CLATWORTHY RESERVOIR: PERSONAL REFLECTIONS ON THE CHANGING ECOLOGY OF AN ARTIFICIAL LAKE.

SIMON RATSEY

(formerly of The Leonard Wills Field Centre, Nettlecombe Court, Somerset)

Clatworthy Reservoir, situated in the Brendon Hills in west Somerset, was created in the late 1950s by damming the headwaters of the River Tone. With the primary function being to provide a water supply on the western side of the county of Somerset, it also has a recreational function in providing angling, specifically fly fishing for trout. A highly biodiverse aquatic ecosystem developed, including a breeding population of rainbow trout, derived from fish introduced to enhance the sport for anglers. By the end of the 20th century, American Signal Crayfish had become established in the reservoir, having been introduced to the UK under government licence some decades previously. The local source of this alien species is uncertain. Within twenty years, the Signal Crayfish appeared to have more or less wiped out most other aquatic fauna apart from Sticklebacks, and the artificially-reared Rainbow Trout with which the lake is stocked. With the added stresses resulting from more frequent severe reductions in water level, partly attributable to climate change, it is doubtful if the lake could now be described as containing a functioning ecosystem.

INTRODUCTION

Unless otherwise stated, information contained in this paper has been compiled from the diaries, observations and recollections of the author, who has known Clatworthy Reservoir since its creation. Much material of value was retrieved from the angling diaries of the author's late father, H.A. Ratsey (referred to as Mr Ratsey in the text below), covering the period from 1961–2004. He recorded the numbers, and weights in Imperial units (approximate metric conversions provided here are based on ca. 28 g to 1 oz), of trout caught at the reservoir each season, and the successful patterns of fly. He also made notes on the stomach contents of trout, conversations with reservoir staff, and observations of water levels. The author's own diaries provide further information about fishing in the 1960s, and in the period from 1987 to the present day. During the six decades spanned by this study, 3,288 Clatworthy trout were caught and weighed by Messrs Ratsey, a large enough sample for statistical purposes. The rainfall data used in this study are from the UK Meteorological Office climate station run by the Field Studies Council at Nettlecombe Court, starting in 1968, cross-referenced with and supplemented by the author's personal records, commencing in the local area in 1962. A detailed study of the local climate was published in 2019 (Ratsey, 2019).

FIGURE 1: Schematic Map of Clatworthy Reservoir. (Grid Ref. ST043313). Courtesy of Wessex Water, 2022.

HISTORY

As a boy in the 1950s, the author was once shown a 1904 large-scale OS map by his father. On it in pencil was an outline which, he was told, marked what would be the high-water mark of a lake that was to be created in the nearby hills. Subsequently, a family outing by car followed the lane that would be at the bottom of that lake, an experience that left a lasting impression. In due course, a 30 metre-high dam was constructed to impound the headwaters of the River Tone, near the village of Clatworthy in the Brendon Hills in Somerset (Figure 1). The topography of the area consists of a series of steep-sided valleys incised into a plateau with summit heights generally in the range ca. 330–370 m/1100–1200 feet. The site of the dam was selected so as to allow the flooding of two major stream valleys, and the smaller valleys of tributary streams which now form the distinctive arms of the reservoir.

The project was completed in the winter of 1959–1960, the resulting lake being just over 2 km in length, with an area of about 50 ha and a capacity of over 5 million m^3 of water when full. It was opened as a fly-only trout fishery in May 1961, managed by the West Somerset Water Board, with a perimeter track created by the end of that decade to allow public access. The lake is currently one of the two largest surface water bodies owned and managed by Wessex Water plc, which company now actively encourages recreation at the site, with a recently-enhanced car park and picnic area near the dam, and instructive information boards at intervals along the 8 km perimeter walk.

FIGURE 2. The view north over Clatworthy Reservoir in early spring, 1969. *Photo S. Ratsey.*

THE CLATWORTHY AQUATIC ECOSYSTEM

Land use in the catchment area of the reservoir, some 1800 hectares in extent, has always been predominantly pastoral farming and woodland. While the creation of the lake involved the felling of some areas of woodland and the abandonment of two farms (Syndercombe and Westcott), the local environment was otherwise enhanced by its presence in a number of other respects. The concrete dam quickly became a tourist attraction, while the reservoir itself offered scenic elements that the district had previously lacked, with fields and wooded slopes reaching almost to the water's edge (Figure 2). While angling was (and still is) the main recreational use of the reservoir, there was also a sailing club at the site until 1977.

As an inland water body of significant size, the reservoir has from the start been frequented by a variety of waterfowl and wading birds. Most commonly seen are Canada Geese (*Branta canadensis*), Little Grebes (*Tachybaptus ruficollis*), Great Crested Grebes (*Podiceps cristatus*), Mallard Ducks (*Anas platyrhynchos*) and Tufted Ducks (*Aythya fuligula*). Herons (*Ardea cinerea*) have been frequent visitors, while Kingfishers (*Alcedo atthis*), Dippers (*Cinclus cinclus*) and Common Sandpipers (*Actitis hypoleucos)* are seen occasionally. Mixed flocks of Herring Gulls (*Larus argentatus*) and Lesser Black-backed Gulls (*Larus fuscus*) are observed frequently nowadays, although they were not present formerly. The Cormorant (*Phalacrocorax carbo*) first appeared in the 1980s and the Little Egret (*Egretta garzetta*) in the present century. On September 11th 2014 an Egret was seen to be the target for a stooping Goshawk (*Accipiter gentilis*), but it survived by crash-landing in the water. A Black-throated Diver (*Gavia arctica*) was observed as a notably rare visitor in January 1997.

Beneath the water, there was also an abundance of life. In the pre-existing feeder streams, there had been native Brown Trout (*Salmo trutta*), Bullheads (*Cottus gobio*), Three-spined Sticklebacks (*Gasterosteus aculeatus*), and almost certainly Eels (*Anguilla anguilla*) and White-clawed Crayfish (*Austropotamobius pallipes*). These latter two species were known by the author from his boyhood angling experiences to be widespread in the catchment of the upper Tone. In the early years, any reasonably observant angler at the reservoir might encounter a wide variety of invertebrate fauna, including aquatic Snails (*Lymnaea* spp.), Pea Mussels (*Pisidium tenuilineatum*), Shrimps (*Gammarus pulex*), Caddis larvae of various species (*Trichoptera* spp.), Mayfly nymphs (*Ephemeridae* spp.) and Leeches (species unknown). To this list of fauna should be added the non-native Rainbow Trout (*Oncorhyncus mykiss*), introduced deliberately for sporting purposes. It became apparent within a few years that (most unusually in the UK) Rainbow Trout were breeding in the reservoir or its feeder streams, with large shoals of Rainbow Trout fry sometimes being observed at the surface.

Most of the invertebrates inhabited the shallower margins (the "littoral zone", extending to a depth of 2–3 m at Clatworthy). In any lake, this part of the shore is of great ecological importance, containing aquatic plants that provide habitat, and being the area which receives most nutrient input, either from feeder streams or from disturbance of sediment by wave action in stormy weather. At Clatworthy, because of the steepness of the pre-existing valley sides, the littoral zone is mostly quite narrow. Experience has shown that the most biologically productive areas in the reservoir are the relative shallows of Rowes End, Westcott Bay, and to a lesser extent, Tripp and Dudderidge bays.

In the absence of any recorded survey of the aquatic life of the reservoir, the details of stomach contents of trout noted in the angling diaries provide proxy evidence. It should be noted that, in the early years, it was normal for the fish (though of small size) to be well fed on mostly invertebrate life forms, so few specific notes were made. There were vast hatches in spring of a large species of Chironomid fly (a midge, up to 10 mm in length), which became known locally as the Clatworthy Black, followed later by good numbers of adult Ephemerids (Mayflies), and Sedge or Caddis flies in the summer. Anglers used traditional techniques, fishing with imitations of water beetles and the wide variety of natural fly life or their nymphs, on or just below the water surface. The occasional abundance of certain terrestrial species, such as the Hawthorn Fly (*Bibio marci*) in late spring, could provide anglers with excellent sport on an appropriate dry (floating) fly. The author and his father always preferred these traditional styles of fly-fishing. (See Appendix A)

Although populations of aquatic insect species seemed to vary from one season to the next, being notably more abundant after years with wet summers such as 1988, 1997, 2000, and 2007, the available evidence indicates that the lake ecosystem as a whole remained in a relatively stable state until the end of the 20th century. While the numbers of Mayflies and Caddis flies to be seen on the wing reduced with time, sundry notes on trout stomach contents include references to *Daphnia* ("water fleas") at intervals, along with occasional small fish identifiable as Bullheads and Sticklebacks. Many different kinds of aquatic insect larvae were noted, as well as Pond Snails, although the latter seemed scarce by the mid-1990s. Pea Mussels were last noted in August 2000, and although Caddis larvae were apparently quite abundant in the spring of 2002, they have rarely been noted since. More surprising stomach contents included the remains of mice or Voles and Frogs, while a Rainbow Trout of 1120 g/2 lb 4 oz taken on April 22nd 1997 had indulged in cannibalism! Occasionally trout were caught that had apparently become vegetarian, with stomachs containing Canadian Pondweed (*Elodeia* spp.) shoots, blades of grass or filamentous algae (*e.g*. June 18th 1993, July 23rd 1996 and June 15th 2011).

One clear trend in the 1980s and 1990s, detectable in the records, was for a growing proportion of the trout caught to have taken flies fished well below the surface, if not near the bottom (Appendix A). Only in June might one expect significant surface feeding, with the hatching of large numbers of the terrestrial Garden Chafer (*Phyllopertha horticola*), known to anglers as the Bracken Beetle, (or, in Wales, the Coch-y-bonddu). Even freshly-stocked trout soon learned that these were food, possibly because they landed heavily on the water in the manner of fish-food pellets. This period of surface feeding remains a reliable phenomenon at the reservoir, the trout being easily deceived by some of the very naturalistic dry fly patterns now available. The only other terrestrial insect to cause active surface-feeding by the trout was the Crane Fly or Daddy-Long-Legs (*Nephrotoma appendiculata*), appearing mostly in late summer and autumn, sometimes in large numbers.

The presence of an adequate natural food supply was indicated by the capture from time to time of well-conditioned Rainbow Trout that had survived the winter. This was fairly common well into the 1990s, these fish being characterised by large fins and a slim body shape. Records of their stomach contents suggest that they had become bottom-feeders, and they were often caught on patterns of fly that might be taken for a Caddis larva or Leech, for example. It is probable that, in the absence of angling, they would have survived for a few years more. (The natural life-span of Rainbow Trout is known to be shorter than that of Brown Trout, which may live for up to twenty years.) The records suggest that most over-wintered trout were caught in the early part of the fishing season.

Mr Ratsey's diary entries for 1995-96 are especially informative. In that year, low-water conditions combined with high temperatures seem to have had a negative impact on the ecology in the short term, it being noted that the trout appeared to be "starved" by the end of August. The water level was then 8 m down, falling slightly further in September. Partial refilling was rapid in November, but the reservoir did not fill completely until the end of February. Overwintered trout caught in the spring of 1996 were noted as being thin. However, with high water levels until midsummer that year, trout caught in July and August were recorded as containing a wide variety of invertebrate fauna in their gut. Aquatic life forms had evidently been able to recover their numbers after the drying-out of the shallower parts of the reservoir the previous year.

The next year to have very low water levels was 2003, when the situation was of similar severity to that in 1995. Although the reservoir level was only 7 m down at the end of August, it continued to fall until early November. Significant reductions in water level have subsequently been recorded in the autumns of 2010, 2011, 2016, 2018 and 2022. The shallower parts have been dry for increasing lengths of time, no doubt adversely impacting the populations of aquatic invertebrates. The author has found no evidence that research has been carried out in recent years into the impact of fluctuating water levels on the fauna and flora of the littoral zone in UK reservoirs. However, fifty years ago an unpublished PhD thesis looked at populations of aquatic snails in Blagdon Lake and Chew Valley Lake, two established reservoirs in north Somerset. (Mance, 1973) Some of the findings then seem to support the author's own more recent observations.

One visible result of prolonged periods with low water levels at Clatworthy has been the colonisation of the shore by amphibious plant species such as Water Mint (*Mentha aquatica*) and Marsh Woundwort (*Stachys palustris*), along with terrestrial plants including Silverweed (*Potentilla anserina*) and Bird's-foot Trefoil (*Lotus corniculatus*) which seem to tolerate periodic inundation. Other botanic arrivals, not native to the site, include Bur Marigold (*Bidens cernua*) and, more seriously, New Zealand Pigmyweed (*Crassula helmsii*). This latter alien species, banned from sale in the UK since April 2014, had probably reached the reservoir before then. When water levels are consistently high, the pigmyweed forms a dense blanket as much as 1 m deep around the margins wherever the substrate is stable, suppressing other plant life. The impact on aquatic fauna is unquantified.

Adding to the problems created by wide variations in water level and invasive plant species, the 21st century has seen another significant change in the aquatic ecosystem. The Signal Crayfish (*Pacifastacus leniusculus*; Figure 3) was known to be present by the year 2000. In the 1970s, this alien species from America - already established in Europe - was introduced legally to British waters, but it is unclear how it arrived at this site. However, it was probably present before March 1997, when the River Tone Management Plan published by the Environment Agency (Anon., 1997) noted that the species was already found in at least two tributary streams in the Tone catchment area, but not identifying the site of its introduction. The same document records the fact that, following survey work, no White-clawed Crayfish (*Austropotmobius pallipes*) had been detected in the River Tone between Huish Champflower and Wellington, where the species had been widespread in the author's younger days. With the reservoir being little more than a mile upstream from Huish Champflower, this would imply that Signal Crayfish were already present in the lake by 1997, the invasive species both out-competing the native one and also infecting it with crayfish plague. This phenomenon has become all too common in many bodies of freshwater in the British Isles, with a number of studies having been carried out on the devastating ecological impact of the Signal Crayfish and on how to manage, or eliminate, those crayfish populations. (Holdich *et al*., 2014)

FIGURE 3. Signal Crayfish caught on an artificial fly (length 12 cm). *Photo S. Ratsey.*

Signal Crayfish body parts among the contents of a trout's stomach were first noted in the author's diary in August 2000, (in which year there was an authorised crayfish trapping experiment at the reservoir). In this instance, the fish had also been feeding on Pond Snails and Pea Mussels, indicating that a choice of bottom-dwelling food was still available. During the following decade, notes of crayfish parts among the stomach contents become more frequent, with the recording of a 900 g/2 lb rainbow trout taken on 18th September 2006 which contained the remains of a crayfish 10 cm in length. Having noticed that more trout were being caught on large patterns of wet (*i.e.* sinking) fly that might resemble a crayfish, the author created some "crayfish flies" following a pattern given in an angling magazine. These proved to be readily accepted as food by the trout, often being taken with some violence. Several times, trout caught on the fly contained crayfish remains in their stomach or gut, indicating that some stocked fish at least were learning to predate on the alien invader.

In more recent years, the effectiveness of the crayfish fly has waned, as has the frequency of trout with crayfish remains inside. Notably, in August 2013 the author caught a native-bred Rainbow Trout weighing 705 g/ 1 lb 9 oz which had the remains of eight small crayfish in its gut. By that time, it was possible for the angler to catch crayfish almost at will, by using a large pattern of artificial fly fished very deep and slowly. A crayfish "take" was quite different in character from that of a trout, often consisting of repeated gentle tugs that sometimes resulted in the fly hooking into the crustacean's claw or leg. Any crayfish caught by the author in this way would be swiftly killed and left on the shore as food for either gulls or crows, both of which species seem to relish the treat. (Gulls are sometimes to be observed catching crayfish in the margins, with a crow or crows soon arriving to claim the catch for themselves. This is evidently learned behaviour and can lead to an altercation.)

There are indications that the large numbers of Signal Crayfish as the "top omnivore" in the lake are impacting the ecology in a variety of ways. There has been a reduction in the presence of aquatic plants, with no evidence that the once-prolific Canadian Pondweed still occurs there. (More frequent drying out of the littoral zone may be a contributory factor here.) Amphibious Bistort (*Persicaria amphibia*) is still abundant in some of the relatively shallow margins, as this plant can tolerate the seasonal drying out of those areas. Fishing reports, as well as the author's own experience, indicate that in recent seasons a greater proportion of the trout caught have been taken on very small flies that imitate the free-swimming larvae of Chironomids etc., as well as on dry fly patterns (Appendix A). It is possible that this is a response to the dearth of bottom-dwelling fauna. In the absence of Pond Snails, Caddis larvae and such like, the trout have stopped looked down for food, because there is nothing down there to eat, apart from Crayfish. This seems to be the opinion of the reservoir staff.

In January 2022 the author carried out a small survey of aquatic life that might be found in the feeder streams and water margins. A 15 cm diameter fine-mesh sieve attached to a pole allowed sampling to depths of about 50 cm in the littoral zone. Despite numerous samples being taken at accessible points around the reservoir, no fauna of any description could be found. In contrast, invertebrate life was found to be abundant in the four main feeder streams. The two that enter the reservoir from the east, in the bays known as Dudderidge and Tripp, yielded large numbers of Freshwater Shrimps and smaller numbers of the larvae of at least two species of Ephemerid. One stream also yielded a Stickleback, and a Bullhead was disturbed in the other. The juvenile River Tone, entering the reservoir in the bay known as Stolford yielded Ephemerid larvae, but no Shrimps. Noticeably absent from the stream samples were any kind of Caddis larvae or aquatic snails.

It is possible that the lack of fauna in the margins could be attributed to the fact that these areas were high and dry for several months in the previous year. There may have been insufficient time since then for invertebrates to migrate shorewards with rising water levels, assuming that such creatures were present in the reservoir when it was low. However, a similar survey carried out in August 2022, with the reservoir level about 7 m below the high-water mark, yielded almost identical results, and included, in the Dudderidge stream, a Damselfly larva (probably the Common Blue Damselfly, *Enallagma cyathigerum*, which was formerly abundant at the site). Sampling of the margins at a number of locations produced a solitary Diving Beetle (*Dytiscus* sp.) about 5 mm in length.

Further research on this topic would be useful. Using the simple method described above to sample the margins when the water level is high in spring may give a more informative picture, but sampling at depths of 1 m or more would require the use of a boat. Present monitoring of this water body by the Environment Agency would appear to concentrate on water quality based on the presence or absence of pollutants, rather than on its biology. In recent years the phytoplankton status has been classified as "Moderate" or "Good", while the water body as a whole is awarded "Moderate Ecological Status" (Anon., 2022). That is perhaps debatable.

As Moss (2008) acknowledges, "It is very difficult to increase the ecological value of reservoirs, given their purpose". However, he advocates efforts to restore "as much as possible of biological structure and community despite the absence of a functional littoral zone, and the complete destruction of a natural hydrological regime". It is reasonable to suggest that only a full ecological audit carried out on behalf of the water company will establish the true state of health of the Clatworthy aquatic ecosystem.

THE EARLY CHARACTERISTICS OF THE FISHERY (1961–1970)

Even before it was full, the reservoir was stocked with large numbers of young trout (less than about 225 g/8 oz in weight), predominantly Brown Trout with a smaller number of Rainbow Trout. The fish grew rapidly in the early years on the abundant supply of food produced by the recently-flooded land. Water levels remained high in Clatworthy Reservoir throughout the 1960s, every year except 1967 including at least one summer month that was very wet (150% or more of the average rainfall). Under these conditions, the littoral zone became heavily vegetated with a variety of aquatic plant species, including extensive patches of floating grass (probably Floating Sweet-grass, *Glyceria fluitans*) that could present problems to anglers fishing from the bank, notably in Westcott Bay. The vegetation that flourished in those early days supported an abundance of fish food, with Caddis flies appearing in large numbers through the summer months, and likewise enormous populations of Pond Snails and Sticklebacks, on which some trout would feed greedily.

It was recognised early on that the most productive areas for fishing were between the Fishing Lodge and Rowes End, the main area of relatively shallow water (and therefore most prone to drying out). Around the rest of the reservoir, much of the steeply-sloping shoreline (where at all accessible on foot) was found to be devoid of aquatic life. In many such places, the shore below the high-water mark consists of fragments of the eroded slate bedrock, inherently unstable and not a favourable substrate for sedentary or bottom-dwelling fauna. Also, between the Fishing Lodge and Westcott Bay there are several areas of iron-smelting slag, the result of industrial activity in Roman times if not earlier, which also create an inhospitable environment.

Another feature of this water body that was soon recognised was the phenomenon of thermal stratification, in which layers of water of different temperatures develop, especially in summer. With a depth of almost 30 m at the dam when the reservoir is full, the base of the water column could become deoxygenated, so measures were installed to counteract this in the form of an airline that might be switched on at intervals. (This well-aerated water is also clearer and therefore attractive to the trout in hot weather, so boat anglers often succeed there when all else fails.) Although blooms of phytoplankton have at times reduced underwater visibility, the water clarity has on the whole been good, sometimes with the bottom clearly visible at a depth of more than 2 m. For the trout, a species that feeds by sight, this is an obvious advantage.

Initially, the fishing season ran from 1st May to 30th September, with a bag limit of twelve, reduced within a few years to just six. The anglers were mostly local people, season tickets being relatively cheap, and the trout were abundant though generally much less than 450 g/1lb in weight. Very small (< 225 g/< 8 oz) trout were habitually returned unharmed, if possible. These were native-bred trout, of both species. Considerable numbers of stock fish survived from year to year, some of them growing to significant size. The author's largest Rainbow Trout in 1965 (when he held a season ticket and fished frequently) weighed 625 g/ 1 lb 6 oz - a notable fish, in those days. This was followed in 1966 by one of 795 g/1 lb 12 oz, while a 1275 g/2 lb 13 oz rainbow trout taken by Mr Ratsey in May 1967 was a most extraordinary fish for the water at the time. Those trout would certainly have been less than 240 g /12 oz in weight when stocked. Pond Snails and Caddis larvae often featured heavily in the gut contents of such trout, artificial flies that imitated these generally being successful patterns.

THE EVOLUTION OF THE FISHERY TO THE PRESENT DAY

The policy of stocking with relatively small trout (*ca*. 20 cm in length) was continued into the early 1970s, although the proportion of Rainbow Trout tended to increase as the faster growing-rate of the species was recognised as advantageous. Having been reared in fairly small ponds containing many trout, freshly stocked fish were often recognisable by damage to their fins and tail, as well as having a fatter body shape. They also had pink flesh resulting from certain additives in the fish food used to rear them, and usually contained much visceral fat. Fish that evaded capture would with time became "naturalised", the damaged tissues healing, and the body shape becoming more streamlined.

By the mid-1970s, naturalised female Rainbow Trout of more than 900 g/2 lb in weight were caught in most years, as well as male Rainbow Trout of rather smaller size, but showing all the clear physical signs of having bred at least once (notably the "kype", or hook on the lower jaw). The Rainbow Trout that resulted from natural spawning usually had a different appearance from the stock fish, being slim, silver-flanked, and with large fins and white flesh. Three very different trout caught on the same day (June 5th 2001) are compared in Figure 4: a recently stocked fish weighing 1190 g/2 lb 10 oz, a well-mended 900 g/2 lb stock fish, and a 595 g/1 lb 5 oz native Rainbow Trout. Also caught that day, and released, was a native Rainbow Trout weighing about 900 g/8 oz. Although normally elusive, the natives could be greedy and opportunistic feeders, with very small specimens (<10 cm) sometimes willing to take a disproportionately large artificial fly. They were genuinely wild Rainbow Trout, silver-flanked and very hard-fighting.

It was less easy to distinguish between native and stocked Brown Trout, as the species normally shows a considerable variation in colour and spottiness. However, as time passed the stocking policy moved progressively towards the Rainbow Trout as the faster-growing, more "sporting" fish. Any Brown Trout caught were increasingly likely to have been the result of natural spawning.

FIGURE 4*:* Three Rainbow Trout caught on June 5th 2001
Top: a recently-stocked fish weighing 1190 g/2 lb 10 oz; Middle: a well-mended fish weighing 900 g/2 lb; Bottom: a native Rainbow Trout weighing 595 g/1 lb 5 oz. (Reel diameter: 10cm). *Photo S. Ratsey.*

The first year in which the water level dropped significantly was 1972, followed by 1975 when (judging by photographic evidence) the level fell to at least 8 m below maximum, but the most serious situation occurred in the famously hot dry summer of 1976. There was concern that the water supply would be unable to meet demand, and while the effect on invertebrate aquatic life was not recorded, it would probably have been severe. However, an autumn with almost double the normal amount of rainfall meant that the reservoir refilled before the end of the year, and angling diary records for 1977 suggest that the quality of both fish and fishing had been little affected. By implication, the numbers of aquatic invertebrates present must have recovered well.

Low water conditions were experienced again in 1978, 1984 and notably in 1989. On September 4th in that year Mr Ratsey wrote in his diary: "Clatworthy is now at its lowest since 1976. The belt of Canadian Pondweed is above the water line, and much mud has to be endured to reach the boats. I nearly got stuck getting ashore. (Don't tell Mother!)." He was 77 years old at the time. His diary entry on October 2nd that year contained the footnote "Syndercombe Bridge is showing!" (The bridge he had driven across on that family outing in the 1950s.)

Some of the intervening years had wet summers, with a likely beneficial effect on the supply of natural trout food. 1986 was a notably cool, very wet year when water levels remained high, and although 1987 was dry overall, an exceptionally wet October meant that the reservoir refilled very quickly. The very wet first quarter of 1988, followed by a wet summer, ensured that the water level remained high for much longer than usual. The latter part of that fishing season was notable for the appearance of huge numbers of an unusually large black Chironomid, presumed to be a result of the relatively high water level. (It was not the "Clatworthy Black", which hatched only in spring.) The trout fed enthusiastically when these were hatching. Late in that same season, several trout were caught which had been feeding heavily on Pond Snails. Such evidence suggested that healthy populations of aquatic invertebrates were being maintained, and the successful fly patterns were still generally representations of natural food, including terrestrial insects that were blown on to the lake. In 1988 the average weight of trout caught was 770 g/1 lb 11 oz, the highest in the life of the fishery up to that date. There was then a slight decline in the average weight into the early 1990s.

Judging by the records in the angling diaries, the majority of the fish stocked in the 1970s and early 1980s were in the 450-675 g/ 1–1 lb 8 oz group, with a few 900+ g/2+ lb fish to add a bit of excitement. These were reared in ponds just downstream from the dam. There was an overall increase in the size of the fish caught with the passage of time, as represented graphically in Figure 5, below. By the late 1980s, there was the possibility of catching the occasional larger fish. Mr Ratsey took his first 1350 g/3 lb Clatworthy trout in 1987, with one of 1800 g/4 lb the following year. These were both Rainbow Trout that had been “grown on” to that size in the rearing ponds.

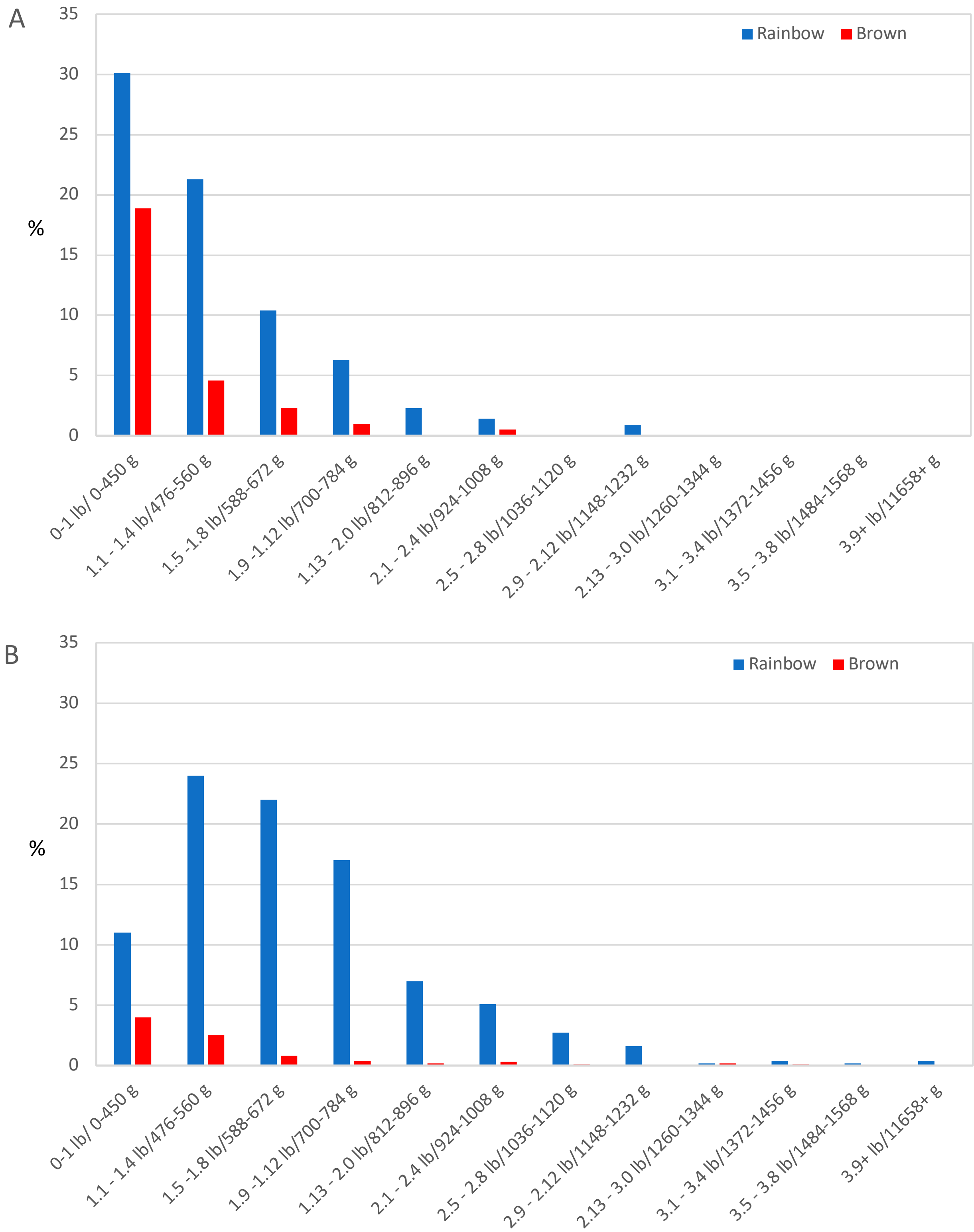

FIGURE 5. Size distribution of fish caught as percentage of total number recorded:
(a) 1970s: mean size 1 lb 1 oz / 476 g. (b) 1980s: mean size 1 lb 7 oz / 644 g.
(b) .Brown Trout – **red**; Rainbow Trout – **blue**.

With the increasing popularity of fly fishing for trout, and more still-water trout fisheries being created, the 1980s spanned a period of significant change in the management of the fishery at Clatworthy, by that time under the authority of Wessex Water. The start of the fishing season was brought forward to Easter, even if this fell in March, and extended into October to be more in line with the majority of English reservoir fisheries. Positive efforts were made to attract anglers, especially by stocking with larger fish, almost exclusively Rainbow Trout. As far as possible, female fish were stocked, to be substituted in later years by the new non-breeding triploid variety. The average size of Brown Trout taken from the water remained steady at just under 450 g/1 lb, these being mostly wild trout that depended entirely on the natural food sources provided by the lake and its environment. Very rarely, Brown Trout weighing more than 675 g/ 1 lb 8 oz would be caught, generally assumed to be stock fish that had maintained or increased body weight by adapting to natural foodstuffs. In August 1983 Mr Ratsey caught a Brown Trout weighing 1435 g /2 lb 9 oz, at the time noted as a native fish, and possibly the largest recorded up to that date. If in fact a stock fish, it would probably have been about 450 g/ 1 lb in weight when stocked some years previously. Whichever case applied, it had evidently enjoyed a good supply of natural food, the previous four years having all been wetter than average with fairly sustained high water levels.

Interestingly, the 1980s was the period when trout were most often seen hunting Sticklebacks in the shallows. Both Rainbow and Brown Trout would do this and could be caught on artificial flies that resembled small fish. In the summer of 1988, the author witnessed the capture of a Rainbow Trout of 1690 g/3 lb 12 oz (Figure 6) which had been observed chasing fry, and proved to have a gut full of them when the autopsy took place. This was easily recognisable as a male fish, and with the policy by then being to stock with female fish, this particular trout would appear to have survived for several years, perhaps breeding whenever winter conditions were suitable. Mr Ratsey took a slightly larger Rainbow Trout with similar features in the spring of 1990.

FIGURE 6: The author's wife and the 1690 g/ 3 lb 12 oz rainbow trout she caught in August 1988.
(Note the relatively high water level at the time.) *Photo S. Ratsey.*

One policy change at the start of 1991, probably reflecting the increased cost of rearing stock fish to a larger size, was to reduce the daily bag limit from six to five, and just four for a season ticket holder. Subsequent further amendments to policy included limiting the total number of visits that a season ticket holder might make, with suspicions that some anglers were selling trout to pay for their ticket, a practice of which reservoir staff disapproved.

The trend towards stocking with larger (900+ g /2+ lb) trout was in part a response to predation by Cormorants. These birds were not present at all until the 1980s, when a solitary specimen might at times be observed. Mr Ratsey's first sighting of two Cormorants in September 1988 was clearly noteworthy, being underlined in his diary entry. Through the 1990s, Cormorants became more common, with five or six sometimes being observed at once. The line of buoys used to cordon off the area of water near the dam became popular perches, and it was during this period that anglers first began to catch trout with damage that could be attributed to an attack by a Cormorant. Most often, diagonal beak marks on either side of the fish, in the vicinity of the anal or ventral fins, indicated that the bird had approached from below and behind. Wounds were sometimes severe, and varied from fresh to fairly well-healed, indicating that a proportion of the trout thus attacked survived for some time. The author recalls catching one trout that showed signs of having experienced two Cormorant attacks on different occasions. (While in recent years the reservoir appears to have had two or three "resident" Cormorants, on occasion as many as 20 have been observed together. The impact on the fish population is difficult to gauge.)

With a growing weight of evidence that the larger the fish, the greater its chances of not being predated, stocking policy changed accordingly in the 1990s, as illustrated in Figure 7a. In the first half of that decade, 15% in this sample of trout caught were 900 g/ 2 lb or more in weight, deemed to be a "safe" size. In the second half of the decade that proportion rose to 56%.

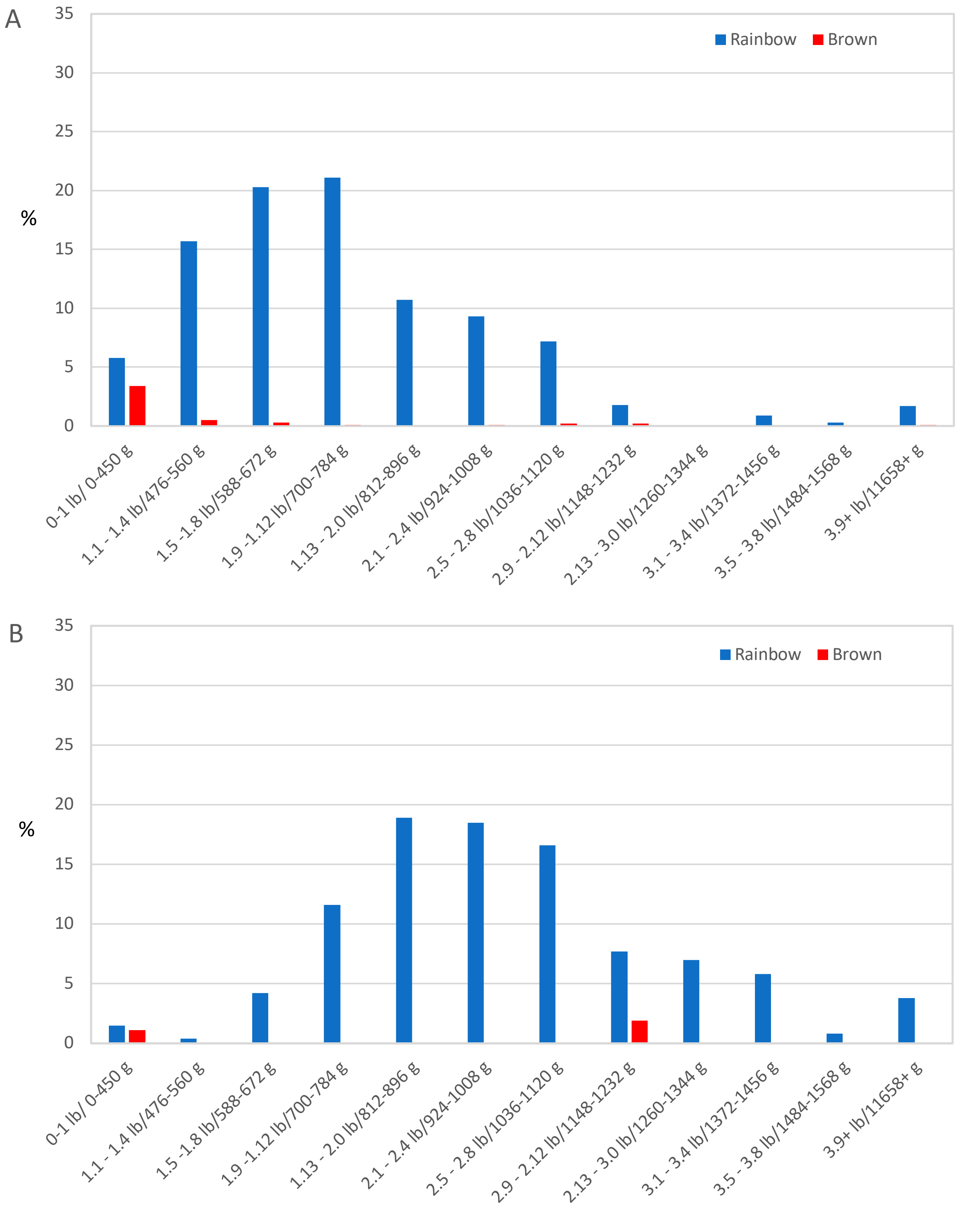

FIGURE 7. Size distribution of fish caught as percentage of total number recorded:
(a) 1990s: mean size 1 lb 12 oz / 784 g. , (b) 2010s: mean size 2 lb 11 oz / 1204 g.
Brown Trout – **red**; Rainbow Trout – **blue**.

By the turn of the century, angling pressure was at a sustained level not experienced previously at the fishery, with an extended fishing season from mid-March to the end of October. The reservoir's own fish farm could not meet the anglers' demand for trout, which had to be purchased from other sources, as remains the case to this day. The practice of stocking with larger fish has been continued, including a small number of "specimen" trout (*i.e*. more than 4.5 kg /10 lb in weight) at the start of the fishing season. Between 2001 and 2010 the average size of fish in this sample was 1070 g/2 lb 6 oz, with 12% weighing more than 1350 g/3 lb. For the period 2011 to the time of writing, the average size is 1220 g/2 lb 11oz with the proportion of 1350+ g/3+ lb fish having almost doubled to 23% (Figure 7b). These large stock fish have no chance of maintaining body weight on the available natural food, and it has to be assumed that those not caught in the first season will ultimately starve. (As long ago as June 1990 Mr Ratsey recorded his capture of a 1750 g/ 3 lb 14 oz rainbow trout which had "gone back" from a weight when stocked of at least 2025 g/4 lb 8 oz, based on length to the fork of the tail.)

This raises the topic of the potential total weight of fish that might be supported by the food supply available in this particular body of water. In the early 1950s a highly-regarded angler and expert on trout named Lancelot Peart wrote a series of articles in the *Fishing Gazette,* later assembled in a book titled "Trout and Trout Waters" (Peart, 1956). In this work, arguably still a valuable handbook for anyone managing a trout fishery, the author addressed this very question. He wrote: "Trout waters are, in general, far less productive than many authorities suppose… It is doubtful whether the very best waters in southern England are capable of producing more than 45 kg/100 lbs of trout to the acre, and in many British waters (famous ones among them) the annual rod-catch is not more than 9 kg/20 lbs per acre and sometimes very much less. It is certain, in any case, that no water in this country can stand up to heavy fishing indefinitely."

Using Imperial measurements in line with Mr Peart's practice, the most that the roughly 130 acres of Clatworthy Reservoir might be expected to yield would be 2,600 lbs (1180 kg) of trout in a year. That equates to just 1,300 two-pounders. More than that number of trout had been taken by anglers in the first six weeks of the 2022 fishing season. The fishery is now entirely artificial with the size of fish bearing no relationship to the natural food supply, so the lake might be seen as a holding tank for trout awaiting capture. In fact, experience in recent years has suggested that the majority of trout introduced to the water are caught relatively soon after stocking, autopsies usually revealing much visceral fat and few if any stomach contents. In the opinion of a former head ranger (the late Dave Pursey), stock fish might spend two months or more in the lake before learning to feed for themselves.

On a few occasions in recent years, some "grown on" Brown Trout in the 1800+ g/4+ lb category have been stocked, in preparation for a fishing competition, for example. It would appear that most of these were soon caught. In September 2018 the author caught one such trout, which was in excellent condition. Reservoir staff assumed it to be one of a number stocked in the previous spring, so it had clearly settled down to life in the wild. Also in the spring of 2018, there was an experimental stocking with some Sparctic Trout, a hybrid produced by cross-breeding Arctic Char with Brook Trout from America. Many were caught within the following few weeks. Surprisingly, in the summer of 2021 the author caught one weighing 1070 g/2 lb 6 oz. It had apparently survived for three seasons, but from its very lean shape would appear not to have grown much, if at all.

Regarding the native trout there appears to have been a progressive reduction in numbers over time. It is probable that there was still a small population of breeding Rainbow Trout in existence at the start of the 21st century, as females with unshed spawn were caught occasionally. However, there was no evidence of the shoals of juvenile Rainbow Trout that could be observed feeding at the surface in earlier years, the last recorded sighting of these being in 1998. The most recent record of the capture of a juvenile Rainbow Trout (estimated at 900 g/ 8 oz in weight) was in 2005, since when there has been no evidence of the species breeding in the reservoir.

In recent years, a few fish having all the characteristics of a native Rainbow have been caught, the last one noted by the author taken on June 5th 2014, and weighing 795 g/1 lb 12 oz. Diary entries for earlier years suggest that this was about as large as the native Rainbows grew, with no confident reports of a 2-pounder (900 g) having been taken. Predation of these smaller fish by Cormorants was likely, although the experiences of anglers suggest that they tended to frequent deeper waters than stock fish and were most often encountered in the northern half of the lake where there is generally less angling pressure. A few small native Brown Trout remain, but the evidence suggests that even that population is under threat.

Tabulated data on the numbers and sizes of trout caught during the six decades can be found in Appendix B.

RAINFALL AND WATER LEVELS

As has already been noted, there have been several periods during the life of this reservoir when water levels have fallen well below average. With climate change now recognised as a reality, and demand for water showing no signs of decreasing, one has to expect fluctuations in the reservoir water level to become of greater magnitude and frequency in the coming decades. Some data analysis has been carried out by the author in the hope of clarifying the relationship between rainfall and the water level at different seasons.

Although daily rainfall was monitored for the Somerset Rivers Authority at a site near Clatworthy village in the 1960s, there are no known rainfall data for the reservoir itself. The nearest UK Met Office climate station, run by the Field Studies Council at Nettlecombe Court (Grid Ref. ST057378), is located in a valley some 7 km north-north-east of the reservoir. This rainfall data series ran from 1968 to 2017. Although the absolute amounts of rain recorded there will generally be lower than over the reservoir's catchment area (much of which is more than 300 m ASL), the relative variation of rainfall over time in the area as a whole will follow a similar pattern. For rainfall data representing the years 2018– 2021, the author used his own records from a site in Wellington, some 15 km south-east of the reservoir. Previous research (Ratsey, 2019) had shown average rainfall amounts at the two sites to be very similar, and the two data sets were therefore considered suitable for this study.

Regarding water levels, apart from references in the angling diaries, no data from the early decades are known to exist. However, the UK Centre for Ecology & Hydrology, with the British Geological Survey, conducts a National Hydrological Monitoring Programme (NHMP), and their archived monthly reports provided information about water levels at Clatworthy Reservoir at the end of each month since the start of 1993. The data are shown in Appendix C, and displayed in Figure 8.

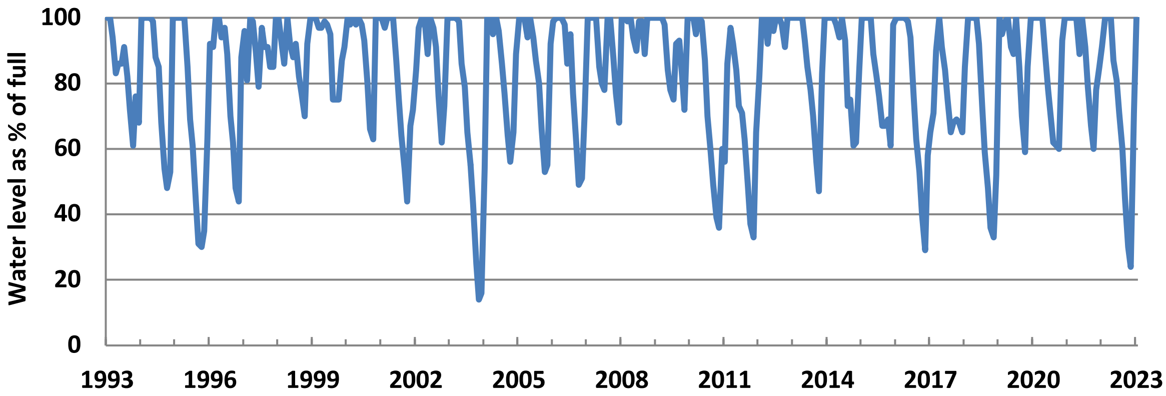

FIGURE 8. End-of-month water levels at Clatworthy Reservoir, as percentage of live capacity for 1993-2023.

While there is no statistically-significant overall trend in the annual average water level, some distinct patterns appear. In the mid-1990s there were few months when the reservoir was full to capacity, while between the winter of 1996-97 and the spring of 2001 it was at least 90% live capacity for more than half the time. This period received the highest five-year cumulative rainfall total in the series starting in 1962. There was another period of sustained high water levels between 2007 and 2010, with some very wet summer months, and the ecologically important littoral zone remained under water for much of the time. With hindsight, it would have been interesting to carry out surveys of the aquatic life during these periods. In 2012, by far the wettest year on record, the minimum recorded live capacity was 91%, a situation that probably had not occurred since the 1960s.

Of the dry years, 1995 stands out clearly with just 31% live capacity at the beginning of September. This corresponded to the water level being 8 m below maximum, as recorded in Mr Ratsey's angling diary entry at the time. As Figure 8 illustrates, the year with the lowest recorded level was 2003, when there was an 18% reduction in live capacity in August alone. Figure 9 shows the view across the lake at the beginning of October in that year, with the parapets of Syndercombe Bridge clearly visible. On the pre-reservoir OS map, the lowest point of Syndercombe Lane where it crossed the stream was shown to be just above the 700-foot (ca. 215 m) contour. With the reservoir's high water mark having been stated as 225 m/740 feet ASL, one can deduce that the level was about 12 m /39 feet down. Live capacity at the time was recorded as 25%, subsequently reaching a minimum of just 14% at the end of October. With the combined rainfall for November and December being below average, the reservoir was little more than half full at Christmas, but full by the end of January. Rather surprisingly, angling diary entries for the summer of 2004 indicate that the trout, if not as large as usual, were finding plenty of natural food. Perhaps the crayfish population was still small enough for predation by that species yet to become significant.

FIGURE 9. Looking north across the reservoir on October 7th 2003, from a point south-west of the Fishing Lodge. *Photo S. Ratsey.*

Also noticeable in Figure 8 is that the reservoir never filled completely during the winter of 2010/2011, the driest pair of years in the series with just 75% of the normal rainfall. In both years live capacity had dropped to about 70% by the end of June, meaning that much of the littoral zone was exposed to the air for the next six months, in both years. Not surprisingly, the ground was colonised by land plants, as can be seen in Figure 10a (below) taken at the beginning of October 2011. There was a fairly complete cover of vegetation in places, extending to more than 2 m below the high-water mark. Live capacity at the end of September 2011 was recorded as 37%, falling to 33% at the end of October.

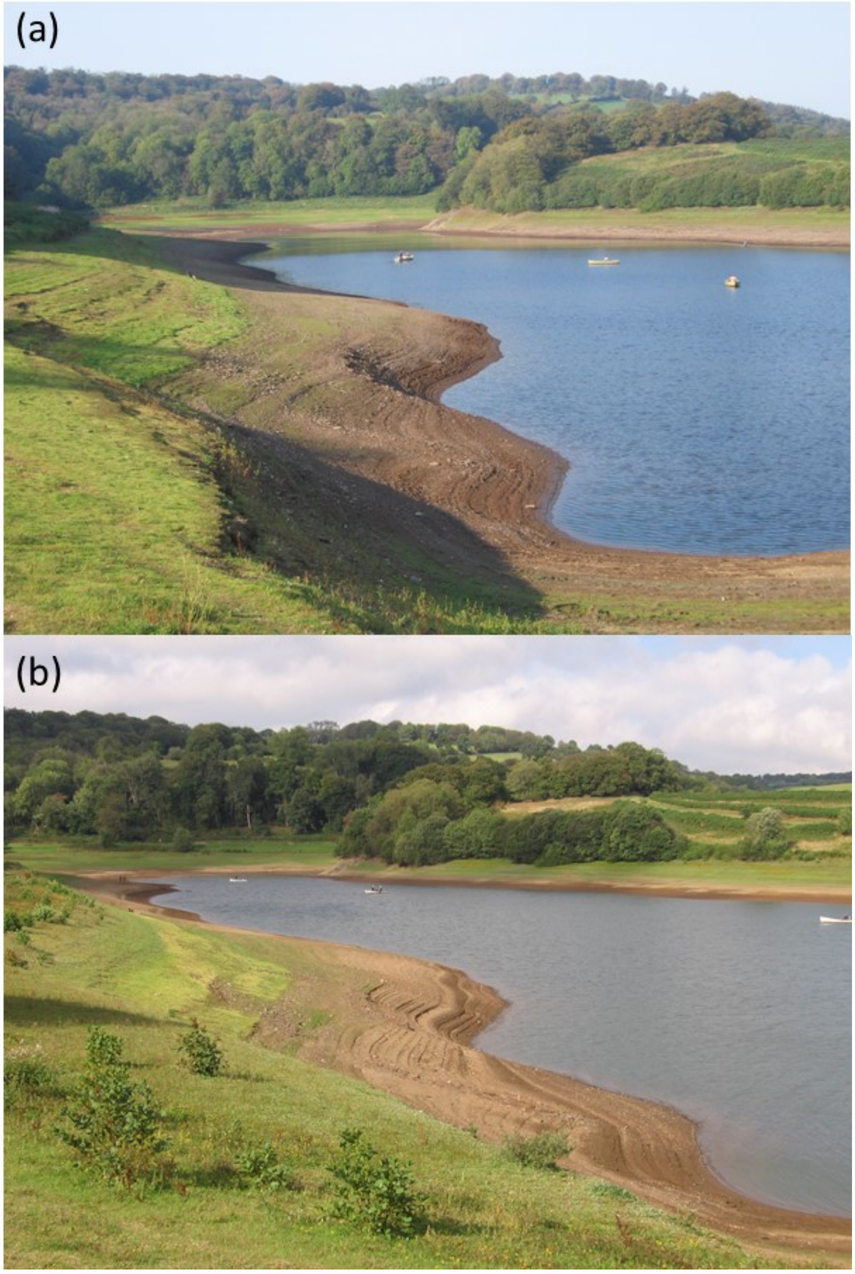

FIGURE 10. Comparison of the same view south-westwards towards Westcott Bay, almost eleven years apart.
(a) October 3rd 2011, (b) August 31st 2022. Although the same view, probably different anglers. *Photos S. Ratsey.*

Every winter in the most recent decade has seen the reservoir refill to capacity, with it remaining full for five months over the winter of 2020–2021. The next winter was comparatively dry but the reservoir refilled nevertheless, with water levels in 2022 not falling much until after midsummer. Then the combination of heat and drought resulted in a decrease to 45% live capacity by the end of August, Figure 10b showing the situation at that time, from roughly the same viewpoint as Figure 10a. The small bushes on the shore are mostly seedling alders (*Alnus glutinosa*), which apparently survived a period of immersion at the start of the year. By the end of September, the water level had receded to a point not seen since 2003. The entire Rowes End arm was dry, apart from the much-reduced feeder stream, with a more or less complete cover of vegetation, as visible in Figure 11. (This photograph also shows the extent to which that arm of the reservoir is infilling with sediment, the stream having created a small gorge more than a metre deep, with the resulting section revealing layers of silt and organic debris.) The lake continued to shrink through October, to be at 24% live capacity at the start of November. However, more than 150% of the normal rainfall was received in the last two months of 2022, and the reservoir was overflowing at the end of December.

FIGURE 11. Rowes End viewed from the north-east on 29th September 2022. *Photo S. Ratsey.*

Noting the current tendency for the shore to become vegetated when the water level drops, one question that arises must be: Does decaying vegetation provide a rich food source for detritus-feeders when the reservoir refills? As already described, in the past the populations of aquatic invertebrates evidently recovered well after some drought years, when autumn rains raised the water level quickly. Will things be different now, with the crayfish being present? There is clearly scope for further research on this aspect of the aquatic ecology of the reservoir.

Further statistical analysis, comparing reservoir levels with rainfall totals over different periods, has yielded interesting results. While there is no significant statistical correlation between the rainfall in the previous 12 months and the reservoir level on any particular date, there is a highly significant positive Pearson correlation ($r = +0.82$, $p < 0.001$, $n=30$) between total rainfall in the summer half of the year (April to September inclusive) and the minimum recorded water level in the reservoir later that year, usually in early October but sometimes not until November. This relationship is illustrated in Figure 12, below.

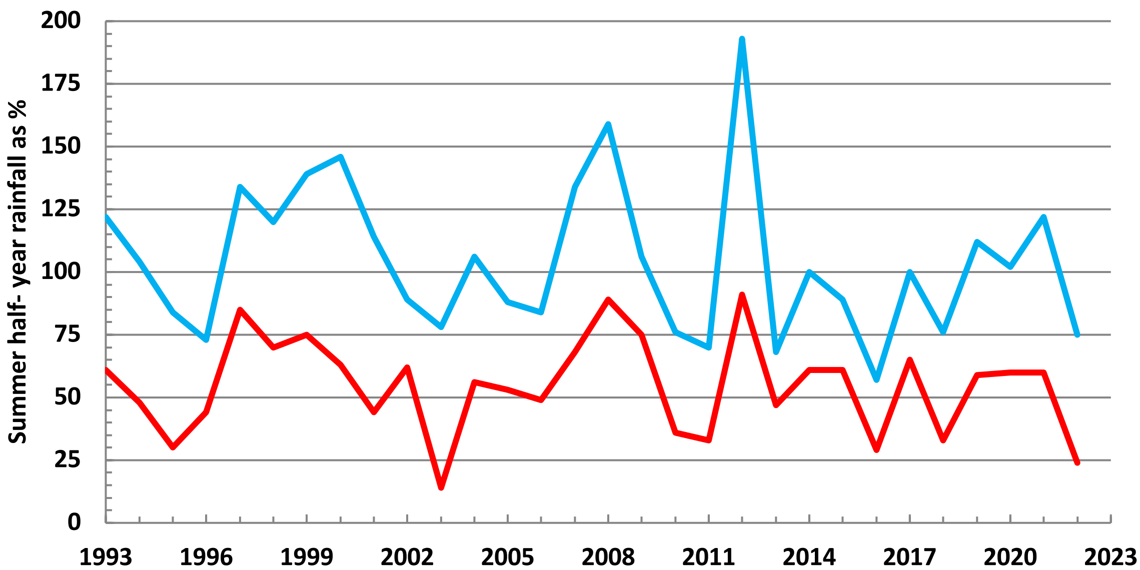

FIGURE 12. The relationship between summer half-year rainfall as % of the average (**blue** line) and lowest recorded % live capacity in Clatworthy Reservoir in that year (**red** line).

Somewhat surprisingly, there was found to be a weak negative correlation coefficient of -0.21 (not significant) between the total rainfall in the preceding winter half-year and the subsequent minimum recorded water level. A good example is 2018, when after a wet start to the year the reservoir was apparently still full at the end of April. A sequence of drier-than-average months then resulted in the lake shrinking by more than 10% each month to give a minimum of

33% live capacity at the end of October. Similarly, although the reservoir was full from November 1994 to at least the end of March 1995, this did not prevent the live capacity from dropping to 31% by the beginning of September that year.

This apparent discrepancy between winter rainfall and water levels later in the following year can be accounted for fairly simply. The geology of the catchment area is predominantly Devonian slate of low permeability and porosity. With clayey soils and relatively little natural underground storage of water within the catchment, the feeder streams can become depleted even in a "normal" summer, some of them drying up completely. For the same reasons, in periods of heavy rainfall there is a high proportion of runoff, with associated soil erosion. On one memorable fishing visit (October 5th 2001), the author and his father observed water discoloured with suspended sediment entering the main body of the lake from the Rowes End arm, following a torrential rainstorm a few hours previously.

In the light of such evidence, it is not surprising that refilling can be rapid. At the end of November 2018 the reservoir was at 52% live capacity, with 100% being reached by the end of December, an increase of 48%, while in 2022 the wettest November in living memory in the area resulted in a 47% increase in one month, the reservoir subsequently being one of only a handful in the UK to have completely refilled by the end of the year. Unlike in Exmoor National Park, where the project to restore the mires is already helping to regulate runoff and percolation (Anderson *et al*., 2020), there is no obvious practical method to modify the very "flashy" hydrology of the streams that feed Clatworthy Reservoir.

THE FUTURE

Research to date on dealing with infestations of American Signal Crayfish suggests that the species can be eradicated using techniques involving biocide (Peay *et al*., 2019). Clearly, this is not an option for a body of water that feeds into a river system, as well as being a public water supply. However, the Crayfish problem in Clatworthy Reservoir would now seem to have reached the stage where doing nothing is likewise not an option. Trapping in other locations has been shown to have limited effectiveness in reducing numbers, partly because the method tends to catch the larger specimens, and the Signal Crayfish is known to become sexually mature at an early age. Certain fish species that are native to the British Isles, including Perch, Pike and Chub, are known to eat Signal Crayfish, and prosper on the diet. These species have never been part of the Clatworthy aquatic ecosystem, and to introduce any of them could have unforeseeable consequences, although evidence from other waters suggests that the Crayfish might prevent the establishment of breeding populations of these coarse fish, by eating all the fish eggs.

On the other hand, the Brown Trout is a species that was present in the tributary streams before the creation of the reservoir. It would be the natural top predator within this aquatic ecosystem. With evidence, described above, of even artificially reared and stocked Rainbow Trout learning to recognise the Signal Crayfish as food, perhaps one course of action might be to add some fairly large (*i.e*. more than 900 g/2 lb in weight) Brown Trout when stocking takes place. A policy would need to be set in place that any such fish caught by an angler should be returned unharmed. Hopefully, such trout would develop a taste for crayfish, and the bigger they grew, the more impact they might have in reducing crayfish numbers. Further, if these trout could discover while in the rearing ponds that crayfish were edible, they might hunt them from the start, once introduced to the lake. Given the natural longevity of Brown Trout, some of these bottom-feeders might become very large, but crayfish predation of any spawn produced might yet prevent the creation of a self-sustaining Brown Trout population. (Ideally, male and female rainbow trout could be re-introduced to the lake, to see if a breeding population of that species might once more develop, and also predate on the crayfish.)

Alongside a systematic trapping programme, this approach might reduce the crayfish population sufficiently for other parts of the ecosystem to recover. No possible adverse environmental effects of such a strategy are immediately obvious, but the other factor that may impede the reestablishment of a stable ecosystem is the increased variability of water level. As well as the issue of growing demand with continued urban development within the Wessex Water region, there is the issue of climate change. As the author's own studies in this field have shown, even in the relatively temperate climate of west Somerset there have been significant changes in the last half-century. (Ratsey, 2021)

During the preparation of this paper, the UK as a whole experienced its highest ever temperatures, with an associated surge in demand for water. Following the driest July in England in living memory, and with grass fires being reported from numerous districts, on August 12th 2022 a drought was declared covering much of the country. The "Today" programme on BBC Radio 4 that day included two very interesting and relevant discussions. First to be interviewed was Tony Juniper, Chair of Natural England. He spoke about the need for more action in repairing our degraded environment, highlighting Natural England's so-called Nature Recovery Network. This aims to create half a million hectares of new habitat, one priority being the recreation of missing wetlands. He urged an "intelligent and integrated" approach to water in the landscape, using nature to hold water in the environment for use at a later date. These comments were supported and amplified by Baroness Barbara Young, former Chief Executive of the Environment Agency, who spoke of the role of reservoirs as part of the mix in terms of improving water supply, saying: "They [reservoirs] should be a last resort rather than a first resort…" and "When we have a dry winter, then we'll know what drought is all about!"

Although this paper is subtitled "Personal reflections", the author would like to conclude with some questions that may stimulate further discussion. Has the time come for a change in our attitude towards artificially-created lakes such as the one in question? Might the future include a Clatworthy Reservoir with a flourishing aquatic ecosystem and a recreational fishery that is at least partly self-sustaining, with sufficient water to help promote the "rewetting" of parts of the River Tone catchment further downstream? Are these suggested aims incompatible with the primary function of providing humans with a reliable water supply?

ACKNOWLEDGEMENTS

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REFERENCES

Anon. (1997). http://www.environmentdata.org/archive/ealit:1335. [Accessed February 11th 2022].
Anon. (2022). https://environment.data.gov.uk/catchment-planning/WaterBody/GB30844473.
Anderson, K., Ashe, J., Benaud, P., Brazier, R.E., Carless, D., Freeman, G., Gallego-Sala, A., Gatis, N., Grand-Clement, E., Hand, A., Hartley, I.P., Luscombe, D.K., Malone, E., Angus, M., Barrowclough, C., Smith, D., Gillard, M., Hornibrook, E. and McAleer, A. (2020). Mires on the Moors: Science and Evidence Report 2020. University of Exeter, Exeter, UK. https://www.exeter.ac.uk/media/universityofexeter/research/microsites/creww/miresprojectreports/CREWW_Mire_on_the_Moors_report_2020.pdf [Accessed February 11th 2023].
https://www.exeter.ac.uk/research/creww/research/casestudies/ [Acessed via Mire Project 21st March 2023]
Holdich, D.M, James, J., Jackson, C. and Peay, S. (2014). The North American signal crayfish, with particular reference to its success as an invasive species in Great Britain. *Ethology Ecology & Evolution* **26**, 232-262. http://dx.doi.org/10.1080/03949370.2014.903380.
Mance, G. (1973). https://research-information.bris.ac.uk/ws/portalfiles/portal/34506391/540859.pdf
Moss, B. (2008). The Kingdom of the shore: Achievement of good ecological potential in reservoirs. Freshwater Reviews, **1**, 1-28, (1 March 2008) https://doi.org/10.1608/FRJ-1.1.1.
Peart, L., (1956). *Trout and Trout Waters*. London: George Allen & Unwin Ltd, 175pp..
Peay, S., Johnsen, S.I., Bean, C.W., Dunn, A.M., Sandodden, R. and Edsman700 L. (2019). Biocide Treatment of Invasive Signal Crayfish: Success, Failures and Lessons Learned. *Diversity*, *11*, 29. https://doi.org/10.3390/d11030029.
Ratsey, S. (2019). Local climate and climate change in lowland west Somerset. *Field Studies* **15.** https://www.field-studies-council.org/resources/field-studies-journal/local-climate-and-climate-change-in-lowland-west-somerset/
Ratsey, S. (2021). Long term trends in air temperature at Nettlecombe Court, Somerset, and the regional context. *Field Studies* **17**, https://www.field-studies-council.org/resources/field-studies-journal/long-term-trends-in-air-temperature-at-nettlecombe-court-somerset-and-the-regional-context/

Appendix A: Fly patterns and fishing techniques used.

The diary entries recording successful fly patterns and how they were used do not lend themselves to objective scientific scrutiny. At the start, one must consider the anglers' preferences (and prejudices) bearing in mind that "a good day's fishing" is as much about the enjoyment of the activity, as it is about catching as many fish as permissible. Also, the only way that a trout can investigate something that sparks its curiosity is to take it into its mouth, so some trout caught on an artificial fly may not in fact have perceived it as a potential meal.

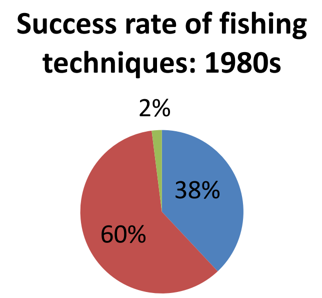
The fishing techniques employed might be placed under the simple headings "Deep", "Mid-water" and "On the surface", but in practice no such clear distinction can be drawn. There can be a significant element of randomness, in that a fly intended to be fished near the bottom may be taken by a trout before it has a chance to sink, or, alternatively, just before it leaves the water as the angler lifts the line to cast again. On occasion, a dry fly will take a fish after becoming saturated and sinking below the surface, while certain patterns of artificial fly are, for no obvious reason, sometimes reliably successful regardless of depth and weather conditions. However, with numbers in the available data sets running into the hundreds, one can reasonably deduce that how and at what depth the trout were caught must reflect to some extent the prevailing patterns of feeding behaviour of the trout over time.

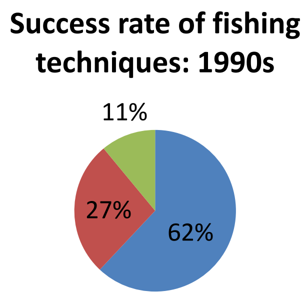
Experience has shown that trout learn where to expect to find food. Anglers in turn learn where to expect to find the fish, and such information, as well as the currently successful patterns of fly, spreads rapidly within the local angling fraternity. This is reflected in the records, which show distinct phases with patterns of fly and fishing techniques waxing and waning in popularity. In the first five Clatworthy fishing seasons, starting in 1961, anglers used almost exclusively what were regarded as traditional flies for lake trout (many of them originating in Scotland), which were fished within a foot or two of the surface at the end of a floating line. Most of these patterns imitated free-swimming insect larvae, which would at times migrate upwards in large numbers before hatching as winged adult insects. Trout would learn about this behaviour, leading to the phenomenon known as the "evening rise".

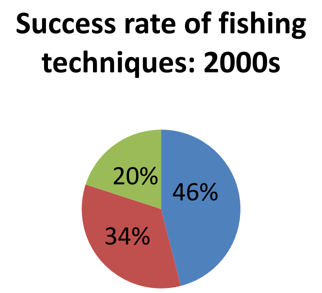
Between 1965 and 1970, the records show that new techniques and patterns of fly were starting to be used. Mostly originating in the large reservoir fisheries in the Midlands, flies designed to imitate fish-fry or bottom-dwelling invertebrates required lines that sank quickly to reach depths at which (it was believed and was sometimes true) the larger trout could be found. These techniques were initially frowned upon by many fly-fishermen (including Mr Ratsey), and the great majority of trout caught at Clatworthy fell to the more traditional methods, including the dry fly.

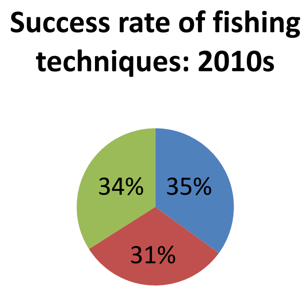
During the 1970s there was an accelerating trend to experiment with novel flies and fishing techniques. At Clatworthy, in the late 1970s, the vast majority (90%) of trout were still caught near the surface, but traditional trout flies were employed much less frequently. Mr Ratsey's successful patterns included some that were very close imitations of Chironomid nymphs, while others seemed to bear no resemblance to any natural food item that the fish might encounter in the lake.

In the early 1980s, for the first time, anglers at Clatworthy began to adopt a style of fishing popular in North America, using fast-sinking lines and large fly patterns designed to imitate bottom-dwelling fauna such as crayfish. This proved particularly successful in summer, when trout tended to frequent deeper, cooler water, and fishing with flies on or near the surface was often fruitless. Thereafter, this technique was used regularly (and in some cases almost exclusively) by local anglers at the lake. Consequently, the proportion of trout caught near or at the surface diminished significantly. The series of pie charts below illustrates the changing success rate of the various fishing techniques in the past four decades. In all cases, the blue sector represents the percentage of trout caught at depth, the red sector, mid-water, and the green sector, on the surface (i.e. "dry fly" techniques).









There may be a connection between the increasing success of using mid-water or dry fly techniques since the 1990s, and the presumed reduction in bottom-dwelling trout food, attributable to the increased presence of signal crayfish since the turn of the century. On a number of occasions in recent years, when trout have been shown to be in the vicinity and feeding, the author has deliberately chosen to experiment with "old favourite" patterns of fly fished near the bottom, with little if any success. Reverting to fishing on or just below the surface has resulted in a trout, sometimes on the very first cast, implying that the fish were looking upwards for their next meal, rather than hugging the bottom of the lake. (It should be noted that in some of the recent very hot summers, it has become almost impossible to catch trout at Clatworthy, by any permitted method.)

Perhaps some controlled fishing experiments would provide more data to substantiate, or refute, these observations.

Appendix B: Frequency distribution by size (%) of trout caught in each decade.
(*conversion to grams based on 1 oz = 28 g)

Fish weight		**% fish per size band**					
Grams	lb oz	**1960s**	**1970s**	**1980s**	**1990s**	2000s	2010s
Up to 450 g	**Up to 1 lb**	86.3	48.6	**15.6**	4.6	0.1	**-**
476-560	**1.1 - 1.4**	9.3	25.4	**25.2**	15.6	0.9	**0.3**
588-672	**1.5 -1.8**	3.3	12.7	**23.6**	21.6	2.5	**1.8**
700-784	**1.9 -1.12**	0.5	7.7	**16.5**	19.2	11.4	**7**
812-896	**1.13 - 2.0**	0.3	3.2	**7.8**	9.9	17.2	**10.6**
924-1008	**2.1 - 2.4**	0.3	2	**5.2**	9	20.7	**18.1**
1036-1120	**2.5 - 2.8**			**2.4**	6.4	15.6	**14.3**
1148-1232	**2.9 - 2.12**		0.4	**1.4**	6.3	12.7	**14.4**
1260-1344	**2.13 - 3.0**			**0.9**	2.4	6.9	**10.6**
1372-1456	**3.1 - 3.4**			**0.4**	2.4	5.2	**5.3**
1484-1568	**3.5 - 3.8**			**0.2**	0.9	3	**5.5**
1696+	**3.9+**				1.7	3.9	**12.1**
	Total	100	100	100	100	100	100
	n=	431	254	1083	959	278	283
	Mean (g)	336 g	504 g	644 g	784 g	1064 g	1204 g
	Mean (lb)	12 oz	1 lb 2 oz	1 lb 7 oz	1 lb 12 oz	2 lb 6 oz	2 lb 11 oz

Appendix C: End-of-month (%) live capacity data 1993 – 2022.

	1993	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	Mean
Jan	100	100	100	91	81	92	100	98	97	97	**95.6**
Feb	94	100	100	100	100	86	97	100	100	100	**97.7**
Mar	83	100	100	100	99	100	97	98	100	100	**97.7**
Apr	86	99	85	94	89	92	99	100	100	89	**93.3**
May	86	88	69	97	79	88	98	98	87	100	**89.0**
Jun	91	85	61	89	97	92	95	93	75	97	**87.5**
Jul	82	68	44	70	91	82	75	80	64	91	**74.7**
Aug	72	54	31	62	91	77	75	66	54	76	**65.8**
Sep	61	48	30	48	85	70	75	63	44	62	**58.6**
Oct	76	53	35	44	85	92	87	100	67	73	**71.2**
Nov	68	100	63	88	100	100	91	100	72	100	**88.2**
Dec	100	100	92	96	100	100	100	100	84	100	**97.2**
Annual mean	**83.2**	**82.9**	**67.5**	**81.6**	**91.4**	**89.2**	**90.7**	**91.3**	**78.7**	**90.4**	**84.7**

	2003	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	Mean
Jan	100	100	100	100	100	100	100	100	86	100	**98.6**
Feb	100	100	100	100	100	99	100	95	97	100	**99.1**
Mar	99	95	94	100	100	100	98	100	92	92	**97.0**
Apr	86	100	100	98	85	94	84	99	84	100	**93.0**
May	79	96	94	86	80	90	78	87	73	96	**85.9**
Jun	65	86	87	95	78	99	75	70	71	100	**82.6**
Jul	55	77	80	77	100	99	92	59	63	100	**80.2**
Aug	43	64	66	62	100	89	93	49	49	98	**71.3**
Sep	25	56	53	49	88	100	83	39	37	91	**62.1**
Oct	14	65	55	51	77	100	72	36	33	100	**60.3**
Nov	16	89	92	70	68	100	100	60	65	100	**76.0**
Dec	54	100	99	100	100	100	100	56	82	100	**89.1**
Annual mean	**61.3**	**85.7**	**85.0**	**82.3**	**89.7**	**97.5**	**89.6**	**70.8**	**69.3**	**98.1**	**82.9**

Appendix C continued:

	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	Mean
Jan	100	100	100	100	71	100	95	100	100	100	**96.6**
Feb	100	100	100	100	90	100	99	100	100	100	**98.9**
Mar	100	98	100	100	100	100	100	100	100	100	**99.8**
Apr	93	94	89	99	91	100	91	90	89	87	**92.3**
May	85	100	82	94	84	92	89	78	100	81	**88.5**
Jun	78	93	76	76	75	73	100	70	91	71	**80.3**
Jul	70	73	67	63	65	59	85	62	79	60	**68.3**
Aug	56	75	67	53	68	48	70	61	67	45	**61.0**
Sep	47	61	69	40	69	36	59	60	60	30	**55.7**
Oct	83	62	61	29	68	33	85	93	78	24	**65.8**
Nov	100	84	98	58	65	52	100	100	85	71	**81.3**
Dec	100	100	100	65	85	100	100	100	91	100	**94.1**
Annual mean	**84.3**	**86.7**	**84.1**	**73.1**	**77.6**	**74.4**	**89.4**	**84.5**	**86.7**	**72.4**	**81.3**