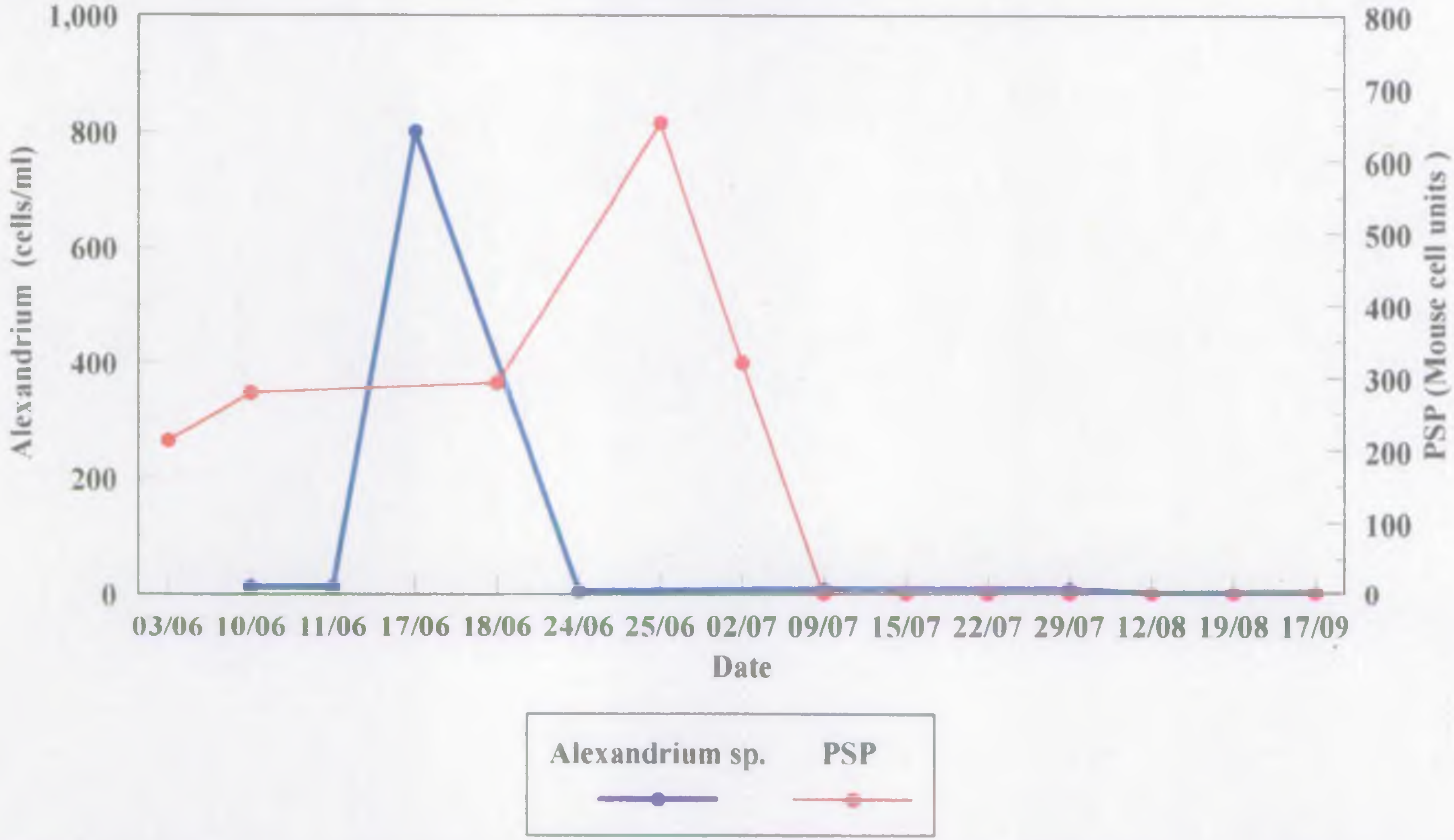
Appendix 3.1. Paralytic shellfish poison (PSP) results for the upper Fal Estuary

DATE SAMPLED	SITE	SPECIES	PSP (Mouse units)
1995			
06/07/95	MALPAS	MUSSEL	559
06/07/95	RUAN PONTOON	MUSSEL	906
13/07/95	RUAN PONTOON	MUSSEL	805
13/07/95	MALPAS	MUSSEL	< 200
18/07/95	NEWHAM STW	SHORE CRAB	693
25/07/95	MALPAS	MUSSEL	< 200
25/07/95	RUAN PONTOON	MUSSEL	< 200
27/07/95	NEWHAM STW	SHORE CRAB	< 200
27/07/95	RUAN PONTOON	SHORE CRAB	< 200
02/08/95	RUAN PONTOON	MUSSEL	< 200
08/08/95	RUAN PONTOON	MUSSEL	< 200
15/08/95	NEWHAM STW	SHORE CRAB	250
22/08/95	NEWHAM STW	SHORE CRAB	< 200
29/08/95	NEWHAM STW	SHORE CRAB	< 200
1996			
03/06/96	RUAN PONTOON	MUSSELS	212
10/06/96	RUAN PONTOON	MUSSELS	278
18/06/96	RUAN PONTOON	MUSSELS	292
25/06/96	RUAN PONTOON	MUSSELS	652
02/07/96	RUAN PONTOON	MUSSELS	320
09/07/96	RUAN PONTOON	MUSSELS	< 200
15/07/96	RUAN PONTOON	MUSSELS	< 200
22/07/96	RUAN PONTOON	MUSSELS	< 200
29/07/96	RUAN PONTOON	MUSSELS	< 200
08/08/96	NEWHAM STW	SHORE CRAB	226
12/08/96	RUAN PONTOON	MUSSELS	< 200
19/08/96	RUAN PONTOON	MUSSELS	< 200
17/09/96	RUAN PONTOON	MUSSELS	< 200
08/08/96	NEWHAM STW	SHORE CRAB	226
10/07/96	NEWHAM STW	SHORE CRAB	< 200

Appendix 3.2. Alexandrium tamarense cell counts

DATE SAMPLED	SITE	Alexandrium spp. (Cells / ml)
1995		
03/07/95	E19B9	965.0
03/07/95	E19B2	1261.0
07/07/95	E19B9	167.0
07/07/95	E19B2	3131.0
13/07/95	E19B9	2.4
13/07/95	RUAN PONTOON	14.1
1996		
11/06/96	RUAN PONTOON	12.0
17/06/96	RUAN PONTOON	800.0
24/06/96	E19B9	1.1
24/06/96	E19B2	47.5
24/06/96	RUAN PONTOON	5.0
12/07/96	E19B9	0.0
12/07/96	E19B2	7.6
25/07/96	E19B9	0.0
25/07/96	E19B2	2.0
29/07/96	RUAN PONTOON	9.0
05/08/96	RUAN PONTOON	16.0
12/08/96	RUAN PONTOON	0.0
19/08/96	RUAN PONTOON	0.0
09/09/96	RUAN PONTOON	0.0
17/09/96	RUAN PONTOON	0.0
30/09/96	RUAN PONTOON	0.0

Appendix 3.3. A graph showing how PSP data responded to increasing and decreasing Alexandrium spp. cell counts during 1996 at Ruan on the Fal estuary.



Appendix 3.4. Prohibition notice

FALMOUTH & TRURO PORT HEALTH AUTHORITY
THE DOCKS, FALMOUTH, CORNWALL. TR11 4NR.
Telephone: 01326 211581 Fax: 01326 211548 Mobile: 0831 623 237/8

The Falmouth & Truro Port Health Authority as the riparian Local Authority for the Fal Estuary have been advised by the Department of Health and The Ministry of Agriculture, Fisheries and Food to post the following warning.

WARNING

NATURALLY OCCURRING ALGAL POISON

Mussels, Cockles and Oysters taken from this area between 1st April and 31st August may be contaminated and should not be eaten. For further information contact the FALMOUTH AND TRURO PORT HEALTH AUTHORITY on (01326) 211581.

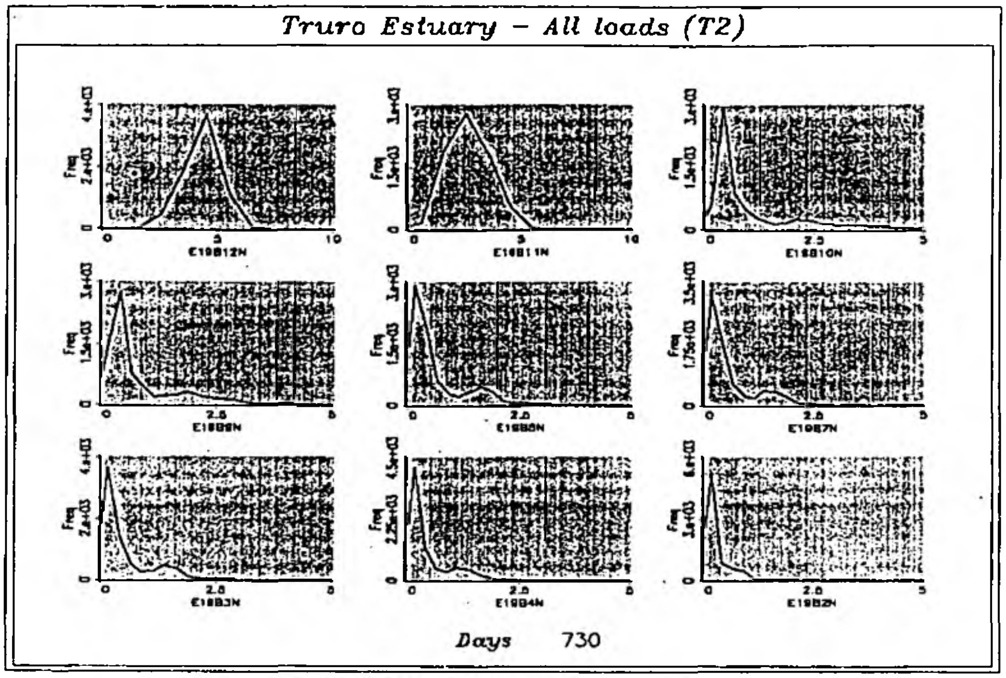
The algae poison referred to above has occurred due to the large bloom produced by the Marine Algal Species Alexandrium Tamarense which may also have caused discolouration of the water, causing a variety of colours ranging from a dirty grey colour through greens, browns and red colourations. It has sometimes known as a 'red tide'. Shellfish filter their food from the sea water surrounding them and therefore quickly concentrate extremely large numbers of algal cells.

Discolouration of the water by an algal bloom does not necessarily indicate the presence of toxin and therefore members of the public are advised to contact the Port Health Authority if they notice a presence of an algal bloom, thereby assisting the Authority in monitoring the situation.

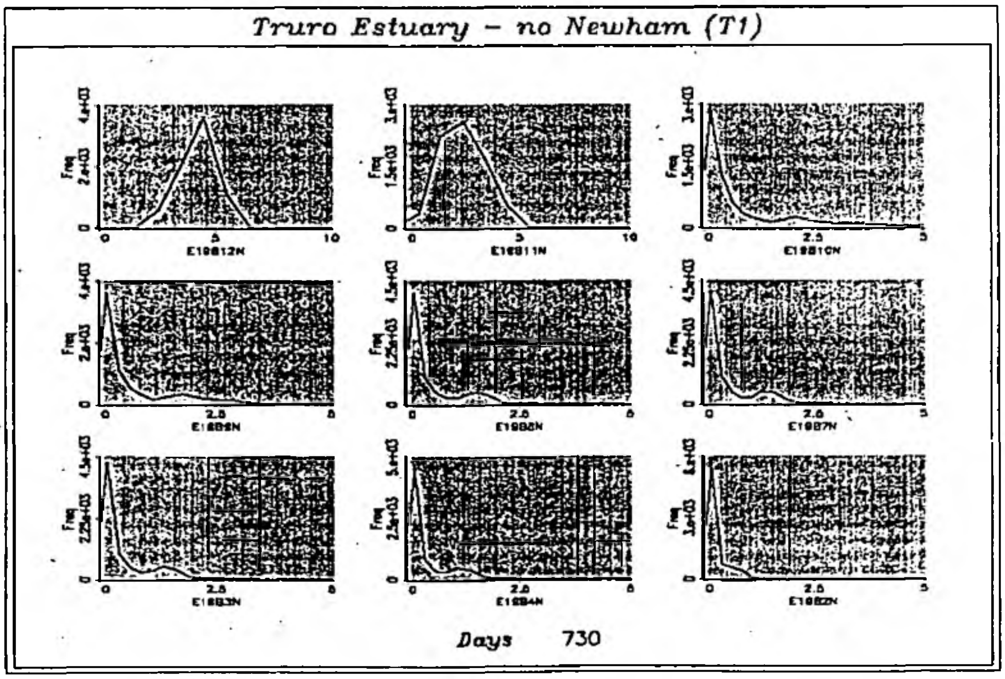
The Port Health Authority will continue to take regular samples and keep the public informed of any possible risks.

MR A J HOPSON
Chief Port Health Officer
FALMOUTH & TRURO PORT HEALTH AUTHORITY.

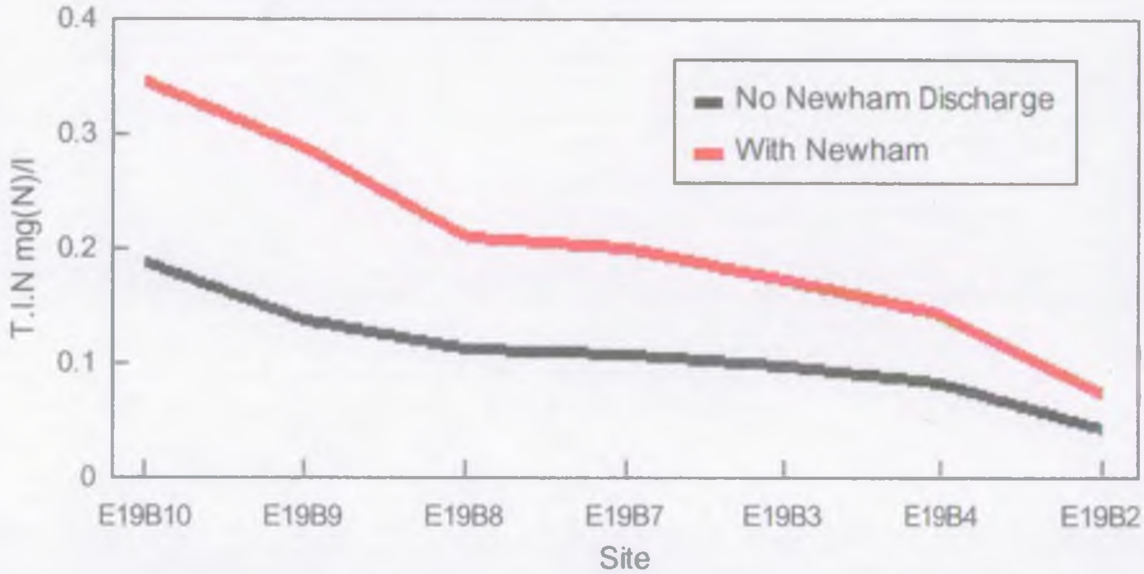
Appendix 4.1. Frequency distributions for Upper Fal Estuary monitoring sites (including Newham STW)



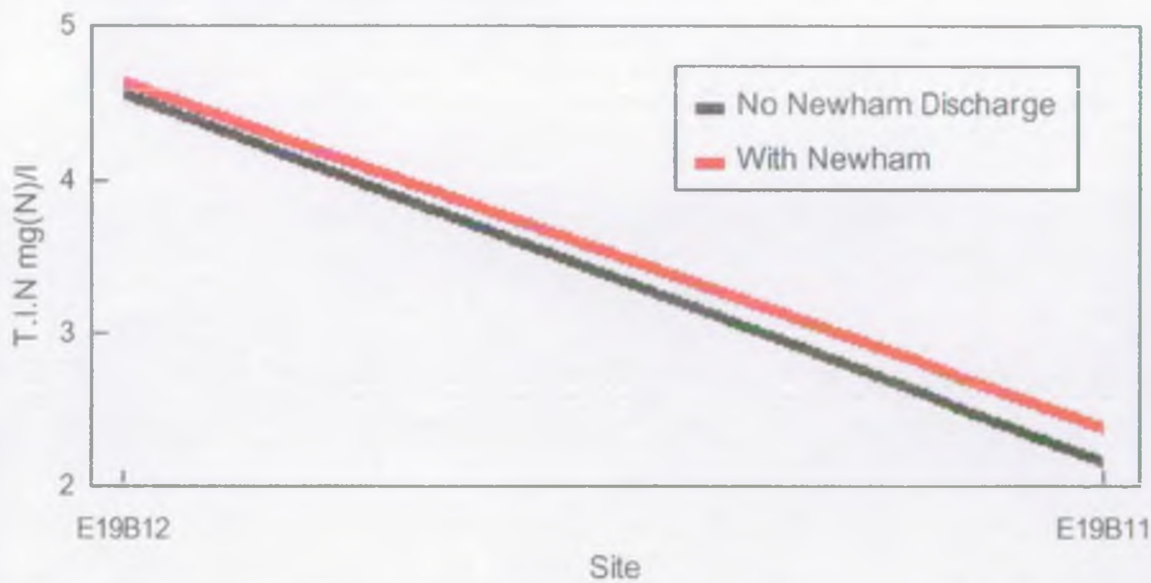
Appendix 4.2. Frequency distributions for Upper Fal Estuary monitoring sites (excluding Newham STW)

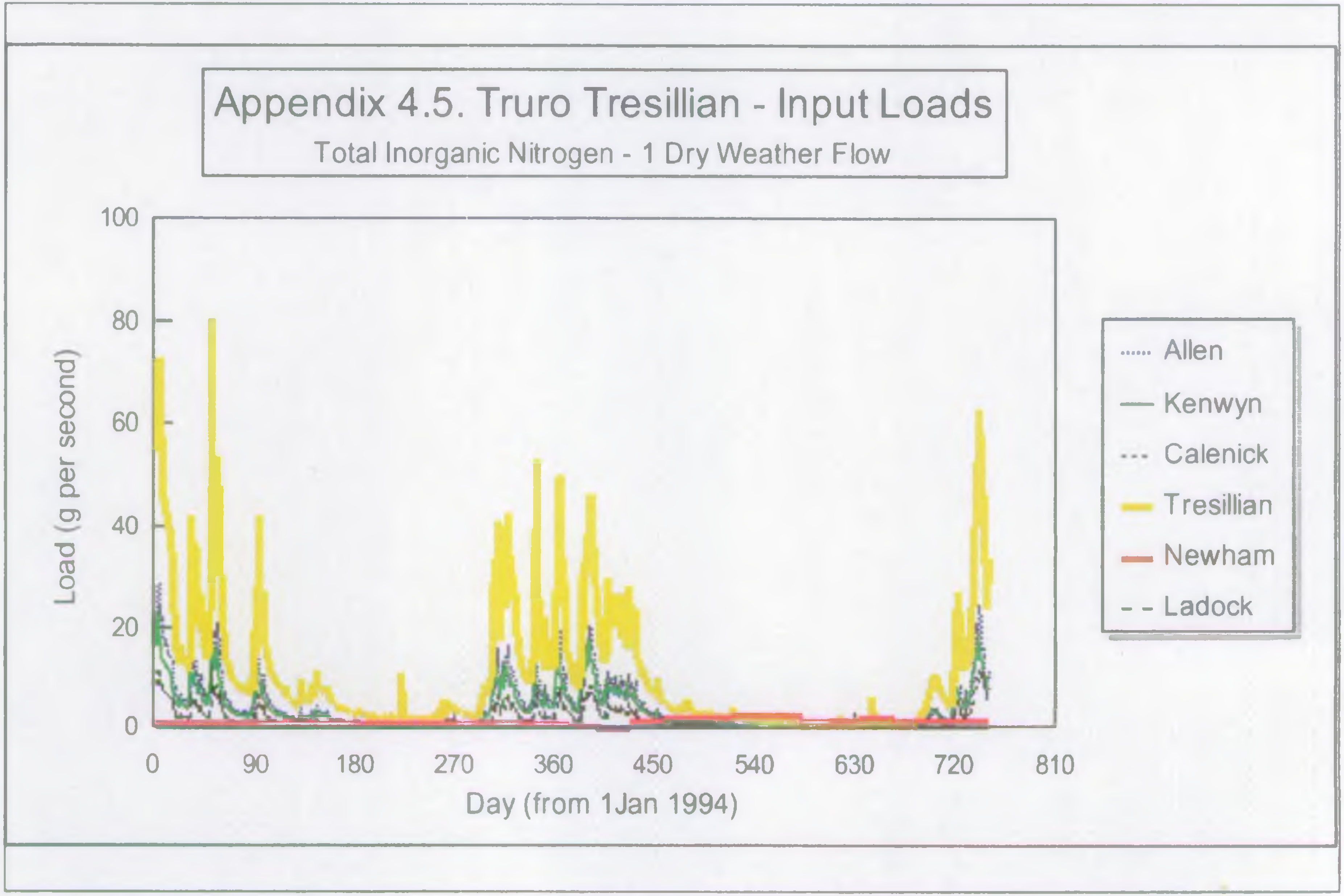


Appendix 4.3. Truro Estuary
Mean Concentrations (Summer)



Appendix 4.4. Tresillian
Mean Concentrations (Summer)





Appendix 4.5. Truro Tresillian - Input Loads
Total Inorganic Nitrogen - 1 Dry Weather Flow
Load (g per second)
100
80
60
40
20
0
0
90
180
270
360
450
540
630
720
810
Day (from 1Jan 1994)
Allen
Kenwyn
Calenick
Tresillian
Newham
Ladock