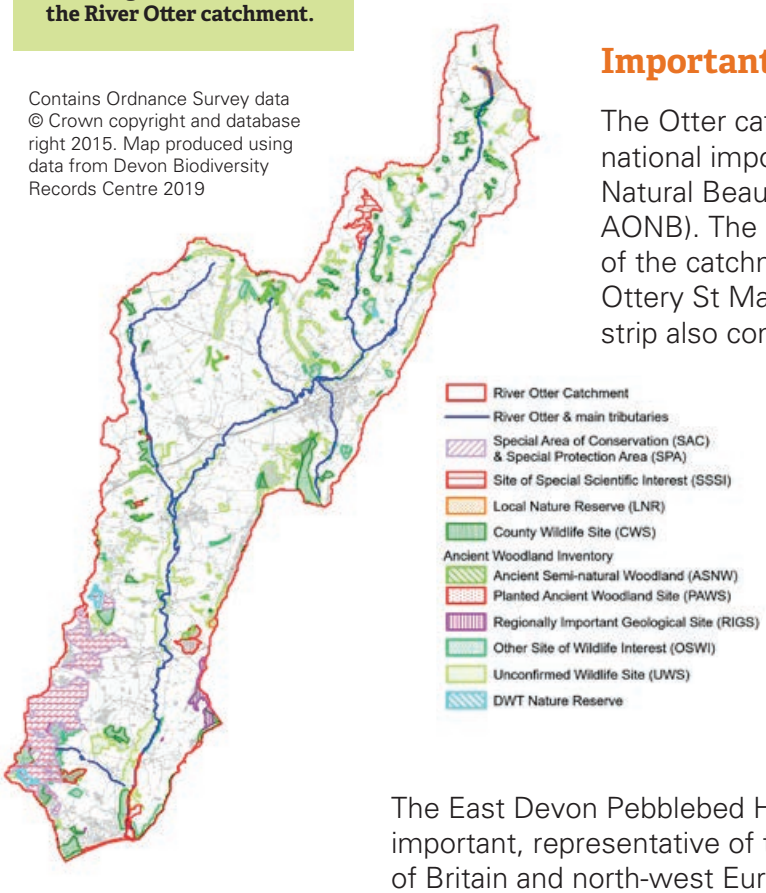
CHAPTER 2:
Biodiversity, including fish species

Beaver wetland on Budleigh Brook

Photo: Steve Pease

Overview of the ecology and protected areas of the River Otter catchment

↓ **Figure 2.1 Map showing the designated sites within the River Otter catchment.**



Important habitats and designated sites

The Otter catchment is located within two landscapes of national importance recognised as Areas of Outstanding Natural Beauty (East Devon AONB and the Blackdown Hills AONB). The Blackdown Hills AONB covers the upper reaches of the catchment, north of Honiton, while the area south of Ottery St Mary includes the East Devon AONB. The coastal strip also comprises part of the Dorset and East Devon Jurassic Coast World Heritage Site.

Of the 12% of the catchment that supports important wildlife habitats, lowland heathland covers the largest area, mainly in the south-west of the catchment (the East Devon Pebblebed Heaths). In addition, there are also smaller heaths to the north and east. Coastal and floodplain grazing marsh is the second most abundant habitat found alongside the main River Otter from Honiton to Budleigh Salterton.

The East Devon Pebblebed Heaths were designated as a SSSI as 'nationally important, representative of the inland Atlantic-climate, lowland heathlands of Britain and north-west Europe.' It is the largest block of lowland heath in Devon (1,133 ha) supporting a diverse range of heathland communities. It supports a wide range of birds and invertebrates, with 24 species of dragonfly and damselfly, including the southern damselfly, *Coenagrion mercuriale,* and small red damselfly, *Ceriagrion tenellum,* rare butterflies such as the pearl-bordered fritillary, *Boloria euphrosyne,* and silver-studded blue, *Plebejus argus,* and heathland birds such as the nightjar, *Caprimulgus europaeu*s, Dartford warbler, *Sylvia undata,* and the hobby, *Falco subbuteo*.

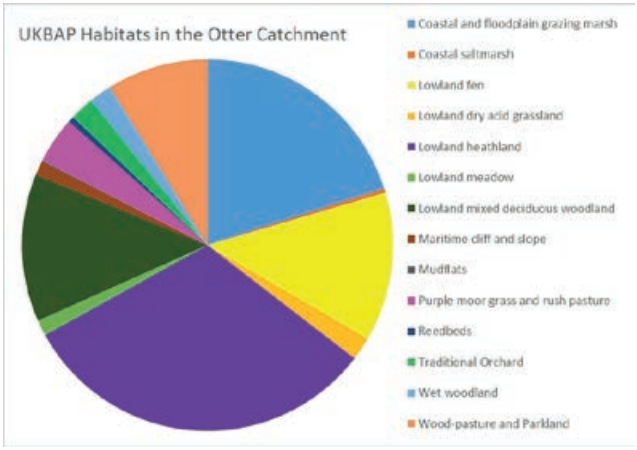
They are also designated as a Special Protection Area, as they support breeding populations of European importance of Dartford warblers and nightjars, and as a Special Area of Conservation (SAC) for the northern Atlantic wet heaths, European dry heaths, and southern damselfly populations.

There are five other SSSIs in the Otter catchment, including two geological SSSIs:

- Hense Moor SSSI includes some of the best remaining examples of lowland mixed valley bog in Devon, with a mosaic of different habitats.
- Hense Moor Meadows SSSI contains herb-rich meadows with unimproved neutral grassland and fen communities.
- Otter Estuary SSSI contains a wide range of saltmarsh communities which together with additional areas of tall herb fen and scrub, supports significant populations of overwintering wildfowl and waders. Otterton Point is an important location for vertebrate palaeontology.
- Budleigh Salterton Cliffs geological SSSI exposes the full thickness of the Lower Triassic Budleigh Salterton Pebble Beds.
- Ladram Bay to Sidmouth geological SSSI is an important site for coastal geomorphology, with a series of well-developed cliffs, stacks and shore platforms cut in the red sandstones of the Keuper (dolomites, shales and claystones) representing one of very few assemblages in southern Britain.

There are two Local Nature Reserves (LNR):

- Fire Beacon Hill LNR is a lowland heathland site, supporting heathland birds such as the yellowhammer, *Emberiza citronella,* Dartford warbler and nightjar.
- Otterhead Lakes LNR consists of two lakes and landscaped gardens of the former Otterhead House, with surrounding wet and dry woodland, grassland, and freshwater streams and ditches.



↑ **Figure 2.2 Map and chart showing extent of different Biodiversity Action Plan (BAP) habitats within the River Otter catchment. These make up 12% of the catchment area.** Contains Ordnance Survey data © Crown copyright and database right 2015. Map produced using data from Devon Biodiversity Records Centre 2019

There are 90 County Wildlife Sites (CWS) covering 1,131 ha.

County Wildlife Sites are sites of county-level importance for wildlife, designated on the basis of the habitat or the known presence of particular species. There are 90 CWSs in the Otter catchment - 80 of these are in Devon (1,074 ha) and 10 are in Somerset (57 ha).

The sites range in size from a pond with amphibian interest that is less than 0.1 ha to Gittisham Hill, a 137 ha site with purple moor-grass and rush pasture, wet heath, and wet woodland. Other CWS habitats include wet and dry woodland, unimproved neutral and acid grassland, spring-line mire, wet and dry heath, and parkland. Half of the sites contain wet or dry woodland, and many of these are found associated with the headwaters, rather than the main river. Key sites include the Otterhead Lakes Reserve at the head of the catchment, which covers a 1.5 km stretch of riverbank and contains a complex of habitats including wet woodland and marshy grassland. This links to four CWSs just downstream that also contain wet woodland and marshy grassland, providing nearly 3 km of semi-natural habitat along the river.

Other key sites include Wolford Lodge, a large area of spring-line mire and semi-improved neutral grassland at the top of the River Wolf tributary, with woodland CWSs either side; and Clyst William Cross, an area of tall-herb fen and unimproved marshy grassland on the River Tale.

Fish populations in the River Otter

The River Otter catchment was once recognised as an important river for breeding Atlantic salmon, *Salmo salar*, although the species has undergone dramatic population declines in recent years. The River Otter is known locally for its trout, *Salmo trutta*, and important for a number of other fish species such as bullhead, *Cottus gobio*, stone loach, *Barbatula barbatula*, European eel, *Anguilla anguilla* and brook lamprey, *Lampetra planeri*.

Atlantic salmon are listed in Annex II of the Habitats Directive, and are a UK Biodiversity Action Plan (BAP) Priority Species. European bullhead are listed in Annex II of the Habitats Directive. Brook lamprey are listed in Annex II of the Habitats Directive and Annex III of the Bern Convention. European eels are a UK Biodiversity Action Plan (BAP) Priority Species and covered by the European Eel Regulations.

Photos: Andy Vowles

Detailed electrofishing surveys conducted by specialists from the University of Southampton (UoS) of the main River Otter in September 2015 caught eight species and 1067 individual fish. The combined sample of fish from the three electro-fishing reaches consisted of 43.4% bullhead, 37.9% minnow *Phoxinus phoxinus*, 10.2% stone loach, 3.3% brown trout, 2.3% three-spined stickleback *Gasterosteus aculeatus*, 1.9% lamprey *Lampetra* spp., 0.9% European eel and 0.09% Atlantic salmon.

The same research team conducted a detailed survey of three reaches in the River Tale in October 2016 and July 2017. Six fish species were captured in both 2016 and 2017 and in similar numbers (555 in 2016 and 543 in 2017). The European fish community composition was similar between years, with bullhead, stone loach, brown trout and eel being the first, second, fourth and sixth most abundant species in both 2016 and 2017. Survey work by the same team in 2019 on four reaches on the same stretch captured the same six species (as above also with minnows and brook lamprey), and also detected three-spined stickleback, on this occasion.

The Environment Agency requires salmon and sea trout fishing licence holders to submit an annual 'catch return' for salmonids[1]. Between 2010 and 2017 there was a reported catch of 705 sea trout on the River Otter (576 of which were released). Annually there was considerable variance in the reported numbers of sea trout caught, with the lowest being reported as 27 in 2012, and the highest reported as 152 in 2014. Across the same years there were only three salmon catches reported on the River Otter, two of which were in 2013 with the other in 2017. All of the salmon caught were reported as released.

The Water Framework Directive (WFD) ecological status of the sub-catchments; the Lower Otter, Middle Otter and Wolf, are all classified as Poor in the 2016 assessment, e.g. due to man-made barriers to fish. The River Love and the Upper Otter have also been downgraded from Good to Moderate, with the Tale being the only area showing an improvement from Poor to Moderate since 2012 (not as a result of beaver presence).

The issues identified included elevated levels of phosphates and phytobenthos caused by poor soil management on arable farms, and poor nutrient management from livestock, though there was also sewage discharge from waste-water treatment. The Middle Otter and River Wolf also had man-made barriers to fish movement. Diffuse pollution alongside man-made barriers are likely to contribute significantly to the depleted nature of fish populations in the Otter catchment.

↓ Brook lamprey are often found in slower flowing areas where finer sediments are deposited.

↓ Minnows are commonly encountered in glides and pools in the River Otter and provide an important food source for many other species.

↓ Trout require a variety of habitats to be present to complete their life cycle. Some trout migrate to sea (sea trout) before returning to the river to spawn. Exact reasons why this occurs remains unclear.

Otter on main river

Family of 3 otters on River

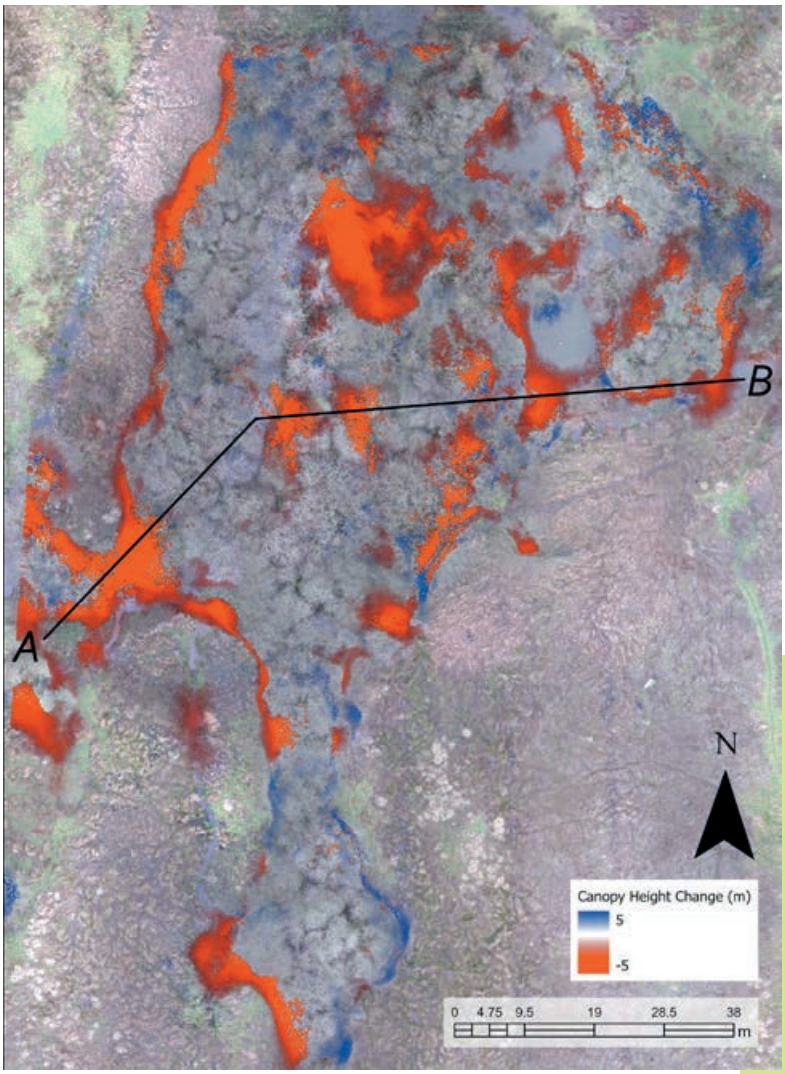
↓ Eurasian otters are found throughout the catchment and picked up with camera traps.

Other key species present

The River Otter catchment overview (Appendix 1) provides more information on some of the species for which the catchment provides important habitats. These include Eurasian otter, *Lutra lutra*, European water vole, *Arvicola amphibious*, and a number of species of specialist *Odonata*; most notably the southern damselfly, *Coenagrion mercuriale,* and small red damselfly, *Ceriagrion tenellum*. Populations of great crested newts *Triturus cristatus* are also present in isolated parts of the catchment.

Fourteen species of bat have been recorded in the catchment including western barbastelle, *Barbastella barbastellus*, grey long-eared, *Plecotus austriacus*, greater horseshoe, *Rhinolophus ferrumequinum,* and the lesser horseshoe, *Rhinolophus hipposideros*.

Effects of beavers on ecology and protected areas

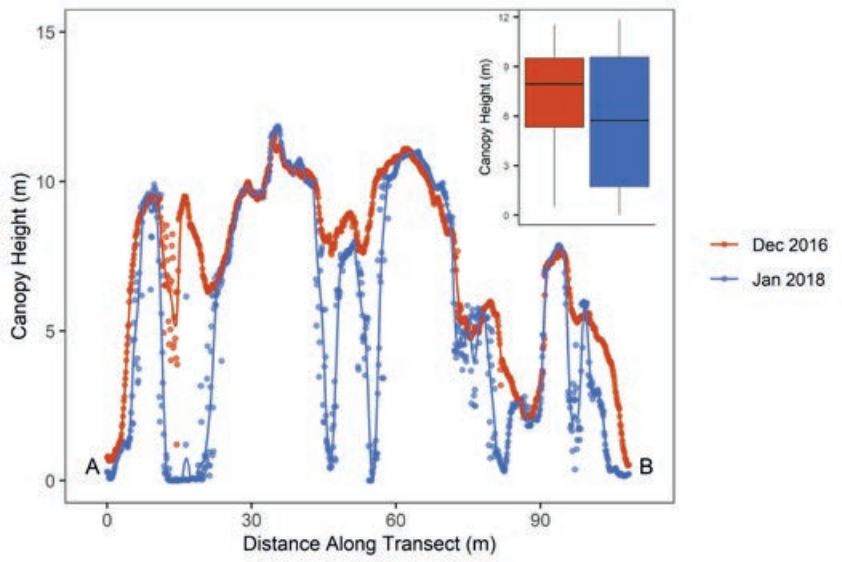


← **Figure 2.3** In total, Clyst William Cross CWS was surveyed four times between December 2016 to January 2018 using a drone to capture images. Photogrammetry software was used to create a time series of 'orthomosaic' images (geo-rectified aerial image maps) and a Canopy Height Model (CHM) (3D height model describing canopy extent and elevation). Results revealed that areas of riparian woodland, where beavers are foraging, had a structure which differed significantly from riparian woodland not impacted by beavers. Beavers were found to reduce mean canopy height and increase the variability in canopy heights. This impact on riparian vegetation drives two key changes: a greater range of canopy heights and therefore habitats made available to different species, and increased light penetration in areas of dense riparian woodland enabling the regeneration of understory vegetation.

Impacts on vegetation and canopy structure

It is widely acknowledged that the foraging behaviour of beavers on woody riparian vegetation alters the structure of vegetation in beaver-occupied river reaches. This alteration is reported to improve habitat for a range of species such as birds[2,3], bats[4], and a range of terrestrial species e.g. otters, pine marten etc.[5] due to the increases in canopy variability and increased dead wood abundance[6]. Despite the many references to this phenomenon, little information quantifying this structural change currently exists.

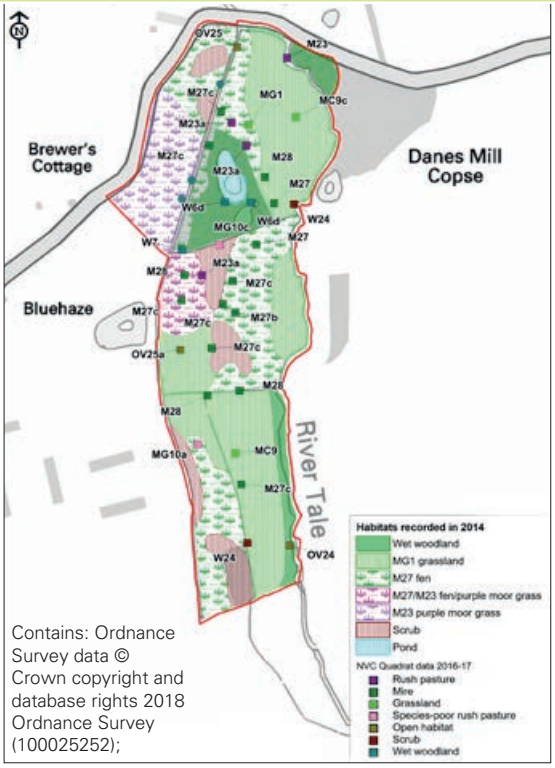
↓ **Figure 2.4** A transect A-B shows that tree stands impacted by beaver foraging were not removed completely, rather gaps in the canopy were created, enabling light penetration, and increasing the variability in plant/tree heights.



Vegetation communities

Detailed work has been conducted elsewhere on the impacts of beavers on aquatic macrophytes and plant communities[7–10] and it has not been deemed necessary to repeat that work here. The understanding of impacts on aquatic macrophytes will be built upon by Kye Davies, as part of his NERC-funded aquatic ecology PhD just getting underway with the University of Exeter and Devon Wildlife Trust.

↓ In addition to the canopy structural survey work carried out at Clyst William Cross CWS, botanical quadrats and transects have been used to assess plant communities and species present so that these changes can be monitored over time.



Contains: Ordnance Survey data © Crown copyright and database rights 2018 Ordnance Survey (100025252);

← More detailed botanical transect surveys have been undertaken by expert volunteer Christopher Hancock in 2017, 2018 and 2019, and this could be used in the future to understand how the change in vegetation structure is impacting on the plant species present.

Effects on invasive non-native plant species

← The invasive plant Himalayan balsam, *Impatiens glandulifera* is found throughout much of the River Otter catchment (except for the River Tale where concerted effort by the Tale Valley Trust has eradicated the species). In some parts of the lower river it is the dominant bankside plant. The beavers have been recorded feeding on it, but are unlikely to be having any effect on its abundance or distribution, either positively or negatively

Photo: David White

↑ On one site, a stand of Bohemian knotweed *Fallopia x bohemica* growing within 10 m of the water's edge appears to have been used by the beavers as dam building material – in a similar way to their use of riverside maize. The plant appears to be growing in the dam where it has been deposited, although there is no certainty about whether it was placed or was washed there.

← The beavers have been feeding regularly on both *Rhododendron ponticum* and cherry laurel *Prunus laurocerasus*, including using it as lodge and dam building material.

↓ Fortunately, there is very little Japanese knotweed *Fallopia japonica* in the catchment. There is a stand at one location where the beavers were resident in 2015, and a camera trap caught an image of them feeding on it on one occasion.

→ Otterhead Lakes in Taunton Deane District, Somerset, is designated as a Local Nature Reserve and a County Wildlife Site. This neglected Victorian planned landscape includes the 'lost gardens' of Otterhead House (demolished in 1952) with terraced walks and drives as well as two former walled gardens. The most obvious features are the two remaining Otterhead Lakes and the River Otter. Semi-natural habitats now make up the reserve including alder and willow carr, dry deciduous woodland, unimproved neutral grassland, and freshwater streams and ditches. Parts of the reserve are successively carpeted with snowdrops, daffodils and other narcissi and bluebells. Primroses, foxgloves and marsh marigolds are present in large numbers as well as other native plants including various species of ferns. To date impacts of the beavers have been to increase the diversity and extent of wetland habitats around the top lake and over time this is likely to increase.

Impacts on designated sites

The effects of beavers on statutory designated sites have been very limited within the trial period. Beavers have not been recorded within the East Devon Pebblebed Heaths (SSSI, SPA, SAC), and there has been no observable effect on the landscape of the East Devon or Blackdown Hills AONBs or the Dorset and East Devon World Heritage Site.

Adult feeding at Otterhead (Nick Upton)

River Otter Estuary SSSI

Since the beginning of the Trial in 2015, beavers have been recorded within the River Otter Estuary SSSI which is designated for a number of different features. The SSSI notation written in 1986 describes the river 'terrace' upstream of White Bridge, as a dense growth of willow, *Salix* spp, scrub and tall herbs providing undisturbed cover for many breeding birds, particularly for summer visitors such as reed and sedge warblers, *Acrocephalus scirpaceus* and *A. schoenobaenus,* as well as listing other key species breeding on the site.

Between April and June 2016, a detailed breeding bird survey was conducted within this site so that any changes in habitat structure that resulted from the beaver activity could be assessed. A total of 42 species were recorded on site during the 2016 breeding season, of which 13 were confirmed to have bred, 20 were considered likely to have bred and three possibly bred. It is worth highlighting that the SSSI citation lists a number of bird species which historically used to breed and are no longer present as breeding birds. These are serin, *Serinus serinus*, lesser spotted woodpecker, *Dryobates minor*, little owl, *Athene noctua,* and shelduck, *Tadorna tadorna*.

Since 2016, the effects of the beavers on the willow scrub has been negligible, with no significant trees coppiced, and no impact on the canopy or vegetation structure which might influence breeding bird communities. Should changes in canopy or vegetation structure occur in the future, breeding bird surveys could be conducted, and results compared with the baseline data collected in 2016.

Clyst William Cross County Wildlife Site

The effects of the beavers on the vegetation structure and scrub dynamics of the Clyst William Cross CWS have been previously introduced, and the array of new wetland habitat features and mosaic of habitats that are being created by the activities of the beavers are outlined in **Case Study 5**. The site is designated as a County Wildlife Site and described as supporting a variable marshy community with some areas dominated by rushes, *Juncus* spp., yellow flag iris, *Iris pseudacorus*, and small patches of purple moor-grass *Molinia caerulea* and sedges, *Carex* spp. In 1993 when it was originally surveyed, the site was grazed 'extensively' with cattle, and fencing has since fallen into disrepair and the grazing of the site has ceased.

In May 2014, a detailed habitat survey and condition assessment was carried out. Habitat assessments follow a standardised methodology and are tailored to each vegetation community. Management of each habitat is also assessed, as well as any potential threats to the designated site features.

In 2014, the overall condition of the site was categorised as 'red' (declining). The description concluded that 'The recent lack of management has encouraged dominance of the site by hemlock water-dropwort *Oenanthe crocata*, and rank grass growth and as such the botanical diversity at this site has reduced.'

In 2019 the condition assessment was repeated and reclassified the site as 'amber' (recovering). Although this survey did not record a significant change in the vegetation community (in particular the dominance of hemlock water-dropwort due to lack of grazing), there is evidence that the beavers are beginning to impact on this issue positively. For example, by construction of channels between the main river corridor and the pre-existing ditch system, the hemlock water-dropwort dominance is now being broken up and this process provides a natural agency for the litter removal specified by the JNCC[11] as being necessary to maintain plant species diversity in fens which are not regularly grazed. In the longer term this would influence greater structural variability and plant diversity as channels, channel edges and litter mounds create conditions where less competitive plants and light demanding species can become established.

↓ Since 2016, the beavers have been increasing the diversity of wetland habitats present within the Clyst William Cross CWS with resulting improvement to site condition.

Wildlife using beaver dams

Fish populations

The diversity and abundance of a river's fish community is a reliable indicator of the health of that aquatic ecosystem[16]. Fish communities are heavily influenced by the physical habitat structure, the hydrological regime and water quality, all of which are interrelated, and can be influenced by the activity of beavers[17].

→ Until recently European eels were common and provided an important food source for otters and many bird species, but populations have been declining rapidly in recent years. Wetland habitats created by beavers have the potential to be an important habitat resource for them.

Photo: Ros Wright

The River Otter catchment has depleted fish populations resulting from chronic diffuse pollution, poor habitat diversity and man-made barriers to fish migration. Eight species of fish were recorded in the catchment during the Trial period. The life stages of these various species have different requirements. Therefore, in order to support a diverse and healthy community of fish, a wide variety of river habitats, flow regimes and channel features would ideally be present. Indeed, the presence of more surface water in a catchment is likely to lead to more habitat for fish, especially during periods of drought.

Whilst the effects of beaver damming have the greatest potential to impact aquatic ecology and fish populations, the impacts of beavers coppicing bankside trees, changes in bankside canopy structure and degree of shading will also exert significant influence[17].

Heron catching elver

The approach taken to monitoring impacts on fish populations

Beaver dam building activities have been limited to a few locations and, in line with what is suggested by the Dam Capacity Modelling work (Chapter 5), no dams have been built in the main River Otter. Priority was given to understanding the health of the overall fish populations and aquatic ecosystem when viewed at a catchment or sub-catchment scale. It was also recognised that any significant changes to fish populations that might be attributed to beaver activity might only be observed over a longer time frame, rather than in the relatively short period afforded by the Trial.

A small number of dams in the catchment may prevent fish passage under certain flow conditions. As a result the Fisheries Forum were concerned this may impact on salmonid populations, and this has been considered as part of the Beaver Management Strategy Framework[18] (Appendix 7, https://www.devonwildlifetrust.org/sites/default/files/2019-07/Appendix%207.pdf).

Through the establishment of a Fisheries Forum, local fishermen and scientists have provided their knowledge and insights into the importance of different parts of the catchment for salmonid populations. It was clear throughout that detailed quantitative information was limited, with information on the other fish species present being even more so.

University of Southampton provided a quantitative baseline survey for part of the middle River Otter catchment where beavers were active, and salmonids were present. Whilst this baseline understanding established the presence of eight species of fish, as detailed above, no dams have been built and thus no direct impacts have been recorded.

When beavers first began building dams in the River Tale, this provided an opportunity to monitor fish populations in an area where beavers might influence habitat structure and start to have a measurable effect over the Trial period. Detailed electrofishing surveys were carried out by University of Southampton in 2016 and 2017 where a control / impact design was employed. Electrofishing surveys were then repeated in August 2019 in four stop-netted reaches using the same multiple-pass method (Appendix 2). The reaches comprised an upstream and downstream scientific control, a beaver pool and an area previously impounded by a beaver dam.

Westcountry Rivers Trust were commissioned to carry out a fisheries habitat survey for the lower 8 km of the River Tale that included the two reaches where beavers had constructed dams across the channel. These surveys provided an understanding of potential beaver impacts from two dams on the whole Tale sub-catchment.

Beaver dams were also constructed in two 3rd order streams in the lower part of the River Otter catchment with historical records for sea trout and a single salmon.

Camera trap video evidence of trout swimming over beaver dams was obtained during high flows in the Colaton Raleigh stream in 2016 with some of these fish providing a food source for herons.

↑ In total 1.9 km of the 594 km of watercourses within the River Otter catchment was impounded by beaver dams in October 2019, which equates to 0.31%. This includes 813 m of floodplain ditch system in the Colaton Raleigh stream.

Heron with trout

Observations of trout jumping a beaver dam on the River Tale were also made in November 2019. However with such a small proportion of the catchment and fish population impacted, tagging fish (to electronically track their progress over a limited number of beaver dams), was considered impractical. In order to significantly add to the scientific understanding of fish passage around and through beaver dams, it will be necessary to study a watercourse where higher numbers of fish and dams are involved[19,20]. There are likely to be many more suitable catchments than the River Otter for this research.

The influence of beaver dams on water quality and the hydrological regime is considered elsewhere in this report (Chapter 3). The relationship between beaver activity and fish populations in lowland streams and rivers will also be the subject of more detailed research (Kye Davies PhD project, Sept 2019>).

← The ROBT is very grateful to the members of the Fisheries Forum and an associated Working Group established with members of the River Otter Fisheries Association and South West Rivers Association for their generosity with their time and expertise.

Photo: Alastair Rogers

Impacts on fish populations in the River Tale

Beavers have built dams in two stretches of the River Tale **(Case Studies 5 and 6).** The stretch at Clyst William Cross has seen the most significant change and has been the subject of the most detailed research on the impacts on fish populations. Electrofishing surveys were conducted in August 2019 around the main *in situ* dam and immediately downstream of where a previous dam had been washed out. These surveys were undertaken by the same team from the University of Southampton who surveyed this part of the River Tale, including the two control reaches, in 2016 and 2017.

In the beaver pool (glide), a reach where flow was impounded upstream of the dam, water was deeper and velocity was slower in comparison with both the upstream and downstream controls and the reach immediately downstream of the old, defunct, beaver dam. The latter was generally shallow and swift flowing, characteristic of good quality riffle habitat.

The slow flowing water in the beaver pool deposited fine sediment/silt (ca. 57% of streambed material), in contrast to the upstream and downstream control reaches and the area immediately downstream of the dam which were dominated by gravel (37–71%). The effect of the beaver dam on the physical characteristics is broadly consistent with results from July 2017. Then, a beaver dam (which has since collapsed) also increased depth, reduced velocity and promoted fine sediment deposition.

Total fish abundance was similar immediately downstream of the old beaver dam (161 fish) and in the control reaches (upstream: 174, downstream: 153). Total abundance in the beaver pool was 37% higher than the other three reaches (260). The two beaver impacted reaches (beaver pool and immediately downstream of the old beaver dam) contained the largest number of brown trout, supporting different life stages of the species (mature adults in the pool, juveniles in the riffle downstream of the old dam). Although there was a notable reduction in bullhead, the number of minnow and lamprey was markedly greater in the beaver pool in comparison to the other reaches. Furthermore, it was the only site to support the three-spined stickleback; a species not recorded in either the 2016 or 2017 surveys.

Differences in the fish community composition were reflected in the Bray-Curtis similarity comparisons (Appendix 2 - lowest values = greatest difference). The beaver pool was most different when compared with the control reaches and the site downstream of the old beaver dam. These differences are driven by the contrast in habitat type brought about by the beaver dams i.e. some deep slow water, some shallow faster water. Thus, if variability in fish habitat within a channel reach is considered desirable, beaver dams and consequent channel change will help facilitate diverse channel characteristics.

↓ In 2018 the summer dam created by the beavers to access maize in the lower River Tale was removed on a number of occasions over the course of 2 months. A new riffle is all that remains as a result of the gravel deposition that occurred when the dam was in place.



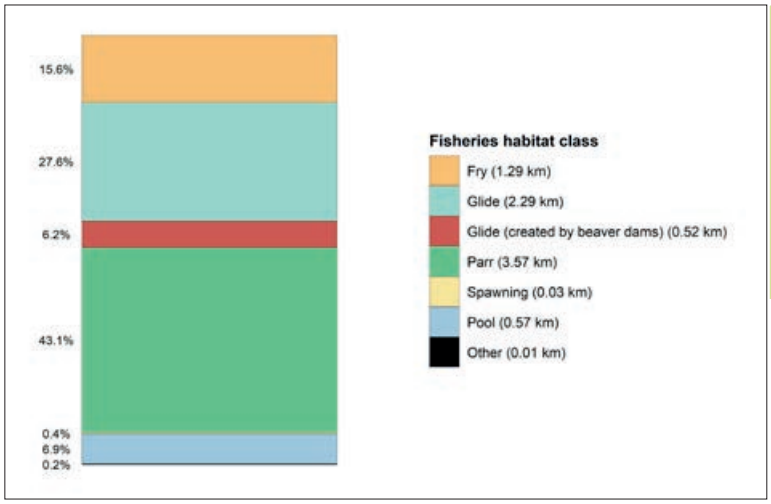
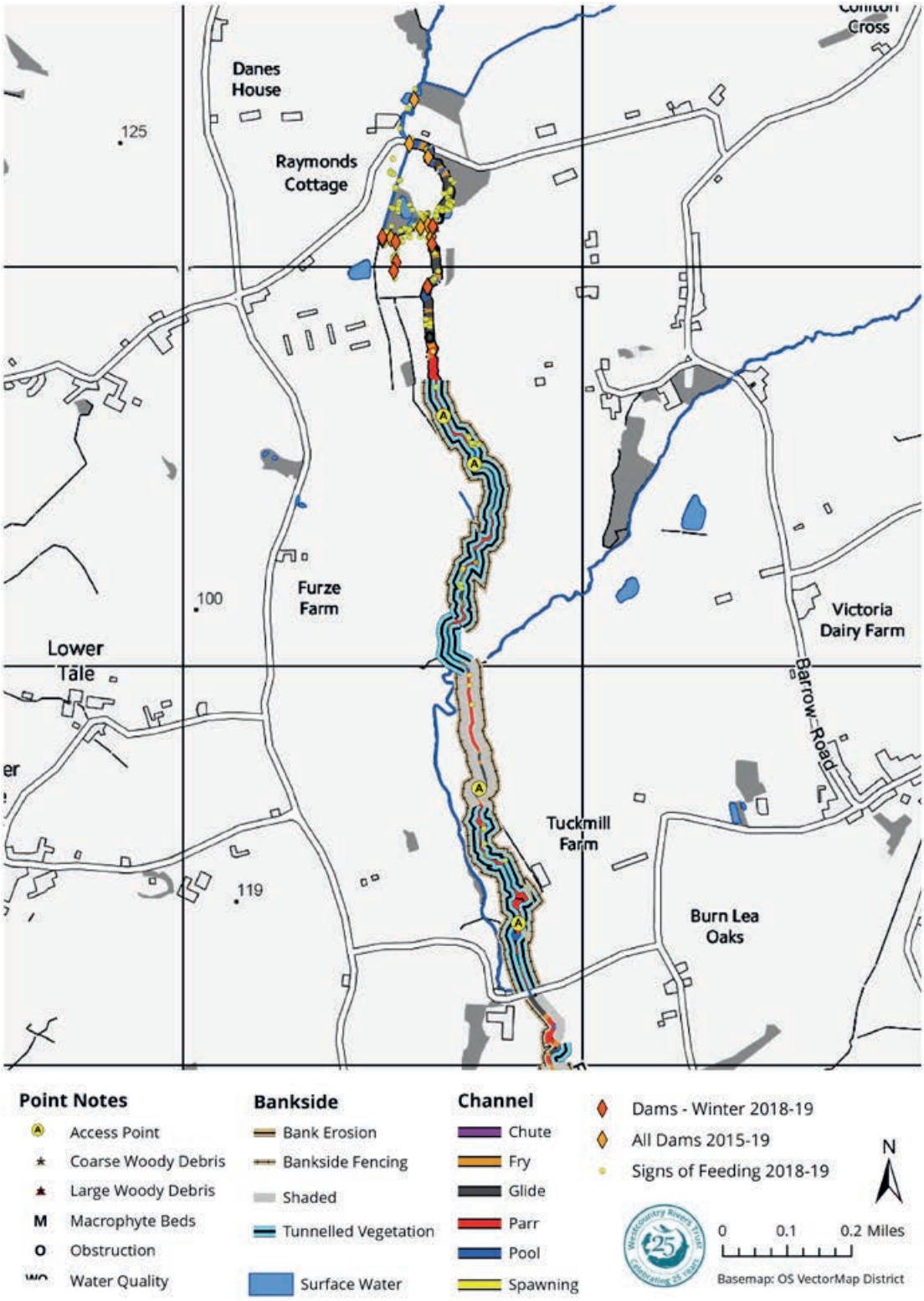


Figure 2.5 A survey of the lower 8.3 km of the River Tale by Westcountry Rivers Trust (WRT) in 2019 quantified the salmonid (salmon and trout) habitats present. The habitat types are broken down into the various stages of the salmonid life cycle using WRT's fisheries walkover manual. (Sample map below).



↑ European eels made up 2.3% of the fish caught during the 2019 survey.

Photo: Ros Wright

Figure 2.6 Results of electrofishing survey work by the University of Southampton on a short stretch of the River Tale demonstrates that the effects of a dam in reducing velocity and increasing depth in the resulting pool (glide) has a marked effect on the fish community. The beaver pool supports the highest total fish biomass with more and larger trout than either the upstream or downstream controls. In contrast the shallow, swift flowing conditions created where the previous beaver dam had washed away provided good habitat for juvenile trout which were abundant.

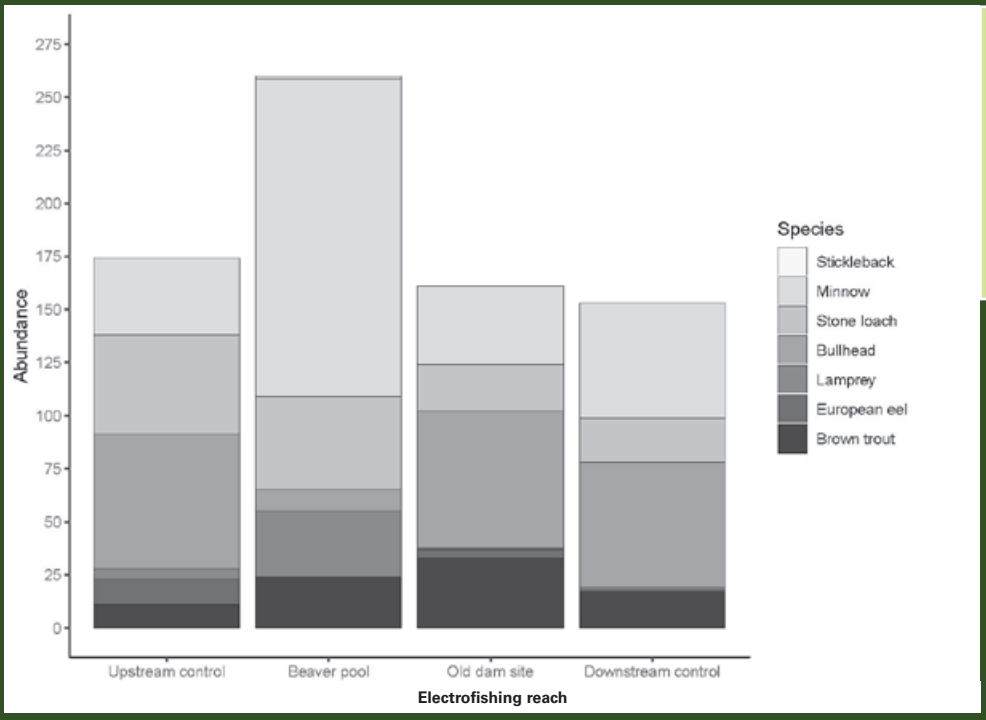
Brook lamprey and bullhead are both species of conservation concern, with numbers severely in decline largely due to habitat degradation. This survey has shown that beaver pools are significantly better habitats for lamprey, as indicated by the numbers caught, than upstream and downstream control reaches, or riffles downstream of beaver dams. This is due to the availability of silty/fine sediments in slow-flowing waters, needed to rear juvenile lamprey. In contrast, bullhead require fast-flowing, riffle habitats, that are (ideally) clean of fine sediments, as is shown by 64 individuals being captured in the riffle downstream of the old beaver dam (compared with 63 and 59 in the up- and downstream control respectively, and 10 in the beaver pool).

The beaver pool was the only location to contain any three-spined stickleback and also three times as many minnows, when compared with other reaches (150 in the beaver pool) illustrating the role that beavers can play in providing diverse habitats for fish.

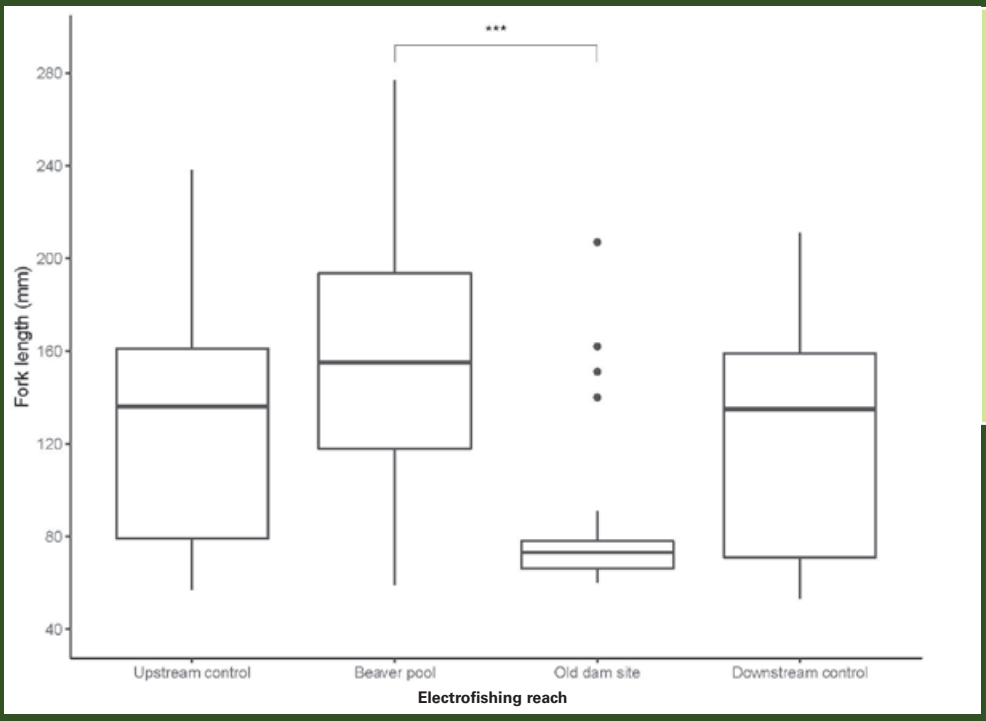
River restoration by beavers

Routes for fish passage over dams

→ This image illustrates part of the reaches surveyed upstream and downstream of the beaver dam highlighting the contrasting habitats present.



← Total abundance of fish within four reaches sampled in August 2019 including a beaver pool (glide) formed by a dam in place throughout 2019, and a reach immediately downstream where a dam had been washed out in 2018. Bars are stratified by fish species.



← Fork length of brown trout in the four reaches sampled in August 2019. The horizontal lines represent the median value, and boxes define the 25th and 75th percentile. The whiskers represent maximum and minimum values, excluding outliers. Outliers (> 1.5 x the interquartile range) are shown as dots. Significant differences are highlighted with horizontal lines above boxplots.

Impacts of changes in canopy structure on fish

The River Tale is heavily shaded throughout its course and this will affect the productivity of salmonid recruitment. Where beavers are coppicing trees in these areas (figure 2.3), then the juvenile development stages of the salmonid life cycle could benefit due to increased macroinvertebrate production, if there is suitable habitat present, providing more potential prey[21]. The *ad-hoc* nature of this coppicing needs to coincide with the right areas and be in proportion, as some cover is required in habitats for adult fish such as pools, which helps to keep rivers cool - especially important in our changing climate[17].

Temperature effects of beaver dams were not monitored in the ROBT due to logistical and financial constraints. Peer-reviewed data from elsewhere[22], show that stream temperatures are buffered i.e. reduced in summer, with cooler and deeper water, enhancing refugia for species such as salmonids. The overall variability of water temperatures in beaver-dammed rivers is also greater, supporting a wider diversity of aquatic life.

Before

After

The high energy River Tale at Clyst William Cross has demonstrated the most interesting effects of beaver damming on fish habitat. Since 2016 a sequence of dams has been repeatedly built and washed away during high flows, resulting in significant changes to the channel morphology. During periods when dams impound water, sediments and gravels are deposited in the pools, and erosion of the banks around the dams has occurred. As dams breach during high flows, fine sediments are flushed downstream and larger sediments redistributed, creating new riffles and gravel beds. This has resulted in a noticeable increase in bed level height in these reaches and a wider, more meandering and multi-threaded channel. With the creation of new dams elsewhere, the process is repeated. This results in the restoration of dynamic morphological processes and an increase in habitat variability within the reach, including deep pools, mobile gravels, extensive in-channel woody material, eroding banks and other natural features.

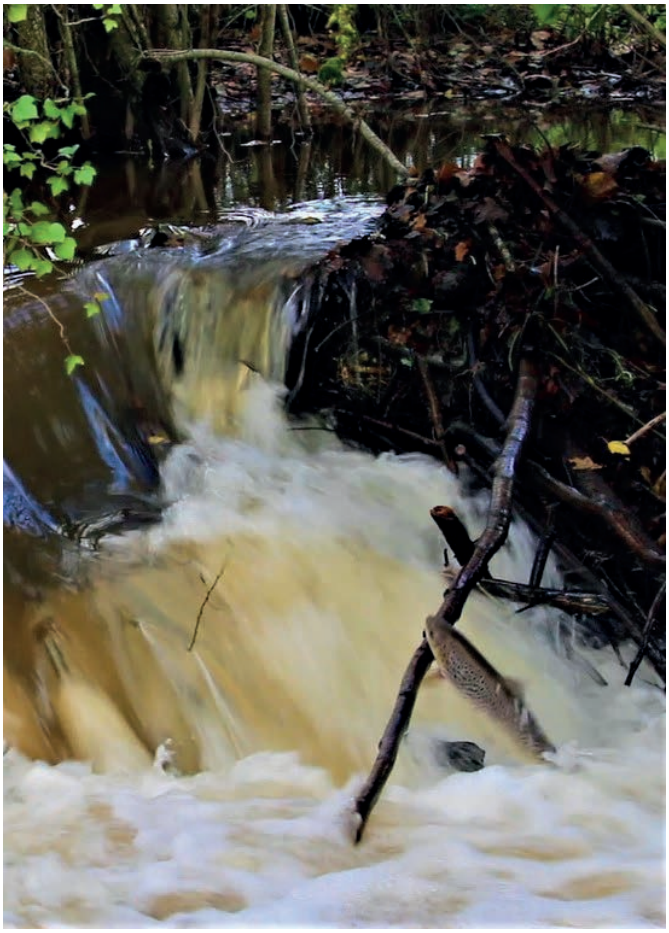
Fish migration over beaver dams

On 26th November 2019, sea trout were observed migrating at a beaver dam site at Clyst Williams Cross. The trout were jumping and attempting to make their way over the dam of approximately 1.5 metres in height (from river bed to dam crest). Following prolonged rainfall, the high flows had overtopped the crest of the dam and created a focused stream where the trout were jumping.

A number of successful attempts were witnessed from both small and large trout. Five film clips of successful attempts were captured of fish of different sizes successfully passing the dam. The successful attempts mostly occurred when a fish jumped halfway and then used an unbroken tongue of water to swim up the remainder.

Many attempts were unsuccessful due to factors such as jumping from too far back, jumping in the wrong direction, or being obstructed by an overhanging piece of woody material. Six film clips of failed attempts were captured, demonstrating examples of each of these reasons.

The films demonstrate that sea trout were attempting to pass the dam and that, in high flow conditions, this dam was passable for some fish.



Fish jumping beaver dam on River Tale (Video: Roger Auster)

Photos: Roger Auster

↑ **Figure 2.7** Water voles have responded positively in response to the increase in aquatic habitats created by the beavers with an increase of approximately 200m of water meadow habitat now available to them.

Mammals

Water Vole *(Arvicola amphibious)*

Between 2004 and 2010 the Devon Water Vole Recovery Project trapped mink and reintroduced water voles in the River Tale. In June 2016, the Devon Mammal Group funded mammal specialist Mervyn Newman to survey the entire River Tale for riparian mammals, including water voles and otters, to gain a baseline understanding of populations early in the colonisation of beavers into this important sub-catchment. A more detailed survey for water voles and other mammals was conducted of the Clyst William Cross site in 2017 which mapped the distribution of water voles but did not detect any significant difference from the previous survey. Signs of otters were once again found throughout the main River Tale corridor but were not recorded in the adjacent wetland habitat.

Mervyn then repeated his survey of the Clyst William Cross site in Spring 2019. He concluded that despite the presence of mink in the area, the water voles were now utilising new rewetted sections that were holding a depth of water (30 cm or more) as a result of beaver damming. Since 2017, the beavers have increased the amount of water channel available for water voles by over 200 linear metres.

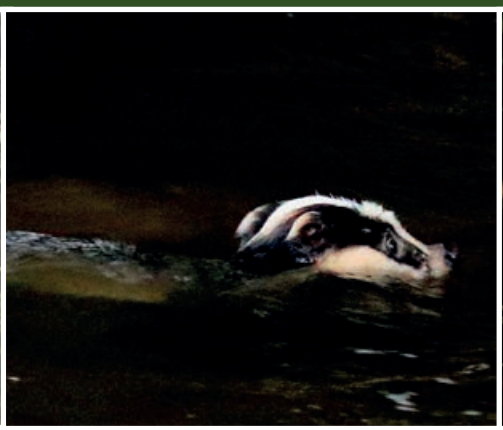
Anecdotal account of beaver interaction with a badger by David White on 18th July 2016

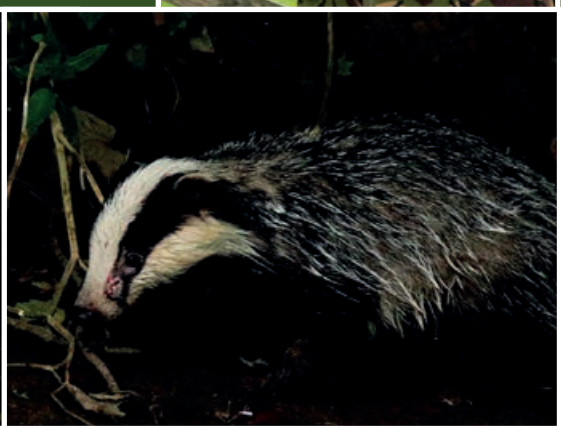
"At dawn we saw a badger come down to the river for a drink. It then moved off up a steep riverside bank; lost its footing and fell some 10 to 12 feet into the water below. It hit and broke a dead branch during its fall which made a considerable noise. This commotion immediately attracted the attention of the adult male beaver who was some 30 yards away. He very rapidly swam to the badger and without hesitation, attacked it, biting its nose and possibly its leg. The beaver may then have realised the badger was no threat to him or his family and swam off.

The confused badger swam around in several circles, and I was able to take this photograph before it left the water and limped away."

Photos: David White

Field Observation by local naturalist and photographer, David White





Otter *(Lutra lutra)*

↑ Otters rely on natural holes in riverbanks as holt sites, and spraints found inside collapsed beaver burrows indicate that they are being used for this purpose.

The River Otter supports a healthy otter population, and their interaction with beavers is of interest to many stakeholders. Beavers and otters are both frequently encountered along the same stretch of river in the evenings. Being unlikely to dig their own burrows, otters rely on natural holes in riverbanks as holts. On two occasions since 2015, otter spraints (droppings) have been recorded by ROBT surveyors in the chambers of collapsed beaver burrows in the lower River Otter catchment.

One of the main natal lodge sites in the lower valley is frequented by otters which have been seen fishing and playing in the adjacent deep-water pool on many occasions by ROBT staff and local beaver watchers.

There is also a suggestion that otters may predate on young beaver kits. Clear evidence of this is difficult to come by. Anecdotal information suggests increased otter activity around natal burrows during the period where young kits are present, and more defensive behaviour by adult beavers towards otters at this time. A video of a beaver acting defensively towards an otter was taken in July when kits were emerging.

Otter using beaver created habitats

Lucky footage of otter by drone (Daniel Cawthorne)

"In June and July I was often waiting for daybreak during peaceful periods on the riverbank hoping to see young beaver kits. I became aware that, on these occasions, I had more otter sightings than I would normally expect and always at or near the beaver burrow. These sightings included otters moving fast on the surface. They were obviously not fishing and I believe they were opportunistically hunting hoping to find an unattended beaver kit to predate. Over a two week period between 17th June and 5th July 2016, I had at least eleven otter sightings."

Photo: David White

Bird species

In 2017 and 2019, breeding bird surveys were conducted at Clyst William Cross CWS. The conclusions were that the current habitat continues to favour a diverse range of birds, particularly those that depend on more open woodland habitat with low canopy structure and the presence of dense scrub for nesting, for example willow warbler, *Phylloscopus trochilus,* and chiffchaff, *Phylloscopus collybita*. The assemblage also includes woodland, riparian and wetland species reflecting the mosaic of habitat conditions within the site. Observations on the beavers' use of the site suggests that their influence maintains a dynamic scrub community, suitable for migratory warblers which are a feature of the site's breeding bird fauna.

No significant difference in the species diversity of the site or in the numbers of territories of individual species was detected between the two surveys. Subtle changes observed may be due to chance factors, differences in detection between surveys, wider changes in the fortunes of bird species populations or as a result of the alteration of the available habitat accruing from beaver activity.

Several additional species were recorded in the 2019 survey. Although breeding evidence for some of these was inconclusive it supports the interpretation that, if there is any beaver-mediated influence on the site's breeding bird assemblage, then it is most likely to be positive.

In the lower part of the valley where open water and marshy grassland conditions have been created, large numbers of ducks, waders and herons have been attracted **(see Case Study 1)**.

↓ The marshy grasslands that have been created periodically by the beavers have attracted many snipe, *Gallinago gallinago.*

Photo: David White

Dippers have recently been recorded around the new wetland created by the beavers on the Budleigh Brook

Photo: David White

Heron catching frogs

↑ Teal, *Anas crecca*, and other wetland birds have flocked to the open water created in the floodplain by beavers during the winter months.

Photo: Sylvia Meller

↑ One beaver-created wetland in the floodplain has supported passage migrants such as common sandpiper (photo) *Actitis hypoleucos* and green sandpiper *Tringa ochropus* which were frequently observed foraging on the waters' edge and along the tops of the dams.

Photo: David White

Wildlife using beaver dams

← Research into the amphibian responses to increases in aquatic habitats have not been conducted on the River Otter to date. Within the Enclosed Beaver Project site in West Devon, annual counts of frogspawn have shown the number of breeding pairs of common frogs, *Rana temporaria*, have increased from 10 pairs in 2011 to 681 pairs by 2017. This corresponds with a significant increase in available spawning habitat as a result of the construction of 13 beaver dams along 180 m of 1st order stream.

Photo: Nick Upton / Naturepl.com

Key documents in Appendix 2

- Clyst William Cross surveys (various)
- Water Vole (and other mammal) surveys of River Tale (various)
- Fisheries surveys (various)
- Breeding bird surveys

The appendices are available to view at www.exeter.ac.uk/creww/research/beavertrial/appendix2/

NB. These appendices will be updated with other relevant supporting documents, not necessarily listed here.

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