Kemerton Conservation Trust
Kemerton Court
Kemerton
Tewkesbury
Gloucestershire
GL20 7HY

Tel: 01386 725 254

www.kemerton.org

Registered Charity No. 702488

Fish and Aquatic Plant Survey of Kemerton Lake Nature Reserve Project Report
October 2022

Project Background

Kemerton Lake Nature Reserve (KLNR) is a designated Local Wildlife Site in south Worcestershire that supports a wide array of flora and fauna including many Section 41 Species of Principal Importance. Many species rely on the water for all or part of their lifecycle. These include:

- invertebrates and mollusc such as Mayflies, Caddis Flies, Dragonflies and Damselflies (many of which form a key part of the diet of animals higher up the food chain); KLNR is home to thousands of Swan Mussells and is an 'Ark' site for the endangered native White-clawed Crayfish;
- birds such as Great Crested Grebe, Teal, Kingfisher, Cuckoo, Reed Bunting and Lapwing;
- mammals including Otter, Noctule Bat and Daubenton's Bat;
- fish including Roach and Rudd (fish form a key part of the diet of animals further up the food chain);
- amphibians and reptiles such as Common Frog, Common Toad, Palmate Newt and Grass Snake;
- aquatic plants including Amphibious bistort, Fennel Pondweed and Nuttall's Waterweed (a non-native invasive).

With such a wide variety of species dependent on the water body, it is critical that the Trust understands as fully as possible which aquatic species are present, and how they may be effecting the overall ecology of the reserve. The catalyst for this project was the increasing encroachment of an invasive non-native pondweed Nuttall's Waterweed (Elodea nuttallii), which was first recorded at the lake in 2002 and which has subsequently spread rapidly through the lake. Invasive waterweeds are known to have negative impacts on water bodies: they outcompete most native plant species and so reduce biodiversity; and they cause large fluctuations in the amount of oxygen available in the water which is harmful to invertebrates and fish.

There are various ways of dealing with invasive waterweeds but none of them is easy, cheap or guaranteed to work. All of them are associated with some negative consequences for biodiversity. It was essential that we gain a more complete picture of the aquatic ecology before taking any decisions about the future management of Elodea.

Before the project began, we did not have a precise understanding of the extent of waterweed coverage, nor did we know the extent to which native aquatic plants are being supressed. As part of this project, we proposed surveying the waterweed from above using a drone, as well as carrying out a survey of aquatic plant from sample points throughout the lake.

We also lacked knowledge about which fish species are present and in what quantities. In the early years, Roach and Rudd were introduced to provide food for fish-eating birds. Since then, several other species are likely to have arrived naturally (perhaps as eggs stuck to weed on birds' feet and feathers). Other species, such as common goldfish, are likely to have been released illegally by members of the public. Ad-hoc observations and bird surveys had clearly demonstrated that large quantities of fish are present in the lake. Birds such as Cormorant, Heron and Great Crested Grebe are to be found fishing year-round, while Otters visit occasionally and have been photographed with fresh kills. As fish numbers can both impact on the spread of waterweeds (through eating plants) and be significantly impacted by the waterweeds (through changing oxygen levels), it was important that we gather the data necessary to inform how best to manage invasive waterweed. As part of this project, we proposed a detailed fish survey of the lake.

Fundraising for the project began in January 2022 and the Trust received a £1000 grant from Highfields Trust CIO and a £500 grant from the Gordon Gray Trust. Additional support came from Broadway Natural History Society, who donated £370.25. The balance of funds came from KCT's own reserves.

Project Aims

The aim of the project was to gather good quality up to date information on fish species present in the lake and size of fish population, aquatic plant species present in the lake and their location, and the current spread of Nuttall's Waterweed in the waterbody, to help us make the right management decisions into the future.

Overview of Works

Project works commenced in February 2022 with a drone survey of the lake carried out by a volunteer, Sarah Dusgate (using her own drone). Sarah was assisted by Project Manager Kate Aubury. February was chosen to avoid bird nesting season. The drone was in use for less than 30 minutes and flown at a height that minimised bird disturbance. On reviewing the footage, it failed to show the extent of waterweed, as the weed had not yet started growing and was still quite some way below the water. We therefore decided to try again in September when water levels would be lower, and the plant would be at the end of its growth cycle and much higher in the water (and bird nesting season would have finished).

After securing the relevant permissions, our fisheries contractor Fishtrack arrived on site in April 2022 to complete the fish survey. They surveyed the whole of the main lake using High Intensity Point Abundance Sampling by electrofishing (HIPASE) from a boat (see Appendix A Photo Montage). They also returned for a second visit a week later to carry out sonar imaging of the lake to create 3D maps of the depths and substrates of the lakebed. They compiled a comprehensive report of their survey and the results (see Appendix B Kemerton Lake Fishery Report).

In May botanists Will Watson and Giles King-Salter surveyed the aquatic plants across the whole of the main lake, including the marginals growing on the lake shore. They used KCT's boat to survey deeper water areas.

After the first survey, Will Watson suggested adding native White Water Lily to Project Manager Kate Aubury, as Kemerton Lake did not have any water lily and it is a useful wetland plant that can hold its own against Nuttall's Waterweed. Will kindly donated 6 mature plants with local provenance in late June and in early July Project Manager Kate Aubury, assisted by her daughter Lottie, planted the water lilies in flexible pond planters and aquatic compost and the water lilies were placed in the shallow margins of the lake to acclimatise to the water. After 2 weeks, they were moved to their final planting areas; 3 in 0.5-1m deep water just off the north shore, and 3 in 1m deep water just off the western island. Dragonflies and Damselflies were spotted landing on the plants within minutes of them being added to the lake, while small shoals of 3-Spined Stickleback fry were seen darting under the large leaves once they were in-situ.

In August surveyors Will Watson and Giles King-Salter returned to repeat the aquatic plant survey (two visits were necessary due to the varying growing and flowering times of a variety of plants). They used KCT's boat to survey deeper water areas. After the visit, Will compiled a list of species seen and an estimate of waterweed coverage (see Appendix C Aquatic Plant Survey Results).

Finally, in early October volunteer Sarah Dusgate returned to carry out the drone survey (using her own drone). This time the photos and video captured were extremely clear and the full extent of Nuttall's Waterweed could be seen.

Project Results

Our project was completed on time and on budget and resulted in some excellent data.

The fish survey results (See Appendix B) highlighted a very low population of fish in the lake, with no sign of the Roach or Rudd originally added to the lake over 25 years ago. Instead, the survey found a reasonable number of native Three-Spined Stickleback (an excellent food source for Kingfisher and Little Grebe) and a small number of non-native Brown Goldfish (presumed to have been illegally added by fish pet owners, a good food source for Otter, Great Crested Grebe, and Cormorant). The small numbers found were a surprise given the number of fish-eating birds and mammals that live on the lake, and our working theory is that numbers were severely depleted by the 3 otters that were on site during January and February this year, as they are known to fish out lakes and then move on. We have several photos from their visit taken by visitors that show they caught good sized fish, all of which have been identified by Fishtrack as Brown Goldfish. Fishtrack also used sonar during their survey and noted that there were small numbers of large fish in the deeper areas of the lake which would have been beyond the scope of the electro-fishing, so numbers may be higher than the survey suggest. Nevertheless, the fish stock are far from healthy and action will be needed to change that. The survey highlighted the lack of suitable fish refuges in the lake currently and included advice on improving the habitat to prevent overfishing and allow fish stocks to recover. The 3D sonar carried out as part of the fish survey also resulted in accurate data on lake depths and lakebed hardness, which will be invaluable when planning follow up work.

The aquatic plant survey results (see Appendix C) confirmed our fears that Nuttall's Waterweed has swamped the native water plants, with very few of the aquatic plants recorded before the invasive plant arrived being found. The survey did confirm that on marginals the site has an excellent range of native species that are creating some great habitat.

The drone footage (see Appendix A) showed that Nuttall's Waterweed has now spread throughout the lake at depths of between 0.25-2m. The footage highlighted that the very shallow areas (less than 0.25m) were clear of the waterweed along the north shore and around the islands, while the deepest areas of the lake (more than 2m) were also relatively clear at present. The areas between those ranges were very thickly covered, with most having 100% coverage. This matches the results of the aquatic plant survey and also our own site observations from the boat and shoreline.

The Future

This project has been invaluable in extending our understanding of the water habitat at Kemerton Lake and in providing a baseline for monitoring any changes we now make. We are now planning a follow-up project for winter/spring 2023 that will include creating more fish refuges to improve numbers within the lake, trialling removing some of the waterweed biomass with water rakes to see if that may be an effective tool for managing it, and adding a small number of native aquatic plants to the areas we clear to see if we can improve the biodiversity of the plant community within the water. We are also considering adding fish to the lake once the habitat has been improved to increase numbers, but will need to monitor the effectiveness of the refuges first.

Acknowledgements

Kemerton Conservation Trust would like to thank Highfields Trust CIO and the Gordon Gray Trust for generously supporting this project and making it possible. We would also like to thank Broadway Natural History Society for their donation to the project.

We would also like to thank all those who assisted in the delivery of the project, including our Project Manager Kate Aubury, Warden John Threadingham, and volunteer Sarah Dusgate. Finally, we would like to thank Andy Hines from Fishtrack, Will Watson and Giles Salter-King for their expertise on the project.

Appendix A: Fish & Aquatic Plant Survey Project Photo Montage

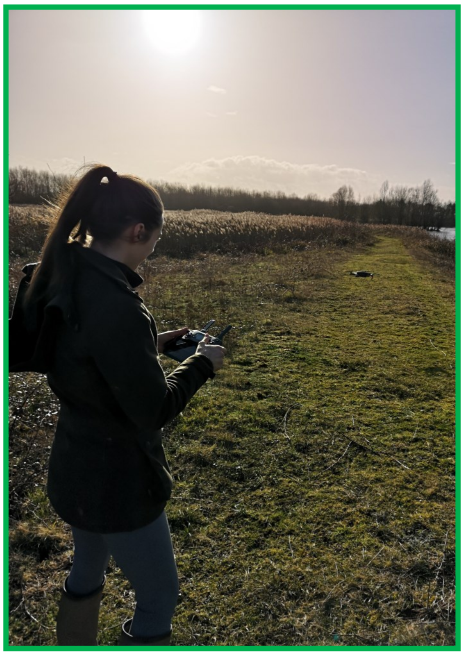
Kemerton Lake (view from north shore)

Great Crested Grebe with fish, KLNR, 2021

Emperor Dragonfly female laying eggs on *Elodea nuttallii,* KLNR, 2020

Otter, KLNR, February 2022

Grey Heron, KLNR, March 2022



Volunteer Sarah carrying out drone survey, KLNR, February 2022

Kingfisher, KLNR, August 2022

Fishtrack carrying out HIPASE fish survey, KLNR, April 2022

Fishtrack carrying out HIPASE fish survey, KLNR, April 2022

3 Spined Stickleback caught during survey, KLNR, April 2022

Volunteer Lottie planting water lilies, KLNR, July 2022

Project Manager Kate Aubury planting water lilies, KLNR, July 2022

Will Watson carrying out the first aquatic plant survey, KLNR, May 2022

White water lilies acclimatising in the shallows, KLNR, July 2022

Common Damselfly, Small Red-eyed Damselfly & Dragonfly nymph making use of the new water lilies, KLNR, July 2022

3-Spined Stickleback fry swimming in the shallows by the new water lilies, KLNR, July 2022

Drone photo of lake looking south-west, September 2022

Drone photo of lake looking east, September 2022

Drone photo of lake looking at south-west corner, water-weed clearly visible, September 2022

Drone photo of lake looking at south-east corner, the deepest areas are weed-free , September 2022

Kemerton lake

Fishery Report 2022

Project manager: Kate Aubury, Kemerton Conservation Trust

Author: Andy Hindes, Fishtrack Ltd

Kemerton Lake

Fishery Report 2022

1. Introduction

Kemerton Lakes are the centre piece of Kemerton Conservation Trust reserves. Comprising of one large and several smaller lakes, the larger covering 64420m^2. The wetland was created from a former gravel working and has established reedbeds (*Phragmities australis*) as well as some tree coverage on the southern side. Several islands are present and one with some established tree canopy, the remainder left deliberately bare as breeding areas for Oystercatcher (*Haematopus ostralegus*) as well as Canada geese (*Branta canadensis*) etc. Amongst avian piscivores, Heron (*Ardea cinerea*), moorhen (*Gallinula chloropus*) and little grebe (*Tachybaptus ruficollis*) were also present on the site. There is also evidence of otter (*Lutra lutra*) periodically present on site. The lake comprises of extensive shallows with depth variation from 0.38m to 4.77m. Most of the lake bed is devoid of structure, with exception of log piles deployed as habitat for introduced white clawed crayfish (*Austropotamobius pallipes*). The lake has prolific weed growth primarily attributed to Canadian pondweed (*Elodea canadensis*), an aggressively competitive macrophyte which is known to broach the water surface during summer months and inhibit free underwater locomotion. Extensive weed growth in lakes can cause super saturation of oxygen during daylight hours and oxygen crashes during the night. These often contribute to suppression of fish populations causing periodic moralities.

2. Methods

Fishery surveys are usually conducted on an annual or biannual basis to determine abundance and biomass estimates related to the fish community and its components as well as population trends (growth, distribution, new species, shifts in age class, etc).

The surveys are comprised of one, or one of two elements, which are Point Abundance Sampling by electrofishing (PASE) and/or continuous electrofishing. For the purposes of Kemerton it has been decided to conduct High Intensity Point Abundance Sampling by electrofishing (HIPASE) and subsequent side scanning sonar survey.

The area of the lake is calculated using Geographic Information System (GIS) software, QGIS. This enabled whole area estimates including any zones to be generated for the lake, which in-turn enables estimates with a measure of variance to be generated for each zone (ie littoral and limnetic) as well as provision of whole lake estimates, which give a better overall picture of the fish community, and with regard to decisions based upon future. In addition to this, the wetted extent of the littoral margins will also be comprehensively estimated.

Each zone is covered systematically by electrofishing high frequency points/sample points (HIPASE), both for open water (limnetic) as well as littoral margin, to provide comprehensive geographical coverage. HIPASE has advantages over conventional PASE where fish distributions are clumped, such as during autumn and winter or where discrete stands of macrophyte are present, where dense, tight shoals can easily be missed (Hindes, 2016).

The method comprises fishing from a small, dedicated electrofishing fishing boat, suitable for negotiating confines and small watercourses as well as open water and is operated by two personnel. The boat is propelled either by ‘push rowing’ the boat backwards through the water in the direction of travel (Nelva et al., 1979; Copp & Penaz, 1988) or conventional *front forwards* using electric outboard). This enables the oarsman to observe the operative deploying the electrofishing equipment. The electrofishing operative stands fishing off the stern or bow in the case of electric outboard, rapidly submerging the anode (a fiberglass rod with waterproof switching and incorporating an anode head of stainless steel) through the water column each time the boat is stopped in the water. The handheld net is then swept through the ‘point’ and any fish present captured. Progressing in this way the boat hops along the watercourse sampling a series of 'points'. The boat is fitted with sound deadening material to reduce conduction of generator and operator noise through the water column, which will otherwise influence fish behaviour and distribution, (Lane, Hindes, & Reeds, *in Prep*) and thus producing more accurate results than conventional PASE. This method has been quality assured using the High-Resolution Sonar Assessment (HRSA) method (Hindes et al., *in Prep*).

The electrofishing equipment comprises of a dedicated electrofishing box (WMD IEF 250v 2.2kw, output 0-250v, 50-100 p/sec^{-1}), fishing at a frequency of 50-100Hz. A pulsed dc electric current is passed into the water through a handheld anode with an anode ring of 380-450mm in diameter. The larger size of anode ring reduces voltage gradient, causing less harm to the fish. The area of influence is estimated from determining the distance, from the outer edge of the anode ring, at which the voltage gradient decreases to 0.12v. Power to the electrofishing box is provided by a Honda 2.2 Kva, 240v, specialist electrofishing generator. Fish that are within the sphere of influence of the anode are drawn towards the operator by involuntary muscle spasm (galvanotaxis), which inhibits swimming. This enables the operator to use a handheld net to capture the fish for processing within the boat. All fish are processed for biometric data and returned at the point of capture.

Where HIPASE was deployed along littoral margins, sampling took place at the interface between water and margin. Where margins were deep, the point boat was manoeuvred into the margin, enabling sampling of the margin depths. Where margins were shallow, sampling took place at the interface. At each sampling point the wetted margin depth was recorded. Sampling was repeated systematically along the entire margin, stopping every 5-7m to sample a point. All fish captured at each point were identified, measured by fork length (mm), for length frequency ($\pm$ 5mm) and age class estimation.

The open water zone was also sampled in a systematic way across the entire lake. All fish captured by HIPASE were individually measured, to provide size class information, estimates of young of year (YOY), and growth rates for those species with high densities that are considered to be principal components of the fish assemblage.

A SIM sonar is deployed from a stable boat within the watercourse. The transducer is submerged below keel depth and away from influence of propeller entrained air (usually mounted on either port or starboard gunwale). The length of survey is variable between 500m to entire reach proportions, depending upon river and survey purpose. Travel is unidirectional along each transect and repeated in the opposite direction in order to ensure isonification of the water column on either side of the boat and representation of all the river habitats. Survey speed is dependent upon the strength of current and direction of travel along with other parameters such as extent of macrophyte presence, sward height, debris within water column etc. At set intervals (determined by survey team) snap shots of the sonar data, termed sampling points, are collected along the transect in both directions. The resultant data is entered into post processing software for interpretation.

The sonar is configured to multiscan (horizontal and vertical simultaneously) and may be configured in omnidirectional mode within the side scan parameters depending upon waterbody and conditions.

Data collected during the surveys will comprise of individual fish signals, their location within the water column and/or river reach. Additional data are: macrophtye presence and extent, riverbed comparative bottom hardness. Bathymetric data and water temperature and thermal mapping are all possible outputs from the survey methodology.

Deployment of SIM sonar provides rapid evaluation of fish presence, distribution, and relative abundance as well as several key variables that influence fish distribution and density along a much larger sample area than traditional methods. Furthermore, SIM sonar are able to operate at shallower depths and at faster survey speeds than multi-beam sonar.

Output of fish population assessment is in the form of relative abundance per length transect or reach of river within the sample, referenced by GPS. Within this data are various parameters that influence fish distribution and abundance. Fish data are usually represented within GIS and depicted by a series of coloured circle markers denoting relative abundance for each sampling point or collection of sampling points within a set length of river reach (Fig. 2). Additionally, an overall relative fish abundance for the sampled reach can be estimated.

3. Results

The results of the HIPASE survey were disappointing. The principal fish species captured were 3-spined stickleback (*Gasterosteus aculeatus*). A total of 145 were captured droning the HIPASE survey. Sizes of stickleback ranged from 19-45mm (FL). These were distributed uniformly throughout the site, within the littoral margin zone. No other fish species were observed or captured apart from 3 small (~110mm [fork length]) brown goldfish (*Carassius auratus*) (Plate 1) at the far western end of the lake deep within the reedbeds.

Plate 1. Brown Goldfish (*Carassius auratus*)

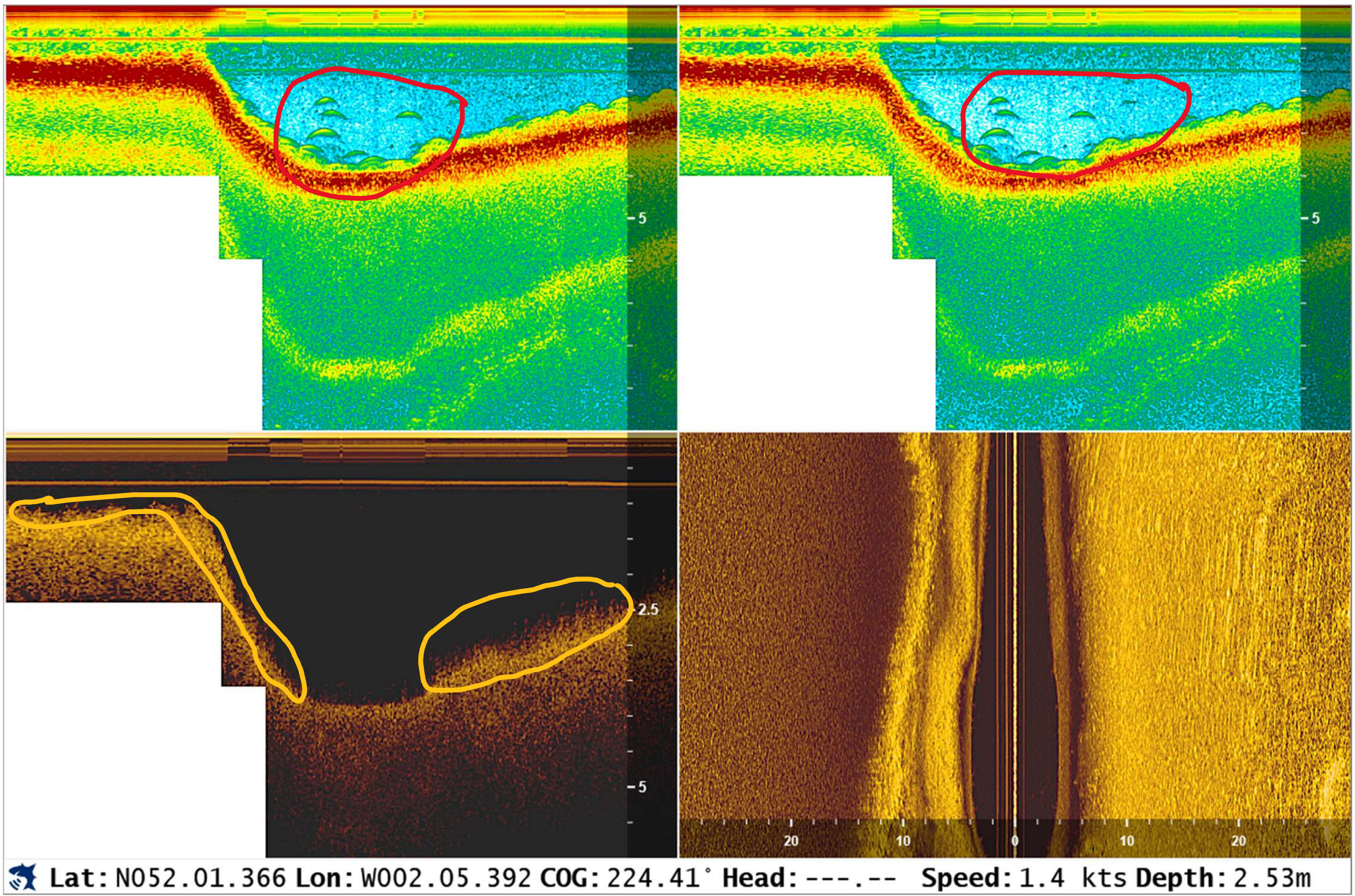
No fish were captured in the limnetic zone, almost certainly due to lack of available cover for the fish. The limited fish assemblage and lack of fish numbers precludes any meaningful analysis and fish estimations at this time. Instead focus changes to the SIM surveys conducted the following week before weed growth precluded their deployment.

The entire lake was isonified by the sonar. Post processed data revealed fish were present in the lake, but only in the deeper sections often outside the range of electrofishing (Plate 2) tending to hug the lakebed. The main area of fish congregation was the southeastern corner where the deeper sections of the lake including a deep 4.77m hole were found (Plate 3). Besides revealing presence of some fish within the lake the SIM survey enabled the map to be mapped bathymetrically, producing a 3-dimensional model of the lake (Plate 3). Furthermore, the SIM data also provided the opportunity to create a map of the lakebed bottom hardness, a measure of composition to relative hardness, with 'least' being gravels and stone and 'more' being softer sediment depositions (Plate 4). The total volume surveyed was 71533 m^3 and is broken down below (Table 1). The largest area of the lake by water volume was the shallow areas 0-0.5m (41%) demonstrating how shallow much of the lake is. Over 87% of the lake volume comprised of water between 0-1.5m deep. Maximum and minimum depth were 4.77m and 0.38m respecitvely. Average depth over the lake was estimated as 1.1m.

Table 1. Lake Volumes & relative representation, Kemerton 2022

Lower (m)	Upper (m)	Volume (m³)	Relative Vol %
0	0.5	29334	41.01
0.5	1	19685	27.52
1	1.5	13435	18.78
1.5	2	6058	8.47
2	2.5	1863	2.60
2.5	3	625	0.87
3	3.5	329	0.46
3.5	4	165	0.23
4	4.5	40	0.06

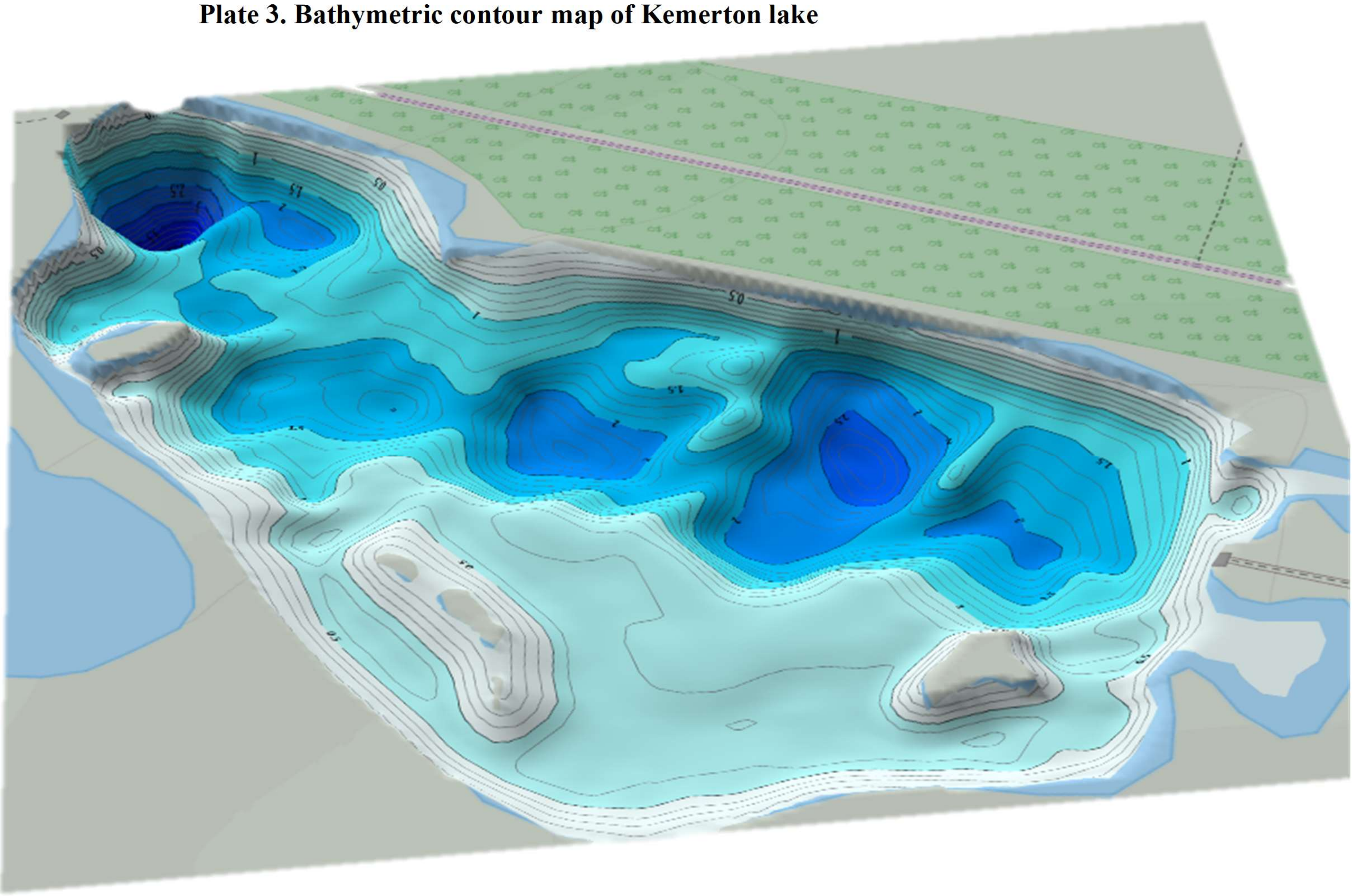
Plate 2. Fish within weedbeds in deep sections, Kemerton Lake, 2022



The topmost echograms reveal arches (circled in red) typical of fish echoes. Note, these are close to the bottom where they are hard to detect and strongly associated with deeper sections. The echogramme shows 2.53m depth, but this measurement is taken from the far-right hand side of the graph. The area where the fish are found is 3.47m deep and out of the sphere of influence of electrofishing equipment. Most of the fish were found in the southern corner of the lake with exception of the northern reedbed where the brown goldfish were captured. The SIM survey post processing analysis generated a total fish count of n=133. The quality assurance manual post processing (usually more accurate) generated an overall fish estimate of n=103. This equates to a lake total population estimate of 0.0015988 fish/m^2. A more typical expected fish population estimate for such a lake would be a factor of 10 higher ie 0.016 fish/m^2.

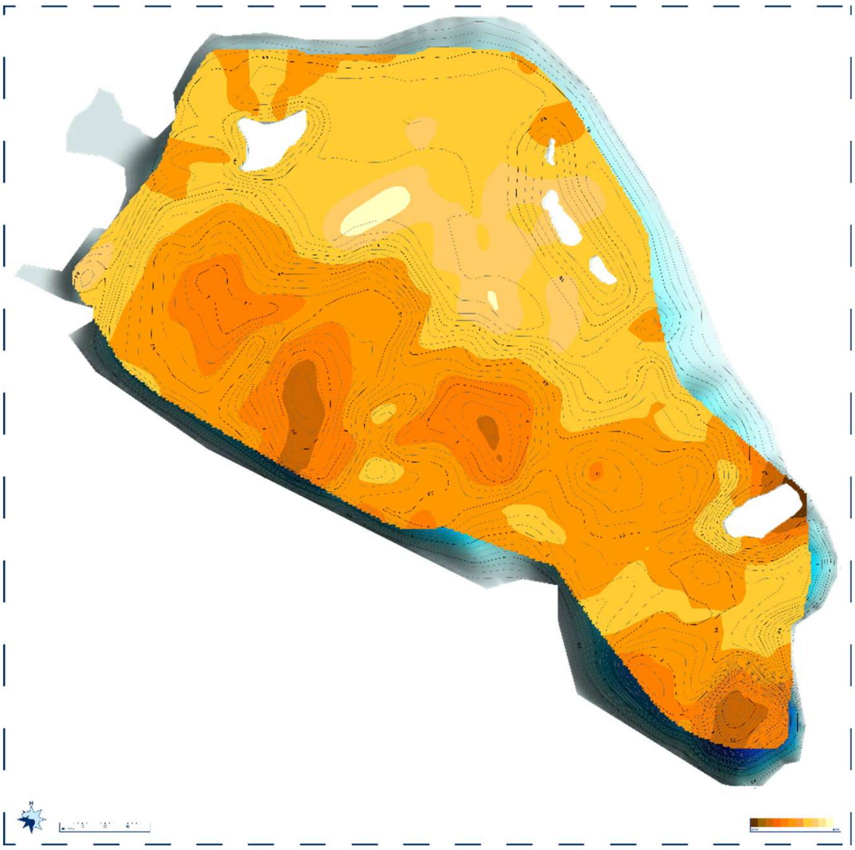
Weed growth is evident in the bottom left-hand graph (circled yellow) and the fish are closely associated with these features for cover and protection from predation. The extent of weed growth, even this early in the season can be seen in Plate 5 below.

Plate 3. Bathymetric contour map of Kemerton lake



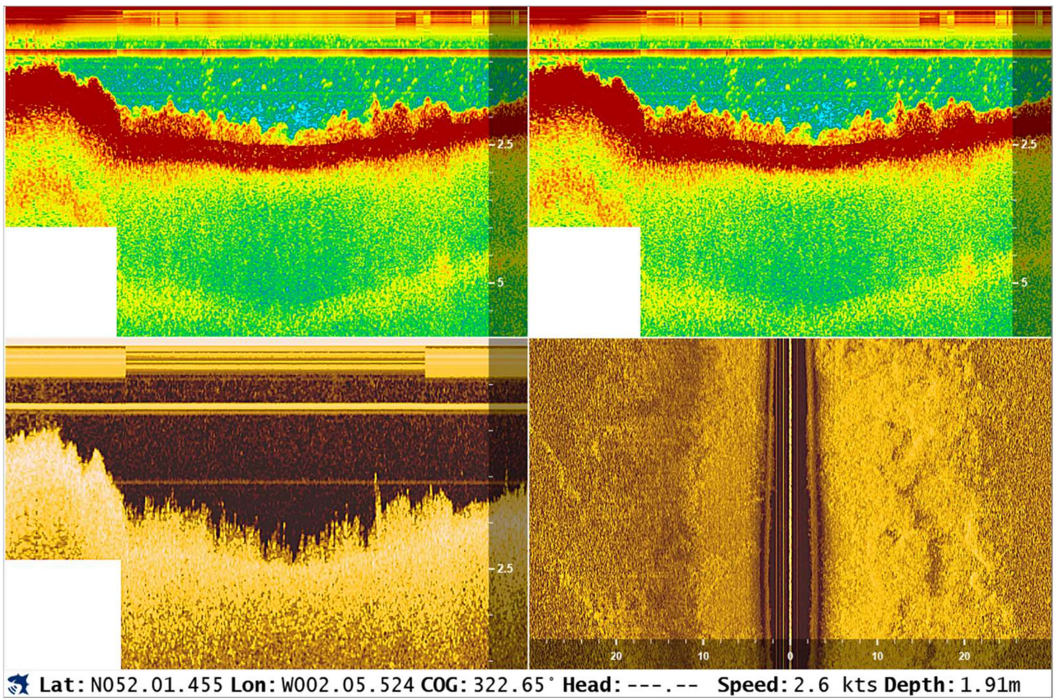
The bathymetry of the lake is interesting in its variation (Plate 3). With instream cover and foraging habitat, this bathymetry would suit fish assemblages and provide some form of safety from arial predation. Indeed, the fish that were located during the SIM survey were all detected in proximity of these deeper sections. The deepest section (4.77m) is located in the far southern corner of the lake and most of the other deeper sections are distributed along a rough line running SSE-NNW (Plate 3). The majority of the islands provide no functional role in habitat for fishes, the only exception being the largest tree covered island in the southern end of the lake (see frontispiece). The northern end of the lake has the best developed reed margins, and these do provide habitat for fish. All 3 of the brown goldfish were captured in these reed margins. The rest of the site has sparce reed growth or reed margins that lack density. This density of habitat is essential for fish and fulfils several functions. The reedbed itself has a functional role in fish refuge and foraging for some species. It provides additional habitat for invertebrates which fish feed upon, and for some species will provide material to spawn on as well as providing nursery areas for young fish.

Plate 4. Lakebed hardness map, Kemerton, 2022



Lakebed hardness is a measure of substrate, and the deposition of softer substrates can be clearly seen in Plate 4 (above) where the deep hole in the bottom right of the plate shows a depth of 4.77m and softer deposition than most other areas of the lake. The harder areas are denoted by paler colours, with white and pale yellow being the hardest material, and brown the softest.

Plate 5. Echogramme of weed growth in vertical and horizontal profiles



The bottom right graph shows the side scanning results of the lakebed and the granular nature of some areas of the lakebed are evident from this. The lack of lakebed structure provides little foraging habitat or refuge for fish and precludes them from the limnetic zone of the lake. Although dense macrophyte growth provides cover for fish during mid-summer, it conversely inhibits their movements. The same cover limits avian predation during this period, and this reduced effectiveness of feeding may impact upon bird populations and their breeding success. Thus, macrophyte growth is a double-edged sword, providing cover and shelter, but also limiting hunting and feeding opportunities for both fish and birds. From a water quality perspective, such extreme growth leads to super saturation of water oxygen levels during daylight hours and oxygen sags (low dissolved oxygen [DO] levels) during night-time. This is not good for fish communities or the wider aquatic ecology, leading to potential diversity loss. Eel representation was non-existent and is disappointing, given the potential for eel habitat in the softer areas of the lakebed (Plate 4) and the presence of reed margins. Poor electrofishing efficiency in these deeper areas typically associated with softer sediments may have contributed to the lack of eel captures, though their presence is normally detected via benthic movements or silt kicks. It is likely that either, eel have not found their way to the site or, their population is very low, and they have evaded capture.

The lack of lakebed structure (Plate 6) is apparent, and this will affect fish communities and their ability to survive and thrive within the lake system.

Plate 6. Side imaging sonar, Kemerton Lake 2022

The lakebed can and its structure can be seen from the SS sonar imagery above (Plate 6), along with the tracks of the survey route. The survey using SS conducts sweeps 25-30m wide either side of the boat and provides a clear picture of the state of the lakebed. The islands can be identified along with some minor structure, primarily along the western side. Weed growth and beds are partially visible too.

Conclusions and recommendations.

- Fish population is estimated to be 0.0015988 fish/m^2. An expected fish population estimate would be between 0.016 – 0.148 fish/m^2. This small fish population supports initial assessment of the lake:
  - Clear water
  - Excessive weed growth

- Fluctuating oxygen levels
- Lack of marginal fish habitat and cover
- Lack of in-stream structure and lakebed features
- Excessive predation

* No silver fish were captured or observed during the surveys
* No eel were captured or observed during the surveys
* Fish population comprises of brown goldfish (non-native) and 3-spined stickleback
* Lack of lakebed in-stream structure for fish is inhibiting fishery development
* Further littoral margin habitat enhancement would help the wider fish assemblage
* Placement of woody debris for fish would help the limnetic zone habitat availability and functionally serve to provide shelter and foraging habitat
* The additional in-stream structure would reduce the large stands of macrophytes a little, this will also help fish populations and reduce predatory pressure on fish
* Further development of the excellent reedbed establishment programme would enhance the lake, not only for fish but birds and invertebrates too
* Consideration should be given to planting up the far northern island with goat willow (*Salix caprea*) and possibly a single crack willow (*Salix fragilis*) in the middle of the island to provide some canopy and cover for fish
* We would suggest planting reedbeds in the littoral margins of the lee side of the two largest islands in order to provide further marginal habitat. We do recognise that the lakebed may be too hard in these areas, but would encourage planting if conditions would permit growth
* Improvements to the lake instream structure as well as that of the lakebed itself would help enhance zooplankton populations, providing refuge from predation from the fish that they also shelter from

Fish stocking recommendations:

- rudd (*Scardinius erythropthalmus*)
- tench (*Tinca tinca*)
- European eel (*Anguilla anguilla)*

References and further reading.

Burrough R.J., Bregazzi P.R. & Kennedy C.R. (1979) Interspecific dominance amongst three species of coarse fish in Slapton Ley, Devon. *Journal of Fish Biology* **15**, 535–544.

Cowx I.G., Pitts C.S., Smith K.L., Hayward P.J., & Van Bruken S.W.F. (1995). Factors influencing coarse fish populations in rivers. Research & Development Note **460**. Bristol: *National Rivers authority*. 125pp.

Cramp S. & Simmons K.E.L. (1977) Handbook of the Birds of Europe, the Middle East and North Africa: The Birds of the Western Paleartic. Vol. **1**. Ostrich to Ducks. Oxford: Oxford University Press, 722 pp.

Cramp S. (1992) The Birds of the Western Palaearctic, Vol. 4. Oxford: Oxford University Press, 247–252.

Gilbert G., Tyler G. & Smith K. (2003) Nestling diet and fish preference of bitterns *Botaurus stellaris* in Britain. Ardea

Hindes, A.M.; Perrow, M.; Tomlinson, M.; Leigh, S. (1999). *Status of fish populations in biomanipulated and macrophyte dominated broads in 1998.* Broads Authority.

Hindes, A.M., (2004) Tench, In: *Freshwater fishes in Britain - the species and their distribution.* (eds. Davies, C. E., Shelley, J., Harding, P. T., McLean, I. F. G., Gardiner, R. & Peirson, G.). Harley Books, Colchester.

Lane, S., Hindes, A.M. (2016). Restoration of Hoveton Great Broad. *Proceedings of the Institute of Fisheries Management 47th Annual Conference* (eds: J.B., Coulson, P., Gardner, C.J., Hindes, A. & Wellby, I.), IFM Nottingham.

Jacobsen L. & Perrow M.R. (1998) Predation risk from planktivorous fish influencing the diel use of macrophytes by planktivorous fish in experimental ponds. *Ecology of Freshwater Fish*, **7**, 78–86.

Johansson L. (1987) Experimental evidence for interactive habitat segregation between roach (*Rutilus rutilus*) and rudd (*Scardinius erythropthalmus*) in a shallow eutrophic lake. *Oecologia* **73**, 21–27.

Lucas, M.C.;Walker, L.; Mercer, T.; Kubecka, J. (2002). A Review of Fish Behaviours Likely to Influence Acoustic Fish Stock Assessment in Shallow Temperate Rivers and Lakes. *R&D Technical Report*: **W2-063/TR/1.** Environment Agency, Bristol.

Noble R.A.A., Harvey J.P. & Cowx I.G. (2003) The management of cyprinid fish populations as an important prey group for the endangered bittern (Botaurus tellaris (L.)). In: I.G. Cowx (ed.) Interactions between Fish and Birds: Implications for Management. Oxford: Fishing News Books, Blackwell Science, pp. 151–164.

Noble R.A.A., Harvey J.P. & Cowx I.G. (2004) Can management of freshwater fish populations be used to protect and enhance conservation status of a rare fish-eating bird, the bittern, Botaurus stellaris in the UK? *Fisheries Management and Ecology* **11**, 291–302.

Peirson G., Cryer M., Winfield I.J. & Townsend C.R. (1985) The impact of reduced nutrient loading on the fish community of a small, isolated lake, Alderfen broad. Proceedings of the 4th British Freshwater Fisheries Conference, Liverpool University 1985, pp. 167–175.

Perrow, M.R.; Hindes, A.M.; Leigh, S.; Winfield, I.J. (1999[a]). Stability of Fish Populations after Biomanipulation. *R&D Technical Report*: **W199**. Environment Agency, Bristol.

Perrow, M.R.; Jowitt, A.J.D.; Leigh, S.A.C.; Hindes, A.M.; (1999[b]). The Stability of Fish Communities Undergoing Restoration: Expectations and Experiences from the Norfolk Broads (U.K.). *Hydrobiologia,* **408/409:** 85-100.

Persson, L., (1991). *Interspecific interactions*. In Cyrpnid Fishes- Systematics, Biology and Exploitation (ed. I.J.Winfield & J.S. Nelson), pp. 530-551. Chapman Hall, London.

Schlosser I. J. (1998). Predation risk and habitat selection by two sizes of stream cyprinid: experimental test hypothesis. *Oikos* **52** 36-40.

Winfield I.J., Peirson G., Cryer M. & Townsend C. (1983) The behavioural basis of prey selection by underyearling bream (*Abramis brama*) and roach (*Rutilus rutilus*). *Freshwater Biology*, **13,** 139–149.

Winfield I.J.(1986). The influence of simulated aquatic macrophytes on the zooplankton consumption rate of juvenile roach (*Rutilus rutilus*), rudd (*Scardinius erythrophthalmus*) and perch (*Perca fluviatilis*). *Journal of fish Biology,* **29** (suppl.A). 37-48.

Winfield I.J., and Townsend C.R. (1988). Factors affecting pery selection by young bream (*Abramis brama*) and roach (*Rutilus rutilus*): insights provided by parallel studies in laboratory and field. *Environmental Biology of fishes.* **21**, 279-292.

Aquatic plant survey of Kemerton Lake
Will Watson and Giles King-Salter
23rd May and 3rd August 2022.

Methodology

Seven sampling plots were selected along the shoreline, with 4 in the northern section (plots 1–4) and 3 in the southern section (plots 5–7). In each plot, aquatic and marginal plant species were recorded along a length of approximately 10 m of shoreline. The same plots were visited in May and August to produce a single species list for each.

Percentage cover of the invasive alien species *Elodea nuttallii* Nuttall's Waterweed and *Crassula helmsii* New Zealand Pigmyweed was recorded in May and August for plots 1–7 in 3 zones:
0–3 m from the shore
3–6 m from the shore
6–9 m from the shore

A rowing boat was used to record plant species in deeper water and to assess coverage of *Elodea nuttallii*. This involved rowing a route around most of the lake, encompassing the shorelines of the islands, deeper water in the centre of the lake and the inlet near the western bird hide where particular aquatic plant species had been recorded in former years. A grapnel was used to pull up samples of aquatic vegetation at regular intervals along the route. Plants were also identified visually in the shallower water with samples being collected for confirmation of identification.

Plots 8–10 were surveyed from the boat. 8 was located to the north of the wooded island, 9 was in deep water near the centre and 10 was near the entrance to the channel. *Elodea nuttallii* and other aquatic species were recorded throughout the boat trips, not just in the defined plots.

Results

Submerged aquatic flora
Elodea nuttallii abundance
Elodea nuttallii was growing densely over almost the entire lake. Plot 9 was typical of the situation in deeper water, with 100% cover in both May and August. The dense growth of *Elodea* could mostly be confirmed visually, but it was confirmed by the use of the grapnel in deeper water. In August, there were large patches of *Elodea* reaching the surface, which impeded the passage of the boat.

Percentage cover of *Elodea* was less dense in the shallow water, with localised bare patches around each of the islands and along parts of the shoreline. Cover was slightly higher in August compared to May, although most of the bare patches remained.

Other submerged species

Other submerged plants were recorded both visually and by use of the grapnel. The only species recorded were *Stuckenia pectinata* Fennel Pondweed and *Potamogeton crispus* Curled Pondweed. Multiple plants of *S. pectinata* were recorded in May in plots 8 and 10. It was not seen in any other parts of the lake. In August, this species was not seen in plot 8 and the plants in plot 10 appeared in poor health and were covered in algal growth.

P. crispus was recorded in May as detached fragments in plots 1, 6 and 7. In August, rooted plants were present in a grapnel sample taken from the deeper water at around SO93683624. Rooted plants were not seen visually

Heat stress

On the August visit, *Elodea nuttallii* plants growing in shallow water in plots 1 and 2 were fragmenting and appeared in poor condition. It is likely that these plants were suffering heat stress from the recent warm weather. Plants in deeper water appeared unaffected, including areas where strands were growing at the surface.

Crassula helmsii

This invasive alien species was present at 6 out of 7 plots along the shoreline. It was particularly dense in plots 1–4, with coverage in the zone 0–3 m from the shore of 20% – 90% in May and 40% – 95% in August. *Crassula* was less dominant in plots 5–7 at the southern end of the lake, with coverage of 1% – 10% in May and 0% – 15% in August. It is likely that its abundance in this area is limited by the steepness of the banks and limited extent of the drawdown zone, although it is also possible that it hasn't yet had sufficient time to colonise all potential areas.

Marginal aquatic vegetation

A total of 50 species and varieties were recorded from Kemerton Lake over the 2 visits. The number of species recorded per plot ranged from 11–32. 33 of the species are listed as aquatic on the list used by the Freshwater Habitats Trust for the purposes of their Predictive System for Multimetrics analysis (PSYM).

Notable records included *Veronica x lackschewitzii* Hybrid Water-speedwell, which was found in plots 3 and 4 in August. This hybrid is recognised by its long racemes which are largely sterile and produce no fruits. It does not seem to have been previously recorded in Worcestershire. One of the parents of this hybrid, *Veronica anagallis-aquatica* Blue Water-speedwell, was also recorded flowering and fruiting in plot 2.

Non-fruiting plants of *Rorippa nasturtium-aquaticum* Agg. Watercress were recorded in May in plots 1, 2 and 4, but no fruiting plants were seen in August to confirm identification to species.

6 species and varieties of *Salix* Willow were recorded, including both subspecies of *Salix cinerea* and the Golden Willow form of White Willow, *Salix alba var. vitellina*.


4
3
2
1
10
Kemerton Lake
9
8
5
7
6
Potamogeton crispus

Family	Species	Common Name	1	2	3	4	5	6	7	8	9	10	Notes	FHT aquatics
Araceae	*Lemna minor*	Common Duckweed						1						1
Asteraceae	*Bidens tripartita*	Trifid Bur-marigold		1	1	1	1	1						1
Asteraceae	*Cirsium arvense*	Creeping Thistle	1	1	1									
Asteraceae	*Cirsium palustre*	Marsh Thistle				1								1
Asteraceae	*Pulicaria dysenterica*	Common Fleabane	1	1		1								1
Asteraceae	*Schoenoplectus lacustris*	Common Club-rush			1	1								1
Asteraceae	*Tussilago farfara*	Coltsfoot		1				1						
Betulaceae	*Alnus glutinosa*	Alder	1	1	1	1			1					1
Boraginaceae	*Myosotis laxa*	Tufted Forget-me-not	1	1		1	1							1
Boraginaceae	*Symphytum officinale Agg.*	Common Comfrey Agg.			1	1	1							1
Brassicaceae	*Cardamine pratensis*	Cuckooflower	1	1		1		1						1
Brassicaceae	*Rorippa nasturtium-aquaticum A*	Watercress Agg.	1	1		1							Recorded in May. No fruiting plants seen in August.	1
Crassulaceae	*Crassula helmsii*	New Zealand Pigmyweed	1	1	1	1	1		1					1
Cyperaceae	*Carex flacca*	Glaucous Sedge	1	1	1	1								1
Cyperaceae	*Carex otrubae*	False Fox-sedge	1	1	1	1								1
Cyperaceae	*Carex pendula*	Pendulous Sedge		1		1	1	1						1
Cyperaceae	*Eleocharis palustris*	Common Spike-rush	1	1		1								1
Equisetaceae	*Equisetum palustre*	Marsh Horsetail	1	1		1	1							1
Hydrocharitaceae	*Elodea nuttallii*	Nuttall's Waterweed	1	1	1	1	1	1	1	1	1	1		1
Hypericaceae	*Hypericum tetrapterum*	Square-stalked St John's-wort			1									1
Juncaceae	*Juncus articulatus*	Jointed Rush		1										1
Juncaceae	*Juncus effusus*	Soft Rush				1								1
Juncaceae	*Juncus inflexus*	Hard Rush	1	1	1	1		1						1
Lamiaceae	*Lycopus europaeus*	Gypsywort	1	1	1	1	1	1	1					1
Lamiaceae	*Mentha aquatica*	Water Mint	1	1	1	1	1	1	1					1
Lythraceae	*Lythrum salicaria*	Purple Loosestrife	1	1		1		1						1
Onagraceae	*Epilobium hirsutum*	Great Willowherb	1	1	1	1	1	1						1
Onagraceae	*Epilobium parviflorum*	Hoary Willowherb	1		1	1	1							1
Orchidaceae	*Dactylorhiza fuchsii*	Common Spotted Orchid	1	1										
Orchidaceae	*Dactylorhiza praetermissa*	Southern Marsh Orchid		1										
Poaceae	*Phragmites australis*	Common Reed	1	1	1	1	1		1					1
Poaceae	*Poa trivialis*	Rough Meadow-grass		1				1						
Polygonaceae	*Rumex conglomeratus*	Clustered Dock	1	1	1	1	1							
Potamogetonaceae	*Potamogeton crispus*	Curled Pondweed	1					1	1		1		Detached fragments in plots 1,6,7 in May	1
Potamogetonaceae	*Stuckenia pectinata*	Fennel Pondweed	1		1					1		1		1
Ranunculaceae	*Ranunculus repens*	Creeping Buttercup				1		1	1					
Rosaceae	*Potentilla reptans*	Creeping Cinquefoil		1										
Rosaceae	*Rubus fruticosus Agg.*	Bramble					1	1	1					
Salicaceae	*Salix alba*	White Willow	1	1	1			1						
Salicaceae	*Salix alba var. vitellina*	Golden Willow	1	1	1	1								
Salicaceae	*Salix cinerea subsp cinerea*	Grey Willow	1		1	1								
Salicaceae	*Salix cinerea subsp oleifolia*	Rusty Willow				1								
Salicaceae	*Salix fragilis*	Crack Willow							1					
Salicaceae	*Salix viminalis*	Common Osier				1								
Scrophulariaceae	*Scrophularia auriculata*	Water Figwort	1	1	1	1	1							1
Typhaceae	*Typha latifolia*	Common Bulrush					1							1
Urticaceae	*Urtica dioica*	Common Nettle			1		1	1	1					
Veronicaceae	*Veronica anagallis-aquatica*	Blue Water-speedwell		1									Fruiting (site 2)	1
Veronicaceae	*Veronica beccabunga*	Brooklime		1										1

Veronicaceae	*Veronica x lackschewitzii*	Hybrid Water-speedwell			1	1							Sterile, racemes long and without fruits
	May	Elodea 0-3m	5	30	70	5	60	60	25				
	May	Elodea 3-6m	50	50	40	60	80	70	80				
	May	Elodea 6-9m	100	95	60	90	95	60	80				
	May	Crassula 0-3m	90	50	20	40	10	5	1				
	May	Blanketweed 0-3m	5	10	2	5	0	2	0				
	May	Elodea cover (plots 8-10)								80	100	85	
	August	Elodea 0-3m	0	20	40	10	70	30	60				Elodea fragmenting in 1 and 2 (probable heat stress)
	August	Elodea 3-6m	90	85	75	90	100	90	80				
	August	Elodea 6-9m	100	100	40	100	90	90	90				
	August	Crassula 0-3m	95	65	40	80	5	15	0				
	August	Crassula 3-6m	5	15	0	5	0	0	0				
	August	Blanketweed 0-3m	0	0	0	0	0	0	0				
	August	Blanketweed 3-6m	5	5	0	0	0	0	0				
	August	Elodea cover (plots 8-10)								90	100	90	