Dissertation

Title To conduct a chemical survey of the water quality at Borwick Fishery to justify the potential impact mass baiting may have on fish welfare.

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To conduct a chemical survey of the water quality at Borwick Fishery to justify the potential impact mass baiting may have on fish welfare.

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Geography and Environmental Management

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Chapter 1

1.1 Aims and Objectives

- To investigate chemical properties of water quality at Borwick fishery within the lakes at Borwick Fishery.
- To analyse water quality properties nitrogen, sulphate, chlorine, phosphate, pH, dissolved oxygen, temperature and organic matter.
- To identify and explain the findings shown from Borwick fishery to inform management.
- To compare finding from lakes at Borwick Fishery, to establish differences in chemical properties.
- To establish the significance baiting can have on the ecology and water quality of the fishery.

1.2 Introduction

This project is aimed to investigate the water quality in relation to the chemical properties of all the fishing lakes currently being used at the fishery. The methodology will involve analysing water samples collected from the lakes at specifically distributed intervals. This will enable samples taken to be measured, analysed and to evaluate the results which will show the current condition of the lakes water properties in relation to pH, dissolved oxygen content, temperature, nitrogen content, and electrical conductivity.

The methodology will include the measurements of the current chemical condition of water at the site to establish the current condition of the water quality. On the day of data collection, pH, temperature and dissolved oxygen will be taken at each site in both still water lakes and the regularly replenished lakes. This influence of inflow streams and controlled outlets may have an impact on the Water quality. This is in comparison to the still waters at the complex which have been separated. The still waters only receive groundwater flow and surface precipitation in combination with surface run off as the inputs of freshwater. This provides the issue during dry periods were the level of the lakes will lower until it is replenished again. However, the outflow process is reliant on evaporation and ground water seepage resulting in a very slow rate of replenishment of fresh water. Therefore the lakes water level may have an influence on the concentration of the nutrients in the lakes. This could also lead to water quality issues and factors which influence the aquatic condition for the species present to a poor state.

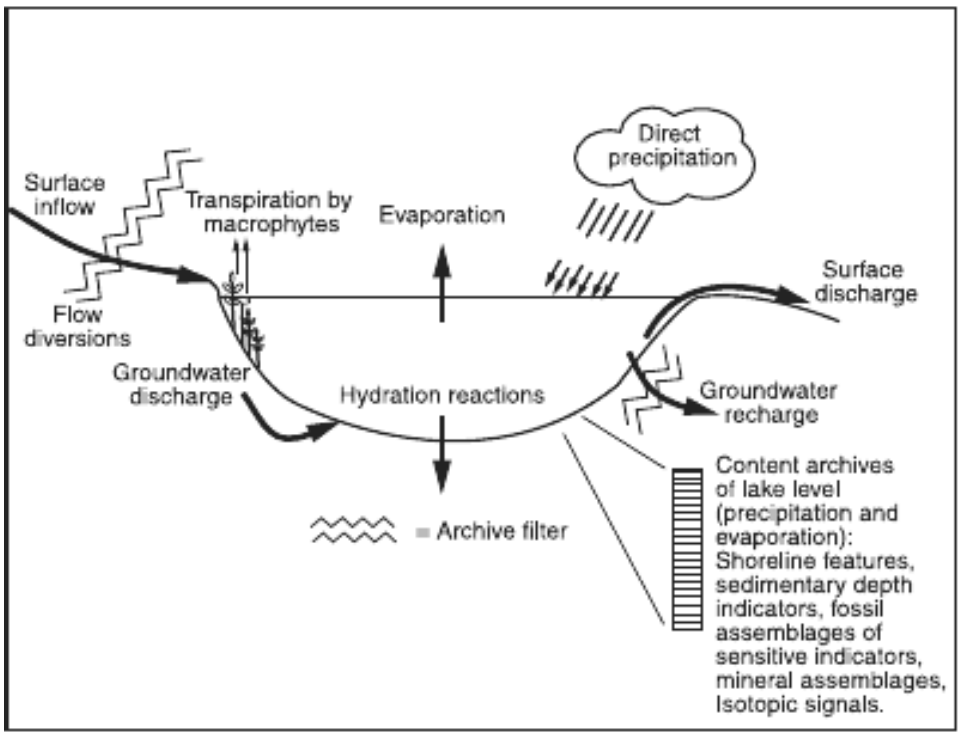
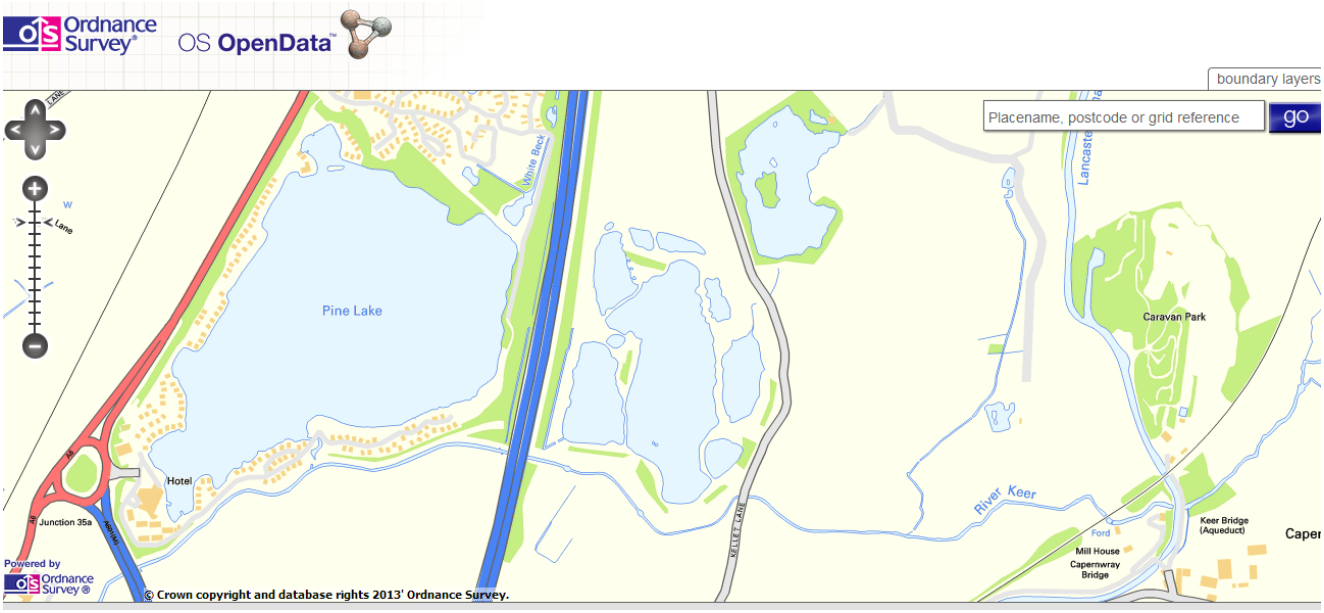


Figure 1: shows the hydrological cycle of lakes and relationship/filters to sediment archives of lake level, precipitation, and evaporation. (Cohen, 2003)

In conclusion the data presented could then provide a reason for currently unexplainable fish kills occurring in the minority at Borwick Fishery. The influences from the lakes physical condition in comparison water quality and also the stocking density may have an impact on the suitable environment for the fish present.

1.3 Borwick Fishery site description and history

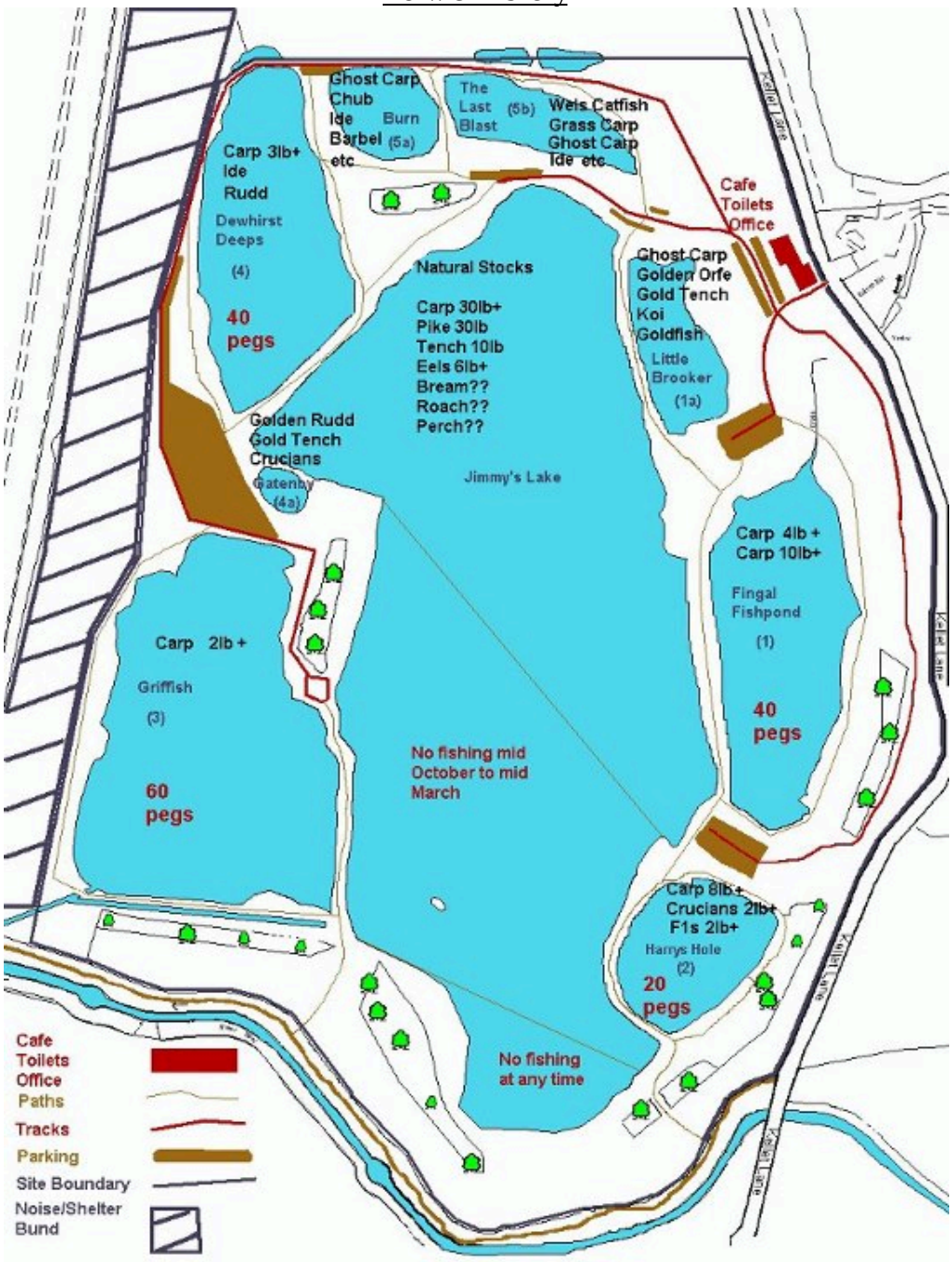
One reason for the environmental interest in Borwick Fishery is due to the recent changes of land use from an underdeveloped gravel pit dug for the construction of the M6, which is one of the North's Premier fisheries. This sudden change may have had an impact on the aquaculture, hydrology and ecology of the lake. Over the last 4 years the site has been under management to develop the fisheries species diversity and establish the fishing lakes for recreational use. The separation of five lakes has been constructed using large manmade walkways, however consequentially seizing the direct inflow of freshwater to the surrounding lakes which have been created. This has resulted in issues arising relating to water quality and the impact this may have on the welfare of the species within the lakes at the fishery.



(Ordnance survey, 2013)

Figure 2: shows an ordnance survey map of Borwick fishery, located in-between the blue M6 motorway and the grey Kellet lane.

Borwick fishery



(Borwick fishing, 2012)

Figure 3: shows the species diversity and the location of the fish at Borwick fishery

The lakes at borwick vary from 0.25 acre up to 15 acres with average depths ranging from 6ft to 15ft. the woodland surround is very sparse with only small areas located on figure 2 which give very little coverage from prevailing south westerly winds.

1.4 Study fish stocks

Currently at Borwick fishery there is no specific data to show how many fish are currently in the lakes as stock checks are not carried out accurately. The species diversity is still relatively well known as the lakes do don't regularly flood into one another, therefore the species which were introduced at the beginning of the fisheries stocking process are still currently in place. However the known amount of the stock density is not applicable.

The species currently in the lakes are barbel, chub, blue orfe, golden orfe, golden tench, ghost carp, catfish, common carp, mirror carp, grass carp, pike, perch, roach, eel, bream, tench, cruisen carp, koi carp, goldfish, rudd, golden rudd and f1 carp.

To data Borwick fishery, located north of Carnforth, was stocked with £30,000 of fish in 2006 before British waterways decided to abandon the site. This included the high majority to be smaller 6-8inch carp with some specimen fish up to 32lb.

1.5 Participation in fishing

"Fishing is big business in England and Wales. Almost four million people go fishing, making it more popular than any other participation sport. Anglers spend around £3 billion a year, bringing enormous benefits for local employment and the rural environment.

But it's not just the countryside that profits. Increasingly angling is flourishing in urban areas, where rivers are now cleaner than at any time in the last century. Young people, many of them discovering the sport through new participation projects, are enjoying all kinds of unexpected benefits. In some cases it's their first contact with wildlife and the natural environment, and angling is even helping to reduce truancy, anti-social behaviour and youth offending" (Environment agency, 2004)

Recreational fishing is one of most recent rapidly increased hobbies in the UK in combination with an increase in established fisheries becoming accessible. The sudden mass of participants adopting fishing may have environmental impacts, specifically to the water quality of the lakes.

Table 1a: Course and Game fishing licence sales over the last 10 years.

Year	Sales	Income
2000/01	1,085,446	£14,419,060
2001/02	1,143,430	£14,868,720
2002/03	1,180,061	£16,009,823
2003/04	1,261,972	£18,004,606
2004/05	1,218,218	£18,593,000
2005/06	1,296,865	£20,292,629
2006/07	1,268,313	£20,264,136
2007/08	1,352,423	£21,662,806
2008/09	1,292,933	£22,326,368
2009/10	1,469,994	£25,409,157
2010/11	1,431,981	£25,397,472

(Environment agency, 2013).

Table 1: illustrates the increase in participation freshwater fishing and therefore shows the affect on water quality from bait use could potentially increase over time as fisheries are more regularly used.

There are several reasons for the rise in popularity of fishing. One is due to the encouragement and push from the environment agency to increase participation to enhance biodiversity of ecosystems, public awareness of species diversity. Further more, to help provide another recreational activity which is seen as educational and enjoyable for youths. Angling is used to drive youths into an interest which removes them from dark streets and crime. Another reason for the rise in angling participation reflects on the involvement and gateways provided by the environment agency. There are three elements to this achievement such as rising public awareness, in 2002, the environment agency distributed over 50,000 guidebooks on where to fish and approximately 340,000 local fisheries Magazines (Environment agency. 2004). This is seen by opportunities being created in 2002, £750,000 was invested in 70 fishery development projects around England and Wales. Lastly, providing angling taster sessions has helped to provide people with an introduction to the basics to angling with angling coaches. These factors have been the reason for the increase in the amount of people angling today. All anglers used bait to go fishing with in various forms, therefore to reflect the effects of the rise in angling participation may have a severe impact to anglers used of bait and the water quality impact.

1.6 Carp fishing and the context

The idea of carp fishing is to catch a fish using a rod and line either as many as possible or the biggest specimen in the lake. However, often some anglers choose to escape away from the working environment and the unsettled life to the more tranquil peaceful world of the natural environment. This element narrows down to the natural instinct for a man to go hunting for food, were he may go hunting for several days just for some food.

1.7 Current management

Due to continuous development, the fishery has not yet reached it full running potential. Recently a café and restaurant has been opened. This will help generate revenue to help further improve the fisheries standards. Thoughts into a sheltered lake, to provide an alternative to those anglers who do not wish to sit in the bad weather. Over the last year two rows of 30 metre long solar panels have been installed to generate sustainable energy for the fisheries requirement. Recently quoted from borwick fishery website blog, “Borwick fishing new stock to grow on went in yesterday, just under 2000”.

Currently to prevent bacterial infectious disease being transferred between fisheries, a rule is in force to ensure any landing nets must be dips into disinfectant tanks. This enhances the protection of the fish species present currently within the lakes.

Otters are recently been spotted on the fishery, evidence of feces which is suspected to be otters. These on some areas around southern England have had a catastrophic affect to fish stocks. Therefore electric fences surround areas of entry to the fishery via pipes and stream transfer gaps. Additionally, currently to data (12/04/2013) the whole complex is being surrounded with otter fencing. This will help protect the fisheries stocks.

In relation to bait use, there is a no rules to what baits are allowed to be used and in what quantity, however discussion has suggested bait that is bought on site can only be used in the future but due to angler response this may affects business and revenue in day ticket sales.

Currently lakes 1 and 3 are used for match angling and receive most interest as in bait application is heavier, however with more fish. Therefore in hypothesis stock density may affect water quality in terms of bait application being significant or not. Lakes 4, 8 and 9 receive least interest in bait therefore the finding are hypothesised to be fairly neutral and standard with no anomalies.

1.8 Health and Safety & Ethics

Health and safety forms were completed before commencing any field or laboratory work.
All basic health and safety issues were highlighted, as well as anything that could have posed a potentially problem or risk to health and safety (Refer to appendices titled Risk assessment)
A Safety and Ethic form was also filled out before carrying out work (see appendix titled Ethics form).
An ethics form was then conducted in relation to the risk assessment and completed.

Chapter 2: Literature Review

2.1 Importance of lakes

Water quality is relative and is defined as the characteristic of water that influences its suitability for a specific use (Sharma, 2007), therefore their use and quality standard varies depending on the requirements it is used or needed for. The quality of water is of extreme importance in potentially determining the abundance of life, reflecting on that poor quality water leads to decreased amount of life forms and more fatalities whereas good quality water would in theory lead to increased amounts of species and healthier lifestyle. This shows that the importance of water as a natural resource does require careful management and conservation which must be universally recognized (Tebbutt,1998).

2.2 Angler perception

The knowledge of bait application to how it may affect the water quality is much unknown as it is presumed from anglers that there bait always gets eaten by the carp, however the issue of excess baiting is a lake is ignored and the potential side affects it may have against the water quality and the carp welfare. The bait most commonly used is boilies and particles. According to the angler response survey conducted 12/53 of the response revealed that particles are the favoured bait to use when fishing and 28/53 responses favoured boilies. According to Niesar et al, 2004 research shows the chemical composition and total phosphorus content of a range of bait types and brands, which specifically show the amount of gross energy per kilogram drawn from particles compared to other bait types (refer to appendices 2). This impact of the increase in participation and bait type and mass usage shows a issue to if the bait being fed is being eaten and if it is by the carp, do they benefit from this and if the bait is left what are the phosphorus contribution figures affecting the water quality.

Other bait forms are important to take into account as pellets and unknown additives which is seen as secret ingredients to anglers therefore what is used is generally secret. However bait companies such as CCmoore. CCmoore are a bait distributer and are well known on the carp fishing sector for supplying very high quality ingredients. From recent contact, CCmoore were able to confirm that they are not required to test the affect of the baits that they design and a sell for affects to water quality, however they do test for the quality standard of nutrients they supply. This sector contributes massively to the unknown levels of very powerful and highly concentrated additives and attractors and their effects to water quality. These baits vary in solubility and leakage rate of attractors. Also these come in forms of solids and liquids from powders to large solid matter, to various forms of colour, hi-viz and various weight densities. (Refer to appendices 1).

2.3 Bait forms

Carp bait is used to draw fish in to the area which the individual is fishing (Wood, 2012). This may be an area of interest were fish can be seen. Bait is used to draw the fish's confidence to feed without the presence of a hook with bait attached. This increases the chance of catching the fish as it feeds more confidently without caution. This is an artificial introduction of organic matter into lakes which is aimed to encourage fish to feed unnaturally. This draws the issues with of baiting in large quantities and its potential affects to the water quality.

Carp bait varies in various types, shapes, and sizes, flavours including many combinations of various feeding stimulants, essential minerals and amino acids which are important for the fish's dietary requirements. These elements all in combination are introduced to hundreds of brands across the carp fishing market to resemble food items to the fish. This can be developed too much that natural food is seen as second best and unnatural baits are seen as the instinct food source. This gives the angler an advantage and enables catch rates to increase. The types of baits vary from particles such as pigeon conditioner, maize, tiger nuts, chick peas and maples. These are used as a bulk item in baiting as it is cheap and very effective. Types of pellets commonly used in carp fishing are trout, salmon and recently halibut pellets. These all vary in percentage oil, protein, fats and carbohydrates.

During the annual change, a change in water temperature affects the way carp go about feeding and activity. Studies have shown that in cold temperatures, fish develop phospholipid molecules which adjust the composition of the membranes (Farkas et al, 2001).
On reference to the results from the angler response survey, baiting during the winter periods is significantly decreases however with a small percentage continuing to bait heavily, there is a chance that bait can be left in the water for a very long time without it being eaten and digested. Therefore alternatively the bait left is uneaten and not digested to then decompose on the bottom of the lake bed. However, other factors such as size, depth and current water quality of the lake will determine the significance of any minority of heavy baiting activity that may continue through out the winter periods. As seen in the angler response survey, question 7 indicated there are 2 respondents which stated they use more than 40kg of bait during the winter months. Due to a small sample being used this may vary to be a significant amount of anglers conducting similar baiting methods. This stresses the issue of bait application and affects to the water quality, resulting in damage to the fish stock.

2.3.1 Groundbaits

As citied in Mehnar's study, a carp angler survey indicated that specialised carp anglers used on average 215 kg groundbaits (mostly cereals, nuts, beans, boilies) per year. A feeding experiment was conducted to estimate the nutritional quality and phosphorus retention efficiency of the bait applied. The investigated groundbaits had a rather low nutritional quality (Mehnar et al, 2004). This shows that some baits used could influence the water quality due to supplying the fish with poor nutrient quality baits. However evidence from Niesar, et al 2004 shows that water quality may deteterriate due to the introduction of grounds baits.

Niesar then continues to relate to the content of the baits in relation to their digestibility and their significance to the differences in test diets due to the divergent feed compositions and ingredient treatments applied. The differences in nutrient digestibility suggested that type of groundbait and ingredient may have an impact on water quality.

Although the fish may benefit from this highly digestible source, the nutrients used will have a major effect on potential eutrophication and fish production caused by groundbaiting. This study however does not consider or relate to specific bait types as ground bait can be referred to bait which is put purposely to lie on the bed of the lake. However it does reflect to that bait which is not consumed by fish species and what extent are the effects have on the water properties (Niesar, et al 2004). The chemical water survey at Borwick will indicate if angler's ground baits affect water quality during the winter period.

2.3.2 Boilies

Boilies are recognised as small food items containing several dry ingredients known as base mix. Additionally, liquid foods, powder addictives and essential oils can be added in combination with egg, which is used as a binder to complete a solid food item (Wood, 2010). The variation in base mix defines the type of boilie. For example fishmeal boilies contain fish or crustacean meals, milk protein boilies contain whole milk and birdfood boilies contain bird seed mixes (Wood, 2010). These baits are high in protein and carbohydrates including semolina.

2.3.3 Pellets

There are 3 types of pellets which anglers use to feed fish. These are animal feed pellets, carp/course pellets and high oil content trout and halibut/marine pellets. Many of the pellets fed to animals and poultry can also be useful fish-catching aids. A lot of these pellets tend to be quite low in oil content. Pellets such as hemp, CSL, molasses and cereal based which none are going to harm a fishery or the fish as long as they are used in sensible quantities. (Harrison, S. 2010)

There are lots of different varieties of pellet. koi carp trade lists are very complex and come in a huge variety depending on requirements from the pellet. Koi carp, although prettily coloured, are simply just the same as the specimens for which are fished for such as common and mirror carp.

Due to the requirement for koi carp and the industry which they are bread for meaning they can't supplement their diet with naturals such as snails or bloodworm, etc. They live in a very sterile environment and no one wants to spend thousands on stock, only to see them looking unhealthy in their clinically clear water, therefore pellets which are used for Koi carp have an property to encourage the best quality food for the fish as possible (Harrison, S. 2010).

However on the other hand, it is the high-oil content pellets which cause the problems on many waters. Halibut pellets and high-oil trout pellets are probably the two most commonly used pellets, which can create a problem if lots of anglers are using them or if a particular individual is using them in huge quantities. The typical symptoms of high oil pellets are that they provide oil slicks on the surface of lakes when they are disturbed and broken up, releasing the oils. It is possible, if a lot of high-oil content pellets are used, to seal the water surface with a thin oil slick. This can lead to restricting dissolved oxygen entering surface layers of lake which may result in fatalities of fish (Harrison, S. 2010). This can be demonstrated as fish struggle to live in a deep narrow tank rather than shallow wide tanks due to the required surface area. Specifically as weed in lakes during the winter months is lifted and decreases in intensity and light levels are decreased which results in dissolved oxygen decreasing through photosynthesis. Therefore to allow heavy use of high oil pellets during the winter months will further starve the lake of oxygen. (Harrison, S. 2010).

2.4 Bait density

The most recent scientific information on commercial carp baits has been generated by Niesar et al. (2004) and Arlinghaus & Niesar (2005). These studies investigated the environmental impact of bait use. This study further investigated the impacts of artificial baits compared to natural food sources. Data is provided from the study which illustrates the chemical composition of five angling baits. Additionally, a controlled diet (pellet) was compared. The chemical composition can be seen in appendices 3 extracted from (Wood, 2010).

The bait type boilies were split into two separate groups: those rich in crude protein and crude fat and other rich in NFE (nitrogen free extracts e.g. carbohydrate and fibre). On reflection on the findings, the first group of baits (ready-made boilies) appeared to have a high level of fish-meals, however the second batch of baits (self-made boilies) had a composition similar to cereals. The particles tested were able to be distinguished in differences due to the variety in particles.

These particles ranged from beans, nuts, peas and seeds. The particles showed to vary in properties in fat rich proteins contained in soya beans, peanuts and hemp. However other particles showed low protein and fat content such as maize, barley and wheat. The groundbaits investigated indicated the composition to be high NFE and low in protein. This suggests that fishmeal inclusion was likely to be low. On reference to appendices 6, question 3 (Angler response survey) shows a mixture of baits used and the second most used bait is particles.

In the feeding experiment conducted by Niesar and Arlinghaus, (2004) shows the effects of growth from fish consuming specific bait types, with particles indicating a very low percentage growth. The nutrition quality of the particles (seen in appendices 4) shows the very small specific growth rate. This shows that particles provide carp with a minimum to meet there dietary requirements. Therefore this shows that on reference to the angler response survey nearly 12/53 people predominantly use particles, also responses from ground baits showed to add a further 2 people which in contributes to poor quality nutritional food items being put into lakes.
Further reference to appendices 2, this shows a variety of brands and types of bait used for carp angling. This can also be shown from the angler response survey appendices 6, question 4, which demonstrates the variety of bait used.

Studies from Niesar and Arlinghaus, (2004) show that the suitability of angling groundbaits as a fish feed and the potential for nutrient loss, the macronutrient digestibility of four groundbaits was apparent that digestibility coefficients (ADCs) of protein and lipids were>80% for all angling baits**.** (Niesar, M. Arlinghaus R, 2004). ADCs of nitrogen-free extracts and phosphorus (P) differed significantly between the test diets, probably because of divergent feed compositions and ingredient treatments. The generally high digestibility estimates indicated that fish feeding on angling groundbait will benefit from this food source. This shows a positive affects of highly digestible baits. The differences in nutrient digestibility suggested that type of groundbait and ingredient used will have a major effect on potential eutrophication and fish production caused by groundbaiting. The principle of groundbaits to protect the environment should be to minimise the P-content of the groundbaits and maximising P-digestibility and P-retention efficiency. (Niesar, M. Arlinghaus R, 2004).

This demonstrates that although baits are made to a high quality standard for digestion and nutrition for the fish, the affects of having such highly nutritional baits are the phosphorus content they contain, which if miss used and applied to a greater scale at which it is consumed the effects of eutrophication may have an onset.

However, according to Broughton (2000), it would take an unreasonably large number of baits to produce this alleged polluting effect and, in any event, they would all eventually disappear as they were eaten or decomposed naturally. On very small and heavily-fished waters, it is conceivable that this might produce a temporary but undesirable change in the water quality from which fish could not escape; on large waters, fish would undoubtedly simply avoid any pockets' of pollution - their instinct to survive and their ability to avoid danger is far greater than their desire to feed. (Broughton, 2000).This states that there is clearly an issue with bait application in mass amounts but to what extent is damaging is not stated and unknown. However draw upon feed back from the angler response survey (refer to appendices 6, question 6 and 7). This shows that there is a minority which do still exceed the normal bait application amount which may have an impact on the water quality of a small lake which will be more severely affected due to the higher concentration of the bait in a smaller mass of water. On reference to appendices 8, this shows the average annual bait application across the 24 responses. This shows that over annual period the bait application may show change to water quality through different periods of the year due to the feedback of more bait being applied during the spring/summer period (refer to appendices 6, question 6). Also for further calculations for the amount of bait in kilograms applied per annual year could be combined with total tickets sold on site over a period of time. This knowledge could be very influential on the statistics of bait application and quality. As an average amount of bait could be worked out over a week, month or even a yearly period.

Studies into groundbaiting on Welsh reservoirs and lakes have revealed that the potential input of phosphorous - the plant nutrient which stimulates 'blooms' of algae - is insignificant. On the other hand, the phosphorous input from feeder streams, leaf litter and the waste products of water birds is of far greater importance to the nutrient 'loading' of these bodies of water (Broughton, 2000). This further demonstrates that angling bait is only dangerous to the environment and water quality and severely extreme circumstances. For this reason fisheries not have bait bans on specifies particles which do not benefit the fish or the water quality, for example tiger nuts.

This is due to the very low amounts of nutrition and the sheer high effort it takes to digest nuts as they are not nutritionally adequate enough for the energy required to break down the matter to create energy from. This is very common in lots of large carp fishing complexes in France such as Dream lakes.

2.5 Stock density

Investigating the chemical properties of the lakes at Borwick fishery can help suggest ideas to improve current management for the welfare of the species currently in the lakes. As citied in Britton et al, suggests that anglers in England and Wales, have shifted their behaviour towards visiting catch-and-release lake fisheries that are intensively stocked, mainly of large common carp-*Cyprinus carpio*. This shows the increase in interest towards recreationally angling, which may have an impact to the amount of bait being deposited into lakes, and also if bait applied is to a nutritional standard the fish will grow.

During the study conduced by Britton et al (2009) 187 fish kills investigated in these intensively stocked fisheries in 2004 and 2005. Most of the kills occurred between April and June and were mainly caused by parasitic or bacterial infections. "Bacteria were usually associated with ulcerative diseases caused by strains of the bacterium Aeromonas salmonicida (Emmerich & Weibel) and secondary infections of opportunistic bacteria of the Genus Aeromonas (excluding salmonicida) and Pseudomonas. Parasites involved in fish kills included Ichthyophthirius multifiliis (Fouquet), Chilodenella sp, Ichthyobodo necator (Henneguy) and Argulus sp." (Britton, J. R, 2009).

On reference to the current stock density at borwick fishery due to the lack of data existing of stock introduction, a drawn approximation of the current stock in the lakes has been conducted by existing head bailiff (see appendices 7). This shows that due to the lack of knowledge and management may have an impact to the ecology of the lakes. This would be essesentail for the further development of the current condition of the fishery has and to help improve water quality in relation to the impact to the existing stock. Due to the impact of bait application the water quality may show deteriation which impact the water properties resulting in disease in the water thriving from parasites, consequently causing a higher amount of fish kills.

This evidence shows that Outbreaks were typically in fisheries with high extant stock densities greater than 1500kg and within sub-optimal habitats (Britton et al, 2009), for example of low habitat heterogeneity with few macrophytes in the littoral zone.

This describes an underwater environment were pond weed and habitat cover used for camouflage cover from predators or spawning areas.

This example reflects to Lake 1 at Borwick fishery as this lake is very densely stocked, fairly shallow average depth around 5-6ft, and very little weed present in the lake.

Recent stocking was also a key factor when only carp were affected. Thus, certain fisheries management practices that aim to enhance fishery performance may instead trigger fish kills during spring. This shows that careful management between all elements of environmental change need to be closely monitored to the suitability of the species present for best growth rates. This indicates that chemical properties such as pH, temperature, dissolved oxygen and food availability of lakes can have an influence on the present species depending on the stock density. (Britton, J. R. 2009).

In combination with stocking density influences on fish mortality food availability and affects of excess in very low stock lakes may have an influence on the carp welfare and water quality. Impacts of mass baiting do have influences on plant growth in lakes. In combination this results in supplying oxygen within lakes.

2.6 Water quality parameters

2.6.1 pH

pH in the environment is a much less variable environmental parameter than dissolved oxygen or temperature. Heavy rain can have an affects on pH on relatively shallow lakes, and in come cases, analysing samples close to inflows may have an influence on pH due to the large input of rain water. This may result in a reduction in pH (Wood, 2010).
To manage the pH of a fishery is an important factor which can influence fish mortality. Over a short period of 48 hours mortalities can occur after change of state to the water quality in some circumstances. Natural alkaline waters are not common as acidic waters. Temporary high levels of pH can occur during hot dry summers as an effect of algae blooms.
Studies have been conducted on high pH ponds containing carp larvae. pH levels ranging from 7.8 – 10.3 (korwin-kossakowski, 1992) were growth rates were shows by retarded growths of the carp. This showed differences in growth, weight, and length and survival rate.

2.6.2 Temperature

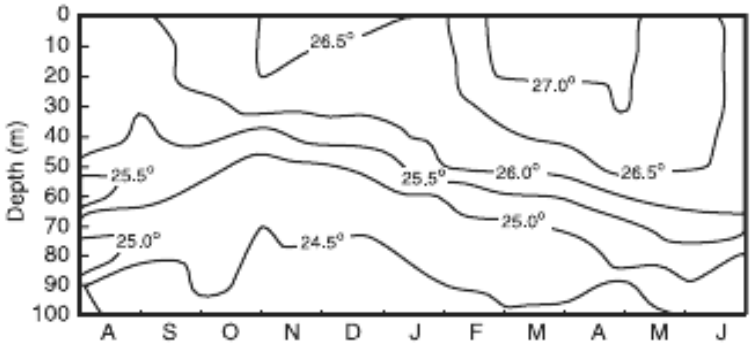


Figure 4- shows seasonal thermal profile for the northern part of Lake Tanganyika, a deep, tropical, meromictic lake near Kigoma. It shows the upper 100m of the lake temperature.

Surface temperature can vary on a large scale over a short period of time throughout the annual year. This can influence the ability for the capacity of dissolved oxygen within the volume of water. The oxygen consumption rate of fish is directly proportional to the temperature of the water, as fishs biological processes are accelerated in warmer temperature. This results in the fish respiratory system working faster therefore feeding activity increases and as a result, energy from food/bait is needed to replenish stores. This is done at a greater and faster rate during the warmer water temperatures than in the cold temperature when feeding activity is reduced (Wood, 2010). Due to fish depending on the water condition and temperature influence on feeding activity, food intake during the winter months is low. Food intake regulation of fish is a complex inter-relationship between endogenous and environmental factors (Peter, 1979; Fletcher, 1984), with water temperature being viewed as one of the main environmental factors influencing feeding and growth (Brett, 1979; Elliot 1982). For example Rozin & Mayer (1961) demonstrated that feeding by goldfish that are temperature dependant, with 10^{o}c decrease in water temperature from (25^{o}c - 15^{o}c). This resulted in a severe reduction in food intake from the goldfish.

2.6.3 Dissolved Oxygen

In water bodies, the bacteria that most influence oxygen concentration are those responsible for the process of decomposition (rotting).

Bacteria can multiply extremely rapidly in warm conditions, but they are much less active in cold conditions. As the number of bacteria increases, there is a corresponding increase in the amount of oxygen they consume.

If sufficient food is available, bacteria can quickly reproduce to the point where they use up practically all the oxygen dissolved in water, leaving none for the other plants and animals, including fish. Events or activities that introduce plentiful food supplies for example bait which is left uneaten can be used by bacteria which can often lead to deoxygenation (Environment Agency, 2008).

During the period of collecting the samples the lakes were partially cover in ice. This may have an impact to the significance the bait may have on the processes within a lake to facilitate oxygenation of the lake.

When fisheries become completely covered with ice, interchange of oxygen at the water/air interface is prevented. However, those animals, including fish that are trapped beneath the ice still require oxygen. If the ice cover lasts for a long time, the dissolved oxygen concentration can fall low enough to cause fish mortality (Environment Agency. 2008). The deoxygenation effect is even more pronounced if the ice becomes covered in a layer of snow, therefore increasing the impact of long term ice coverage. This is due to the snow layering the ice causes a restriction in light passing through the ice, thereby preventing any photosynthesis by the plants. Especially as lakes 1, 3, 5, 6, 7 contain very little aquatic plants therefore creating greater impact to the suffocation of the lake and its species. “Winter-kill” of fish is common in parts of the USA, Canada and mainland Europe, but in Britain it is rare unless the winter is severe and prolonged (Environment Agency, 2008). There fore this is explained by the environment agency that cases of fish kills are rare, however in the course of poor winter conditions in combination with further processes of deoxygenation fish kills are possible.

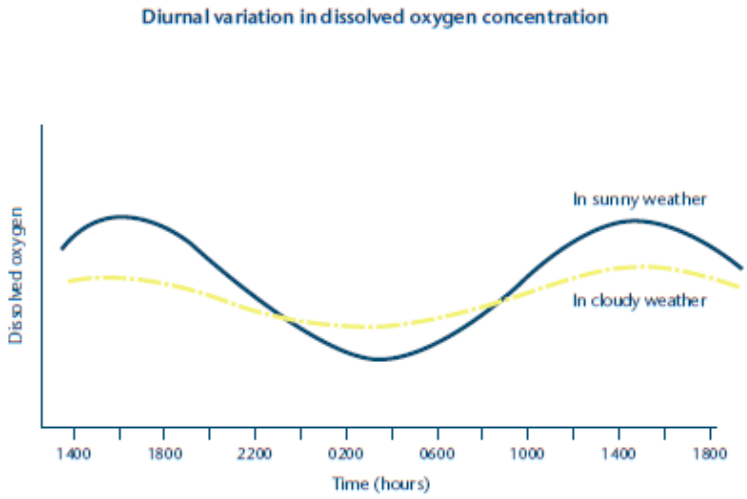


Figure 5: shows the variation of dissolved oxygen through out the night and day period.

(Environment Agency. 2008)

Whether deoxygenation and fish mortality occurs depends on the balance between the two processes. If oxygen is being removed from the water faster than it can be replenished, de-oxygenation will eventually occur.

In circumstances where the biological productivity of a water is running at its maximum (for instance, where there are lots of fish, lots of algae and/or rooted plants and large quantities of organic matter in combination with high temperature) it is important to realise that only a small change in the balance between consumption and replenishment of oxygen can trigger a catastrophic event (Environment Agency. 2008).

The reaction of common carp (*Cyprinus carpio*) in an ice- and snow-covered pond to depletion of dissolved oxygen (DO) in winter was recorded using radio telemetry. The carp moved from the deeper parts of the pond to the shallow areas near the tributary in search of better oxygenated water. Evidence was found that feeding occurred until December but ceased with the oxygen crisis. After the carp farmer started aeration to improve the oxygen supply, carp returned towards the deeper parts of the pond. “The gross activity was significantly correlated with DO ($P<0.001$) and was not influenced by water temperature ($P>0.05$)” (Baurer et al. 2006).

The clear documentation of the carp's reaction to oxygen depletion suggests that radio telemetry may be useful for investigating the effects of various stress factors on fish in pond aquaculture. This evidence indicates that the reaction of carp due to common winter conditions reduced feeding activity. Therefore relating to the angler response survey conducted (refer to appendices 6) this shows that bait applied during the winter is minimal to an extent of the anglers opinion in approach, however this depositing of excess bait may not all be consumed and will potentially decrease the water quality and may have an impact on the water quality parameters. This could encourage eutrophication in some circumstances.

2.7 Nutrients in lakes

Plants and algae require phosphorus and nitrogen for growth. The higher in concentration of these nutrients present in sediments and water, the higher the growth rate of plant matter that can grow in the lakes. Phosphorus is the least available nutrient that enters a lake; therefore it controls the extent of the amount of algae growth in a lake. Nutrients usually come from sewage and fertilizers, however in other circumstances, phosphorus can be created from release of bottom lying sediments once oxygen is absent from bottom waters (Smol, 2009).

Lakes also receive nutrients from human activities from angling methods such as excessive loose bait feeding. This can accelerate the rate of the onset of eutrophication, especially if the feed input is disproportionate to the size of the water body and the contained fish population in the lake (Wood, 2010).

2.8 Eutrophication

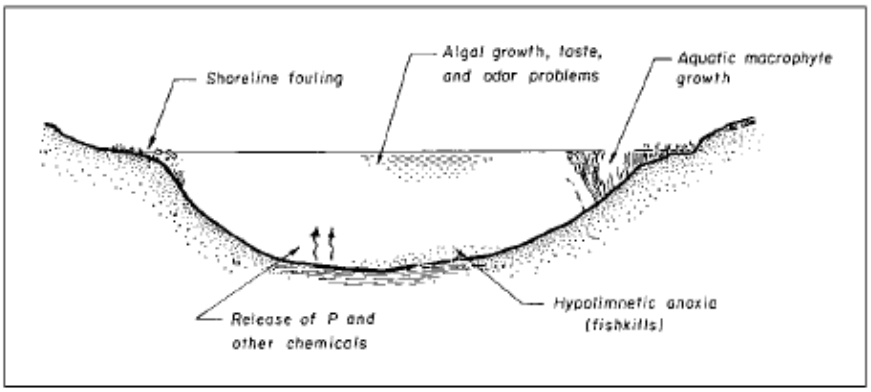


Figure 6– Shows the process of eutrophication and the contributing factors. (Smol, J.P, 2009)

Due to the mass introduction on bait, all is not consumed by fish and some may be left and begin to decompose. In huge amounts, a severe increase in nutrients begins to build in the lake and phosphorus being to be released.

Eutrophication refers to the problem of nutrient enrichment of water bodies. too few nutrients would be a more serious ecological issue, but eutrophication continues to be ranked as the most common water-quality problem in the world, and remains an active area of scientific research (Schindler 2006). The reasons for this are related to the myriad of symptoms that eutrophic lakes, reservoirs, and rivers often exhibit, such as unsightly algal blooms, large growths of aquatic macrophytes, excessive accumulations of decaying organic matter, taste and odour problems, decreased deepwater oxygen levels, marked shifts in food web structure – including possible extirpations of some fish species and other organisms. Once algal blooms reach high concentrations, other problems may develop. For example, blue-green algae are often associated with eutrophic waters, and cause negative impacts on water quality. When certain cyano-bacteria populations reach very high proportions, they can also produce toxins that can render water unsafe for consumption. Toxic blooms have been reported in the scientific literature for over a century and can pose serious problems, especially to livestock. (Smol, 2009).

2.9 Nitrates

Another important concern is that when algae die, the bacteria that consume them use dissolved oxygen to do so and this lessens the supply to fish and other desirable organisms, which may die as a result. (Addiscott,. 2005)

Chapter 3: Methodology

3.1 Sample Collection

The data was collected on the 20th February between the hours of 10:00 to 15:00. The air temperature when I arrived was 3.1°c, and when I left the air temperature was 4.4°c. The weather was very sunny. The last 3 days previous to the collection had been very similar in air temperature with bright sunshine.

Location of Sample Sites

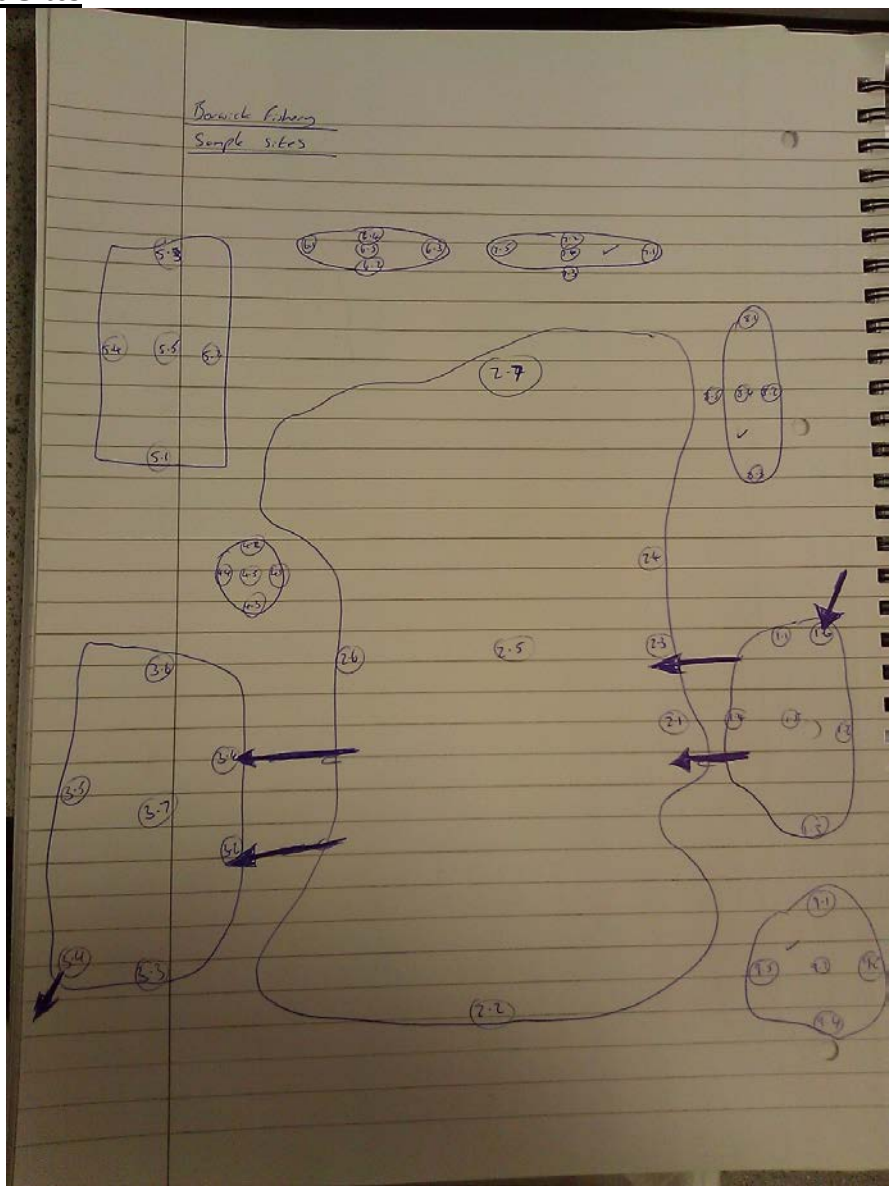


Figure 7: shows the location of each sample site.
Also shown by the blue arrows, the flow of water entering the Lake 1 and entering into Lake 2 via two outlet pipes, which then is exited into Lake 3 via two outlet pipes to then be exited by the south west corner on Lake 3. (The photograph was taken by a mobile phone by the investigator).

Due to the nature of the investigation, the water samples are collected to analyse the chemical properties of the lakes. The samples must provide a thorough representative of the entire lakes water quality. Therefore a preliminary survey was conducted to provide a method of sampling which is high in validity and will be able to justify the water quality as a representative sample. Another reason for a preliminary survey is to establish possible influencing factors which may disrupt collection or influence potentials errors occurring in the sampling process, however this may prove to have an issue with validity. Further reasoning is for safety due to the investigation occurring near deep water; therefore the preliminary survey can provide information to enhance the preparation of the sampling process to enhance safety.

Before the collection of samples pre-sampling checks are vital to ensure the condition of the equipment is functional, sterile, up to data and in excellent working order. This enables results which are collected to be as accurate as possible and to ensure good quality samples are collected to provide high quality data. Also test kits and field instruments are to be set to a correct calibration before use to provide a good level of accuracy of the data. Other preparation before entering the site is to ensure the sampling bottles will be labelled with codes. These codes will be mapped out to illustrate the location from which the sample was extracted from. The bottles will be identified with labels containing a number representing which lake they were taken and which specific location on that particular water body they were taken from. During the process of taking samples, safety procedures are important to follow for the safety of the surveyor. In the presence of deep water and activities such as wading, a suitable lifejacket should be worn securely and the correct safety procedures should be carried out **(**refer to risk assessment). Gloves are worn in area which may contain harmful pollutants is necessary; this is to prevent diseases such as Weil's disease. Weil's disease is associated with rat urine. Once the sample has been collected the lid will be secure to prevent contamination.

Once at the study site, all vehicles will be parked in designated car parks to ensure safety of the vehicle and the study investigator. This will provide a location were a first aid kit, spares and transportation cases will be located. This will help will surrounding awareness and to help avoid spillage of samples.

During the process of collecting water samples it is important to make sure the samples being collected is being correctly taken by representing an exact natural state of water that would be found at any time.

Therefore bottles much be filled directly from the bottle to avoid contamination. This technique should be replicated to give an average representative to help avoid any marginal error. This will help with determining specific data such as the presence of oils or pesticides which can be found in small amounts. During the collection disturbance of the bed bottom much be eliminated as this could interfere with specific aims of collection and may show anomalies.
Once all samples are collected, they will be immediately be put into a sealed box waterproof and transported carefully and stored inside away from any potential contaminators or weathering.

A systematic sampling procedure will be carried out to collect samples from specific evenly distributed areas around the lake. This will be used to calculate the mean, minimum and maximum value of water properties, which will give an overall average for each property. This method will be applied to each lake to gather an overall data collection of water quality around the complex.

The collection will involve samples being extracted from specifically the inlets to all the lakes present with inflows, which will give a direct representative of the current inflow water properties before the initial mixing process within the lake has occurred. This is because the inflow in the first contact the freshwater has with a still water body. The samples will be collected from the surface areas of the lakes from the 4 of the cardinal points to provide a thorough collection of representative samples. This is to take into account of lake mixing processes.

Once the samples are collected they will be sealed inside a plastic bottle and identified with a specific code reflecting the location the water was taken from. This same sampling technique will be applied to the comparing still water lakes on the complex, however due to the absence of any inlets; a sample will not be taken to represent freshwater entering or exiting the lake.
Other samples from the bottom of the lake bed will be collected using a method by sinking a bottle through the surfaces and engaging the bottle to collect water. This is due to the unavailability of a submersion pump.

3.2 Laboratory and Field Methods

For accurate data collection, the water samples must be transported in secure sterile containers which are clearly labelled identifying the area to which they represent on which lake, data and time, any impacting circumstances and the individual person Elle sampling.

These samples are then transported to the university laboratory were further analysis will be conducted.
Areas of interest will be conducted using various methods specifically designed to investigate individual properties.

3.2.1 pH

Electrodes are placed in potassium chloride solution to neutralise the reading. An accurate measurement of water will be measured into a beaker and the readings were taken using pH electrodes. These are left to stand for 1 minute to stabilise in the solution.
This will be measured twice at each site to improve the validity and reliability of the sample. Samples will be taken from all cardinal directions on each lake.

3.2.2 Temperature

"A laboratory thermometer is used for temperature analysis. The thermometer is left in the water long enough to get a constant and steady reading, and the measured temperature is expressed to the nearest degree or less depending on the thermometer's accuracy" (AWWA Staff. 2010).
The Temperature of the lake will be measured on the day to enable a potential connection to appear and an explanation to why the tested results have occurred. Temperature readings must be taken on-site, either directly from the water or from samples immediately after collection. Immediate readings are necessary because the water temperature will begin to change once the sample is taken. This may influence later testing on other variable properties.
This will be measured twice at each site to improve the validity and reliability of the sample. Samples will be taken from all cardinal directions on each lake. Also two reading will be taken to improve validity and reliability of the result.

3.2.3DissolvedOxygen

The electrode method and the modified Winkler method (also called the iodometric method) is a preferred for dissolved oxygen measurements. Due to the electrode method not being as sensitive to interferences as is the modified Winkler test, it is excellent for analyzing dissolved oxygen in polluted waters, highly coloured waters, and strong waste effluents. The importance for testing is due to the reflection on the efficiency supply of dissolved oxygen for the fish welfare at the fishery.

This can have an influence on the growth and development of the fish on the fishery.
This element will be tested on the day of sampling using an Oximeter. This will be measured twice at each site to improve the validity and reliability of the sample. Samples will be taken from all cardinal directions on each lake. The instrument will be inserted into the surface layer of the lake, which then will be held until the Oximeter came to a steady halt. This process took approximately 2-3 minutes.

3.2.4 Organic matter

To test for organic matter a sample from each lake was used as a pilot test to determine any presence of organic matter. If organic matter failed to be detected, then the rest of the sample will be not tested as the presence is very uncommon. A DRB 200 reactor was used to heat up the water sample containing the COD digestion reagent. Using a pipette, 2.00ml of sample was mixed with the vial. This was thoroughly mixed and shaken, then left for 2 hours in the pre heated DRB reactor at a temperature of 150^{o}c. the presence of organic matter is indicated by a change in colour of the substance to a green colour from a yellow. A standard sample was used to standardise the colorimeter which was then compared to a sample taken from the lake. The methods used was extracted and replicated from (Jirka et al 2008) from analytical chemistry.

3.2.5 Total chlorine, sulphate and nitrate

25 µL (microliters) was injected manually into an ion chromatography Dionex ICS-2000 machine . This was used to detect phosphorus, nitrate, and sulphur. This was left to be processed and analysed for 8mins 30 seconds. The data was then processed and printed onto a chart which can then be processed to show the full content of the testing parameters.

Chapter 4: Results

The resulted were collected on the day and in laboratories. The graph presented were processed through Microsoft office excel then used in Minitab 15 to display the basic statistics. This was used to calculate the averages an present the graphs.

4.1 pH

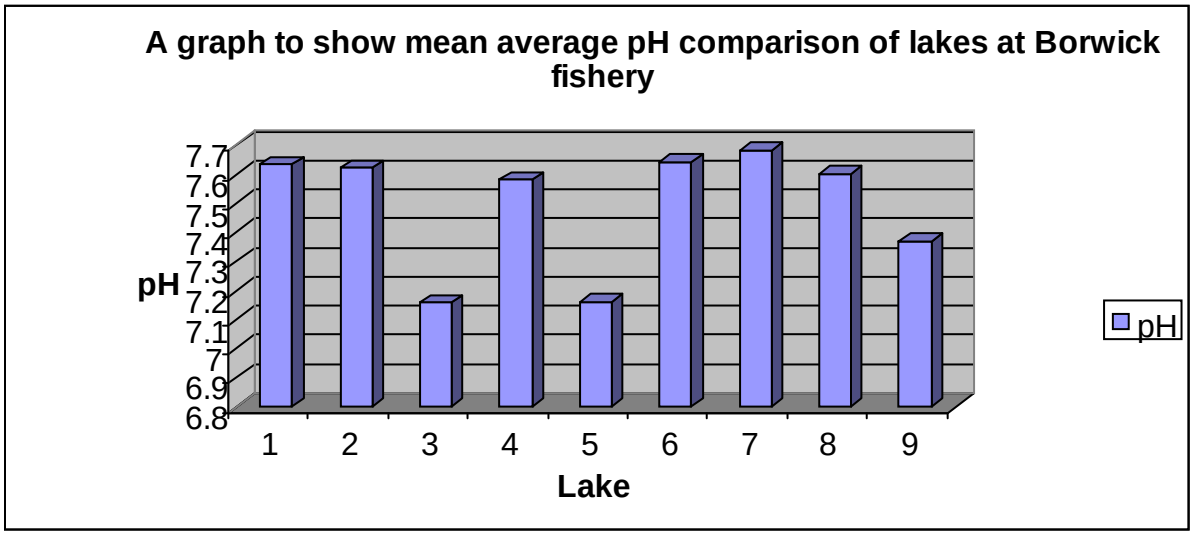


Figure 8: mean average pH of Borwick fishery lakes.

As can be seen in Figure 8 ph levels vary very slightly throughout the lakes with the minimum value 7.157 in Lake 3 and the maximum value of 7.68 (see table 3). On reference to Fisher (1992) the conditions shown over the lakes are optimum for most organisms and do not pose any threat to water quality and the species.

Table 2 – shows the effects pH has on the aquatic species

ph	*Effects on aquatic species*
3.0-3.5	Unlikely that fish can survive for more than a few hours in this range although some plant and invertebrates can be found at pH levels this low.
3.5-4.0	Known to be lethal to all salmonids
4.0-4.5	All fish, most frogs and insects are not present
4.5-5.0	Mayfly and many other insect species are not found. Most fish eggs will not hatch.
5.0-5.5	Bottom-dwelling decomposing bacteria begin to die off. Leaf litter and dead plant and animal materials begin to accumulate. Plankton begin to disappear
5.5-6.5	Freshwater shrimp are not present
6.5-8.5	Optimal for most organisms.
8.5-9.0	Unlikely to be harmful to fish, but indirect effects from chemical changes in the water may occur.
9.0-10.5	Harmful to perch and salmonids if prolonged exposure
10.5-11.0	Prolonged exposure is lethal to carp and perch.
11.0-11.5	Lethal to all species of fish.

This information is taken in part from the LaMotte Company's, The Monitor's Handbook, 1992. (Fisher, 1992)

4.2 Temperature

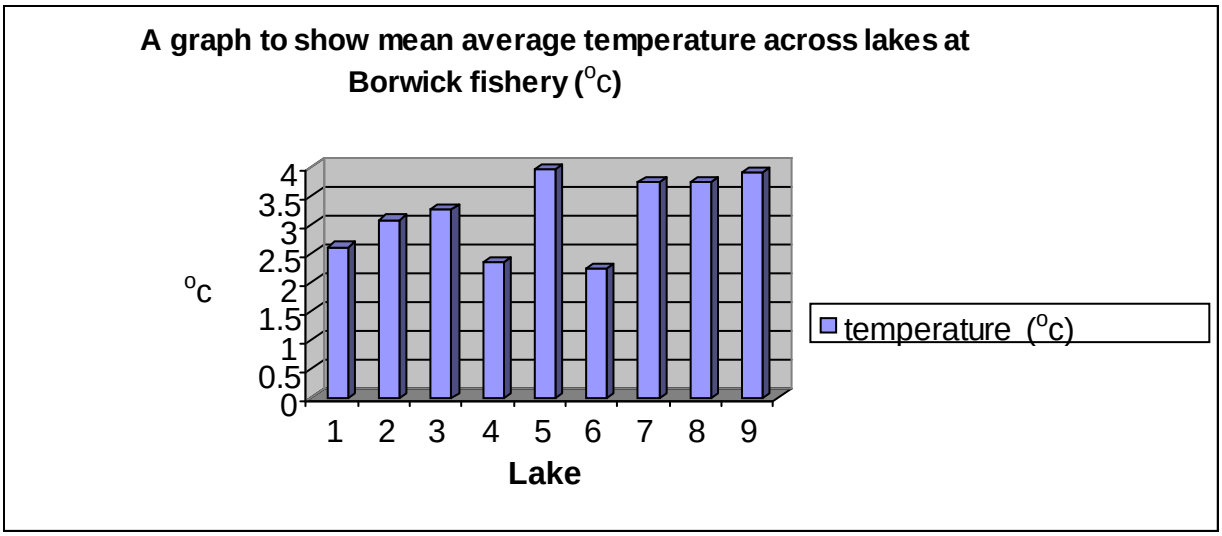


Figure 9: mean average temperature of Borwick fishery lakes

Figure 9 describes the lakes temperature for February. Some of the lakes did have ice on the surface which indicates how cold the day was on sampling. The variation could be due to areas of the complex left were the sun may have not reached causing the slight decrease in temperature. A maximum temperature reading was 3.96^{o}c and minimum 2.23 ^{o}c.

4.3DissolvedOxygen

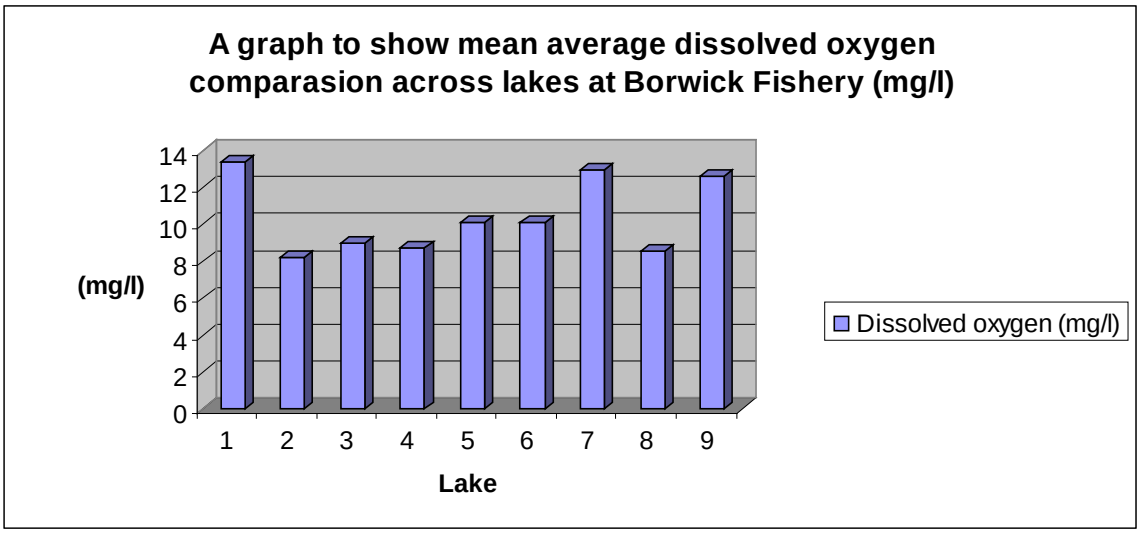


Figure 10: Mean average dissolved oxygen of Borwick Fishery lakes.

Figure 10 shows little variation in mean average dissolved oxygen. The highest reading coming from Lake 1 which receives the first phase of input from a stream. However Lake 7 doesn't and is a still water, therefore there is no relationship between still water and replenished lake.

Laboratory results:

4.4 Nitrates, chlorine, sulphate.

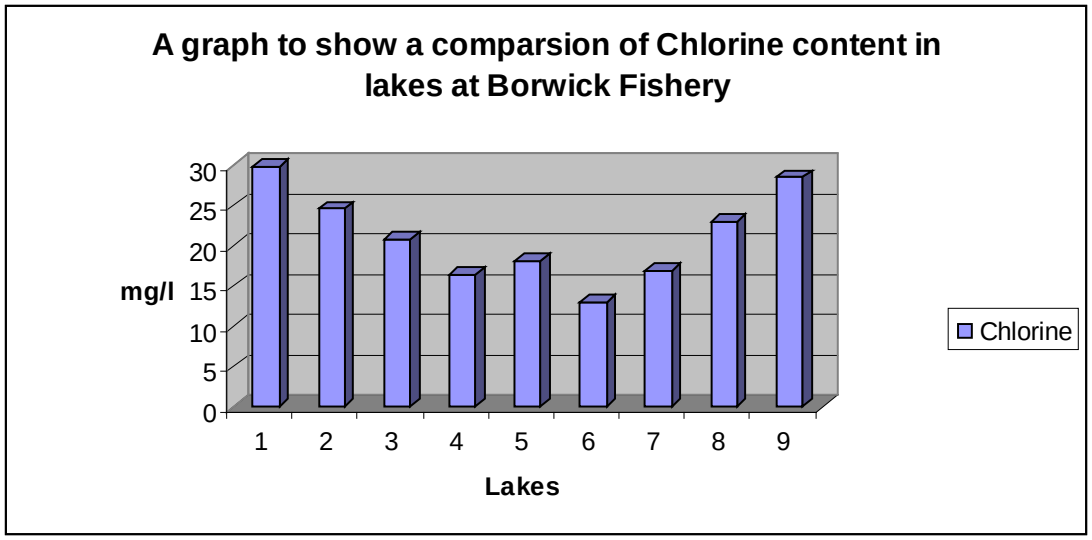


Figure 11: mean average chlorine content of Borwick fishery lakes.

Figure 11 shows that Chorine content was slightly varied but on a small scale. There is no relationship or any anomalies.

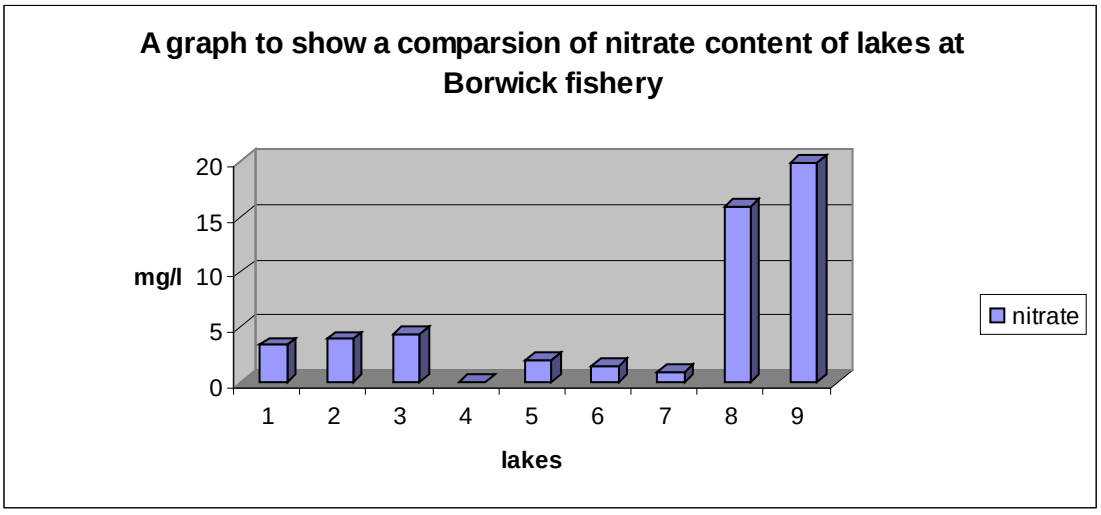


Figure 12: mean average nitrate content of Borwick fishery lakes

Nitrate levels show the largest difference in water parameter analysis of the investigation from Lake 4 being the smallest containing zero trace of nitrate; however lakes 8 and 9 contain a much higher concentrate of nitrate. None of the levels exceed limits referred by unites utilities and WFD UK TAG.

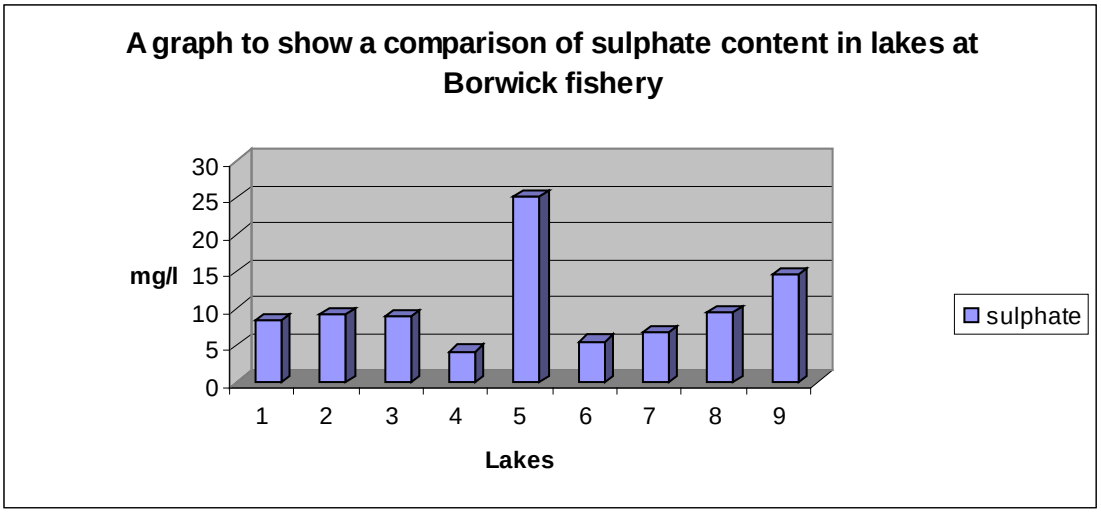


Figure 13: Mean average Sulphate content of Borwick Fishery lakes

Figure 13 shows a high amount compare to other lakes of sulphate but in comparison to water quality standards, the quality is safe and good.

The lowest figures were found in lake 4 which is the smallest lake on the complex with the least stock. Refer to table3 for specific average.

4.5 Organic matter & phosphates.

During the Laboratory experiments, phosphate and organic matter was investigated within a sample from each lake. This proved to be insignificant therefore the investigation into organic matter and phosphates was not continued due to the absence of both elements.

4.6 Averages

Table 3 - Table to show Mean averages for water properties at Borwick Fishery

lake	pH	temperature (^{o}c)	Dissolved oxygen (mg/l)	Chlorine (mg/l)	Nitrate (mg/l)	Sulphate (mg/l)
1	7.6333	2.608	13.4	29.953	3.42	8.295
2	7.6214	3.079	8.221	24.712	3.917	9.22
3	7.157	3.25	9.007	20.855	4.411	8.818
4	7.58	2.34	8.72	16.492	0	4.1824
5	7.16	3.96	10.09	18.194	2.019	25.143
6	7.64	2.23	10.09	13.062	1.513	5.5354
7	7.68	3.74	12.93	16.97	0.917	6.7302
8	7.6	3.74	8.53	23.131	15.985	9.5092
9	7.37	3.89	12.63	28.55	19.933	14.58

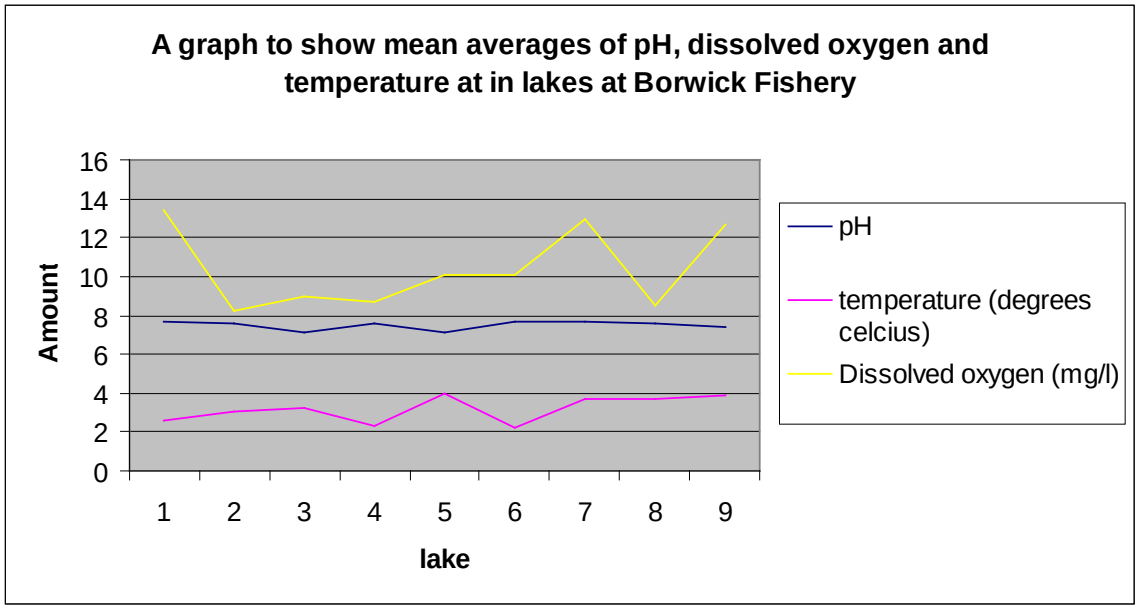


Figure 14: Mean temperature, pH and dissolved oxygen of Borwick fishing lakes.

Figure 13 and 14 shows the collection of data average for water parameters collected from various lakes at Borwick fisheries.

4.7 Anglers response survey

Refer to appendices 6

Chapter 5: Discussion

5.1 Study Limitations

Limitations of the detail of the related literature data and effects of specific bait types to water quality are difficult to establish due to the lack of available data. Also modern, newly established baits are developed constantly to give the angler an edge. Therefore the types and concentrations are continually varying for the interest in business and to give the angler a better chance of a catch. To look at more commonly used and heavily introduced baits would give a good idea of specific toxins, material and effects of decomposed baits in water.
Due to the format of the angler survey, feedback was inaccurate, therefore only allowing averages to represent baiting amounts.

Specific figures would allow for exact amounts to be established and referred.

Due to the samples being taken during only the winter month of January, the water of all the lakes was below 5^{o}c. Some of the lakes has partial bit of ice on the surface, therefore ice cover may have had an influence of dissolved oxygen (refer to 2.8.2. “If the ice cover lasts for a long time, the dissolved oxygen concentration can fall low enough to cause fish mortality (Environment Agency. 2008)”. Therefore to conduct the study during a period of no ice cover may have improved the apparent water quality.

5.2 Future Work

Further work into bait effect would be done through working out the nutritional value of each type of boilie used especially very popular brands, and the affects of particles on sediment quality, for pond weed growth. This may have an impact on dissolved oxygen potential.

For future investigations, to include a similar aims and objective to investigate effect of bait on water quality but to conduct the experiment during an annual period were other altering environmental factors can be taken into consideration.

This will provide an excellent comparison to a busy period were bait is applied heavily to a period were baiting is reduced. The environmental factors such as increase temperature will stimulate feeding activity and therefore baiting may have a different impact on the lakes water quality.

5.3 Study Site

The Sample collection was done only by surface collection; this was by collecting samples and taking measurement from within the top 10cm of the lake. To improve the representable sample for the whole lake a full surface to lake bed water column analysis should be carried out. This will enable any dense organic matter lying by the bed of the lake to have some significance on the results collected. This may influence the overall water quality as most of the organic matter concentration is at the bed of the lake and the process of it decomposing occurs from the bed. A submersion pump would be used to collect the samples from deep water.

Additional improvements would be to conduct a deep water analysis to justify any changes to the pH, dissolved oxygen and temperature as these factors may influence the water quality and the environment at the bottom of the lake.

A physical survey of the lakes would also help improve the knowledge of the stock density and to monitor the water replenishment of the lakes. This will be done by conducting a fully detailed topography map drawn of the lake bed using an echo sounder. This will enable structures to be located and the volume could then be calculated. Using a stream flow meter a discharge rate could be calculated to establish the input and output of the lakes water movement.

A netting collection would allow an accurate count of the current fish stock and therefore enable to management to establish their current welfare for the species and promote any additional improvements which may need introducing e.g. bait rule, oxygenation pump.

5.4 Water quality parameters

5.4.1 Temperature

Figure 9 shows a standard temperature for the time of year. Ice cover may contribute to dissolved oxygen, however cold water does have the ability to absorb a higher level of dissolved oxygen. As shown in figure 9 the levels of dissolved oxygen show to be oxygen rich.

5.4.2 Dissolved Oxygen

From quality standards from (WFD UK TAG. 2008), (Refer to appendices 9) shows that all lakes at Borwick fishery are greater than 7mg/l which indicates the status of the lakes is oxygen rich. This provides a good environment for the species currently in the lakes. Reference to figure 14 shows that there is no relationship with other water parameters.

5.4.3 Nitrate

Figure 12 shows the finding of nitrate levels in the lakes at Borwick fishery. The expected results were that Lake 1 and 3 would suffer from larger nitrate levels as they are heavy used by match anglers with large qualities of bait, however as results have shown. The lower concentrations have sources from these lakes. Therefore this shows that the significance of bait on the water quality is insignificant.

Honesty from an open response survey is issue as anglers tend to keep ideas and tactics secret to help with an edge over angling. This may of influence feedback which can alter calculations given for bait application.

On reference to the angler response survey, findings show that a significant amount of bait is introduced on an annual period on average per angler, however relating to borwick fishery, anglers bait is not detrimental to water quality.

5.4.4 Conclusions

Nitrate levels were higher in lakes 8 and 9 which are some of the smaller lakes which do not receive any replenishment through inlets. Also they contain low stock, however with Lake 4 being the smallest it did not show any comparison. The water in Lake 9 is exceptionally clearer than the rest of the lakes. This study doesn't show any relationships with any of the investigated parameters. However it does show there is variation n the unexpected results, therefore some signs of importance have been shown, therefore further investigation would be advised to determine reasoning for such variation especially for nitrate level.

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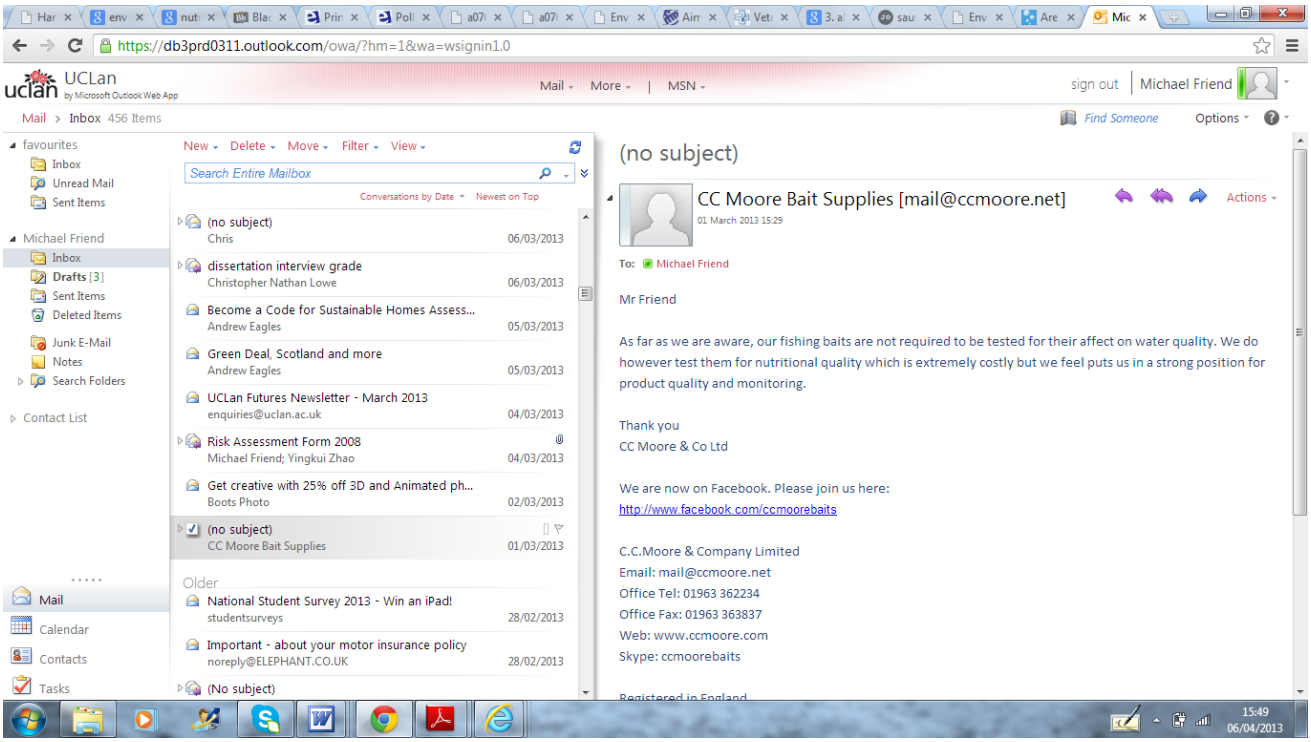
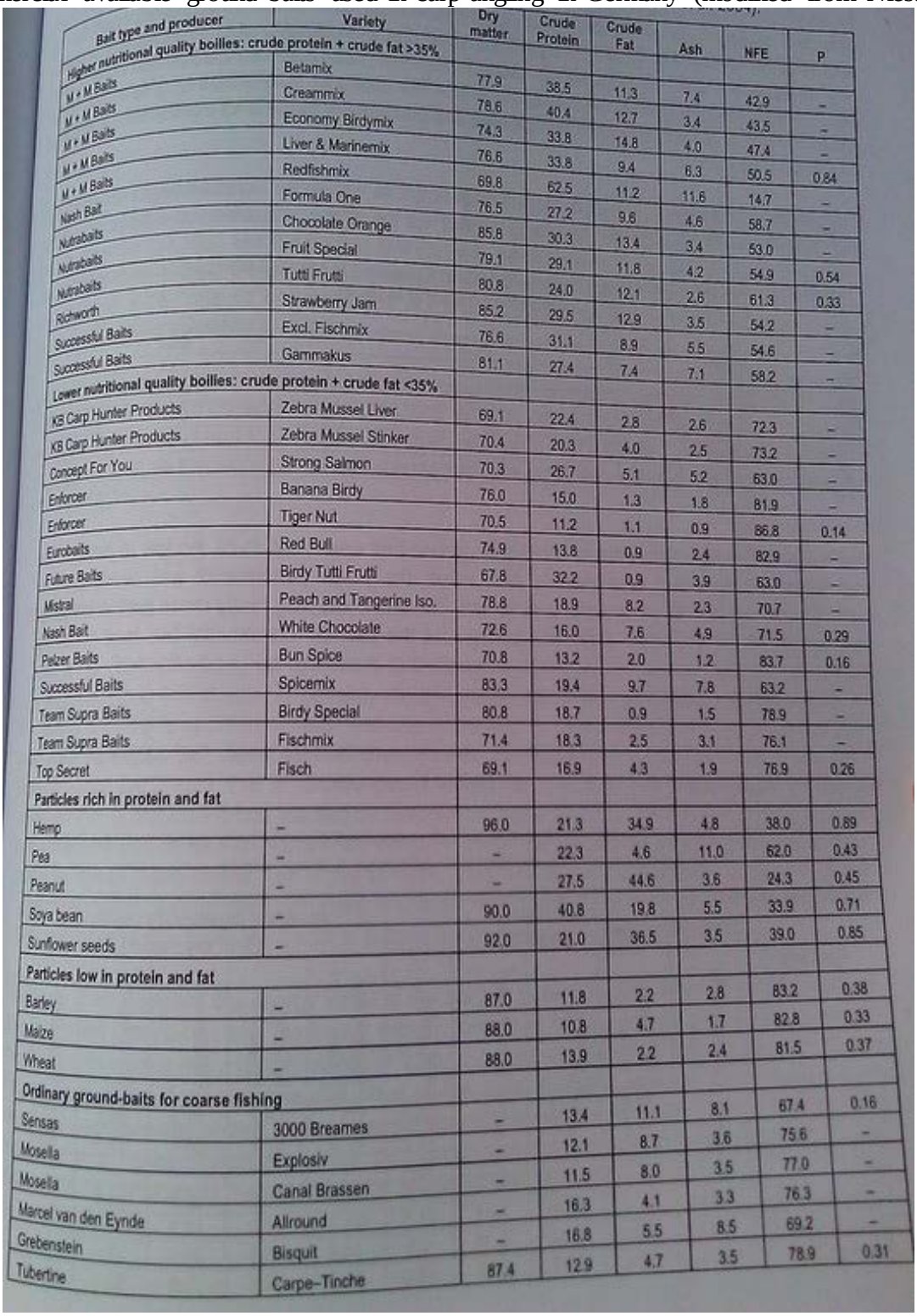
Appendices 1



Appendices 2

Table extracted from "Carp fishing science".

A table to show chemical composition (% of dry matter) and total phosphorus (P) content of a range of commercial available ground-baits used in carp angling in Germany (modified from Niesar et al. 2004).



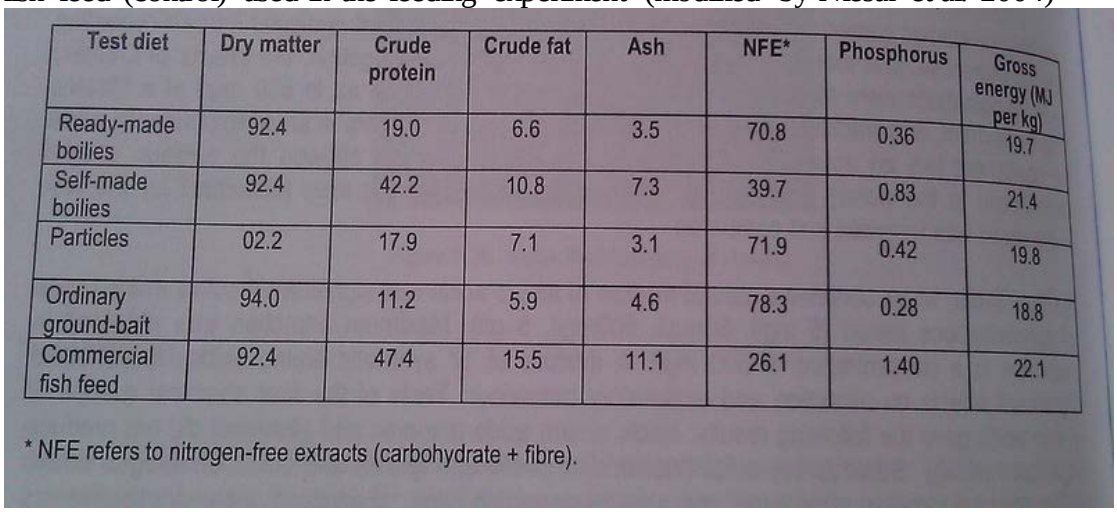
Bait type and producer	Variety	Dry matter	Crude Protein	Crude Fat	Ash	NFE	P
Higher nutritional quality boilies: crude protein + crude fat >35%							
M + M Baits	Betamix	77.9	38.5	11.3	7.4	42.9	–
M + M Baits	Creammix	78.6	40.4	12.7	3.4	43.5	–
M + M Baits	Economy Birdymix	74.3	33.8	14.8	4.0	47.4	–
M + M Baits	Liver & Marinemix	76.6	33.8	9.4	6.3	50.5	0.84
M + M Baits	Redfishmix	69.8	62.5	11.2	11.6	14.7	–
Nash Bait	Formula One	76.5	27.2	9.6	4.6	58.7	–
Nutrabaits	Chocolate Orange	85.8	30.3	13.4	3.4	53.0	–
Nutrabaits	Fruit Special	79.1	29.1	11.8	4.2	54.9	0.54
Nutrabaits	Tutti Frutti	80.8	24.0	12.1	2.6	61.3	0.33
Richworth	Strawberry Jam	85.2	29.5	12.9	3.5	54.2	–
Successful Baits	Excl. Fischmix	76.6	31.1	8.9	5.5	54.6	–
Successful Baits	Gammakus	81.1	27.4	7.4	7.1	58.2	–
Lower nutritional quality boilies: crude protein + crude fat <35%							
KB Carp Hunter Products	Zebra Mussel Liver	69.1	22.4	2.8	2.6	72.3	–
KB Carp Hunter Products	Zebra Mussel Stinker	70.4	20.3	4.0	2.5	73.2	–
Concept For You	Strong Salmon	70.3	26.7	5.1	5.2	63.0	–
Enforcer	Banana Birdy	76.0	15.0	1.3	1.8	81.9	–
Enforcer	Tiger Nut	70.5	11.2	1.1	0.9	86.8	0.14
Eurobaits	Red Bull	74.9	13.8	0.9	2.4	82.9	–
Future Baits	Birdy Tutti Frutti	67.8	32.2	0.9	3.9	63.0	–
Mistral	Peach and Tangerine Iso.	78.8	18.9	8.2	2.3	70.7	–
Nash Bait	White Chocolate	72.6	16.0	7.6	4.9	71.5	0.29
Pelzer Baits	Bun Spice	70.8	13.2	2.0	1.2	83.7	0.16
Successful Baits	Spicemix	83.3	19.4	9.7	7.8	63.2	–
Team Supra Baits	Birdy Special	80.8	18.7	0.9	1.5	78.9	–
Team Supra Baits	Fischmix	71.4	18.3	2.5	3.1	76.1	–
Top Secret	Fisch	69.1	16.9	4.3	1.9	76.9	0.26
Particles rich in protein and fat							
Hemp	–	96.0	21.3	34.9	4.8	38.0	0.89
Pea	–	–	22.3	4.6	11.0	62.0	0.43
Peanut	–	–	27.5	44.6	3.6	24.3	0.45
Soya bean	–	90.0	40.8	19.8	5.5	33.9	0.71
Sunflower seeds	–	92.0	21.0	36.5	3.5	39.0	0.85
Particles low in protein and fat							
Barley	–	87.0	11.8	2.2	2.8	83.2	0.38
Maize	–	88.0	10.8	4.7	1.7	82.8	0.33
Wheat	–	88.0	13.9	2.2	2.4	81.5	0.37
Ordinary ground-baits for coarse fishing							
Sensas	3000 Breames	–	13.4	11.1	8.1	67.4	0.16
Mosella	Explosiv	–	12.1	8.7	3.6	75.6	–
Mosella	Canal Brassen	–	11.5	8.0	3.5	77.0	–
Marcel van den Eynde	Allround	–	16.3	4.1	3.3	76.3	–
Grebenstein	Bisquit	–	16.8	5.5	8.5	69.2	–
Tubertine	Carpe-Tinche	87.4	12.9	4.7	3.5	78.9	0.31

(Wood, 2010)

Appendices 3

Table extracted from "Carp fishing science".

A table to show chemical composition (% dry matter) of five angling ground-baits test diets and commercial fish feed (control) used in the feeding experiment (modified by Niesar et al. 2004)



Test diet	Dry matter	Crude protein	Crude fat	Ash	NFE*	Phosphorus	Gross energy (MJ per kg)
Ready-made boilies	92.4	19.0	6.6	3.5	70.8	0.36	19.7
Self-made boilies	92.4	42.2	10.8	7.3	39.7	0.83	21.4
Particles	02.2	17.9	7.1	3.1	71.9	0.42	19.8
Ordinary ground-bait	94.0	11.2	5.9	4.6	78.3	0.28	18.8
Commercial fish feed	92.4	47.4	15.5	11.1	26.1	1.40	22.1

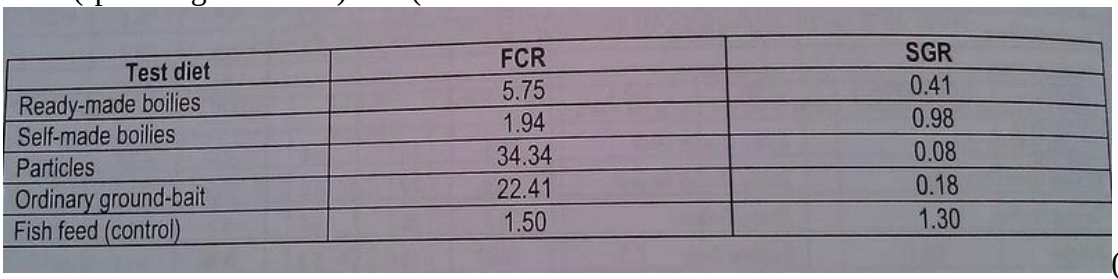
* NFE refers to nitrogen-free extracts (carbohydrate + fibre).

(Wood, 2010)

Appendices 4

Table extracted from "Carp fishing science".

A table to show the results of the feeding experiment expressed as mean FCR (food conversion ratio) and SGR (specific growth rate) and (standard deviation omitted modified from Niesar et al. 2004)



Test diet	FCR	SGR
Ready-made boilies	5.75	0.41
Self-made boilies	1.94	0.98
Particles	34.34	0.08
Ordinary ground-bait	22.41	0.18
Fish feed (control)	1.50	1.30

(Wood, 2010)

Appendices 5

Table extracted from "Carp fishing science"

A table to show chemical composition (%) of test diets as well as apparent digestibility for nutrients (%) (Standard deviation excluded, modified from Arlinghaus & Niesar, 2005)

Nutrients	Composition (% of dry matter)					Apparent digestibility coefficient (% of dry matter)				
	Ready-made boilies	Self-made boilies	Particles	Ground-bait	Fish pellet	Ready-made boilies	Self-made boilies	Particles	Ground-bait	Fish pellet
Crude protein	19.2	43.6	15.9	13.7	51.3	85.1	84.7	81.2	84.5	84.1
Crude lipid	6.8	11.4	9.1	6.9	13.3	84.2	83.2	84.7	83.3	85.9
Crude ash	3.9	8.0	3.3	5.1	13.4	-	-	-	-	-
NFE	70.1	37.1	71.8	74.4	21.1	78.9	60.6	69.1	81.6	52.2
Energy (kJ per g)	19.6	21.4	20.0	19.1	21.3	81.1	77.0	74.3	82.3	79.0
Total phosphorus	0.42	0.92	0.44	0.30	1.8	44.8	26.5	25.1	37.4	14.2
Organic matter	96.1	92.0	96.7	94.9	86.6	80.5	74.8	72.6	82.1	76.5

Appendices 6

Angler response survey

Survey taken from March 2nd to April 2nd

The Survey was advertised for completion on Facebook pages "Wyre Carp anglers" and "Northern Carp anglers".

1. What type of freshwater fishing do you do?

Create Chart | Download

	Response Percent	Response Count
Match	0.0%	0
Specimen	95.5%	21
General course (nothing specific)	9.1%	2
other	9.1%	2
Other (please specify) Show Responses		1
answered question		22
skipped question		2

2. How many days do you go carp fishing per year?

Create Chart | Download

	Response Percent	Response Count
0-10	0.0%	0
11-20	16.7%	4
21-30	12.5%	3
31-40	8.3%	2
41-50	8.3%	2
51-60	20.8%	5
61-70	4.2%	1
71-80	4.2%	1
81-90	8.3%	2
91-100	8.3%	2
101 or more	8.3%	2
answered question		24
skipped question		0

3. What bait do you usually use for fishing?

Create Chart | Download

	Response Percent	Response Count
Fishmeal boilie	54.2%	13
Milk protein boilie	50.0%	12
Bird food boile	16.7%	4
Particles	50.0%	12
Pellets	16.7%	4
Groundbaits	8.3%	2
Natural e.g worms, maggot etc	16.7%	4
none	0.0%	0
other	8.3%	2
	answered question	24
	skipped question	0

4. Please specify type and brand of bait

mainline, nash 23/3/2013 18:08	Northern mere- Impulse baits Choc banana nutmeal- Impulse baits 5/3/2013 22:53
Cc Moore 19/3/2013 20:04	Mainline cell 5/3/2013 22:36
mainline and dynamite 16/3/2013 12:43	Hemp and tiger nuts :) CC MORES fineist 5/3/2013 22:36
RG Bait and Feed 16/3/2013 9:40	mainline cell, mixed particles 5/3/2013 12:18
Magic munch and dna baits 15/3/2013 9:32	nash r manlin 4/3/2013 19:32
Nash, monster squid 15/3/2013 7:21	AA baits particle, impulse baits boilie 4/3/2013 19:28
Dont be so nosey 14/3/2013 23:04	mainline, nash and blakes bait 4/3/2013 17:07
Mainline grange 14/3/2013 15:25	Nash 4/3/2013 16:27
Halibut, milkmin proteins, scopex quid 7/3/2013 12:21	Frank Warwick Baits Relish 4/3/2013 15:56

A Baits NB2 6/3/2013 21:20	Nash boilie scopex squid liver 4/3/2013 15:25
Winter secret 6/3/2013 20:02	mainline new grange 4/3/2013 14:40
mainline cell supermoulting seed. 6/3/2013 11:27	Mainline and Nash boilies. I prepare my own particles

5. How much bait do you use on each session on average?

Create Chart Download

	Response Percent	Response Count
less than 1kg	20.8%	5
more than 1kg	29.2%	7
more than 2kg	**37.5%**	**9**
more than 5kg	12.5%	3
more than 10kg	4.2%	1
	answered question	**24**
	skipped question	**0**

6. How much bait do you use during the spring/summer on average?

Create Chart Download

	Response Percent	Response Count
less than 5kg	12.5%	3
more than 5kg	29.2%	7
more than 20kg	**45.8%**	**11**
more than 40kg	20.8%	5
more than 60kg	0.0%	0
	answered question	**24**
	skipped question	**0**

7. How much bait do you use during the autumn/winter on average? Create Chart Download

	Response Percent	Response Count
less than 5kg	50.0%	12
more than 5kg	25.0%	6
more than 20kg	16.7%	4
more than 40kg	8.3%	2
more than 60kg	0.0%	0
	answered question	24
	skipped question	0

8. What additives and other attractors do you use in your bait? Create Chart Download

	Response Percent	Response Count
Rock salt	52.4%	11
Essential oils	23.8%	5
liquid foods	85.7%	18
Powdered additives	19.0%	4
	please specify type and brand Show Responses	14
	answered question	21
	skipped question	3

Response to question 8:

korda goo, ect... 23/3/2013 18:08	rock salt, feedstim xp powder, molasis 6/3/2013 11:27
Cc Moore ll one bait glug 19/3/2013 20:04	feedstim 5/3/2013 22:53
mainline 16/3/2013 12:43	Mainline dips/flavours 5/3/2013 22:36
Nash Rock Salt 16/3/2013 9:40	cell activator, chilli 5/3/2013 12:18
None 14/3/2013 15:25	eney 4/3/2013 19:32
coconut milk supermarket 7/3/2013 12:21	Varied 4/3/2013 19:28
L0 30 6/3/2013 21:20	FWB tuna amino 7/3/2013 20:12

9. How much attractor and additive do you use per kilogram of bait? Download

Grams

	1g	more than 5g	more than 10g	more than 20g	more than 30g	40g or more	Response Count
Grams or Millilitres	**45.8% (11)**	29.2% (7)	12.5% (3)	4.2% (1)	4.2% (1)	4.2% (1)	24

millilitres

	1ml	more than 1ml	more than 2ml	more than 5ml	more than 10ml	more than 20ml	more than 30ml	more than 40ml	Response Count
Grams or Millilitres	16.7% (4)	4.2% (1)	8.3% (2)	**29.2% (7)**	16.7% (4)	12.5% (3)	8.3% (2)	4.2% (1)	24

Also please specify main attractor or additive used Show Responses 19

answered question 24

skipped question 0

Responses to question 9:

goo 23/3/2013 18:08	Cell or pineapple 5/3/2013 22:36
Mainline flavourings 19/3/2013 20:04	none 5/3/2013 22:36
mainline 16/3/2013 12:43	goo 4/3/2013 19:32
Salt 16/3/2013 9:40	Salmon oil, rock salt, tuna, multi stiim (all dependant) 4/3/2013 19:28
Glm 15/3/2013 7:21	cell hookbait enhancment, nash bollie dip 4/3/2013 17:07
Already mixed 14/3/2013 15:25	Fwb tuna amino 4/3/2013 15:56
rock salt 7/3/2013 12:21	Squid liver food dip 4/3/2013 15:25
L030/ ocean protein 6/3/2013 21:20	I just use them how they come from the freezer 4/3/2013 14:40
feedstim xp 6/3/2013 11:27	Korda goo 4/3/2013 14:32
Green lipped mussel 5/3/2013 22:53	

Appendices 7

Borwick lake Stock

Species/lake	1	2	3	4	5	6	7	8	9
Common carp	2500	150	1600	0	1200	10	20	0	25
Mirror carp	1500	150	2800	0	1500	10	40	50 (koi)	35
Grass carp	0	15	0	0	0	15	15	0	0
Ghost carp	30	5	200	15	10	20	30	40	10
crusien carp	0	0	0	0	0	0	0	0	30
Rudd	40-100	0	0	20	0	0	0	0	0
Golden rudd	0	0	0	20	0	0	0	0	0
tench	10-30	150	100	0	0	0	0	0	5
pike	10-40	200	200	0	30	0	0	0	5
bream	0	100	0	0	0	0	0	0	0
roach	200-300	5000+	1000	0	0	0	0	0	0
perch	100-150	1000+	100	0	0	0	0	0	0
barbel	0	0	0	0	0	40	20	0	0
chub	0	0	0	0	0	40	20	0	0
Wel's catfish	0	20	0	0	0	0	18	0	0
eel	0-30	3000+	200	0	0	0	10		10
ide	0	0	0	0	0	120	30	0	0
Golden orfe	0	0	0	0	0	40	40	30	0
Blue orfe	0	0	0	0	0	40	40	30	0
F1 carp	0	0	0	0	0	0	0	0	20

This data collection was discussed with the onsite baliff who has been in charge of the borwick fishery since the opening day in 2003.

I confirm that I (Jim White had an input to the data above

Signed:…….

Jim White (head bailiff) 2002-2012

Appendices 9: water quality standards

Status	Proposed boundary (all UK lakes)	
	mean in July – August (mg/l)	
	Salmonid	Cyprinid
High	9	8
Good	7	6
Moderate	4	4
Poor	1	1

From the Swedish Environment Protection Agency	
For units see the text	
Oxygen rich	≥ 7
Moderately rich	5
Moderately deficient	3
Oxygen deficient	1
Almost no oxygen	< 1

(WFD UK TAG. 2008)

Appendices 10:

Unitied utilities: Water quality standards

Nitrate	Nitrate occurs naturally in water. Increased concentrations in water sources can occur as a result of fertiliser use. Nitrate concentrations are reduced during water treatment	50 mg/l
Sulphate	Sulphate occurs naturally in all water sources. The concentrations normally found in water do not present any risk to health.	250 mg/l

(Unitied Utilities. 2013)