

# **Hoveton Great Broad and Hudson's Bay biomanipulation - Macrophyte recovery and the requirement for a diverse stable macrophyte community**

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Work on the Broads and elsewhere has shown that whilst biomanipulation of a sufficient magnitude almost inevitably produce clear water, the difficulty has been maintaining this change. Key to maintaining this change is the establishment of a diverse and extensive macrophyte assemblage that as a consequence is stable. The literature suggest there may be a delay of 2-8 years for macrophytes to recover (Lauridsen *et al.*, 2003 & Pot & ter Heerdt, 2014). Experience in the Broads has shown that although clear water is quickly achieved, the time taken for macrophyte establishment is variable, sometimes happening quickly whilst in others taking around 5 years, as in the cases of Pound End and Cockshoot Broad (Phillips *et al.*, 2015). This variability is at least in part due to the availability of propagules. Whilst it is hoped that dredging will have exposed the propagule bank in Hoveton Broad, allowing quick macrophyte colonization, it remains a risk that macrophyte colonisation might take longer than the current proposed time for the fish barriers of 3 years.

In Denmark biomanipulation has repeatedly been attempted as a one off measure (fish being removed from a lake and then no further action being implemented) and as a result in nearly all these attempts the lake has returned to its original condition within 10 years (Søndergaard, 2008). The reasons cited for the failure of these biomanipulation attempts was an insufficient quantity of fish being removed in the first place or water quality continuing to be an issue. In such situations despite sufficient fish being removed and short-term improvements in water clarity the fish assemblage returned to its pre-manipulated state and a stable macrophyte assemblage was not established. It was concluded that repeated fish removal would be required to obtain long-term effects in the most nutrient rich lakes.

The composition and diversity of the plant assemblage has also been reported as key to the success and stability of lake restoration. More than 10 macrophyte species has been reported as being key to lake stability in the Broads and the presence of submerged macrophytes and charophytes are particularly important (Phillips *et al.*, 2015). This has taken 15-20 years in the Broads that have been biomanipulated successfully (Cockshoot and Ormesby Broad).

Therefore it is essential that a sufficiently low density of fish is maintained in Hoveton Broad until macrophytes have been able to establish in sufficient density, diversity and extent. This will require the barriers to remain in place, the removal of fish eggs from artificial spawning materials to reduce recruitment and additional fish removals if fish overtop the barriers or recruitment is successful in Hoveton Broad until a suitable macrophyte assemblage has been established.

Also key to the stability of the macrophyte dominated system are sufficiently low nutrient levels, with charophytes commonly only seen in abundance when TP is as low as 35  $\mu\text{g L}^{-1}$  (Phillips *et al.*, 2015). The establishment of an abundance of macrophytes throughout the growing season contributes to lower nutrient levels as it locks the nutrients in plant biomass

and stabilizes the sediment. In contrast higher nutrient levels make the plant dominated state more unstable and more likely to revert to an algal dominated state with the pre-manipulation fish assemblage. The risk of reverting to such a state can be lowered by reducing the nutrient loads from the catchment. Work is ongoing in the Bure catchment to do this, but significant changes in nutrient loads are not expected till 2027 due to the length of time it takes to plan and implement these changes. Continuing to manage the fish population in Hoveton Broad until nutrient inputs from the catchment have declined increases the likelihood that the macrophyte dominated state will continue once the barriers come down. At this point the fish assemblage will respond to the environment available and consequently a diverse fish assemblage compatible with the macrophyte dominated state should naturally be maintained due to the environmental niches available. The macrophyte assemblage established in Hoveton Broad should then be able to act as a propagule bank to colonise the wider Bure system which will have also improved due to water quality improvement works in the catchment.

### **Additional information**

Submerged macrophytes can find it difficult to establish in some situations, not only due to propagule availability, but also due to herbivory. For example snails released from predation by the removal of benthivorous fish can then preferentially feed on submerged species rather than floating species such as water lilies. This is why tench, which also feed on snails but creates less turbidity than bream, will remain in Hoveton Broad after biomanipulation. This should optimize the chances of the establishment of a diverse macrophyte assemblage.

### **References**

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