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A *Hydrodictyon reticulatum* bloom at Loe Pool, Cornwall

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An extensive bloom of *Hydrodictyon reticulatum* was observed on Loe Pool, a eutrophic coastal freshwater lake in Cornwall. In previous years the Pool has experienced cyanobacterial blooms, but in 1993 *Hydrodictyon* became dominant for the first time. It was estimated that approximately 24% of the Pool was covered by *Hydrodictyon* and dissolved oxygen saturations were observed to range between 220% and 34% within a mat of *Hydrodictyon*. The reason for the shift in algal dominance remains unclear, though large numbers of zooplankton were observed sheltering around the stands of *Hydrodictyon*. These may have restricted the growth of phytoplankton once the *Hydrodictyon* had become established. It is concluded that further study is required to determine the causal mechanism which may be responsible for the explosion in *Hydrodictyon*. The possibility of the growth of a more vigorous strain cannot be discounted.

Key words: Biomanipulation, Cyanobacteria, *Hydrodictyon reticulatum*, Loe Pool.

Introduction

Hydrodictyon reticulatum (L.) Lagerheim, or water net, is a green alga consisting of a coenobium which forms a cylindrical sac-like network (see Fig. 3). It is well known as a nuisance alga, with a rapid growth rate and the ability to maintain high standing crops, and has been observed recently in New Zealand as a 'new invader' which has spread prolifically into lakes and waterways in the central North Island and the Bay of Plenty (Hawes *et al.*, 1991). There appear to be few records of *Hydrodictyon* in the literature for this country, although John *et al.* (1991) reported dense growths in the River Wye in the summer of 1991 when flows were lowest. The alga has only been recorded at two sites by the National Rivers Authority South Western Region in Devon and Cornwall: once in the Exwick Flood Relief Channel, Exeter, in 1992, and each year since 1989 in Loe Pool, Helston, Cornwall.

Loe Pool is a eutrophic lake which has experienced blooms of cyanobacteria in most years since at least 1968 (B. Milford, personal communication) and these have been recorded by the National Rivers Authority since its vesting in 1989. *Hydrodictyon reticulatum* has been observed at the Pool since 1989 and can form mats which drift to its leeward end. Whilst collecting a monthly set of samples from the Pool in August 1993, we noticed an unusually large biomass of *Hydrodictyon* in the Carminowe and Cober arms of the Pool (Fig. 1). Spot readings were recorded of over 200% saturation of dissolved oxygen in the *Hydrodictyon* mats and it was decided to carry out a study to find out the extent of the growth of the algae and to ascertain the diurnal fluctuation in dissolved oxygen in a *Hydrodictyon* mat and compare it with the dissolved oxygen in the open water.

Study area

Loe Pool (Fig. 1) is a coastal lake, 1 km south of Helston, Cornwall. The key morphometric and water quality data are presented in Table 1. Much of the limnological and palaeolimnological studies on this lake are summarised in O'Sullivan *et al.* (1989).

Materials and methods

Water samples were taken from two sites in the Pool at approximately 1300 hours on 24 August 1993. The first site ('surface') was in the main axis of the Pool over the deepest point, and the second site ('HM') was in a surface mat of *Hydrodictyon* in the Cober arm (Fig. 1). The samples were analysed to determine pH, *ortho*-phosphorus, total phosphate and nitrate concentrations. In addition to the water samples, spot dissolved oxygen saturations were

Table 1. Loe Pool lake and catchment data

Area of catchment	54·6 km^2
Lake surface area	55·6 ha
Altitude	4 m above Ordnance Datum
Maximum depth	10 m
Mean depth	4 m
Volume	$3·04 \times 10^6$ m^3
Water residence time	57 days
Annual mean *ortho*-phosphorus	0·07 mg l^{-1} (n=23)
Annual mean total phosphate	0·07 mg l^{-1} as P (n=18)
Annual mean total oxidised nitrogen	4·7 mg l^{-1} as N (n=23)
Annual mean chlorophyll *a*	12·0 μg l^{-1} (n=23)

Morphometric data from O'Sullivan *et al.* (1989); nitrogen, phosphorus and chlorophyll data from National Rivers Authority.

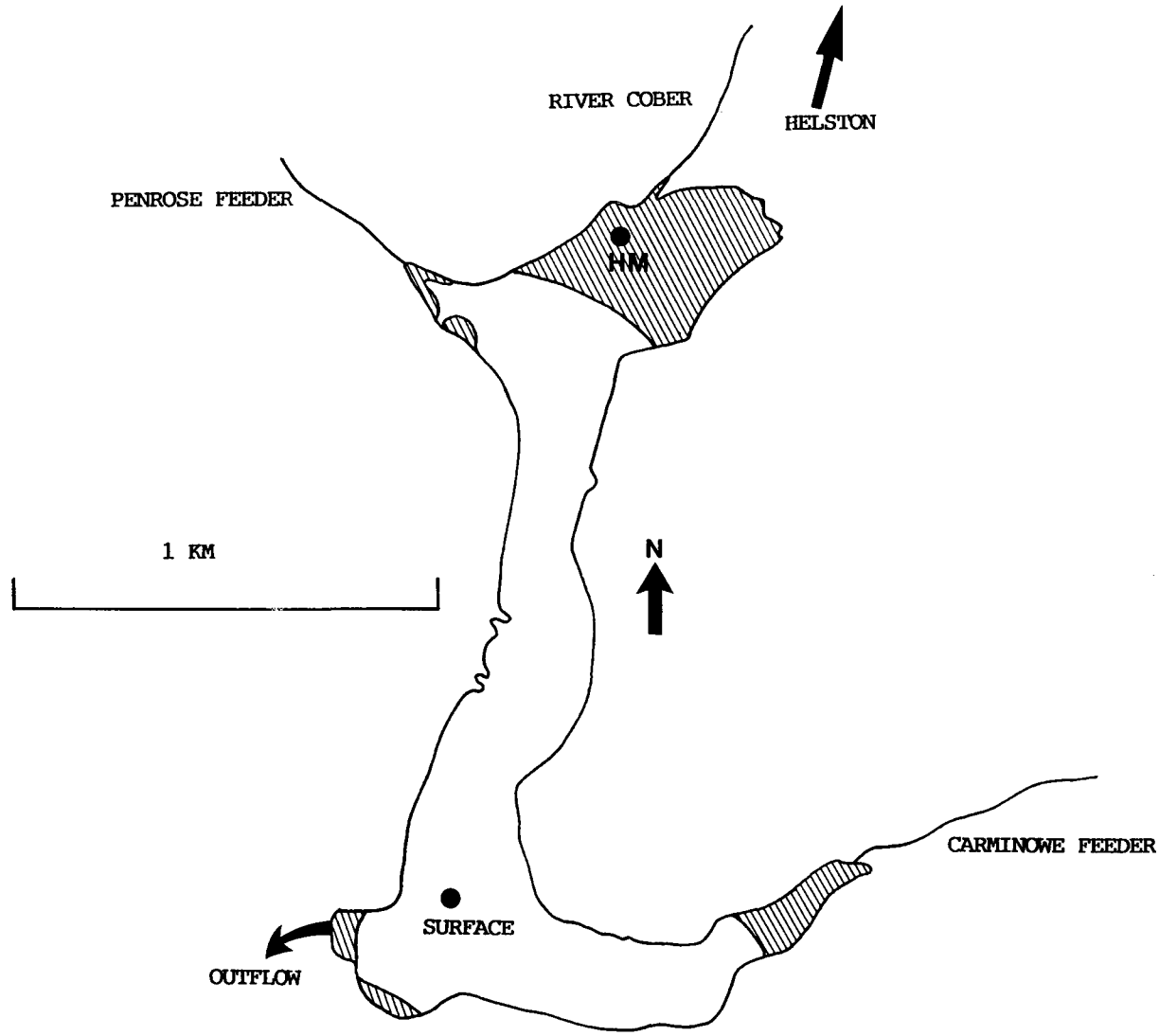

Fig. 1. Location of sampling sites 'HM' and 'surface' on Loe Pool, Cornwall, where dissolved oxygen saturations were recorded. Shaded areas indicate approximate visible cover of *Hydrodictyon reticulatum*.

recorded every 2 h from 1300 hours on 24 August to 0900 hours the following morning at both sites, using a standard Wissenschaftlich-Technische Werkstatten oxygen meter (Model EOT 196, supplied by Semat, St Albans). An estimate of biomass was obtained by removing a single replicate of *Hydrodictyon* using a 0·0125 m^3 box core. The algae were then oven-dried at 105°C to a constant weight. A Secchi depth reading was taken at 1300 hours at the surface site.

Observations

The results of the chemical analysis are summarised in Table 2. The dissolved oxygen saturation demonstrated a dramatic diurnal range within the *Hydrodictyon* mat from 220% at 1900 hours to 34% saturation at 0500 hours; in comparison the surface site remained roughly constant at around 100% saturation (Fig. 2). The apparent drop in saturation at 1500 hours in the algal mat was attributed to cloud cover, which was present from approximately 1430 to 1730 hours; the rest of the survey was conducted under a clear sky.

The *Hydrodictyon* mats were visible on the surface of the

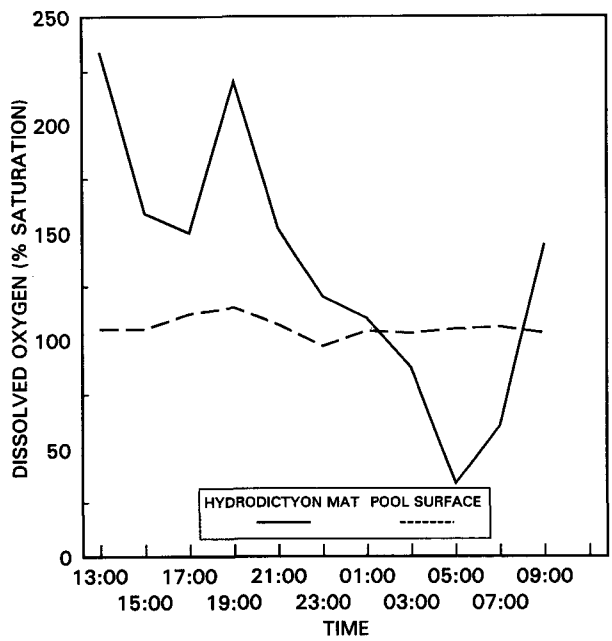

Fig. 2. Dissolved oxygen reading taken at 2 hourly intervals within a *Hydrodictyon* mat and at the surface of Loe Pool, Cornwall.

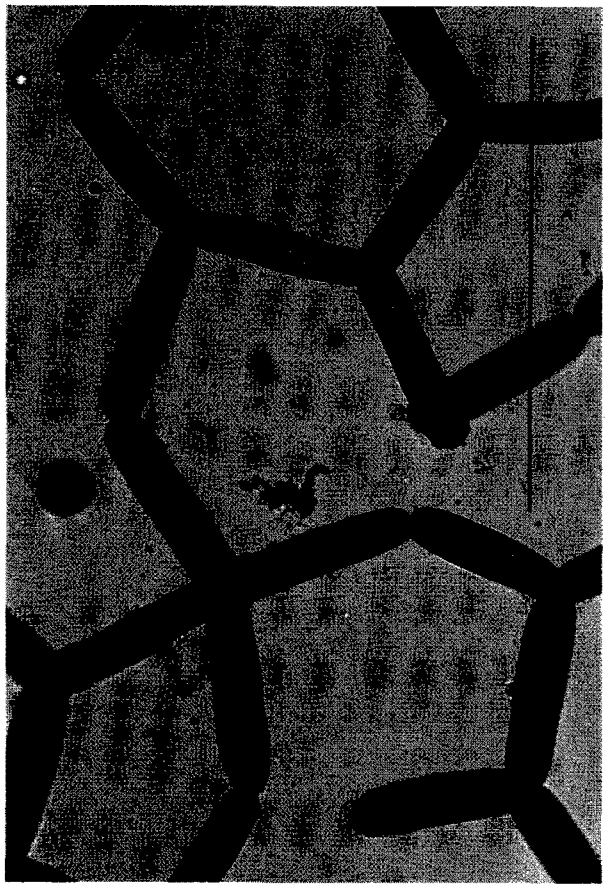

Fig. 3. Micrograph of *Hydrodictyon reticulatum*. Scale bar represents 2 mm.

Table 2. Chemical variables and Secchi depth at two sampling locations in Loe Pool on 24 August 1993

	Surface	*Hydrodictyon* mat
pH	8·3	9·9
Ortho-phosphorus (as P, mg l^{-1})	<0·02	0·02
Total phosphate (as P, mg l^{-1})	0·05	0·04
Nitrate (as N, mg l^{-1})	4·20	4·01
Secchi depth (m)	3·2	—
Chlorophyll *a* (μg l^{-1})	9·0	—

water (Fig. 4) and were also visible growing in the water column down to the sediment to an approximate depth of 2 m. The biomass estimate produced a value of 0·4 g l^{-1} dry weight of *Hydrodictyon* mat.

Discussion

We have attempted to find historical records of *Hydrodictyon* in the Pool but have had no success. From our own observations, *Hydrodictyon* has been present since 1989, but never forming greater than 5% cover of the Pool surface. Observations by the Head National Trust Warden for the Pool confirmed that this is the largest bloom of *Hydrodictyon* in his experience.

In previous years the growth of *Hydrodictyon* may have been light-limited by the dense blooms of *Microcystis*

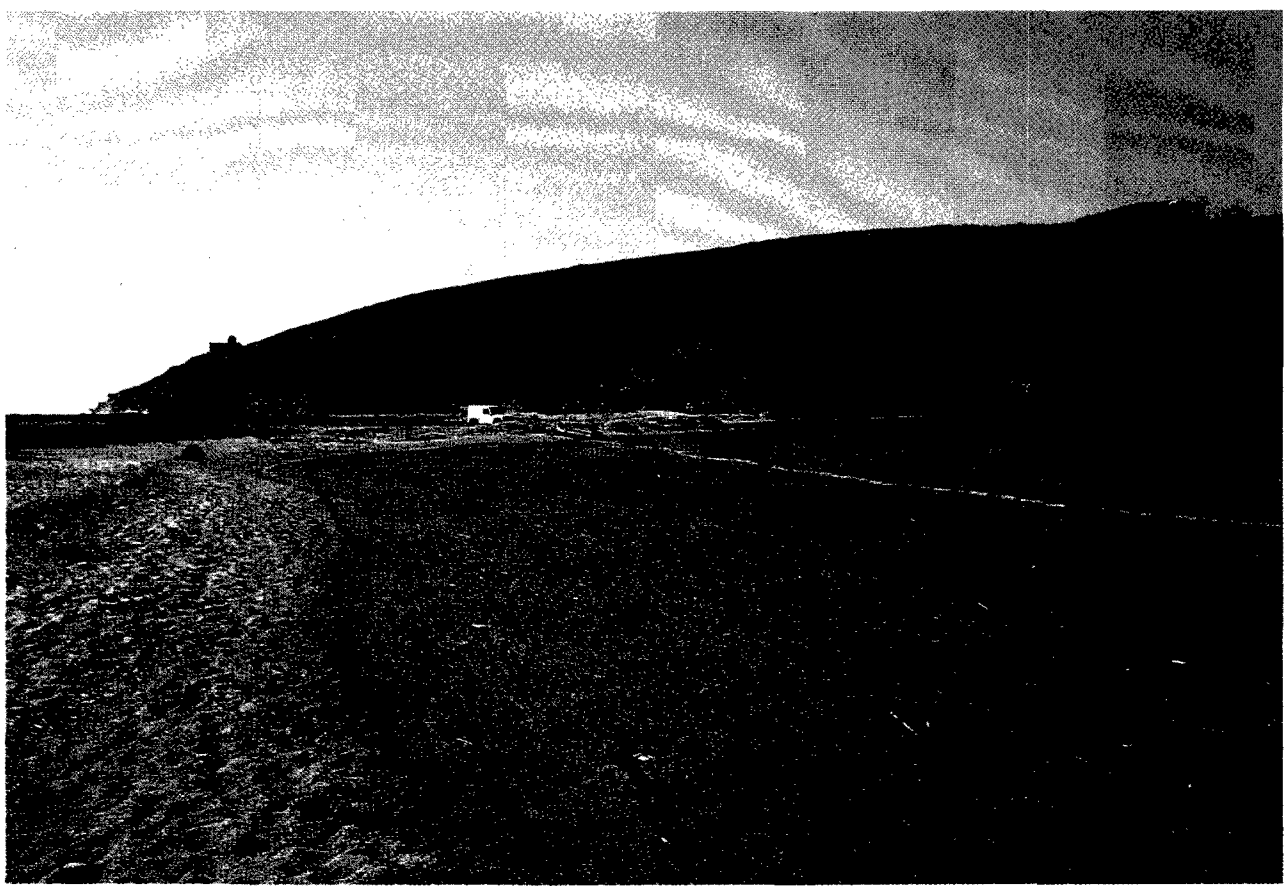

Fig. 4. Dense mat of *Hydrodictyon reticulatum* accumulating on the bar shore, Loe Pool, Cornwall.

aeruginosa Kützing emend. Elenkin, which have been observed each summer since 1989 but were not detected in 1993. Although we have no numerical data, we observed very large densities of cladoceran and copepod zooplankton in the *Hydrodictyon* mats in the Cober arm of the Pool on the day of the survey. It is possible that the *Hydrodictyon* which was present throughout the water column provided a good refuge for the zooplankton and afforded them protection from predatory fish (Moss, 1992). The zooplankton may move out in the night and graze phytoplankton, thereby preventing a bloom. Thus the cyanobacterial bloom generally found in the Pool in the summer may have been controlled in 1993 by a natural biomanipulation event which was facilitated by the dense stands of *Hydrodictyon*. The Secchi depth of 3·2 m and the low chlorophyll *a* concentration (Table 2) reflect the relative clarity of the water column compared with the Pool during a cyanobacterial bloom in 1989, when the Secchi depth was less than 1 m and chlorophyll *a* concentration over 100 $\mu g\ l^{-1}$ (T. Geatches, personal communication). The *Hydrodictyon* could potentially strip much of the nutrient load from the water and so remove this resource from the phytoplankton; however, the *ortho*-phosphorus concentrations in the Pool (Table 2) probably remain sufficiently high to maintain a high biomass of phytoplankton.

The interaction between *Hydrodictyon* and planktonic blooms of cyanobacteria warrants further investigation. It would be interesting to discover what conditions triggered the phenomenal growth of *Hydrodictyon* in 1993 and whether this was at the expense of the more usual bloom of cyanobacteria. The inoculum of *Hydrodictyon* may have increased over a number of years and in 1993 it may have been enough to permit the development of the large biomass observed in the summer. Little is known about the overwintering state of *Hydrodictyon*, but the Pool's close proximity to the sea and consequently relatively high winter water temperatures may ensure that the alga remains in a vegetative state in winter. A gradual increase in inoculum over several years may have triggered a switch from a phytoplankton-dominated assemblage in summer to a dominance of *Hydrodictyon*. It is also possible that a different variety of *Hydrodictyon* was responsible for the unusually large biomass in 1993. This variety may be particularly efficient at sequestering nutrients from the water and could have a faster growth rate than varieties of *Hydrodictyon* observed in the Pool in previous years. This has been postulated as the reason for the success of *Hydrodictyon* in New Zealand (Hawes *et al.*, 1991).

From the perspective of the National Rivers Authority the *Hydrodictyon* bloom resulted in less cause for alarm than a potentially toxic cyanobacterial bloom, as we received no telephone calls from worried members of the public concerned about their dogs being poisoned!

Acknowledgements

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