UCL

Hoveton Wetlands Restoration Project: Zooplankton and Phytoplankton Survey

ECRC Research Report Number 163

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Cover photo: Zooplankton sampling © B. Goldsmith

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1. Introduction

1.1. Background

Hoveton Great Broad and Hudson's Bay form part of the Bure Marshes SSSI which itself is a component of the Broadland SPA and The Broads SAC. They also form part of the Bure Marshes National Nature Reserve (NNR). Currently both Broads are in 'unfavourable' condition with respect to Habitats Directive targets and fail to reach 'good' ecological status under WFD classifications.

With recent improvements in the water quality within the River Bure, there now exists possibilities for restoration of these Broads by habitat management and bio-manipulation to facilitate a shift back to clear-water, plant dominated conditions. Natural England is developing a restoration plan in partnership with the EA, to restore the broads by removing a significant proportion of the upper sediments from both sites in association with bio-manipulation of the fish community. The ultimate goal of biomanipulation is to significantly alter the zooplankton and phytoplankton community (through the reduction of predation on zooplankton). A crucial part of the management will therefore to monitor the populations of zooplankton and phytoplankton prior to any management work being implemented. These baseline data may then be used to assess the progress and impact of the management work once it is completed.

To this end, ENSIS has been commissioned by Natural England to undertake zooplankton and phytoplankton monitoring on a monthly basis and enumerate all sample to the highest achievable taxomonic level.

While on site, ENSIS was also able to collect additional samples of water for analysis by the Environment Agency and *in situ* measurements of photosynthetically active radiation (PAR).

1.2. Aims of the Project

- To collect open water samples of zooplankton, phytoplankton and PAR from Hoveton Great Broad and Hudson's Bay at monthly intervals.
- To identify samples of zooplankton and phytoplankton to the highest achievable taxonomic level
- To collect monthly water samples from open water areas in Hoveton Great Broad and Hudson's Bay at monthly intervals and deliver to EA for analysis.

2. Methods

2.1. Sample sites

Surveys were conducted at monthly intervals using a boat; the sampling locations being selected to ensure a good geographical coverage was achieved within the two water bodies. The sampling locations are listed Table 1and their approximate position show in Figure 1 below.

Figure 1 Sampling locations at Hoveton Great Broad and Hudson's Bay.

2.2. Zooplankton

Samples were collected using standard quantitative protocols which have been demonstrated as effective for shallow lakes, including the Norfolk Broads (e.g. Davidson et al. 2007). Multiple samples of known volume were collected from geo-referenced points across whole-site transects at each site (Table 1). By collecting multiple samples from across a site, some of the patchiness that is well known to be exhibited by zooplankton communities (e.g. George 1981, Folt and Burns 1999) can be minimised and representative samples gained.

A clear Perspex tube, 70 mm in diameter and 1.5 m long was used to collect the samples. The tube is lowered vertically through the water column to within 10 cm of the sediment water interface. Where the water is less than 150 cm, the tube is lowered at an angle sufficient for it to fill completely with water. The top of the tube is then sealed with a bung and lifted until the bottom of the tube is within 10 cm of the water surface and a second bung introduced to seal the tube full of water. The

contents (of known volume) is then gently emptied into a 100 micron pore size zooplankton net. The clear Perspex tube has the additional benefit of allowing sample quality to be confirmed prior to release into the net. A series of samples are taken along the transect and the samples bulked into a single sample and carefully washed into 250 ml sample bottles and preserved with IMS.

Enumeration of the zooplankton samples broadly follows the methods laid out in the EA "Zooplankton Counting Method" (Appendix I) document. The key being the type of circular Perspex counting chamber used for the microscopic examination of samples as described and illustrated in Jones (1979).

Dilution of the preserved samples was described in the EA guidance document. Sub-samples were then dispensed by pipette into the machined 'moat', fitted with a radial barrier, and the chamber rotated on its central spindle until all the animals were counted. Examination of the zooplankton in the counting chamber was through a Wild M3Z stereo dissecting microscope at x25. Detailed examination of selected individual organisms was through a Vickers Instruments compound stage microscope at x70 magnification.

Sample	Grid Ref.	Depth (m)	Samples taken (Monthly)				
			Zoop	PP	PAR	Redox	Water
HGB 1	TG3121116202	0.8					
HGB 2	TG3136916133	1.0					
HGB 3	TG3147116076	1.1					
HGB 4	TG3154016204	1.2					
HGB 5	TG3161016316	1.0					
HGB 6	TG3174316366	1.1					
HGB 7	TG3194416254	1.3					
HGB 8	TG3204216119	0.8					
HGB 9	TG3214015971	1.2					
HUDS 1	TG3126116492	0.6					
HUDS 2	TG3130716556	0.5					
HUDS 3	TG3137216618	0.5					
HUDS 4	TG3141416648	0.6					
HUDS 5	TG3144616678	0.7					
HUDS 6	TG3147516709	0.9					
HUDS 7	TG3151616767	0.8					
HUDS 8	TG3152816805	0.9					
HUDS 9	TG3155516876	0.8					

Table 1 Sample locations for monthly sampling at Hoveton Great Broad and Hudson's Bay May 2014 – March 2015.

The nomenclature of the species and taxa recorded are based on the latest update to the Centre for Ecology and Hydrology (CEH) "BIOLIST" Code List for recording the Macroinvertebrates in Fresh Water in the British Isles: http://www.ceh.ac.uk/data/freshwater-macroinvertebrates-codes.html.
This latest list (as of November 2011) includes the most recent revisions to nomenclature of UK cladocerans provided by the UK Cladoceran Interest Group.

Microcrustacean zooplankton from the *Cladocera* were identified to species level, or to the lowest practical taxonomic level for juvenile individuals. Keys utilized to assist in the determination of *Cladocera* species included Scourfield & Harding (1966), Amoros (1985), Margaritora (1985) and Alonso (1996). All Copepoda were recorded at Order level, with copepodite, adult male and adult female stages distinguished, using Harding & Smith (1974). Rotifers were identified to the lowest practical taxonomic level, using Donner (1966) and Pontin (1974). Density of organisms is reported as number of individuals per litre.

2.3. Phytoplankton

Methods for sampling phytoplankton were conducted within the EA guidance[1] using an integrated sampling technique at multiple locations along a whole-site transect (Table 1). An initial baseline survey was conducted in May 2014, and thereafter monthly surveys taken at the same geo-referenced survey points in Hoveton Great Broad and Hudson's Bay.

At each sample point, an integrated sample was collected using a 20 mm diameter tube lowered into the water to within approximately 10 cm of the lake bed. The tube was then bunged at the top, and raised to the surface and bunged at the bottlem prior to removing from the water. The lower end was then transferred to a 500 ml sample bottle and the water released. Three separate samples were taken from each site and amalgamated to provide a single sample. Samples were fixed and preserved with approximately 1.0 ml of Lugol's iodine.

Phytoplankton identification and enumeration was undertaken by Dr Gina Henderson, one of the few UK analysts responsible for EA WFD phytoplankton counting. Methods for sample preparation, enumeration and data handling followed standard methods prepared by the Environment Agency[2].

In summary, the preserved sample is thoroughly mixed and a sub-sample of known volume is placed in a sedimentation chamber. When the algae have settled to the bottom of the chamber, they are counted and identified using an inverted microscope.

The counts for individual taxa are converted to algal biomass by using the cell/unit volume of the count units, with the bio-volumes based on measurements made during the counting. Final results are presented as algal concentrations and biovolumes.

2.4. Water sampling

During each monthly visit, water samples were taken from the central sampling location of both Hoveton Great Broad and Hudson's Bay (Table 1). Samples were collected from approximately 20 cm below the water surface into dedicated, pre-labelled sample containers provided by the Environment Agency. Samples were kept

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[1] http://www.wfduk.org/sites/default/files/Media/Characterisation%20of%20the%20water%20environment/Biological%20Method%20Statements/Lake%20Phytoplankton%20UKTAG%20Method%20Stateme

[2] www.wfduk.org/sites/default/files/Media/Characterisation of the water environment/Biological Method Statements/Guidance_Phytoplankton counting_Feb2014.pdf

cool and delivered to the Environment Agency in Norwich on the day of collection for onward transfer to the National Laboratory Service for analysis.

2.5. PAR and Redox measurements

In addition to the biological sampling, measurements of “photosynthetically active radiation” (PAR) were also taken at each of the 18 sampling locations. This is the most biologically meaningful measurement of light within a lake as it represents the fraction of sunlight used by plants to photosynthesise (spectral range from 400 to 700 nm). Measurements are taken at the water’s surface and then incrementally at 10 cm intervals down through the water column to determine the potential for photosynthesis at any given depth. In turbid waters, the PAR diminished very quickly, whereas in clear waters, radiation penetrates deeper and thus conditions are more suitable for plants.

Macrophytes and macro-algae establish and tend to zone according to the spectral quality of available PAR and also may be limited by the maximum depth of PAR penetration (the euphotic zone) (Schwartz & Hawes 1996, Schwartz & de Winton 2002). Measurement of PAR gives empirical information which will enable the determination of the maximum depth at which light may potentially limit plant growth under current conditions. This is particularly relevant in this project given that there is no evidence that mud-pumping will reduce the nutrient concentrations (Goldsmith *el al.* 2014) and hence successful biomanipulation will be key driver of water clarity. Monitoring baseline PAR will allow the success of future management to be assessed.

PAR measurements were taken through the water column at monthly intervals at all sampling points m using a Swift™ photon flux meter fixed with the light sensor attached to a 2 m graduated pole.

Data are used to calculate:
the rate at which light is attenuated (Kd)
the theoretical depth at which “effective” light reaches (1% incident PAR)
the theoretical depth at which light can promote plant growth (4% incident PAR)

Redox (Eh) and pH measurements were also taken at each point to establish the spatial and temporal shifts in metabolic conditions in the two broads. Sediment phosphorus release is often, but not always stimulated by variations in oxygen concentrations and oxidation – reduction (redox) conditions at the sediment water interface (Gachter & Muller 2003). Hence an understanding of the quantity, mechanism and associated effects of any such phosphorus release is important in planning or modeling the results of any lake restoration method and planned biomanipulation.

The pH of the sediment / water interface was recorded at each sample station by lowering a calibrated HANNA H31N glass pH electrode weighted with a 5g lead to the lake base.

The Eh of the water in the top 2cm of the sediment was recorded using a weighted (5g) and calibrated* HANNA HI8014 hand meter with a platinum/gold electrode.

3. Results

3.1. Zooplankton

Zooplanton density in both broads appears to follow a typical pattern for shallow eutrophic lakes, whereby algal grazing species of Cladocera such as *Bosmina longirostris* and *Daphnia cucullata* are governed primarily by food (planktonic algae) availability.

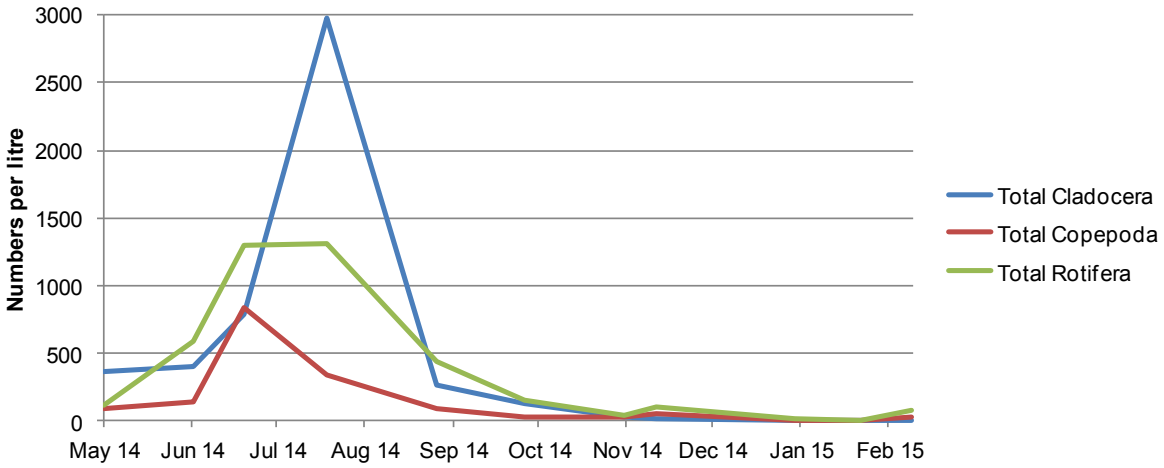

Figure 2 Total numbers of the main zooplankton groups recorded in HBG 2014/15 (numbers per litre)

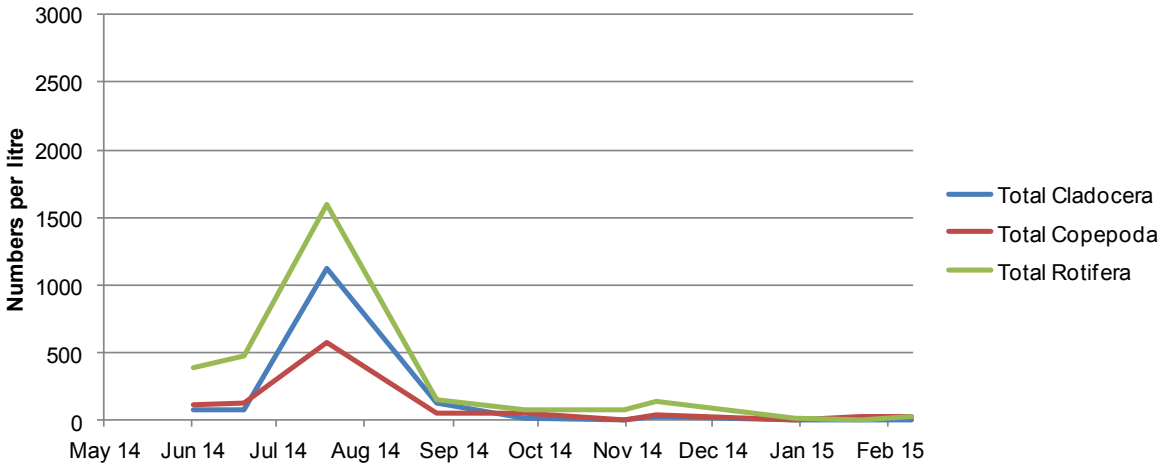

Figure 3 Total numbers of the main zooplankton groups recorded in HUDS 2014/15 (numbers per litre)

Total numbers of zooplankton was similar in both sites for most of the year, with the exception of August which saw a three-fold increase in Cladocera (mainly *Bosmina longirostris*) in HGB. Species composition and numbers were otherwise similar in both sites. The Copepod population was dominated by *Cyclopoida copepodite* and unidentified Copepod nauplii and common rotifer species *included Brachionus angularis, Keratella cochlearis, K. quadrata, Polyarthra* sp. and *Asplanchna* sp. A full list of species is given in the Appendix.

3.2. Phytoplankton

Algal concentrations and biovolumes showed a typical pattern for eutrophic lakes. In HGB the total cell concentrations and biovolume were relatively high by May 2014, dropped slightly in June and then peaked in the summer months before dropping to their minimum in December (Figure 4). February 2015 saw an early season algal bloom dominated by centric diatoms.

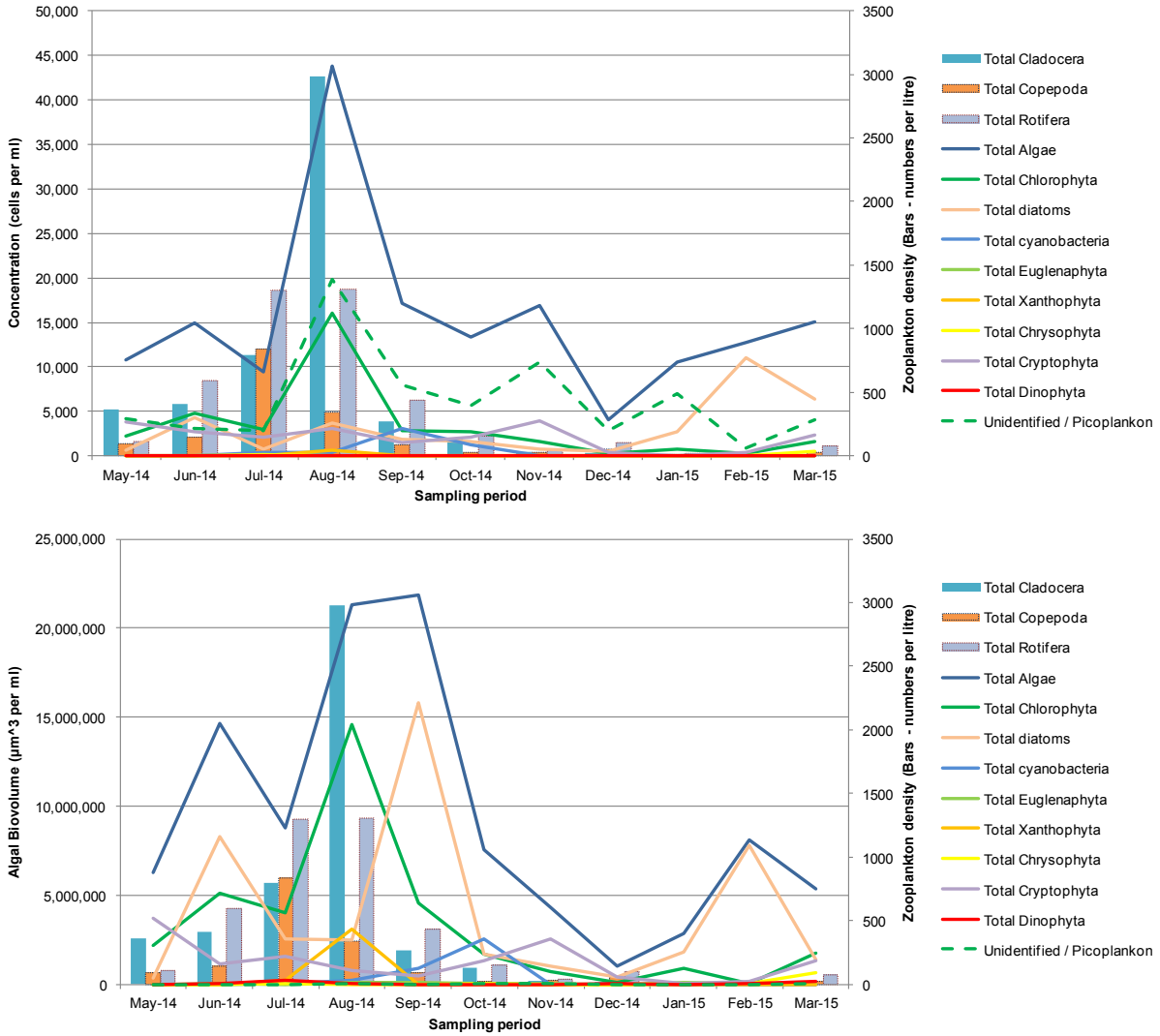

Figure 4 Phytoplankton concentration (top) and biovolumes (bottom) for HGB 2014/15. Secondary y axis shows zooplankton density by group

In terms of cell concentrations the data are driven mainly by Cholophytes (green algae) and pico-plankton, but the biovolume data show diatoms to dominate in June, followed by a rise in Chlorophytes which peak in August, followed by a second peak in diatom biovolumes in September. This later diatom peak is primarily due to long chains of *Aulacoseira* spp. which are likely to be less palatable to Cladoceran grazers than the small centric diatoms that were more common in June and Chloropytes in July and August. The algal biovolume correlates well with chlorophyll, see below.

In Hudson's Bay, a similar peak in total algal biomass was recorded in the summer months. Unlike HGB however, the algal bloom was dominated by non-colonial centric diatoms, rather than the chain forming *Aulacoseira* spp. recorded in HGB. The algal

bloom is again associated with an increase in the Cladoceran (and other zooplankton) population before overall biomass decreases substantially in winter (Figure 5). An early season diatom bloom comprising of non-colonial centric diatoms was recorded in February 2015. A full list of phytoplankton is given in the Appendix.

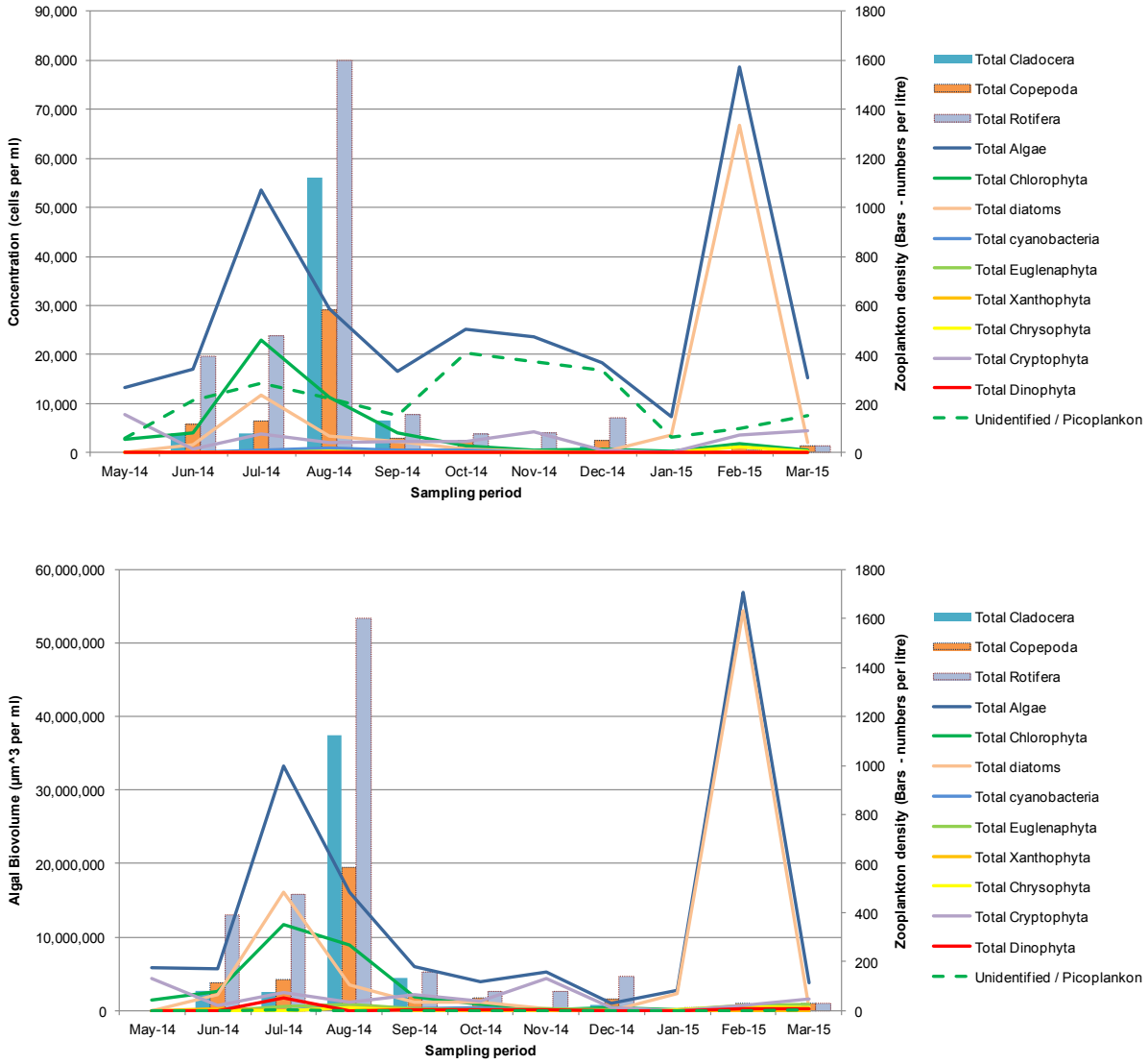

Figure 5 Phytoplankton concentration (top) and biovolumes (bottom) for HUDS 2014/15. Secondary y axis shows zooplankton density by group

3.3. Water Quality

Data are available from June 2014 until January 2015 – more data to follow. There was no TON data in June 2014.

As expected, both HGB and HUDS are eutrophic with mean TP values of 90 μgl^{-1} and 100 μgl^{-1} recorded for the sampling period June to January and relatively high total nitrogen recorded through the year. The demand on soluble nutrients was at its highest during the summer months when orthophosphate and oxidised nitrogen (TON) were lower. Interestingly, although TON concentrations dropped in the summer in HGB, they remained above 0.5 mgl^{-1}, whereas orthophosphate was very low. In HUDS, both TON and orthophosphate were low in summer (Figure 6).

Chlorophyll a concentrations remained above 30 μgl^{-1} in both sites over the summer, dropping earlier in HUDS which reflects the differences in algal biomass between the two sites.

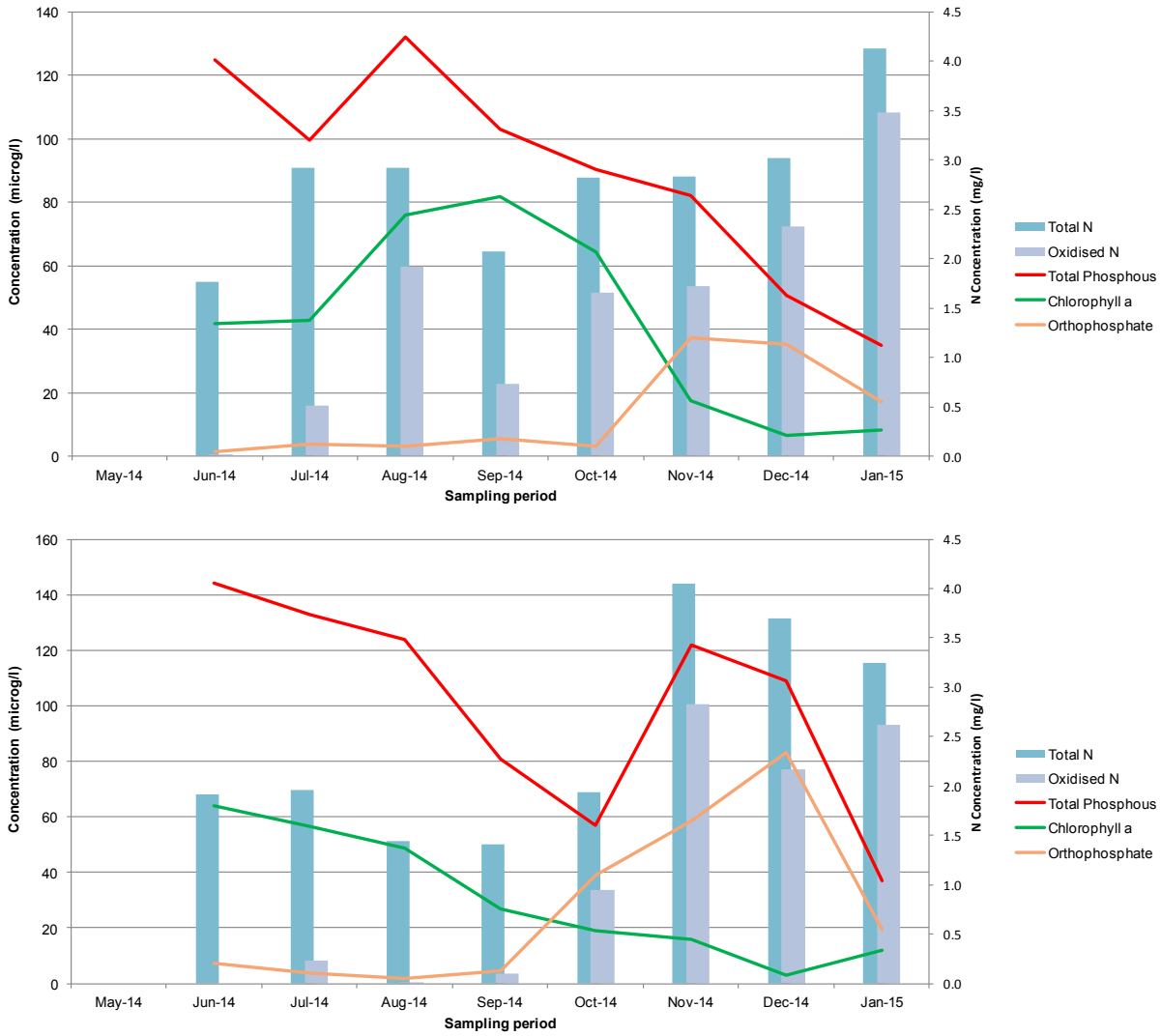

Figure 6 Nutrient chemistry and Chlorophyll for HGB (top) and HUDS (bottom) (no oxidised N data in June 2014)

3.4. Photosynthetically Active Radiation (PAR)

Both broads are shallow (<1.5 m) and therefore light penetrates easily to the sediments when the water is clear. During more turbid phases however, the suspended solids and algal / zooplankton biomass rapidly attenuate the light energy and the PAR reaching the sediments is greatly limited. Results across both sites show very similar patterns with rapid attenuation in summer contrasted by very little in the winter months when the water was clear (Figure 7).

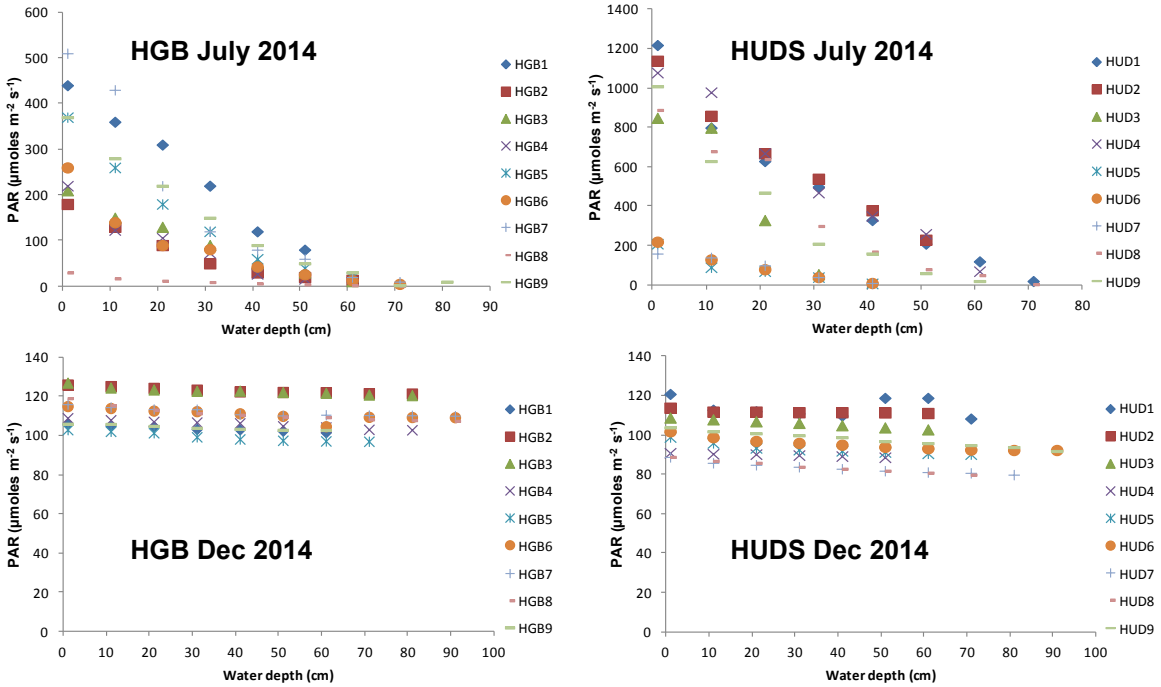

Figure 7 PAR recorded at 10 cm intervals at 9 sites in HGB and HUDS in July (turbid) and December (clear)

Using these data, the mean theoretical depth of 1% and 4% incident PAR can be calculated for each site through the growing season (Figure 8). The results show the sites to have poor light environments from the late spring until the autumn.

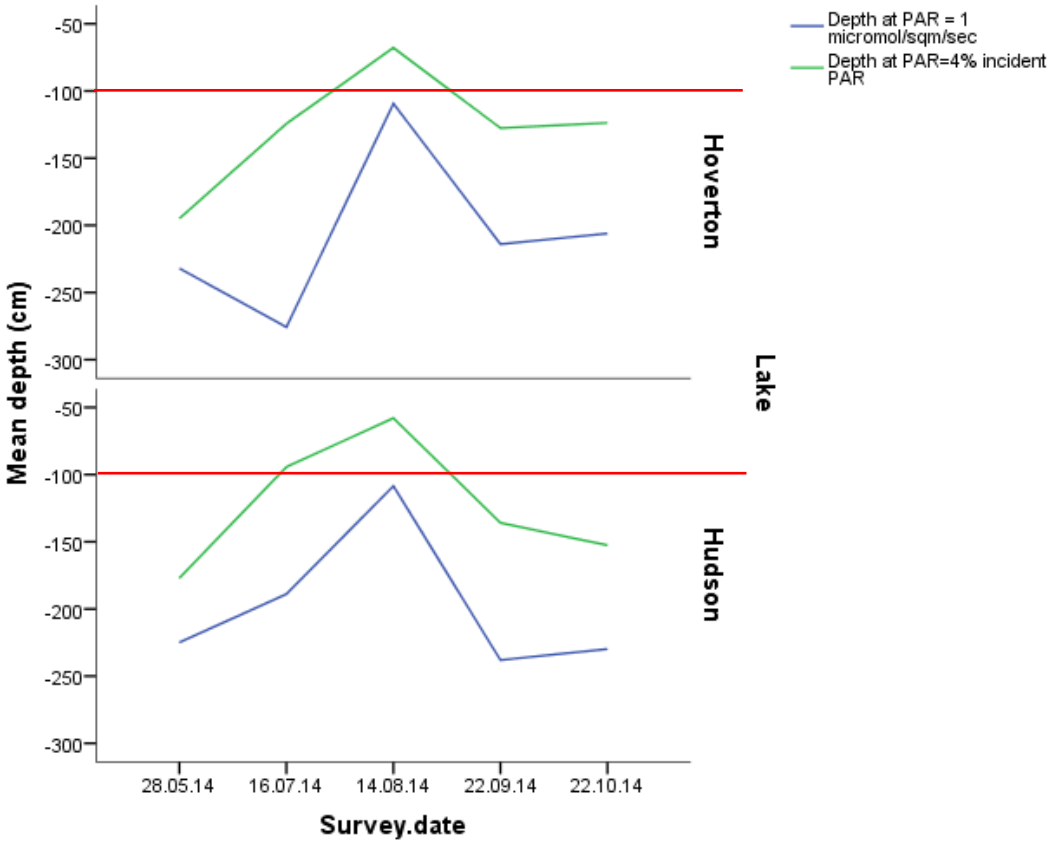

Figure 8 Mean 1% and 4% incident PAR measured during the peak growing season (May-October 2014) for HGB and HUDS

Hudson's Bay is relatively shallow throughout much of the southern end and therefore water clarity is possibly less of an issue for plant growth here, but other factors such as sediment structure and re-suspension may exert other influences of growth. The deeper areas of HUDS (max 1.4 m) and most of HGB (mean depth c. 100 cm) however are beyond the 4% incident PAR for most of the growing season.

3.5. Sediment redox

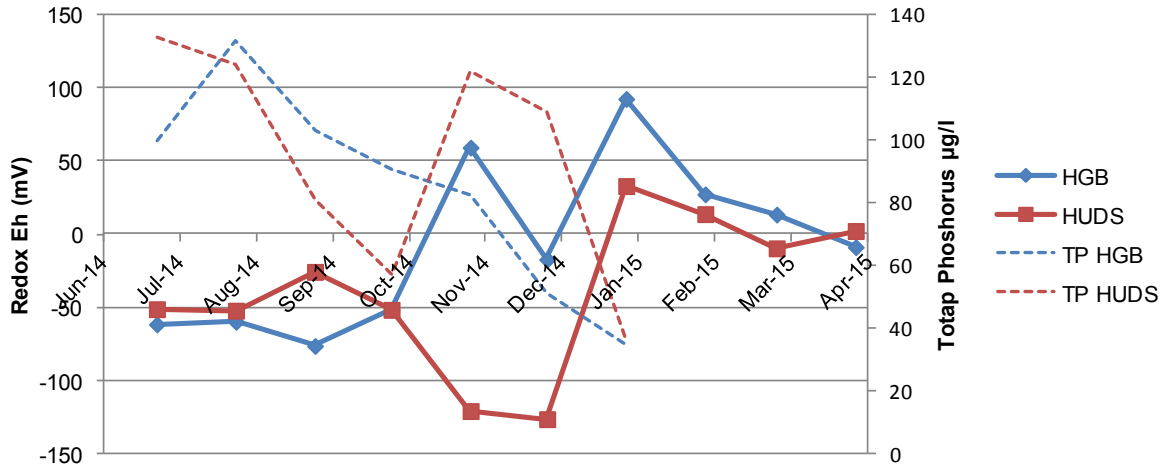

Figure 9 Mean redox (Eh) at the sediment water interface in HGB and HUDS

Some within site variation was observed in the data, but the average redox readings showed the sediment water interface to be negative throughout the summer months in both sites. In HGB, there was a shift to positive values through the cooler winter months, whereas in HUDS, the sediments became more strongly reduced in November and December, before rising in January.

As the redox potential in HGB return towards positive values in the winter months, TP concentrations fall to values similar to the River Bure (63 $\mu g l^{-1}$ in October 2014) suggesting the return to oxygenated conditions causes any P release to cease. A different pattern is seen in HUD whereby the TP levels start to fall in the autumn, but then increase in November and December before dropping back to lower concentrations in January. This winter peak in TP concentration coincides with strongly negative redox values which suggests the anoxia is facilitating P release even during cooler temperatures.

Further comparisons and analysis of these data will be made as more water quality and redox data are made available in 2015.

4. Discussion

The data presents in this report show Hoveton Great Broad and Hudson's bay to exhibit the conditions typical of many of the shallow eutrophic lakes; conditions which have long been observed and documented in the Norfolk Broads (Moss 1977, Phillips *et al.*1978). Relatively high nutrients (both N and P) from the River Bure and surrounding farmland promote the growth of planktonic algae during the summer months causing high turbidity and poor light penetration and hence limited macrophyte growth.

4.1. Zooplankton / phytoplankton interactions

In both broads, the populations of zooplankton can be seen to increase during the summer when algal biomass is at its maximum. The dominant Cladoceran species in both broads was *Bosmina longirostris*, the population dynamics of which are often related strongly to their preference as a phytoplankton grazer. This species is one of the most common in the Bure broads and its remains have been the dominant component of the zooplankton assemblages in the sediments of HGB since before 1950 (Hoare 2007). The presence of *B. longirostris* and other filter-feeding taxa is strongly linked to the shift away from plant-dominated conditions with benthic production, to turbid sites with high pelagic productivity (Davidson *et al.* 2011, Vadeboncoeur *et al.* 2003).

Total zooplankton numbers declined sharply in both sites after the initial increase in July and August 2014. This coincided with a reduction in algal biomass, but food availability was nonetheless still high. Without data on fish populations, it is not possible to say if the zooplankton dynamics are as a result of predation by zoooplanktivorous fish or if they represent changes in food availability of other natural cycles. In HGB the population of Bosmina longirostris dropped dramtically between August and September 2014, while the total algal biolvolume (and Clhorophyll a) remained the same. What did change in the algal population was the species composition. In August, the samples were dominated by single celled and small colony chlorophyes, whereas in September the population was dominated (in biovolume) by long chain colonies of the diatom *Aulacoseira*. These larger diatom species probably represent a less palatable food source to *B. longirostris* and hence numbers decrease.

The role of fish in zooplankton predation is not determined in this study. Data on fish species, size class and density would however help to inform the how the systems are functioning in terms of top-down and botton-up mechanisms. It is thought likely that zooplanktivorous fish (e.g. small roach and bream) will have a significant impact on the numbers of pelagic Cladocera and in so doing reduce the grazing pressure on the phytoplankton, thus increasing turbidity. Given that bio-manipulation of the fish stocks is an integral part of the management plan for HGB and HUDS, fish data should be analysed in conjunction with the data presented in this report.

Irrespective of the mechanisms, the role of zooplankton grazing appears to have little controlling impact on the total algal biomass, with both sites remaining turbid throughout the summer. With only low macrophyte cover in these sites, there is limited habitat and refugia available to the larger bodied Cladocera which are generally considered to be the more effective algal grazers (Jepperson *et al.* 1999).

4.2. Water clarity and light (PAR)

Light and better water clarity are a vital component for the establishment and growth of aquatic plants in the broads and the success of any future management will require good light penetration to promote macrophyte growth. Measurements of photosynthetically active radiation (PAR) show both HGB and HUDS to have poor light penetration. Turbidity is due primarily to high algal biomass, but there may also be other factors influencing water clarity. HGB is a relatively large water body and rarely exceeds 1.3 m in depth and is therefore likely to be susceptible to sediment re-suspension during periods of high winds and wave action. Although more sheltered, the south end of Husdon's Bay is less than 50 cm deep and the sediments here are very flocculent and easily disturbed by fish and waterfowl, as well as wave action.

Averaged monthly PAR readings show both broads to have only very limited, or no effective light penetration to the sediment surface during the peak growing season. In May 2014, more than 4% of the incident PAR was reaching the majority of the sediment surface for both broads, and therefore this should have been sufficient to trigger light dependent germination for stoneworts (*Chara* spp.) and enable photosynthesis in higher plants. These conditions also promote phytoplankton growth however, and by July 2014, the average 4% incident PAR was only 1.2 m in HGB and 1.0 m in HUDS, thus only just reaching the deeper waters. At the hight of summer, there was no effective PAR reaching below 60-70 cm and therefore photosynthesis would only have been possible for plants growing in shallow water or for those that had already grown up into the water column (e.g. water lilies in HUDS).

It is of no surprise therefore that both sites have only very few aquatic macrophytes present under these conditions. We know that plants and propagules of *Chara* spp., rigid hornwort *Ceratophyllum demersum* and fennel-leaved pondweed *Potamogeton pectinatus* are present in the site, but none of these submerged species were recorded in any abundance (Goldsmith *et al* 2014). If water clarity were to improve, it is reasonable to assume that these species would be more prolific in the two broads. Removal of fish may help to facilitate this, but even in lakes where this has been achieved, low plant diversity can result in low resilience with one year being dominated by a single species, followed by a year with no or few plants. (Søndergaard *et al.* 1997, Lauridsen *et al.* 2003). Where aquatic plants dominate, water clarity is good, but without plants, the system becomes vulnerable once again to high turbidity, even at low fish densities.

One further consideration of mud pumping is that the depth to which PAR is required to reach will be increased if sediments are removed and the sites deepened. This requires not only that conditions be improved in terms of the current morphology of the lake basins, but that they improved enough that light reaches the additional depth added to the sites by mud pumping.

4.3. Water Quality

Water quality in the two sites is primarily under the control of the water supply and internal processes. In terms of the hydrology, there is relatively poor exchange of water between the two broads and the river. HUDS is separated from the river, and although it is assumed that there is some exchange between the broad and the River Bure through the bank and during periods of high water, the site has only limited throughput of water. HUDS and HGB are linked via a narrow channel to the south of

HUDS. Unlike HUDS, HGB is open to the River Bure at the Eastern end and there is therefore some exchange of water to and from the broad, but this is probably limited to the eastern end under normal flow conditions.

Based on eight monthly samples (June 2014 – January 2015) the mean TP of HGB and HUDS was 90 μgl^{-1} and 101 μgl^{-1} respectively. The mean TP (based on four measurements March –October 2014) in the River Bure in this area is 51 μgl^{-1}, and therefore it would appear that the broads are subject to internal release of phosphorus from the sediments. This situation is typical of shallow lakes where historic P loadings have been high. As the external nutrient loads are reduced, the internal P loading can become the dominant P source (Marsden 1989) and this situation may persist for many years (Jeppesen *et al.* 2007).

Redox measurements show the sediments to be in a reduced state (anoxic) for much of the summer months in both sites and therefore facilitating the release of P from the sediments. As water temperatures fall in the autumn, TP concentrations also decrease as a result of slowed microbial and biological activity. In HGB this continues into the winter and is accompanied by an increase in redox values to predominantly positive values.

In Hudson's bay, the sediments behave very differently and show strongly negative redox values in November and December. Despite the cooler water temperatures, the strongly reduced sediments appear to facilitate further release of phosphorus into the water resulting in relatively high concentrations of ortho-phosphate.

These data suggest that P release from the sediments is an important process in these sites and is, at least in part, driving the high pelagic productivity seen in the two broads. The relationship between P concentrations and redox will be explored in more detail as more monitoring data are made available in 2015.

Total nitrogen was relatively high in the two sites, but the available oxidised N (mainly nitrate) was low during the main growing period in summer. Soluble (and biologically available) N did not appear to be limited in HGB, whereas in HUDS, concentrations were low enough to suggest N availability may have been limiting phytoplankton growth. The role of nitrogen in lake restoration and recovery is an area that is poorly understood, but there is evidence to suggest that it may have a major role in preventing a return to clear water conditions when exceeding 1 - 2 mgl^{-1} as N, particularly where P concentrations remain relatively high (Jeppersen *et al.* 2007). It is vital therefore that efforts are made to control both N and P within the restoration plans and that these are monitored throughout the programme in order to understand any observed changes in the biology of the sites.

4.4. Conclusions

This report provides the first tranche of data that improves our baseline knowledge of Hoveton Great Board and Hudson's Bay against which any future management can be assed. It is clear from the results that the site remains hyper-eutrophic despite recent reductions in the phosphorus concentrations of the River Bure. This strongly suggests that internal phosphorous release is now a major contributor to the trophic status of HGB and HUDS. While mud pumping may remove some of the P stored in the sediments, there is strong evidence to suggest that P concentrations are

relatively high throughout the sediments (Goldsmith *et al.* 2014) and therefore mud pumping is unlikely to have a significant effect on internal P release in the short term and therefore the success of any future management must be achievable at high nutrient levels.

Under current conditions, zooplankton grazing has only limited control over the phytoplankton community and is unlikely to have any effective impact without significant numbers of larger bodied *Daphnia* spp. In turn, this is unlikely while the site has few plants and no effective control of the zooplankivorous fish populations. While there are many factors at play in these sites, it is clear that control of the fish population is the first step to recovery.

A number of projects have attempted to achieve lake restorations with fish exclusion and manipulation, and to good effect, certainly in the short-term (Meijer *et al*. 1999; Mehner *et al.* 2002). There is however the risk that systems will revert if the manipulations are not on-going and if the system has little natural resilience, due for example to low macrophyte diversity and high nutrients. Most important for any lake restoration project is that good quality data are collected before, during and after the restoration works in order to inform best practice and evaluate the success.

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6. Appendices

6.1. Appendix I – EA Zooplankton Counting Method

November 2011

Principles of the method

Normally a zooplankton sample contains many more animals than can be examined in the time available. Subsamples must therefore be taken and counted instead. These must be taken in such a way as to ensure that each subsample is as representative of the whole sample as possible. This is achieved by agitating the sample vigorously to distribute the animals evenly and quickly remove a small subsample with a pipette before any animals settle out of suspension. Remove subsample by drawing the pipette up diagonally through the sample.

Equipment

Stereo microscope (including x250 and x400)
Counting ring or similar to hold 5 ml of sample
Sedgewick rafter cell
Wide-mouthed adjustable 5 ml pipette
Labelled sealable container(s) for waste IMS
Small sieve with 100 µm mesh
Wash bottle for tap water
Labelled wash bottle for IMS
Measuring cylinder – 50/100 ml
Spare zooplankton pot
Funnel(s)

Detailed method

Strain the preserving liquid of sample through a 100 µm sieve. Decide the required dilution (minimum volume 100 ml): at least 50 of the most numerous taxon excluding nauplii and copepods in 2 x 5 ml sub-samples must be counted. Was the animals from the sieve, using tap water wash bottle, through funnel into a 50 ml measuring cylinder. Note the volume. Pour back into the original container.

Add further measured amounts of tap water to reach the appropriate dilution, as follows:
Continue to flush the water through the sieve and into the measuring cylinder to ensure total removal of all the animals. Make sure the sieve is washed out well during transfer: animals tend to collect around the edges.

Set up a counting ring on a stereo microscope. There must be a stopper to mark the beginning and end of the sample. Shake sample for about 10 seconds to ensure through mixing. Immediately remove a 5 ml sub-sample with a wide-mouthed pipette and release it into the groove around the counting ring. It is possible to take 4 ml subsamples of there are a considerable number of animals, but the whole sample must be counted once placed in the ring.

Count the subsample at x 250 magnification. The animals should be identified and counted using the guidelines in table 1.

Repeat procedure at least once more until 50 individuals of the most numerous taxon (excluding nauplii and copepods) or 10 % of the sample has been counted. Once each ring has been counted, wash into a spare pot.

Note on the records if the sample is muddy or filamentous algae are present. (Filamentous algae have associated taxa.)

Calculate daphnia, ceriodaphnia, simocephalus and sida numbers per litre using the total (or mean for grouped samples) number multiplied by the following factor:
Sample dilution (ml) / (water sampled (l) * sub-sampled (ml))

When 10 or more animals per litre of any of these species are present their size and number of eggs or young carried must be recorded, treating each species separately. At least 50 animals must be measured in the minimum of one ring.

Asses the animal density in the sample and draw up an appropriate sub-sample to attain the above e.g. only 1 ml needs to be placed in the ring if the animals are particularly dense. As before once a sub-sample is placed in the ring, the whole ring must be counted.
The body length is measured from the top of the head, excluding any crest if present, to the base of the spine, i.e. excluding the spine. Size is recorded in classes of 0.1 mm. At the same time record the number of eggs carried, if any by each individual, e.g. 1_8 for 8 eggs. If an individual is carrying ephippa the record 1_e.

If the body is ballooned and it is possible eggs have escaped the brood pouch record 1_0 (for no eggs) or $1_{(x)}$ if some eggs (x) are present. Record the number of loose eggs and neonates and note the extent of ballooning in the sample.

Once counting is complete drain off the water from the counted sub-samples and the uncounted part back through the sieve. Wash the sample back into a small storage container using an IMS filled wash bottle. Again pay particular attention to the edge of the sieve.

Rinse the original sample bottle into the new storage container and top up with IMS. Label the new pot with as much information as possible in longhand and pencil. It would be helpful to add the initials of the counter,
e.g. Hoveton Little Broad,
Littoral – Cladium
1/08/12 No. 4, LDT

Table 1. Level of identification

Nauplii	No further identification
Copepodites	Calanoid / Cyclopoid
Adult copepods	Calanoid / Cyclopoid
Chyrdorids	Genus
Ceriodaphnia	Genus
Simocephalus	Genus
Rotifers (if present)	Variable
Daphnia	Species
Bosmia	Species
Polyphemus	Species
Leptodora	Species

6.2. Appendix II – Zooplankton Species

Hoveton Great Broad – numbers of individuals per litre

Date	May 2014	Jun 2014	Jul 2014	Aug 2014	Sep 2014	Oct 2014	Nov 2014	Dec 2014	Jan 2015	Feb 2015	Mar 2015
Cladocera											
Diaphanosoma brachyurum	0.0	0.0	0.0	17.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ceriodaphnia quadrangula	6.9	6.9	6.9	20.0	3.4	0.6	0.0	0.0	0.0	0.0	0.0
Daphnia cucullata	3.4	8.0	73.1	114.3	4.6	0.0	0.0	0.0	0.0	0.0	0.0
Daphnia longispina	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
D. hyalina/longispina group	5.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bosmina longirostris	335.1	392.0	710.9	2825.7	260.6	126.9	30.6	19.4	0.9	0.9	2.3
Acroperus harpae	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Alona affinis	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Alona guttata	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Alona quadrangularis	1.7	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Chydorus sphaericus	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coronatella rectangula	0.0	0.0	2.3	2.9	0.0	3.4	0.0	0.0	0.0	0.0	0.0
Pleuroxus aduncus	0.9	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleuroxus trigonellus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleuroxus uncinatus	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Copepoda											
Calanoida copepodite	3.4	0.0	2.3	17.1	0.0	0.6	0.0	0.0	0.0	0.0	0.0
Calanoid male	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyclopoida copepodite	22.3	128.0	230.9	205.7	42.3	13.7	4.9	2.3	0.0	0.6	1.7
Cyclopid male	1.7	4.6	9.1	117.1	4.6	0.6	0.0	0.0	0.0	0.0	0.6
Cyclopid female	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Copepod nauplii	66.9	12.6	596.6	2.9	42.3	11.4	27.1	54.9	8.9	8.6	22.3
Harpacticoida	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0
Rotifera											

Date	May 2014	Jun 2014	Jul 2014	Aug 2014	Sep 2014	Oct 2014	Nov 2014	Dec 2014	Jan 2015	Feb 2015	Mar 2015
Rotaria neptunoidea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
undifferentiated Bdelloidea	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	1.1
Pompholyx sp.	0.0	140.6	116.6	102.9	57.1	1.7	0.9	18.3	1.4	3.4	4.6
Filinia longiseta	0.0	0.0	0.0	11.4	75.4	0.6	0.0	1.7	0.0	0.3	0.0
Epiphanes senta	0.0	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0
Brachionus angularis	1.7	32.0	237.7	211.4	16.0	0.6	0.6	0.6	0.0	0.0	1.1
Brachionus calyciflorus	0.0	1.1	38.9	37.1	27.4	0.0	0.3	0.0	0.0	0.0	0.0
Brachionus urceolaris	0.0	0.0	6.9	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Keratella cochlearis	27.4	305.1	699.4	800.0	195.4	60.0	11.1	17.7	3.4	0.6	2.3
Keratella quadrata	12.0	45.7	130.3	97.1	18.3	9.7	13.1	24.6	2.3	1.1	3.4
Keratella valga	0.0	0.0	2.3	2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lepadella ovalis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lecane sp.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cephalodella gibba	0.0	0.0	0.0	0.0	4.6	0.0	0.0	0.0	0.0	0.0	0.0
Trichocerca sp.	0.0	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0
Ascomorpha sp.	0.9	0.0	11.4	0.0	0.0	0.0	0.0	1.1	0.6	0.0	0.0
Synchaeta sp.	0.9	0.0	0.0	0.0	0.0	0.6	0.6	11.4	1.7	1.1	53.7
Polyarthra sp.	33.4	68.6	54.9	42.9	34.3	78.3	13.1	17.1	0.9	0.3	7.4
Asplanchna sp.	35.1	0.0	2.3	0.0	4.6	2.9	2.6	1.7	0.6	0.0	0.0
undifferentiated male rotifera	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.1	0.3	1.1	0.6
undifferentialed rotifera	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.4	5.4	1.1	1.7
Total Cladocera	362.6	409.1	793.1	2980.0	268.6	130.9	30.9	19.4	0.9	0.9	2.9
Total Copepoda	94.3	145.1	838.9	342.9	89.1	26.9	32.0	57.1	8.9	9.1	24.6
Total Rotifera	111.4	593.1	1300.6	1308.6	436.6	154.3	42.6	102.9	16.6	10.9	76.0

Hudson's Bay – numbers of individuals per litre

Date	May 2014	Jun 2014	Jul 2014	Aug 2014	Sep 2014	Oct 2014	Nov 2014	Dec 2014	Jan 2015	Feb 2015	Mar 2015
Cladocera											
Diaphanosoma brachyurum		0.0	0.0	20.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0
Ceriodaphnia quadrangula		11.4	3.4	11.4	2.9	0.0	0.0	0.0	0.0	0.0	0.0
Daphnia cucullata		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Daphnia longispina		0.0	0.9	14.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0
D. hyalina/longispina group		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bosmina longirostris		51.4	70.3	1074.3	129.1	13.7	1.4	24.9	0.6	2.3	1.7
Acroperus harpae		2.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Alona affinis		4.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Alona guttata		0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Alona quadrangularis		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chydorus sphaericus		7.1	0.0	0.0	0.0	0.9	0.0	0.4	0.3	0.0	0.0
Coronatella rectangula		0.0	0.9	2.9	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Pleuroxus aduncus		1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleuroxus trigonellus		1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pleuroxus uncinatus		0.0	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Copepoda											
Calanoida copepodite		0.0	0.0	2.9	0.6	1.1	0.0	0.4	0.0	0.0	0.0
Calanoid male		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3
Cyclopoida copepodite		84.3	66.9	448.6	37.7	20.9	1.1	1.3	0.9	0.3	1.1
Cyclopid male		5.7	3.4	117.1	1.1	0.6	0.0	0.0	0.0	0.0	0.0
Cyclopid female		0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0
Copepod nauplii		24.3	57.4	14.3	20.0	29.1	1.7	46.3	2.6	30.6	28.6
Harpacticoida		0.0	0.0	0.0	0.0	0.0	1.1	0.0	0.3	0.0	0.0
Rotifera											
Rotaria neptunoidea		0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0
undifferentiated Bdelloidea		0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0	4.0	2.6

Date	May 2014	Jun 2014	Jul 2014	Aug 2014	Sep 2014	Oct 2014	Nov 2014	Dec 2014	Jan 2015	Feb 2015	Mar 2015
Pompholyx sp.		8.6	58.3	60.0	4.6	0.9	4.0	6.0	2.0	0.9	2.6
Filinia longiseta		1.4	0.9	34.3	30.3	0.3	1.1	3.9	0.0	0.0	0.3
Epiphanes senta		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
Brachionus angularis		65.7	122.6	225.7	14.3	0.3	0.0	2.1	0.0	0.0	0.0
Brachionus calyciflorus		0.0	3.4	31.4	1.7	0.0	0.0	0.0	0.0	0.0	0.0
Brachionus urceolaris		0.0	0.9	17.1	0.0	0.0	1.4	0.0	0.0	0.0	0.0
Keratella cochlearis		160.0	233.1	1040.0	62.9	30.0	20.0	28.3	2.3	0.0	0.3
Keratella quadrata		77.1	54.0	82.9	25.7	4.9	25.7	45.4	1.4	1.1	1.1
Keratella valga		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lepadella ovalis		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
Lecane sp.		0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0
Cephalodella gibba		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Trichocerca sp.		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ascomorpha sp.		0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0
Synchaeta sp.		0.0	0.0	0.0	0.0	0.3	2.3	6.9	1.7	0.6	16.0
Polyarthra sp.		60.0	0.9	91.4	14.3	39.1	20.6	32.1	0.6	0.3	2.3
Asplanchna sp.		18.6	0.9	17.1	0.6	1.4	0.6	1.7	0.0	0.0	0.0
undifferentiated male rotifera		0.0	0.0	0.0	0.0	0.0	0.3	0.4	0.6	0.3	1.1
undifferentialed rotifera		0.0	0.0	0.0	2.3	0.3	2.3	14.1	0.9	1.7	2.9
Total Cladocera		80.0	78.0	1122.9	133.1	14.9	1.7	25.3	0.9	2.3	1.7
Total Copepoda		114.3	127.7	582.9	60.0	51.7	4.0	48.0	3.7	31.1	30.0
Total Rotifera		391.4	474.9	1600.0	156.6	77.4	80.0	141.0	13.4	9.4	29.1

6.3. Appendix III – Phytoplankton Species

Hoveton Great Broad - Algal concentration (no per ml)

Key to families

Chlorophya | Diatoms | Cyanobacteria | Euglenaphyta | Xanthophyta | Chrysophytes | Crytophyta | Dinophytes | Picoplankton

Date	May 2014	Jun 2014	Jul 2014	Aug 2014	Sep 2014	Oct 2014	Nov 2014	Decf 2014	Jan 2015	Feb 2015	Mar 2015
Actinastrum hantzschii			16	37	46	8					
Ankistrodesmus falcatus											
Ankyra judayi				310							
Chlamydomonas	167			1238	528	96		37			
Closterium					15						
Coelastrum astroideum	8				15	8					
Coelastrum microporum	38	88	16	21			4				88
Cosmarium			16	929				2	4		
Crucigenia tetrapedia							45				
Crucigeniella		88	16						4		
Dictyosphaerium pulchellum	8	214	161	107	15	8					
Elakatothrix gelatinosa		88									
Euastrum											
Gonium											
Kirchneriella				11							
Lagerheimia genevensis											
Micractinium				32	62						
Micractinium pusillum											
Monoraphidium arcuatum						96	45				
Monoraphidium contortum		793		310		383	402	37		45	
Monoraphidium convolutum	334			929			312				88

Date	May 2014	Jun 2014	Jul 2014	Aug 2014	Sep 2014	Oct 2014	Nov 2014	Decf 2014	Jan 2015	Feb 2015	Mar 2015
Monoraphidium griffithii		88		310			179	37			
Monoraphidium komarkovae			191			8	45	73	176	262	352
Monoraphidium minutum				2167		287	45				
Oocystis			191	5							
Oocystis lacustris										2	
Pandorina morum				5							
Pediastrum boryanum	38	107	80	43	46	80	8	2			39
Pediastrum duplex		84	16	37		8					
Pediastrum simplex		8	16		31		4				15
Pediastrum tetras			16							2	
Pediastrum tetras											
Pteromonas			191								
Scenedesmus	167	704	383	619		191	268		352		
Scenedesmus communis	1001	1497	957	4335	880	1148		37	176		616
Scenedesmus falcatus	334	176	574	1548	528		89				88
Scenedesmus opoliensis	167	704		929	352	191	134				176
Selenastrum		8			176						88
Spondylosium planum											
Staurastrum	8	8									
Staurastrum tetracerum											
Tetraedron caudatum		176	191		176	96	45				88
Tetraedron minimum				1238							
Tetrastrum											
Tetrastrum staurogeniaeforme				929		96					
Tetrastrum triangulare											
Asterionella formosa		145	48	27	31	16					
Aulacoseira	53	534	241	364	851	298	49	31	27	18	217

Date	May 2014	Jun 2014	Jul 2014	Aug 2014	Sep 2014	Oct 2014	Nov 2014	Decf 2014	Jan 2015	Feb 2015	Mar 2015
Aulacoseira granulata	30	76	80	177	294	32					23
Diatoma tenuis			16			8					
Fragilaria crotonensis											
Large centric diatom (>20 µm diam.)		69	191	11	93	96				22	
Medium centric diatom (10-20 µm diam.)		1497		310	352	383	536	396	1233	6137	
Melosira varians											
Nitzschia		88		16	15				4		
Nitzschia acicularis		8		54	31	8					
Small centric diatom (5 - <10 µm diam.)		1057	191	2787	176	574	223	44	704	4552	3962
Synedra		528				191		2			
Tabellaria flocculosa											
Urosolenia eriensis		176									
Very small centric diatom (<5 µm diam.)	500	88							704	268	2201
Aphanizomenon flos-aquae				70							
Aphanocapsa											
Chroococcus											
Coelosphaerium				16							
Coelosphaerium kuetzingianum			16								
Merismopedia			383	310							
Oscillatoria				37	2816	829		2			
Oscillatoria agardhii											
Oscillatoria limnetica (Pseudanabaena limnetica)		15		16	201	370					
Oscillatoria redekei					15						
Euglena							8		11	10	15
Phacus		8		11	15	8					
Trachelomonas							12				
Goniochloris				310							

Date	May 2014	Jun 2014	Jul 2014	Aug 2014	Sep 2014	Oct 2014	Nov 2014	Decf 2014	Jan 2015	Feb 2015	Mar 2015
Ophiocytium				310							
Pseudostaurastrum			32								
Bitrichia			191								
Dinobryon divergens						16	45				23
Mallomonas										22	
Mallomonas akrokomos								2			
Mallomonas caudata				5							
Synura									38	6	471
Cryptomonas (large) Length >30 µm	53			21		64	36	10		8	23
Cryptomonas (medium) Length 20-30 µm	872	313	547	123	201	241	499	89	11	101	263
Cryptomonas (small) Length <20 µm	218	397	241	145	46	394	495	64	19	22	255
Rhodomonas	2668	2025	1340	2787	1233	1435	2856	293		312	1849
Glenodinium		8	16	5			4	4		6	39
Peridinium											
Nanoplankton - unidentified flagellates 2–20 µm diameter				310		383	268	37			88
Picoplankton - unidentified single cells <2 µm diam.	4169	3082	2871	19506	7924	5263	10265	2861	7045	893	3962

Date	May 2014	Jun 2014	Jul 2014	Aug 2014	Sep 2014	Oct 2014	Nov 2014	Dec 2014	Jan 2015	Feb 2015	Mar 2015
Total	10,828	14,945	9,440	43,814	17,169	13,314	16,919	4,059	10,509	12,689	15,031
Total Chlorophyta	2,266	4,830	3,017	16,053	2,827	2,696	1,623	224	712	310	1,639
Total diatoms	583	4,266	769	3,744	1,844	1,606	807	473	2,672	10,998	6,403
Total cyanobacteria	0	15	399	449	3,033	1,199	0	2	0	0	0
Total Euglenaphyta	0	8	0	11	15	8	20	0	11	10	15
Total Xanthophyta	0	0	32	619	0	0	0	0	0	0	0
Total Chrysophyta	0	0	191	5	0	16	45	2	38	28	494
Total Cryptophyta	3,811	2,735	2,128	3,076	1,480	2,135	3,886	456	31	444	2,390

Date	May 2014	Jun 2014	Jul 2014	Aug 2014	Sep 2014	Oct 2014	Nov 2014	Decf 2014	Jan 2015	Feb 2015	Mar 2015
Total Dinophyta	0	8	16	5	0	0	4	4	0	6	39
Unidentified / Picoplankon	4,169	3,082	2,871	19,815	7,924	5,646	10,533	2,898	7,045	893	4,050

Hudson's Bay - Algal concentration (no per ml)

Key to families

Chlorophya | Diatoms | Cyanobacteria | Euglenaphyta | Xanthophyta | Chrysophytes | Crytophyta | Dinophytes | Picoplankton

Date	May 2014	Jun 2014	Jul 2014	Aug 2014	Sep 2014	Oct 2014	Nov 2014	Decf 2014	Jan 2015	Feb 2015	Mar 2015
Actinastrum hantzschii		24	193	96							
Ankistrodesmus falcatus				310							
Ankyra judayi	96										191
Chlamydomonas	287	93	383	929		139				191	191
Closterium			32	32							
Coelastrum astroideum		8			8						
Coelastrum microporum	24		383								
Cosmarium		32	383								
Crucigenia tetrapedia		93									
Crucigeniella	574		64	929	264						
Dictyosphaerium pulchellum		64	611	449	15			88			
Elakatothrix gelatinosa		8		32	8						
Euastrum					8						
Gonium						69					
Kirchneriella	96		383	310	15						
Lagerheimia genevensis		93									
Micractinium											
Micractinium pusillum				64							
Monoraphidium arcuatum					264	69	96				
Monoraphidium contortum	191	1115	1148		1057	486	239	176			
Monoraphidium convolutum	96	93	4593	1858	1321	208	48				
Monoraphidium griffithii	96		383								
Monoraphidium komarkovae				310	23				279	1340	

Date	May 2014	Jun 2014	Jul 2014	Aug 2014	Sep 2014	Oct 2014	Nov 2014	Decf 2014	Jan 2015	Feb 2015	Mar 2015
Monoraphidium minutum	191	186	766	310				88			
Oocystis		93	32					88			
Oocystis lacustris											
Pandorina morum											
Pediastrum boryanum	20	80	129	32	31				3		
Pediastrum duplex		64	97	96		8					
Pediastrum simplex	4		32				4	5			8
Pediastrum tetras	4			310							
Pediastrum tetras											
Pteromonas											
Scenedesmus		464				69					
Scenedesmus communis	478	929	6890	1238	352	208	48	264	93	383	191
Scenedesmus falcatus	96		1531	619	264	69	48				
Scenedesmus opoliensis	287	372	2297	1238	264	69	96				
Selenastrum		8	32								
Spondylosium planum		16									
Staurastrum											
Staurastrum tetracerum			129					5			
Tetraedron caudatum	96		1148	929							
Tetraedron minimum		186	1531	929							
Tetrastrum					176						
Tetrastrum staurogeniaeforme											
Tetrastrum triangulare				310							
Asterionella formosa		32		32	8	23		5			
Aulacoseira	8	120	97	385	23	30	4	5	2	32	
Aulacoseira granulata		32	161	225	31	23	4		3		
Diatoma tenuis						8					

Date	May 2014	Jun 2014	Jul 2014	Aug 2014	Sep 2014	Oct 2014	Nov 2014	Decf 2014	Jan 2015	Feb 2015	Mar 2015
Fragilaria crotonensis					8						
Large centric diatom (>20 µm diam.)											
Medium centric diatom (10-20 µm diam.)		464	4593	619	881	347	239		2694	36553	
Melosira varians			32								
Nitzschia		372	32	310			48		3		
Nitzschia acicularis					15	30				16	
Small centric diatom (5 - <10 µm diam.)		464	6507	1858	1057	278			743	25071	1531
Synedra		16			176					32	
Tabellaria flocculosa					15				3		
Urosolenia eriensis											
Very small centric diatom (<5 µm diam.)	96	93	383			69			93	4976	574
Aphanizomenon flos-aquae				32	15						
Aphanocapsa				64							
Chroococcus	4										
Coelosphaerium			64		8						
Coelosphaerium kuetzingianum											
Merismopedia			383	619		69					
Oscillatoria				128	8	308				64	
Oscillatoria agardhii				64			4				
Oscillatoria limnetica (Pseudanabaena limnetica)		24			412	128	12			16	
Oscillatoria redekei											
Euglena					46	23	68	10	8	177	153
Phacus			32	64	8				3		8
Trachelomonas							4				
Goniochloris		8		32							
Ophiocytium											
Pseudostaurastrum		16		32	8						

Date	May 2014	Jun 2014	Jul 2014	Aug 2014	Sep 2014	Oct 2014	Nov 2014	Decf 2014	Jan 2015	Feb 2015	Mar 2015
Bitrichia											
Dinobryon divergens				310		8	8				
Mallomonas											
Mallomonas akrokomos							96			32	
Mallomonas caudata	4										
Synura									192	1180	256
Cryptomonas (large) Length >30 µm	64				31	15	113	15		16	
Cryptomonas (medium) Length 20-30 µm	1279	281	611	289	489	316	998	81	2	129	426
Cryptomonas (small) Length <20 µm	402	217	579	193	443	361	837	87		241	378
Rhodomonas	6028	279	2679	1548	1409	1529	2249	440		3253	3636
Glenodinium		8	129		15	8	4			32	32
Peridinium									2		
Nanoplankton - unidentified flagellates 2–20 µm diameter			766			278	287	176		191	957
Picoplankton - unidentified single cells <2 µm diam.	2871	10682	13396	11146	7485	20011	18181	16731	3251	4784	6698

Date	May 2014	Jun 2014	Jul 2014	Aug 2014	Sep 2014	Oct 2014	Nov 2014	Dec 2014	Jan 2015	Feb 2015	Mar 2015
Total	13,393	17,128	53,613	29,280	16,657	25,257	23,733	18,266	7,373	78,712	15,232
Total Chlorophyta	2,636	3,996	22,976	11,233	4,069	1,397	578	715	375	1,914	582
Total diatoms	104	1,594	11,805	3,429	2,213	808	295	10	3,541	66,680	2,105
Total cyanobacteria	4	24	447	908	443	506	16	0	0	80	0
Total Euglenaphyta	0	0	32	64	53	23	72	10	11	177	161
Total Xanthophyta	0	24	0	64	8	0	0	0	0	0	0
Total Chrysophyta	4	0	0	310	0	8	104	0	192	1,213	256
Total Cryptophyta	7,774	776	3,870	2,030	2,371	2,220	4,196	623	2	3,640	4,441
Total Dinophyta	0	8	129	0	15	8	4	0	2	32	32
Unidentified / Picoplankon	2,871	10,682	14,162	11,146	7,485	20,289	18,468	16,907	3,251	4,976	7,655