Request Title: E&B – Lakes Specialist Consultation on Flood Risk Activity Permit (FRAP)

Location: Hoveton Great Broad as part of the Hoveton Great Broad Restoration Project. Barriers will be installed on Hoveton Great Broad at Foxborrow dyke (TG32071581), the Dam (TG32421614), Hoveton marshes (TG31891651). The Dam and Foxborrow dyke are the locations were Hoveton Great Broad connects to the River Bure.

Grid Reference: 631670,316210

Water Body: River Bure (GB105034050931)

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**Internal consultation response by [redacted], Senior Specialist (Lakes), E&B Research, Analysis and Evaluation Team.**

**6 April 2021.**

Hoveton Great Broad (HGB) is currently in Poor ecological status and Unfavourable Condition. As the water body is part of the Bure Broads & Marshes SAC it is a Protected Area under the WFD and requires management intervention if it is to achieve Good Ecological Status and Favourable Condition. The lake restoration project that has been initiated is employing techniques that have been widely used within the Broads and elsewhere, and which have been developed over many years based on scientific studies of shallow lake ecology (see, for example, Moss et al 1996, Phillips et al 2015).

It is well documented in both the wider scientific literature, and in relation to the Norfolk Broads in particular that shallow lowland lakes can exist in two alternative stable states (Scheffer et al, 1993). A clear water, aquatic plant dominated state existing at lower nutrient levels, may be relatively resistant to change but becomes vulnerable with increasing nutrient levels to a "switch" to turbid waters dominated by phytoplankton (microscopic algae). With phytoplankton dominance there is insufficient light for water plants to survive, and the whole structure and functioning of the ecosystem is changed. In terms of lake ecology and habitat condition this second stable state is regarded as undesirable and degraded, with reduced biodiversity.

The phytoplankton-dominated state is consistent with an assessment of less than Good ecological status under the WFD, and Unfavourable Condition under the Habitats Regulations. While these assessments are carried out separately by the Environment Agency and Natural England, they are based on a common view of what would constitute a properly functioning shallow lake, which aligns closely with the clear water, aquatic plant dominated state.

Shallow lake ecology is complex, involving many interactions between physico-chemical and biotic components, and between different elements of the biota themselves. Enrichment by nutrients (principally phosphorus) is widespread in lowland habitats, and examples of pristine or only slightly impacted lakes are very difficult to find in the UK. In the Broads however there is much anecdotal evidence of past conditions (which does not mean "pristine", since even historic records will relate to periods of time where human activity had already had an impact) (see e.g. George, 1992) . There have also been numerous palaeoecological studies investigating the sediment record, showing changes in the ecology associated with changes in nutrient status (e.g. Moss, 1980, Davidson et al,

2008, Goldsmith et al 2014). Up until the mid 20th century the Broadland lakes had clear water and abundant submerged and emergent aquatic plants - at this stage they were already enriched to an extent, but retained some resilience against increasing nutrient levels. The plants were important in providing a habitat structure within the lakes that supported a wide range of invertebrates, zooplankton and fish, as well as plant- and fish-eating birds in large numbers.

Since the 1950s the majority of the broads have switched to the phytoplankton dominated state. Recognition of the damage caused by excess phosphorus has resulted in many millions of pounds of investment in phosphorus (P) removal at sewage treatment works, and a significant reduction in P concentration in the Broadland rivers.

The aim of lake restoration projects such as that at Hoveton Great Broad is to accelerate the recovery of the aquatic system back to a clear water stable state. With nutrient levels reduced in the river system, removal of sediment from the broad has increased water depth and taken some of the "legacy" phosphorus out of circulation. However, it is highly unlikely that the lake will spontaneously return to a stable clear water state with current phosphorus concentrations. Since a further reduction in nutrient concentrations is likely to be a long-term undertaking (requiring tackling of diffuse sources in the catchment), additional intervention in the form of biomanipulation to restructure the fish community provides the most realistic option for restoring clear water conditions in the short to medium term.

In shallow lowland lakes suffering from the impacts of eutrophication, fish communities tend to be dominated by highly productive populations of bream and roach. In this context the fish represent both a symptom of the enrichment and a pressure preventing recovery of the wider aquatic ecology. In the original clear water state there would have been a relatively diverse fish community, characterised by a balance of species and age structures. While bream and roach undoubtedly formed part of this community, their numbers would be kept in check by predators such as pike and perch, which rely on clear water for hunting prey, and use aquatic plants as cover. The fish community would also have contained a wider range of other species such as rudd, tench and eels. With the switch to turbid water and loss of aquatic plants and therefore habitat structure the predators decline, allowing an increase in biomass and numbers of fish such as roach and bream. Young roach and bream feed on zooplankton and this together with a lack of aquatic plants to provide refuges for the zooplankton leads to reduced consumption of phytoplankton by the larger zooplankton species, resulting in an even greater increase in phytoplankton, thereby reinforcing the stable turbid water state.

Biomanipulation is a well-established technique used previously in the Broads (see e.g. Stansfield et al, 1997, Perrow et al 1999), and more widely in Europe and elsewhere (Bernes et al 2015), to temporarily disrupt the already degraded lake fish community, reducing predation on zooplankton (and sediment feeding activity by fish, which also contributes to turbidity). This allows clearer water and an opportunity for submerged aquatic plants to re-establish. Stable plant populations then provide a habitat that will, in the slightly longer term, facilitate a return to a more diverse and structurally balanced fish community.

While there is debate about what the fish community structure of the Broads was in the past, it is clear that it has been highly productive for a significant length of time. Just like increased plant and algal growth, this productivity is an indication of nutrient enrichment. A highly productive fish community dominated by very few species is incompatible with good ecological status, although once established it may be viewed as desirable from an amenity angling viewpoint. It is important to

make the distinction between the perception of a "good" (and therefore high value) amenity fishery and an objective assessment of good ecological status for fish.

Undertaking biomanipulation of the fish community within the broad for a period of several years may have an impact more widely, since it has been established that HGB currently provides a preferred spawning site for a significant number of bream. The impact of exclusion of these fish from this site may be that they move to other, less optimal spawning sites or that there is a failure of these fish to spawn in the following years. Because of the interconnectedness of the Broadland rivers and lakes this may result in poorer recruitment of bream in the wider system over this time period. However bream is a widespread species that has been shown to spawn on a range of substrates (including artificial ones such as nets). It is unlikely that spawning would not occur elsewhere in the system, although perhaps less successfully than in recent years. A short term reduction in bream recruitment in the wider system may be seen as a threat to the current amenity fishery and the associated economic benefits derived from angling in the local area, but this cannot be equated with a deterioration in ecological status. In addition, although the focus has largely been on bream, Hoveton Great Broad has been shown to be dominated in terms of number of fish (rather than biomass) by roach, and large numbers of young roach will also be detrimental to lake recovery.

A potential deterioration in fish status under the WFD has been raised as an issue with the exclusion of fish from HGB. There is no available WFD classification for fish in very shallow lakes in the UK and no lake fish classifications have been produced for England. The UK WFD Technical Advisory Group has recently developed an eDNA tool (UKTAG, 2020) which has been recommended for adoption, but is not yet formally in place. It is therefore necessary to bring a degree of expert judgement to consideration of the impact of the proposed project on the un-assessed fish status.

The WFD requires that ecological status of the fish community (as with other elements) is assessed in terms of deviation from a reference condition. As noted previously, extant examples of reference condition for shallow lowland lakes are extremely rare due to the widespread impact of human activity. Since neither a reference community nor an agreed set of status thresholds representing deviation from such are available for lake fish, we can only make a judgement based on knowledge of both shallow lake and fish ecology. Since all the measured biological elements in HGB are at Poor status, it is unlikely that the fish community currently is at any better than Poor status, given the dependence of fish on the rest of the lake ecology (and vice versa).

Annex V of the WFD, Section 1.2 provides a series of normative definitions of High, Good and Moderate status for the biological elements, including fish, but only gives generic information on the definition of Poor or Bad status as follows:

*Waters achieving a status below moderate shall be classified as poor or bad.*

- *Waters showing evidence of major alterations to the values of the biological quality elements for the surface water body type and in which the relevant biological communities deviate substantially from those normally associated with the surface water body type under undisturbed conditions, shall be classified as poor.*
- *Waters showing evidence of severe alterations to the values of the biological quality elements for the surface water body type and in which large portions of the relevant biological communities normally associated with the surface water body type under undisturbed conditions are absent, shall be classified as bad.*

Adoption of the current fish community composition as the "baseline" from which to determine risk of deterioration, and the assumption that removal of bream and roach from Hoveton Great Broad

represents a deterioration in status implies that the current fish community is in something better than Bad status (in that deterioration is possible), and that removal of some fish species automatically represents a deterioration. This is a matter for expert judgement, since definitions for, or examples of, fish communities in the different ecological status classes for lakes of this type have not been developed.

The assertion by Natural England that the current fish community represents Poor status seems reasonable given the above WFD definitions. While biomanipulation would result in a significant reduction in the large biomass of roach and bream, complete elimination is very unlikely to be achieved, and other fish species currently present would be retained in the lake. In the context of wider lake ecology, a reduction in the current fish biomass or numbers cannot be said to represent a deterioration in status, and since the aim is not to make the lake completely fish free then a deterioration to Bad status, in line with the definition given, does not appear likely. Since the purpose of the biomanipulation is ultimately to improve the ecological functioning of the lake, if successful this will be of benefit to the fish ecology as well, resulting in an improvement in status, with increased stability and diversity in the fish fauna.

In conclusion, it is my view that it will not be possible to attain restoration to Good Ecological Status /Favourable Condition for the whole lake ecology in Hoveton Great Broad without a change to the fish community. Thus installation of barriers to allow biomanipulation over a period of several years offers the best chance of fulfilling the obligation to restore this designated site.

**References**

Note: Extensive references have been supplied within the documents submitted by Natural England as part of the FRAP application, so I have included only selected references in this response document.


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UKTAG 2020 UK Technical Advisory Group Biological Standards consultation – Lake Fish. January 2020 UKTAG Consultation Document Lake Fish