The addition of artificial macrophytes in an attempt to improve water quality at Barton Broad, Norfolk, England

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SUMMARY

Artificial macrophytes have been suggested as a means of improving water quality by providing zooplankton refugia, the zooplankton in turn consuming algae and phytoplankton. Plastic brushes installed in a lake in eastern England resulted in a short term reduction in phosphates as they were absorbed by the periphyton growing on the brushes. They also initially provided a refuge for a variety of invertebrate taxa. After two years, the brushes became colonised by sponges, which greatly reduced the diversity of invertebrates using them.

BACKGROUND

The Broads is an area of man-made, interlinked, shallow freshwater lakes in Norfolk and Suffolk, eastern England. There are over 200 km of navigable waterways, with many more connecting small streams and dykes. These link a variety of habitats which support a rich diversity of wildlife, including some of the rarest plants and animals in Britain. The main habitats in the Broads are the rivers and broads (shallow lakes) themselves, fens, alder *Alnus glutinosa* and willow *Salix* spp. carr woodland, grazing marshes and coastal estuary. There are 63 broads which range in size from small isolated lakes to large expanses of water. The lakes were formed some 600 years ago when medieval peat diggings were flooded as a result of a rise in water level. Reeds *Phragmites australis* which grow around the margins of the lakes are still harvested and used for thatching.

Much of the water in the Broads has been affected by excessively high levels of phosphates and nitrates draining off from heavily fertilised agricultural land, and sewage pollution. Further habitat pressure has come as a result of the area being a popular tourist destination for boating and fishing. Boat-wash erodes river banks, further increasing sediment inputs and water turbidity. The eroded silt accumulates at the bottom of waterways, which increases the need for dredging in order for the rivers and broads to remain navigable.

The Broads Authority was set up in 1989, with the responsibility for conservation, planning, recreation and waterways management. Restoring water quality is the basis of much of the conservation work. The Broad Authority has worked closely with Anglian Water who has invested in improved upstream sewage treatment facilities. As a result, the quality of the inflowing water has improved greatly, although there is much more work to be done. This case outlines the provision of artificial macrophytes in a Broad in Norfolk in an attempt to improve water quality.

ACTION

Study site: Barton Broad in Norfolk, eastern England, is the second largest East Anglian broad covering an area of 69 ha (170 acres). It is a Nature Reserve which, including marginal habitat, covers 142 (350 acres). Access is only possible by boat. By the 1970s, Barton had been severely degraded by decades of nutrient enrichment from water running off agricultural land and from the two local sewage treatment works. Professor Brian Moss (University of Liverpool) described the appearance of the nutrient-rich mud as being like "a great black tongue" on the bed of the broad. This nutrient overload led to excessive growth of algae and occasional 'blooms' of blue-green algae, in what had been up to the 1960s, a lake dominated by yellow water lilies *Nuphar lutea* and other aquatic plants such as pondweeds *Potamogeton* spp. The algae, growing unchecked in the nutrient-rich water, shaded out all other submergent water plants, and at

Photo 1. Bunches of Italian cobweb brushes used as artificial macrophytes in Barton Broad.

the start of the 'Clear Water 2000' project, the broad appeared murky and lifeless, with a thick layer of mud on the bottom, which also restricted boating to the central navigation channel.

The Clear Water Project: The Clear Water Project, which began in 1995, aims to improve water quality and restore aquatic habitats. It has used several innovative techniques in waterway conservation and has involved a high level of specialised research. Suction dredging removed 300,000 cubic metres of nutrient rich mud from the bed of the broad to reduce phosphorus release, which otherwise encourages algal growth. The dredging has resulted in the return of species lost during previously high water nutrient levels, as well as improving access for boating by deepening and widening heavily silted navigation channels.

The purpose of artificial macrophytes: The Broads Authority and English Nature, initiated a second project to further restore Barton Broad. The aim was to encourage zooplankton such as water fleas *Daphnia* spp. by providing refugia which were mostly absent due to the paucity of aquatic macrophytes. Zooplankton provides a critical role in improving water quality by consuming algae. The hope was that providing refugia would encourage invertebrates to colonise and in turn encourage a wider range of fish species, more typical of the natural state.

Installation of artificial macrophytes: Four areas were enclosed using temporary 'fish curtains', on the north and south side of the ‘Neatishead Arm’ section of the lake, and the eastern and western edge of adjacent Turkey Broad, covering an area approximately 6 ha. Fish curtain is made from flexible plastic, which can cope with seasonal and tidal changes in water level. Its purpose was to create a sanctuary within which to work and keep fish from entering the area while the invertebrate population built up. The curtain does not damage boats if they accidentally collide with it, and since it does not stick up out of the water, it does not intrude on the landscape. The enclosure on the western edge of Turkey Broad was selected for the installation of artificial macrophytes.

Within the west Turkey site, three separate mesocosms (enclosures within which to manipulate environmental conditions) each 0.3 ha in area, were installed in 2001:

Mesocosm 1 - 14,000 ‘Italian cobweb brushes’ (Photo 1) were suspended in bunches on ropes hung from posts installed in the water. The purpose of the brushes was to mimic native

plants which provide zooplankton refugia (e.g. rigid hornwort *Ceratophyllum demersum*). Fish were removed by electro-fishing; all were identified, counted and measured before being released outside the mesocosm.

Mesocosm 2 - Fish removed, no cobweb brushes installed.

Mesocosm 3 - Fish retained, no cobweb brushes installed. The fish abundance and diversity was about the same as outside the mesocosm in the surrounding water.

CONSEQUENCES

Mesocosm 1 - brushes installed and fish removed: In 2001 and 2002, the brushes supported high abundance and diversity of invertebrates. Periphyton rapidly grew on the brushes in the first year. These provided a food source for invertebrates as well as removing nutrients from the water column. Their presence was an indicator of good water quality. There was no algal build up and the water column was clear. The total phosphorus and chlorophyll concentrations were significantly lower than that within the other two mesocosms. However, after two years, sponges colonised and overran the brushes reducing their suitability as refugia for other invertebrate taxa. Scuba surveys undertaken from 2001 to 2005 to examine the sediment and monitor macrophyte growth have revealed no observable benefit of the brushes for natural macrophyte colonisation and there was no observable change in the appearance of the sediment surface.

Mesocosm 2 - no brushes and fish removed: Over two years (2001 to 2002), colonial blue green algae *Aphanizomenon*, built up in extremely high numbers. Zooplankton numbers were impossible to count due to the high concentration of algal cells. However, due to the high numbers of large colonial blue green algae (and few small ones), it is assumed that grazing pressure from zooplankton was initially high. This is because zooplankton only grazes small algae, therefore giving an advantage to larger colonial species, such as some blue green algae, which can then rapidly build up in number. There was no macrophyte colonisation. No sediment survey was done at this mesocosm.

As this mesocosm was close to a public viewing platform and within a public access area, it was removed in 2001/2002.

Mesocosm 3 - no brushes and fish present: High algal populations were observed. It is assumed that the presence of zooplanktivorous fish kept the zooplankton population low. The resultant lack of zooplankton grazing could have resulted in the high algal population. These were observed to be non-colonial species, likely to be present due to the lack of grazing pressure on small algal species. There were no macrophytes recorded in this low-light environment.

Conclusions: The initial benefit of using cobweb brushes as artificial macrophytes was the phosphorus uptake by periphyton which grew on the brushes. As a result, this nutrient was not available for algal growth in the water column, resulting in clear water and macrophyte growth. Initial colonisation by invertebrates increased the biodiversity within the mesocosm. Despite the colonisation of sponges on the brushes over time, invertebrates continued to gain long term refuge benefit at a reduced level.

The use of this type of artificial refugia is unlikely to be repeated due to the short term beneficial nature of the effects, the expense and the practical difficulties of installation and removal. The supporting structures are also conspicuous and ugly, and if in a navigable area of the lake could present a navigation hazard. The Broads Authority and partners are developing a strategy for future lake restoration in order to achieve Public Service Agreements for SSSIs and Water Framework Directive Targets.

For further information about this case see:
http://www.broads-authority.gov.uk/projects/barton-broad.html