

## **Nutrient management for ecological benefit at Barton Broad and Bosherton Lily Pools, UK – achievements, costs and long term sustainability issues.**

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Over the past 20 years considerable effort and finance has been expended in pursuit of ecological restoration in two shallow UK lakes: Barton Broad, part of the Norfolk Broads National Park in Eastern England, and Bosherton Lily Pools, part of the Pembrokeshire Coast National Park in South West Wales. Both are shallow (mean depth ~ 1 m), hypertrophic marl lakes with the capacity to support nationally rare Charophyte communities. Both are popular tourist destinations, forming an important feature supporting the local economy. Bosherton Lily Pools is part of the Pembrokeshire Marine Special Area for Conservation, the Stackpole Estate National Nature Reserve, and was designated a Site of Special Scientific Interest for its Charophyte population.

In both cases point source discharges from Sewage Treatment Works in the catchment have been targeted for management, and in neither case have adequate controls been implemented on nutrient delivery from agricultural sources. In both cases, sedimentary P pools have been physically extracted from the lakes using suction dredging in an attempt to increase water depth and decrease internal loading of P from the lake sediment pool.

In both cases some form of biomanipulation has been implemented. In the case of Bosherton Lily Pools, this has occurred as a side effect of other management practices, including manipulation of water levels in the three arms of the lake, leading to hydrologically isolated systems with no hydrochemical connectivity during summer low flows, and regular 'weed' harvesting. In Barton Broad there has been a deliberate attempt to manipulate ecosystem structure in order to suppress algal production, including the installation of a fish curtain to exclude planktivorous fish including roach, and the installation of exclosures to stimulate plant recolonisation of the lake.

The total sums invested in mitigation of nutrient losses to these waters are estimated at €7 million for Barton Broad, and €2 million for Bosherton Lily Pools. Restoration attempts have been partially successful, in terms of halting further damage to ecosystem structure and the nationally rare Charophyte populations (Bosherton Lily Pools) and supporting recolonisation by a range of aquatic macrophyte species, including Charophytes in protected, biomanipulated areas of Barton Broad. However, these attempts have failed to address continuing nutrient losses from agricultural sources in each catchment, estimated as 90% of the total P loading delivered to Barton Broad, and 99% of the total N load and 85% of the total P load delivered to Bosherton Lily Pools from their respective catchments. This loading compromises restoration efforts, and raises questions about (a) the long term sustainability of these ecosystems and (b) whether we can afford to support such long term restoration measures, given that there are over 55,000 water bodies of more than 1 ha in area in England and Wales alone.