Addendum to Hoveton Wetlands Restoration Project Water Framework Directive Assessment (WFDA)

January 2020

Introduction

The Water Framework Directive Assessment (WFDA) for the Hoveton Wetlands Restoration project was published in June 2014. Since then, project plans have developed and further surveys have been carried out. Survey work to date suggests the broad may be more important for fish, particularly bream, than was originally expected. The Environment Agency has therefore asked that the WFDA be updated in light of improved evidence.

Changes to the project plans relate specifically to the sediment removal and are detailed in 'Addendum to Hoveton Wetlands Restoration Project Water Framework Directive Assessment (WFDA), August 2016'. This addendum relates to the Flood Risk Activity Permit for the installation of fish barriers on Hoveton Great Broad and reviews the new data on how fish are using Hoveton Great Broad and Hudson's Bay (WFD unit GB30535977), and whether this changes the conclusions of the original WFDA.

This addendum should be read in conjunction with the Flood Risk Activity Permit application forms and associated documents.

Revised assessment of the impact on fish

New fish data available

Since the WFDA was published baseline fish surveys of Hoveton Great Broad have been conducted and we have received initial data from fish tracking studies. The results and observations to date suggest that in comparison to other middle bure broads it is visited by a greater proportion of the fish in the system and therefore it may have significant importance for the wider Bure fishery. In particular, the broad may provide an important spawning and resting-up site for adult bream. The data is summarised below.

Figure 1. Overall, whole broad density (a) (ind. m^{-2}) and biomass (b) (g m^{-2}) estimates by season. All broads. 2016-2017 (Hindes 2017)

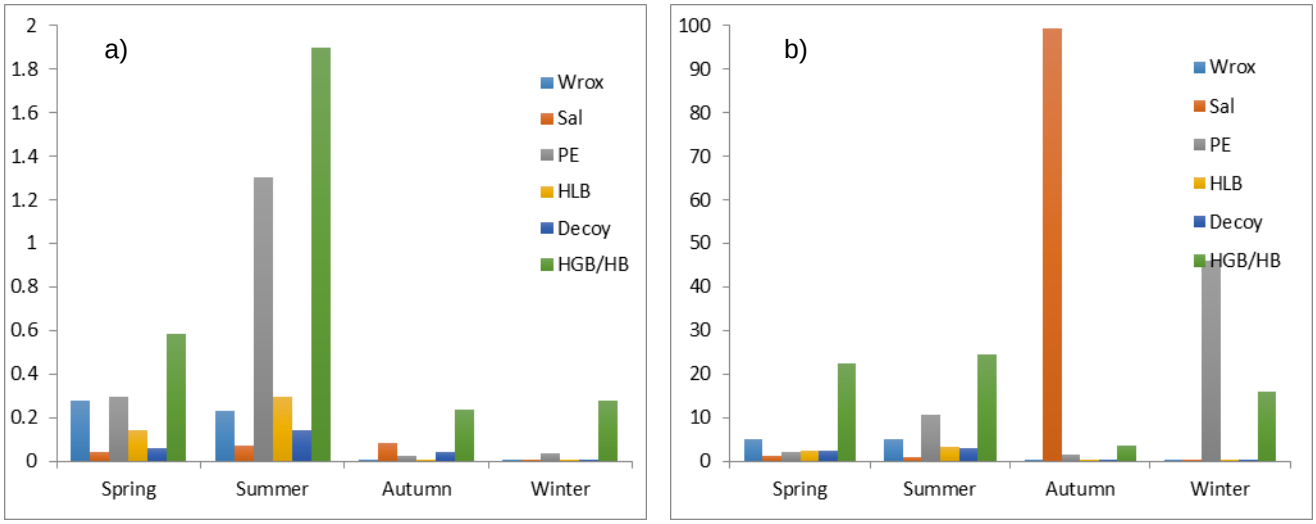
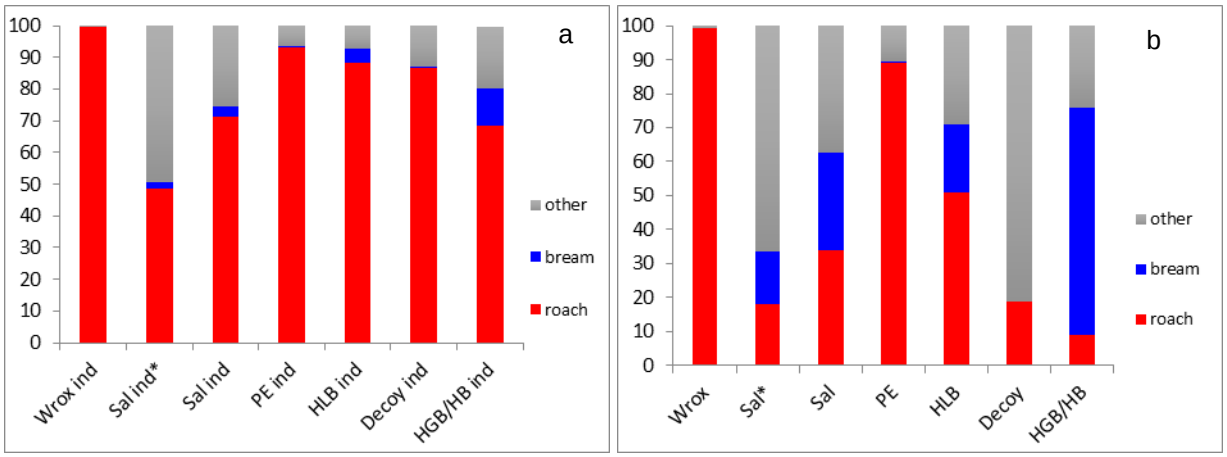


Figure 1 above shows that Hoveton Great Broad and Hudson's Bay (HGB & HB) support higher densities and biomasses of fish in comparison to the other middle Bure broads. Within HGB and HB roach dominate the fish community by number and bream by biomass (see figure 2)

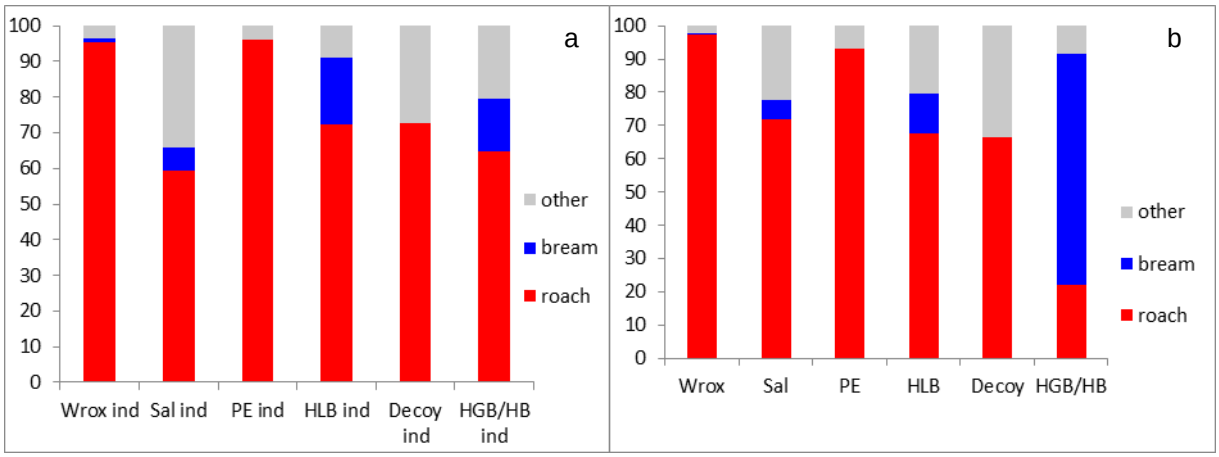
Figure 2. Relative (%) overall density (a) and biomass (b) of roach, bream and all 'other' species category. All broads.

Spring 2016

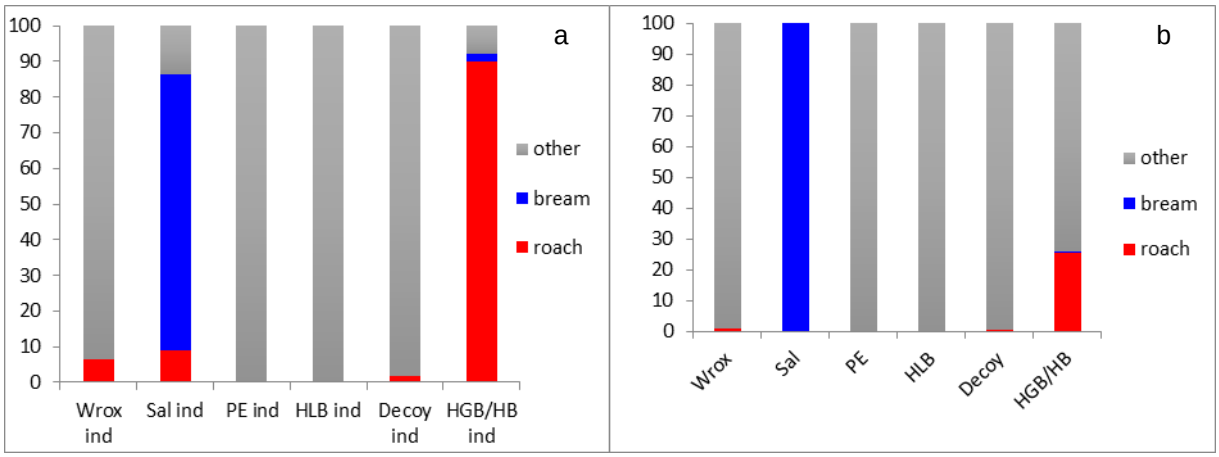


Hoveton Great Broad Restoration Project

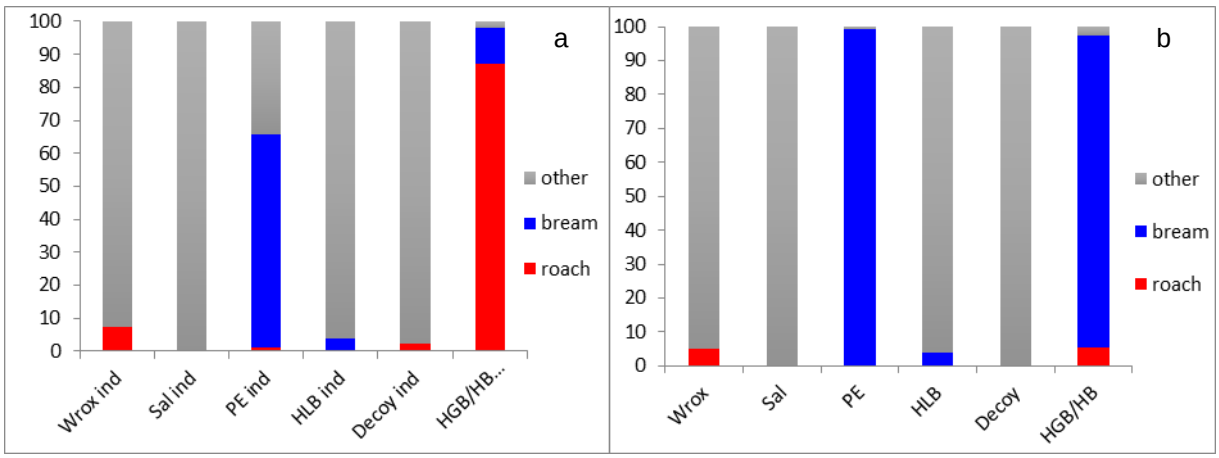
Summer 2016



Autumn 2016



Winter 2016



In combination with the baseline surveys, fish tracking data, collected as part of a PhD funded by the project, has shown the apparent importance of HGB & HB for

bream during the spawning season (15 April and 31 May). In total, of 113 tagged bream alive and active on receivers from 15th April 2018, 77 (68%) were detected in HGB during the spawning period and 39 (35%) were detected in HB. There were 68 tagged bream alive and active from 15th April 2019. 45 (66%) were detected in HGB during spawning and 23 (34%) were detected in HB.

The majority of bream appear to visit more than one broad during the spawning period - 23% of the tagged bream used only HGB/HB in 2018 and 29% in 2019. The figures below indicate the relative proportions of bream visiting more than one broad during the spawning period, and the broads (other than HGB & HB) visited most often by bream during the spawning period.

Figure 3. Data from northern broads PhD project showing the number of broads visited during the spawning season by tagged adult bream.

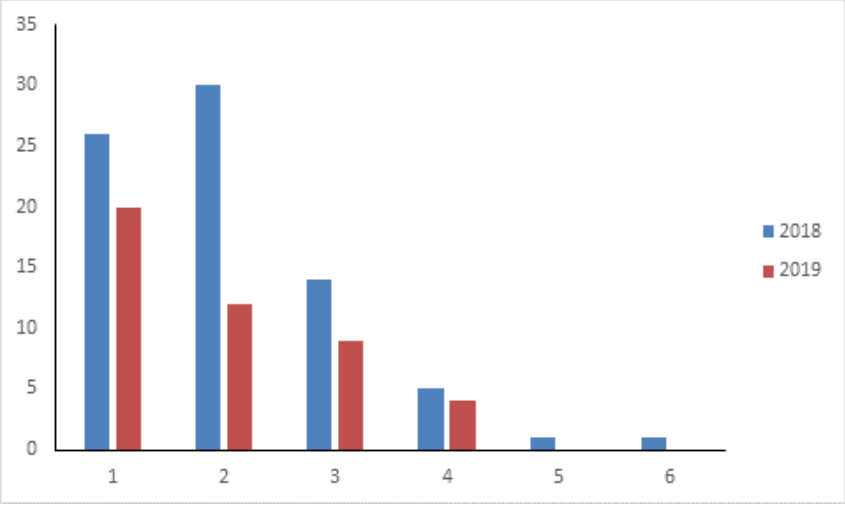
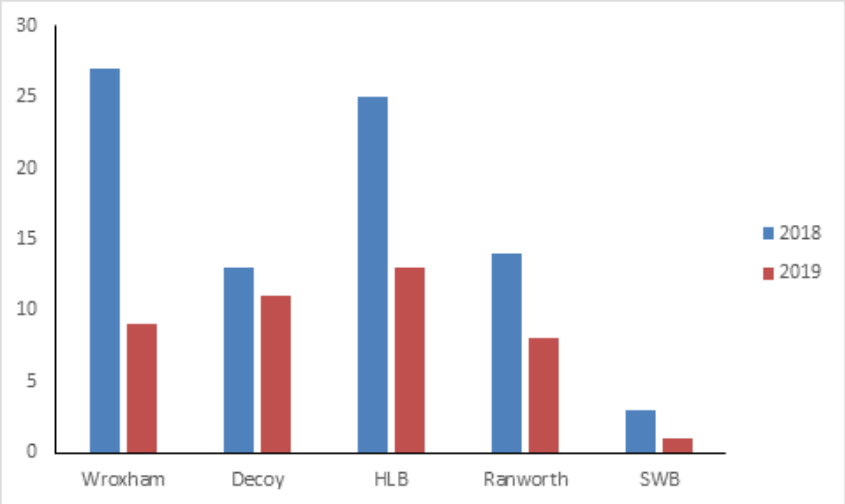


Figure 4. Data from northern broads PhD project showing where adult bream visited other than Hoveton Great Broad during the spawning season.



Spawning surveys carried out in 2019 by EA and Fishtrack observed aggregations of bream in HGB and HB as well as spawning behaviour and egg deposit within HB. No significant aggregations of bream were recorded elsewhere within the Bure, Ant, Thurne system although some egg deposit was observed on the Ant.

An assessment of available spawning habitat in the middle Bure conducted in 2018 found HGB and HB to offer more suitable spawning habitat than the surrounding broads (see figure 5).

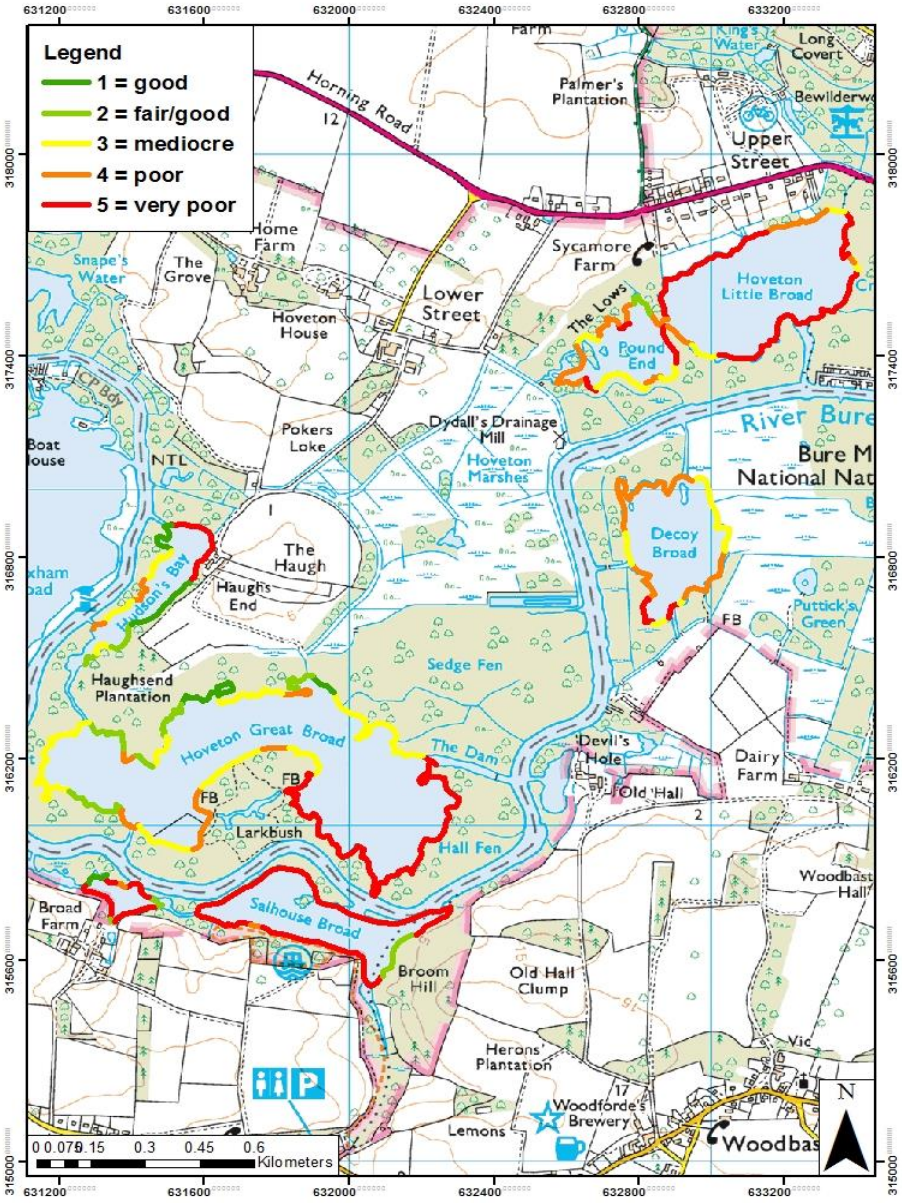


Figure 5. Map of Bream spawning habitat quality assessment and distribution, 2018. Fishtrack ltd.

This data indicates a fish community dominated by roach in number and bream by biomass within the middle Bure broads. This relationship appears to be particularly strong within HGB and HB. The data also shows a significant proportion of tagged bream from across the broads system are migrating to HGB and the surrounding area during spawning, with significant aggregations observed spawning in HB. The attraction of HGB and HB for spawning bream is unknown but in part is likely to be higher quality spawning habitat than the surrounding broads.

Assessing WFD status of fish element

A tool for assessing the WFD status of lake fish communities has been developed and is currently being consulted on, so is yet to be approved by UK admins. Therefore, there is currently no tool for assessing the condition of the fish assemblage of shallow lakes under WFD. The lack of a classification of the fish community under WFD does not remove the requirement to assess if the project will cause a deterioration of the fish community.

The ECJ ruled in the Weser case that the deterioration in any single element from one class to another (not within class deterioration) represents a deterioration in terms of the WFD. This means that any class deterioration (i.e. from moderate to poor) in the fish element associated with this project would constitute deterioration. Any within class deterioration would not. According to the court, Member States must refuse authorisation for an individual project where it might cause a deterioration in the status of a body of surface water or where it jeopardises the attainment of good surface water status or of good ecological potential and good surface water chemical status.

Therefore a review of the best available evidence is required to assess the condition of the current fish community and whether the proposed installation of fish barriers will cause a class deterioration in the fish element both within HGB/HB and the wider system.

WFD status of fish communiity within HGB & HB

Is a fish community heavily dominated by roach by number and bream by biomass appropriate for a healthy clear water, macrophyte dominated lake?

The response of fish communities to eutrophication is well documented with roach, bream and carp eventually dominating the fish community (e.g. Jeppessen *et al.,* 2000; Moss, 2010), see figure 6. Surveys in the Broads have led to the same conclusions. Where habitat complexity provided by macrophytes remains, the piscivores (pike and perch) dominate by biomass. Tench, eels and rudd are also found in greater abundance in these habitats. Conversely, under turbid, algal

dominated conditions roach and bream are more abundant and there are fewer pike, perch, tench, rudd and eel (refer to figure 7, Kelly 2008).

The dominance of roach and bream under eutrophic conditions is not just a symptom of eutrophication, these species play a critical role in the food web, which reinforces the turbid, algal dominated state. In effect, they act as a forward switch, maintain the stability of the algal dominated turbid state and make it harder to switch the lake back to a macrophyte dominated state, even if nutrient concentrations reduce (Bernes *et al*., 2015, Phillips *et al*., 2015). Large numbers of small roach significantly alter the zooplankton community in lakes, which reduces their ability to control the phytoplankton through grazing, allowing algal dominated water to persist. Bream also play an important role as benthic feeders re-suspending the sediment, increasing turbidity and uprooting macrophytes. They also promote nutrient release and cycling from the sediment. This also reinforces the algal dominated state (Breukelaar *et a*l., 1994).

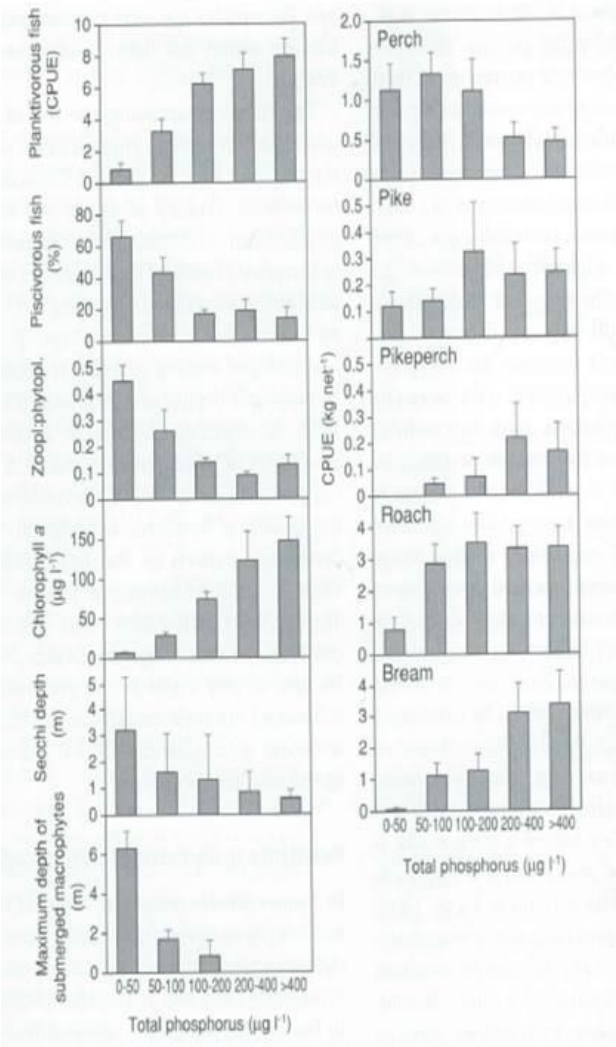
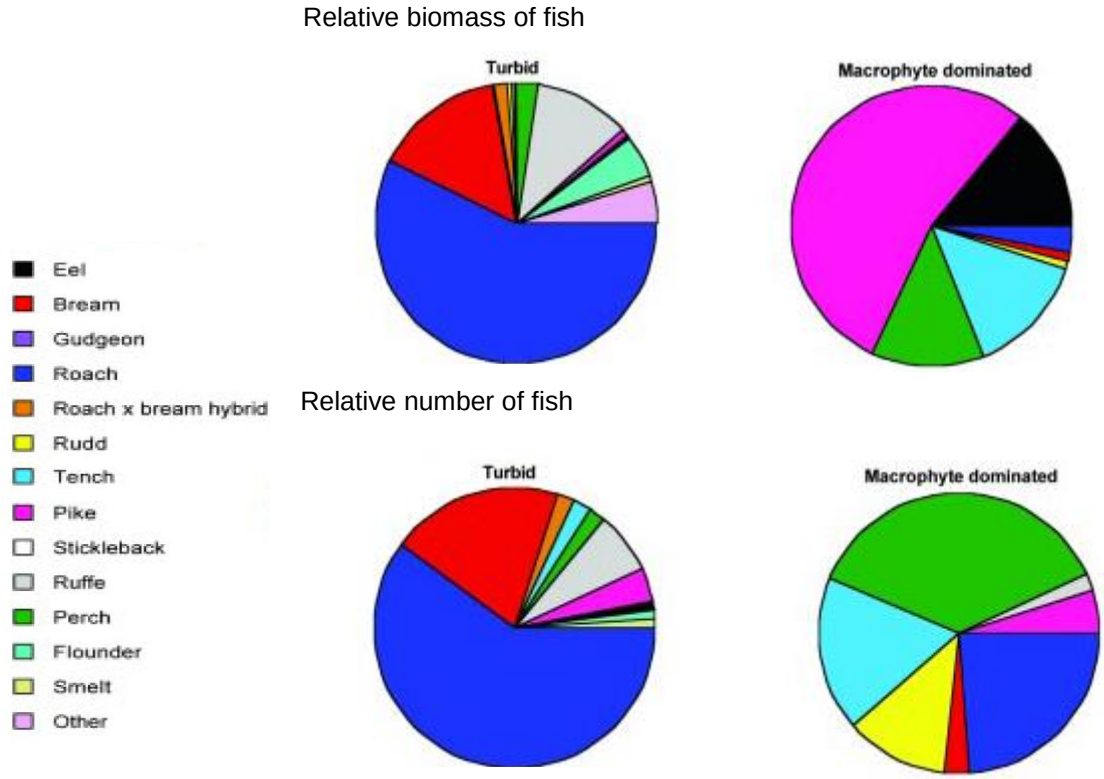


Figure 6. Response of fish communities to increase phosphorus (Jeppesen & Sammalkorpi 2002)

Moss et al (1996), in their Guide to the restoration of nutrient-enriched shallow lakes, provides a summary of the characteristics of the most common fish species in lowland Britain in respect to their compatibility with shallow lakes restored to diverse plant communities (see figure 8). The more negative the score the more incompatible they are with lake restoration. It clearly shows that a fish community so heavily dominated by bream and roach as that in Hoveton Great Broad and Hudson's Bay is not compatible with restoring shallow lakes, i.e. to WFD good status and SSSI favourable status targets. It is of note that bream can coexist with a vegetated state as part of a diverse fish community, but in such conditions they don't dominate the fish community, whereas

in eutrophic conditions they do, and help reinforce the algal dominated state (Moss *et al*, 1996).

Figure 7. Relative biomass and number of fish in the Broads in macrophyte dominated and turbid conditions. Presented in Kelly (2008). Data from selected Environment Agency (National Rivers Authority) fisheries surveys and surveys conducted for the Broads Authority.



The fish surveys of HGB & HB (detailed above) reveal roach and bream populations which are likely to be having an impact on the condition of HGB and HB.

Perrow *et al.* (1999) reported that in open water with no refuges, >0.2 ind. m^{-2} of zooplanktivorous fish, such as roach, may exert a negative effect on zooplankton, although where there were submerged plants, the density may have to be much higher (> 1 ind.m^{-2}) to exert the same effect. Hindes (2017) reported finding more than 5 roach individuals per m^{-2} in Hoveton Broad in spring, although this later decreased it remained above 0.2 m^{-2} throughout the rest of the year. As Hoveton has extremely sparse macrophytes this level of roach abundance has the capacity to detrimentally affect the lake.

Although the exact boundaries of any relationship between fish biomass and macrophyte cover remain difficult to define, a general rule of thumb appears to be

that a broad is unlikely to support good populations of plants with more than around 100 kg ha^{-1} of benthivorous fish (Kelly, 2008). At Hoveton in spring, a mean bream biomass of over 250 kg ha^{-1} was recorded, this declined to nearer 150 kg ha^{-1} in summer and declined further in autumn, but it rose to over 100 kg ha^{-1} again in winter (Hindes, 2017). The presence of such a high biomass of bream, particularly at the start of the growing season, has the capacity to detrimentally affect Hoveton Broad.

Figure 8. Summary of the characteristics of the most common fish species in lowland Britain in respect of their compatibility with shallow lakes restored to diverse plant communities (from Moss et al 1996).

	Bream	Common carp	Crucian carp	Dace	Eel	Roach	Rudd	Perch	Pike	Tench	Brown trout
Native/Introduced	N	I	(N)[1]	(N)[1]	N	N	N	N	N	N	N
Breeds prolifically	+	-	±	+	++	++	++	++	++	+	+
Disturbs bottom	++	++	+	-	-	-	-	-	-	++	-
Pelagial zooplantivore[3]	++	+	±	-	-	++	+	++	-	-	-
Weed-bed zooplanktivore[3]	-	-	+	-	-	-	+	+	-	-	-
Piscivorous[3]	-	-	-	-	+	-	-	+	++	-	+
Intrusive angling	++	++	-	-	-	-	-	-	-	-	-
Usually abundant	+	++	±	±	++	++	+	++	++	+	±
Destroys plants	-	++	±	-	-	?+	-	-	-	?+[2]	-
*Total score**	-7	-23	-2	+20	+28	-3	+1	+5	25	-4	+33

Scoring system
Origin N=5, (N) =0, I=-5; for breeding, -=5, ±=3, +=0,++=-5; for bottom disturbance, ++=-5, +=0, -=5; for zooplanktivory, -=5, ±=-1, +=-3, ++=-5: for piscivory, ++=5, +=3, -=-5; for angling intrusion, -=5, +=-3, ++=-5; for abundance, ±=0, +=-3, ++=-5; for plant destruction, -=5, ±=-1, +=-3, ++=-5.
[1] Introduced from Southern England. [2] Because of predation on epiphyte eating snails. [3] Post-larval.
Pelagial means open water, middle of the lake.

Therefore the current fish assemblage inhibits WFD GES (Good Ecological Status) being achieved for macrophytes, phytoplankton, and macro-invertebrates. Given the aim of WFD is to achieve GES in open waters and rivers, a fish population which prevents overall GES being achieved cannot be considered to be in ‘Good Status’. As GES is defined as slight variation from undisturbed conditions and we know that in the past when the broads was not subject to the nutrient enrichment it supported macrophytes associated with clear water conditions, this is what GES would look like. GES for the fish assemblage would therefore be one that is compatible with such conditions, so it is likely to contain bream and roach but they would not dominate the assemblage which would be more diverse and dominated by piscivores. We know the Broads were once dominated by macrophytes pre-eutrophication as evidenced from sediment core studies (Goldsmith *et al.* 2014) and are the scientific literature described above shows that this is not compatible a fish

community dominated by bream and roach. This is also evidenced by the more diverse balanced fish communities observed in broads with clear water macrophyte dominated conditions (refer to figure 7). There is no doubt that bream and roach will form a part of a more undisturbed broadland community, but not to the numeric extent currently observed.

There is no evidence to suggest that any reduction in the dominance of bream would be considered as a deterioration in WFD ecological status on the contrary it would be considered an improvement. To test this assumption in the absence of a UK shallow lake classification tool the EA trialed the use of a shallow lake fish classification tool from Holland. This model comes with very many caveats as it is not Broadland specific, but it does consider high bream biomass as a percentage of community biomass as an indication of eutrophication and is detrimental to the WFD status of a lake (figure 9). Therefore reducing bream number would generally result in an improvement in WFD fish status.

There is also a proposed new standard approved for consultation by UK admins based on an eDNA fish tool for use in the UK. This supports the findings from the Dutch classification as this sees the presence of bream and roach as negative indicators in eutrophic lakes so that any decrease in number would improve the lake classification. Together these two tools support the view that the current fish assemblage would not be considered to be at GES and reducing bream and roach would result in an improvement not a deterioration in the fish community WFD class.

Figure 9. Class boundary information for fish from Dutch fish classification tool.

M 14, M 27 - Type-specific class boundaries for shallow lakes

Indicator	Weight	Bad	Poor	Moderate	GES	HES (max)
% W *Abramis brama*	0.25	50-100	25-50	8-25	2-8	0,5-2 (0)
% W (roach+perch)/euryt.	0.25	0-10	10-20	20-30	30-35	35-40 (100)
% W phytophilic	0.25	0-8	8-20	20-40	40-65	65-80 (100)
% W low oxygen tolerant	0.25	0-1	1-3	3-10	10-20	20-30 (100)
EQR		0-0.2	0.2-0.4	0.4-0.6	0.6-0.8	0.8-1.0

WFD status of fish community within the wider broads system

The fish tracking data has provided new evidence on the role HGB/HB plays within the wider Bure/Ant/Thurne system, and highlights the potential for bream and roach numbers to reduce in the wider system if they fail to spawn elsewhere or less successfully when the fish barriers are installed on HGB. Therefore, there is a

requirement to consider if installing fish barriers at HGB will impact the WFD fish class of the waterbodies that make up the wider broads system.

As with lakes the objective for WFD is for the ecology to be in good condition with the highest status most akin to reference condition, where the ecology is unimpacted. Consequently the highest ecological status class for fish in rivers would be similar to a fish assemblage unimpacted by human influence. Such a fish assemblage would not be reliant on elevated bream and roach numbers in HB or HGB, which are a symptom of anthropogenic eutrophication, as this reflects very impacted conditions. Restoring the natural fish assemblage in HGB and HB will help restore the natural assemblage in the connected river system as it will provide a refuge, and spawning habitat for a range of fish species that use the Bure and potentially provide a source for recruitment.

The broad's lakes and rivers are a highly interconnected system as shown by our fish tracking data. The condition of the fish communities in the rivers will be heavily linked to the health of the broadland lakes and the fish communities they support. For the river fish communities to be considered to be in GES, (defined as slight variation from undisturbed conditions) the attached broads would also need to be healthy with balanced lake fish communities associated with clear water and macrophytes to not cause variation from undisturbed conditions. The river fish community cannot to be considered to be at GES if it is being influenced by bream and roach populations dominated communities which are a consequence of eutrophication as observed in the middle Bure broads. Therefore, a decline in bream that results in a more natural fish community in the connected broads cannot be considered to be a decline in the WFD status of the river fish community.

Mitigation

Whilst there is strong evidence to indicate a decline in bream numbers would represent an improvement in the WFD fish classification of the broads, bream should still form a part of any broadland fish community. Therefore a large scale and widespread (not local) loss of bream could be considered as detrimental to the fish community. Whilst Natural England acknowledge that there is a risk of bream decline associated with the temporary closure of HGB & HB, evidence would suggest bream will continue to persist in the Broads.

Bream are a very common species across England (and indeed northern Europe), found in a wide variety of waters from ponds and canals to large lakes and slow-to-moderate flowing rivers (Maitland, 1972). This suggests they are able to spawn successfully in a broad range of environments. Indeed, locally bream will attempt to spawn on a wide variety of substrates including lilies, sedge roots and tree roots. It is therefore highly unlikely that within the wider broadland catchment that HGB offers

the only suitable spawning habitat for bream. It is also very unlikely – given that bream have already been recorded covering large distances and wide areas - that bream would not be able to access such suitable spawning / feeding / loafing habitat elsewhere, even if it does not occur local to HGB.

It is bream's tolerance to a wide range of conditions, their ability to successfully colonise and maintain strong populations in a range of different habitats across the UK, which has been the key to their success. In the literature bream are described as favouring rich, muddy and weedy lakes where their sticky eggs are deposited onto submerged macrophytes. However, many fully enclosed lake sites maintain strong populations of bream with a macrophyte assemblage which is largely limited to an emergent fringe and effectively devoid of submerged forms – like many of the broads including Hoveton. The highly fecund nature of bream and their ability to persist in environments in which their favoured spawning habitat is absent indicates a strong competitive advantage over other species with more restricted spawning habitat requirements.

Each female may spawn several times over a week or so until all eggs are laid. The number of eggs laid depends on the size of the female but can range from 90,000 – 340,000 (Maitland & Campbell 1992). Adámek *et al.* (2002) recorded the average number of eggs obtained by stripping 1 kg of female bream biomass from the river Sow and Trent to be in the range of 93,642 ± 20,896 and 151,179 ± 25,123, respectively. Given the reproductive potential of the species, spawning success does not have to be frequent to sustain a population.

So in summary, whilst a number of bream might preferentially choose HGB and HB due to habitat quality and the low disturbance levels, it is likely they will use lower quality habitats if HGB and HB were unavailable.

Whilst we consider the risk of significant bream decline to be unlikely, a fishery improvement plan (see annex 1), including monitoring and habitat improvements, is being proposed by the project to help mitigate this risk as a precautionary approach. This improvement plan needs to be carefully monitored to ensure it is not helping to support and maintain an unsuitable and unsustainable fish community within the Broads, and is instead helping to deliver a more diverse balanced fishery suitable for achieving GES.

Summary

- There is significant evidence that HGB and HB are important spawning sites for a significant proportion of the broadland bream population.

- The fish communities of the middle Bure broads are dominated by roach in number and bream by biomass. Such communities are highly indicative of lakes suffering from eutrophication, and such fish communities help maintain poor ecological condition with turbid waters and low macrophyte diversity and coverage.

- A fish community which helps maintain poor ecological status is not compatible with GES under the WFD. Therefore restoring the fish community to one not dominated by bream and roach even if that means a decline (but not loss) of bream and roach associated with the installation of fish barriers at HGB cannot be considered a decline in the WFD status of the fish community, either within the individual broads or the rivers.

- Bream and roach will form a part of a more undisturbed broadland fish community, but not to the numeric extent currently observed.

- A large scale decline in bream associated with the temporary closure of HGB and HB is unlikely due to the adaptability and fecundity of bream, as demonstrated by their success throughout UK waters.

- As a precautionary approach the project has proposed a fishery improvement programme to mitigate the risk of wide spread large scale decline in bream. EA are a project partner and will continue to advise on and assist with the implementation of all mitigation measures.

Overall the project is still expected to provide long-term benefits through significant improvements in habitat quality, food availability and improved spawning structure. The diversity of fish in the broad is expected to improve, with a higher proportion of typical Broadland fish – tench, perch, rudd – expected to be present once the broad is established in a clear-water, plant dominated state.

References

Adámek Z., Andreji J. & Henshaw, A. (2002). Stripping fecundity of common bream (*Abramis brama* L.) from the rivers Trent and Sow (Nottinghamshire, UK). Aquaculture International 12: 133–137, 2004.

Bernes, C., Carpenter, S., Gardmark, A.,Larsson, P., Persson, L., Skov, C., Speed, J., and Van Donk, E. (2015) What is the influence of a reduction of planktivorous and benthivorous fish on water quality in temperate eutrophic lakes? A systematic review Environmental Evidence 4:7

Breukelaar, A.,Lammens, E., Klein Breteler, J., and Tatrai, I. (1994) Effects of benthivorous bream and carp on sediment resuspension and concentrations of nutrients and chlorophyll a. *Freshwater Biology* 32 113-121.

Goldsmith, B., Lambert, S., Henderson, G., Sayer, C.D., Goodrich, S. and Matyskova, V. (2014) Hoveton Great Broad Macrophyte Study: Using the sediment record to inform lake restoration. ECRC Research Report Number 160. Ensis Ltd. University College London.

Hindes, A. (2017) Hoveton Great Broad Restoration project: Seasonal comparative fish surveys summary report. Fishtrack report to Natural England

Jeppesen, E., Jensen, J., Søndergaard, M., Lauridsen T., and Landkildehus, F. (2000) Trophic structure, species richness and biodiversity in Danish lakes: changes along a phosphorus gradient. Freshwater Biology 45, 201–218

Jeppesen, E. & Sammalkorpi, I. Lakes, In: Handbook of ecological Restoration. Volume 2: Restoration in Practice. M. Perrow & A. Davey (Eds). (2002). Cambridge University Press

Kelly, A. (2008) Lake restoration strategy for the Broads. Broads Authority.

Maitland, P. S. (1972). Key to British freshwater fishes. FBA Publication No. 27.

Maitland, P. S. & Campbell, R.N. (1992) Freshwater Fishes

Moss, B., Madgewick, J and Phillips, G. (1996). A guide to the restoration of nutrient-enriched shallow lakes. Environment Agency, Broads Authority, LIFE.

Moss, B. (2010) Ecology of freshwaters a view for the twenty-first century. 4th edition Wiley-Blackwell

Perrow, M.R., Jowitt, A.J.D., Leigh, S.A.C. Hindes, A.M. & Rhodes, J.D. (1999). The stability of fish communities in shallow lakes undergoing restoration: expectations and experiences from the Norfolk Broads (UK). *Hydrobiologia*, 408/409, 85-100.

Phillips, G.1, Bennion, H.2, Perrow, M.R.3, Sayer, C.D.4, Spears, B.M.5, Willby, N6. (2015) A review of lake restoration practices and their performance in the Broads National Park, 1980-2013. Report for Broads Authority, Norwich and Natural England.