

Step by step: the story of broads restoration

Step 1. Reduction of nutrient loading

A decade after phosphorus inputs were reduced, there was little obvious sign of recovery. Another key problem was thought to lie within recently deposited mud. A huge reservoir of nutrients had accumulated in the sediment at the bottom of the rivers and broads, and this supply of phosphorus and nitrogen was released into the water during the summer. This acted as a secondary pollution source, further fuelling algal growth. In addition, nutrients were still entering waterways from many diffuse sources such as intensive agricultural land, urban drainage and properties not connected to the mains sewer system.

The next stage in broads restoration was therefore to remove the nutrient-rich sediment by suction dredging. Starting in 1982, a variety of broads were dredged and the results closely monitored. Subsequently phosphorus levels in the water were reduced and algal populations were lower in the dredged broads. Suction dredging became a key stage in the restoration process. The largest dredging operation to date has been at Barton Broad, carried out as part of the Millennium Clear Water 2000 project to restore the broad.

Step 2. Biomanipulation: helping biology to work

During the 1980s research pointed to the important role of zooplankton, or water fleas. Species such as *Daphnia* graze on algae cells and are important for controlling the algal populations. Zooplankton filter the water to obtain their food and when their numbers are greatest can filter the entire volume of a lake within a day. They can therefore prevent significant algal populations from developing and so help maintain clear water throughout the summer months when algal growth is usually greatest.

In a shallow broad which still has submerged water plants, grazing zooplankton are able to find refuge from young fish and can continue to graze on the algae. However, in a broad which is dominated by algae, fish prey on the water fleas which do not have water plants in which to seek refuge, so the water remains cloudy. A broad which supports aquatic plants can continue to do so, but a broad which is dominated by algae cannot switch to support water plants - unless there is a little outside help.

Biomanipulation helps the natural biology to work by reversing the switch from plant to algal dominance. The technique involves temporarily removing selected fish species in order to create the right conditions for the *Daphnia* to make a large impact on the algae, and to clear the water.

In 1989, around 700,000 fish (mostly young roach and bream) were captured by electrofishing and transferred from Cockshoot Broad to the main River Bure. This resulted in clear water conditions over the summer months. Follow-up fish survey and removal operations have been successfully carried out over a 16 year period at Cockshoot Broad and have in some years encouraged water plants to re-establish. Only when the barriers separating Cockshoot from the Bure failed, and fish came into Cockshoot, was the clear water lost. Today, a fish community with a wider variety of species has developed, responding to the presence of water plant beds.

In a broad which is connected to the navigable river it would not be possible to manage the fish population in this way due to fish and boat movements to and from the river system. Instead, fish-free enclosures can be put in place, which keep fish out of parts of a broad, so allowing the *Daphnia* to graze on the algae. This technique has been successfully used in Barton Broad, with clear water and abundant submerged plant growth occurring in the fish-free areas.

The importance of biomanipulation lies in its potential for triggering a change from an algal to a plant dominated ecosystem. Small-scale biomanipulation trials demonstrated the power of this technique. During the three year project (1993-1996) which was supported by the

European Union LIFE programme, the detailed effects of this technique and factors affecting water plant recovery were investigated further.

A large-scale demonstration project was undertaken at Ormesby Broad (56 hectares) where over 10 tonnes of fish were removed over the winters of 1994/95 and 1995/96. This resulted in an immediate return of clear water in the summer and a rapid recovery of diverse aquatic plant communities across the broad. Apart from benefits to nature conservation, this project improved the quality of drinking water abstracted from the broad by Essex and Suffolk Water. These clear water and aquatic plant conditions have remained to the present day, highlighting how such techniques can have lasting positive environmental results.

Step 3. Recovery of water plants

The re-establishment of dense, submerged water plant beds in clear water is vital to the recovery of the whole ecosystem and the future stability of the Broads. However, water plants are generally slow to respond to clear water conditions, with restoration very much a long term goal. Two causes that delay the return of submerged plant growth have been investigated: grazing by birds and the physical and chemical condition of the sediment.

A number of monitoring projects and experiments have shown that protection from bird grazing (using mesh enclosures) helps to encourage plant re-establishment. However, if aquatic plant growth is healthy, vigorous and abundant, it has been shown that bird grazing does not particularly affect the aquatic plant beds.

Some work carried out jointly with RIZA (the Institute of Inland Water and Waste Management) in the Netherlands indicated that the unstable, peaty sediment that is characteristic of many of the broads may be limiting water plant recovery, as seedlings are vulnerable to being buried, or uprooted. The presence of high levels of sulphide and ammonium compounds in the sediment may also worsen this problem.

Step 4. Stabilisation of broads in good condition

Once broads are in a plant-dominated state, a number of factors operate to keep them stable. For example, pike and perch act as a natural control on zooplanktivorous fish and they become more dominant in clear water and plant abundant lakes. These conditions favour their visual hunting behaviour. Submerged water plants also act as effective refuges for grazing zooplankton. The interactions between fish, zooplankton and water plants were studied as part of the LIFE project with the Environment Agency.

Research is ongoing to guide the management of broads once water plants are re-established. In particular, it will be important to find ways to ensure the development of the fish community in a way which is in balance with plants and zooplankton and does not destabilise the system.

However there is still much work to be done to reduce nutrient levels to achieve a stable, plant dominated state. This will require the development of a variety of techniques and investment to minimise agricultural and other widespread sources of nutrients and toxic substances. This takes us back to step 1 - further reduction in nutrient loading is required. Together with partner organisations the Broads Authority is looking at ways of reducing diffuse pollution in the Broads. These schemes are focussing on reducing widespread nutrient and sediment inputs from a variety of sources, including agriculture and domestic sewage, and seek to achieve improvement to water quality over the long term.

The future for broads restoration

The scale and complexity of the task of restoring water quality to the rivers and broads is immense. The deterioration of the quality of water has not been a natural, gradual phenomenon but has taken place over the last 100 years, a relatively short time when compared with the evolution of the broads from the days of peat excavation in the early medieval period.

The impact of deteriorating water quality is equivalent to a major catastrophe, the fall-out from which is still being experienced. Not only was this change devastating for the loss of habitats and species but it is detrimental for everyone who comes to the Broads for enjoyment, and for the tourism industry which is crucial to the economy of the area.

The majority of broads have lost virtually all their aquatic life and restoration will therefore be a long-term process. It will not be possible to turn back the clock, but we believe it is possible to take the broads forward, to re-establish a cleaner, healthier and more diverse water environment which is self-sustaining and self-supporting, benefiting wildlife and all who use and appreciate the Broads.