Mbona Private Nature Reserve
Trout Hatchery

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Hugh Murrell, Editor
Pierre Olivier, Technical

with a foreward by:
Dennis Dyer, Chairman

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Preface

This manual is a basic guide to the running of a successful practice of small-scale trout farming. It summarises all the technical information that is important to know for small-scale trout production.

This document was created using Leslie Lamport's document preparation system LaTeX[1]. The content for the first chapter of this manual was mostly copied from a document called *Small-scale rainbow trout farming* issued by the Food and Agriculture Organisation of the United Nations [2] which has been placed in the public domain at http://www.fao.org/docrep/015/i2125e/i2125e.pdf This **fao** document has a copyright notice that encourages reproduction and dissemination of the material it contains with a statement that non-commercial uses will be authorized free of charge on request.

In later chapters, this FAO document is augmented using the local knowledge of:

Dave Forsyth, Mbona Manager, 2016-Present

Guy Reen, Mbona Assistant Manager, 2018-Present

Gareth Powell, Mbona Conservation Officer, 2000-2018

Gavin Chin, retired Trout Hatchery manager.

Editing and oversight of this document was carried out by:

Dr. Dennis Dyer, Mbona fishing committee chairman, 2000-Present

Bernard McDonald, Local fisherman, historian and linguist.

The purpose of this manual is to guide the reader through the necessary technical information, and practical solutions to the day-to-day operation of a small-scale Rainbow Trout farm with particular emphasis on the infrastructure setup and operating procedures at the Mbona Hatcheries.

Foreward

Awesome Mbona! We, members of the Mbona Family, which extends over 50 years, have so much to be grateful and thankful for to a special few, headed up by Eric and Pat MacKenzie. What a profound vision they conceptualised, to build the paradise that we have all shared. Mbona has had a huge effect on our families and our children who have been able to free themselves of fear and many restrictions that have become a way of life in our country. It is my pleasure and privilege to capture for you the history of trout and fishing as an additional recreation available to us on Mbona.

It all started one sunny day in late 1973 as Eric MacKenzie was walking close by the Crystal stream accompanied by a friend Edward Austin. Eric asked if there were any signs of fish in the area, Edward?s response was to catch a grasshopper and toss it into the stream. Almost instantaneously there was a swirl on the surface and the grasshopper was history, yes history in the making of trout fishing available to us.

Such a simple beginning to a sport that has given so much joy to many. Dams were mapped and designed with details of location demarcated. Drummond and Michael MacKenzie were tasked with naming each dam, they came up with the names that have become so familiar to us over the years, each having a special place in the hearts of enthusiastic anglers.

They are: Crystal, Rainbow, Laughter, Amber, Pateric, Emerald, Deep Pool, Evergreen and Holbeck. The list was sent to Pat and Eric, who were most impressed with the names. Pat was puzzled by the name which she pronounced Paterric for a short time until the penny dropped and she and Eric are forever remembered by the special name of this dam.

Today, it is so easy to name the dams, choose where we would like to fish and go and enjoy an experience that includes a magnificent environment, peace and quiet, birds, buck and occasional greetings to other shareholders as they walk or ride the many routes offered in our paradise. What we do not appreciate is the mammoth task that was undertaken to create these facilities. Crystal has a dam wall that is over 200meters long, how much earth works was needed is mind boggling and the cost in today's standards would make it prohibitive to build. Each dam has been skilfully engineered and apart from Emerald, which has an irreparable leak, are functional all the year around.

Some facts about Mbona dams:

Crystal, 21 hectares, 52 acres Completed in December 1972.

Crystal is our largest dam. In the late 1976 a major rain storm occurred in and around Mbona. This resulted in a neighbouring dam above Evergreen, which had Bass in it, to overflow into Evergreen and to introduce Bass into its waters. It was decided to drain Evergreen which at that time was successful in getting rid of the Bass. Evergreen communicates with Crystal and the bass arrived and multiplied at a significant rate. The problem of the Bass in Crystal was the subject of much concern and debate. Draining of Crystal was not a consideration. After some time Bass were again seen in Evergreen. Today the consensus opinion within the Fishing Subcommittee is to rather create another facility for recreation so we have opened Crystal to a limited Bass fishing opportunity. Bass fishing is allowed with fixed spool reels and single hooked lures. Catch and keep is what is encouraged. This in fact has been a great boon to younger children, who now spend hours trying to catch bass and Bluegill which have also proliferated in Crystal. There have been no complaints received and in fact there have been a number of Bass caught between 3.5 and 5kg. Trout are caught in Crystal and one?s impression is that these numbers are on the increase which we believe is due to a more aggressive stocking program. Over the years there has been reference to concerns about reed encroachment in the southern end or inflow area between Laughter and Crystal. This is being discussed again, although it is a daunting task to dredge the area because silting up is the problem with the reeds flourishing in the enriched shallow water. There are discussions re creating a small wetland between Laughter and Crystal.

Evergreen, 10 acres. Completed 1975.

Referred to above is the Bass problem in Evergreen and the floods in 1976. As noted Evergreen was drained and Bass exterminated, this was successfully done with people being asked to get rid of Bass by taking them home and trout were netted and transferred to Crystal. Bass were back in Evergreen shortly after damage to the communication channel between Evergreen and Crystal had occurred. This was thought to be due to the fact that the Bass were able to swim up the damaged runway. Evergreen also had a problem with weed overgrowth and Grass Carp were introduced with good effect. There are no records relating to this, however, despite the fact that Grass Carp are supposed to concentrate their efforts on the periphery, the end result was positive. Of interest is that at one stage off Ernie?s walk, that circumvents Evergreen, a viewing platform was constructed 5 meters above the water from which one could watch the fish swimming in the shallows. Grass Carp are now classed as exotic and it is virtually impossible to get hold of. Evergreen is a popular dam with floating tubes allowed, there are reports of excellent catches including some 3.5 kg bass. For some years it was a catch and release dam, the fishing Committee at that time expressed their satisfaction with the outcome of this, however, other fishermen had had years of happy catching and preparing for the table and the decision to release has been recently lifted. If only our returns were more reliable, we could make a better than guessing as to the results.

Amber, 1 acre and Pateric, 2.5 acres, were both completed in 1973

These two dams have regular reports of good catches. The recent blockage of the outlet from Pateric to Amber has been cleared and Amber has been overflowing for a good part of the year. Pateric has had leaks repaired on a number of occasions, however, every winter during the dry season, there is a significant drop in its level. A definite observation is that this dam is one of the most productive for catching trout and there is speculation that the nutrients available are due to enhanced growth of foliage during the low level periods. Over the years Amber has produced a number of surprises of Rainbows over 2.5kg and a lone Brown of 2.2kg, this fish was returned to the water in good condition.

Rainbow: 3.2 acres, Laughter 4.2 acres, Deep Pool .75 acre and Holbeck 0.25 were all completed before the end of 1975.

Rainbow has also had its catch and release restriction lifted, it is a very popular productive dam with a recent report of a 2.5kg Brown caught and released. Laughter has produced its share of excitement over the years. During the recent past there are no reports of Bass in this dam, although Bluegill are reported intermittently, however, 5 and 8 years ago there were Bass in Laughter. In both cases Laughter was drained and we have successfully rid them of bass. There are a number of hypotheses mooted to explain this as there is no source of water that could be blamed as the source of the contamination. This included the possibility of fertile eggs attaching to the legs of water birds whilst visiting Crystal and then being transferred to Laughter. Our thoughts were more directed to suspect some human mischief. Since the last drainage, we have had no reports of Bass. Each dam is unique and has a special attraction for a number of different fishermen. Both Holbeck and Deep Pool have been productive happy places for many of our shareholders. Holbeck is posing a problem with having silted up considerably. There are two camps, one wanting it to be left alone and the other hoping to dredge it and return it to its glory as a popular spot.

The Hatchery

The dams were eventually completed and we had the waters within which we could pursue our desire to enjoy fly fish for trout on Mbona. The next step was to tackle the project of locating a source for trout, this led to the need to get in expert advice and guidance. This required a well thought out plan taking into consideration all the unique elements pertinent to Mbona. It was obvious that this was not just going to be an occurrence. It was going to be a long process that needed conscientious dedicated people to drive and maintain it. It needed financing and the blessing of the Joint Board of Directors who would support it financially and allow access to the permanent staff. This management team needed to be replicated as time went on and as the Board changed new people were needed to get involved. Throughout our history, we have had these people, many of them giving significant input of time and expertise.

In December of 1973, the first joint board AGMeeting occurred. It was at this meeting that guidance from Terry Oatley was sought with respect to trout fishing at Mbona. Terry Oatley was a member of the Natal Parks Board and fortuitously was a shareholder at Mbona and this was one of his many contributions. It was concluded that the location of Mbona, its elevation and its Climate would at best leave us with a situation that was marginal in our quest for creating a successful sporting and recreational facility for any of our interested shareholders. The initial decision was to stock our dams with 10inch fish. This was thought to be the most viable size to allow for optimal survival against weather conditions, predators such as otters, fish eagles and cormorants, the numbers of trout stocked in each dam was carefully worked out according to the volume of water in each facility, this is still being used as a guide today. Using Terry?s contacts, the Natal Parks Board documented a plan for Mbona. It was soon realised that the transport of the larger fish became a major operation which was both expensive and risky with quite a high mortality rate. The decision was made to buy 3000 6-7inch trout which had been calculated as a reasonable amount to stock our dams and support the fishing demands.

This meant that a facility needed to be built as rearing tanks for the fingerlings to grow them to the ideal stocking size of about 10inches. The basic plan was drawn up and this plan has evolved over the years to our present adequate and efficient system. There is a gravitational water supply from Lake Crystal to the ponds, which has had to be modified over the years. Some of the points are worth mentioning. We have developed this supply over the past 15 years so that it retains its original gravitational principle but so that it is adequate, we have created a dual system. This fulfils two essential functions, an adequate supply, which is at an appropriate depth to access the lowest water temperature, without being at too much risk of clogging up with debris and secondly is to have an adequate back up system. The fact is that the supply has been interrupted at least twice in the past with devastating results of wiping out the whole stock in the ponds. We have a rotational system in place where the inlets to these water supplies are checked regularly as part of our maintenance program. The quality of the water is enhanced by passing it through our aeration tower, which has also been modified at regular intervals. The new system also gives us the choice of increasing our water flow through the system, which is needed in the hotter months. We therefore have a quality, reliable and self-powered system which will be described in detail in the chapters that follow.

Record Keeping

One of the most significant developments in the last 10 years is the weighing and counting of the trout at the various stages of their lives in the hatchery. The handling has been perfected as are the methods of moving them from the ponds into the transporting vehicle, which is fitted with a tank that is well aerated and can accommodate 200 10 inch fish. This has allowed us to stock our own dams and deliver to customers, fish that are not compromised and mostly don?t even need any resuscitating. This is in contrast to previous efforts that always had a mortality rate. We have ensured a process that allows us to accurately size the fish for customers and also for record purposes of what is stocked and where.

Record keeping of expenses has improved, accurate graphs on growth rate and feeding volumes is being more accurately developed and maintained which will allow us to continue improving our production and performance functionally and economically.

The age old problem of monitoring once the fish have left the hatchery continues unabated. From the beginning it was recognised the importance of outcomes of our efforts, fish returns, numbers of fishermen, the impact of catch and release initially and further down the line, the introduction of float-tubes and allowing them access now to Laughter as well as Crystal and Evergreen. Without this data, we will continue to make uneducated guesses rather than produce facts.

From the outset, fish returns have been notoriously poor. There have been a number of unsuccessful schemes, including sending a form with the monthly accounts to every shareholder. Apart from the new electronic accounts system introduced, this was not a success. Returns to the clubhouse, or the gate on leaving and now by email or on to the website are still poorly supported, we would appreciate any suggestions to add a catalyst to this process. The truth is, we are not able to assess the success of what we have done without appropriate data.

Predators

What has been shared is the development of the facility over the years to accommodate decisions made as part of the journey. To conclude this aspect, the original plan was well thought out and has not changed much, including the pitfalls to a perfect system. There have been a number of threats, apart from physical resource maintenance and development. The fish are vulnerable to predators even in the confines of the hatchery, shade cloth and nets are there to protect from birds, an electrified fence has been the most effective deterrent against otters, although the fence itself still needs attention to its strength. We still have a real, although mysterious reduction in numbers of fish from the raceway. It is our suspicion that there may be a human element to this phenomenon and the next step is to monitor by camera more frequently.

Acknowledgements

As previously mentioned, the process was made possible by enthusiastic and interested individuals from conception to where we are today. Sharing with those involved, the success is always affected by the attitude of the joint board, the availability of funds, the management and the support of the trout and fishing committee. Over the years, we have been blessed by having these people to contribute to what we have today. A common thread commenting on the support and expertise of different managers every step of the way is evident and the present situation is better than any of us have experienced previously.

What a long exciting and productive journey this has been spanning fifty years. At the risk of not mentioning all the contributors to the epic, people who have been involved and made contributions are included as we summarise the progress over the years. Kindly accept apologies for any omissions.

To Eric and Pat for their vision and the creation of the vast and superb infrastructure, including the dams, their beauty and their accessibility, the MacKenzie clan as well are the founders and to whom we will all be eternally enriched and grateful.

Over the years we need to acknowledge the invaluable support and contribution made by the respective Joint Board members. The services of managers, without exception, has been remarkable and appreciated by the trout committees. The original plan was researched by Ted Oatley, who used his contacts with the Natal Parks Board to produce a detailed assessment of the situation and then put together

a plan of action. The basics of that plan are still being used today. We are in a process and this plan has been modified and developed to suit the needs of each successive committee.

The initial phase was to create the hatchery with the water supply from Crystal. The aerator was built, the three ponds created which were originally made of corrugated iron and the raceway. Garth Hatton was the first trout committee chairman. His services extended over the next 15 years, he has made a fantastic contribution over these years and was faced with many problems and also contributed to modifying the original plans to improve, not only the physical resources, but also the quality of the actual fishing.

During his time he faced many challenges which included making the hatchery safer from predators, draining of Evergreen to get rid of the bass, increasing the capacity of the ponds as well as converting the ponds to brick and mortar, he rebuilt the aeration tower and produced a number of comprehensive reports which related to quality of the water in the dams, fishing rules and advice on stocking. He was well supported by the board and particularly the managers.

Chairmen that followed were among others, Richard Erasmus and Ken Cohen who was followed by first Nick and then Charles Shave who together served for more than 10 years up until 2005. All these men made every effort to maintain and improve conditions, each one has faced challenges including some disasters where large numbers of fish died. This was due to water supply failure, inclement weather conditions, otter invasions and even a few incidents of poaching. They were party to the decision to create catch and release restrictions in Rainbow and Evergreen, they retained the sourcing, purchasing and growing the trout, they were responsible for maintaining the hatchery and for seeing that the dams were properly stocked. They were continually devoted to improving the fishing as a quality recreation.

During the years, we have had expert advice and input from well known and respected trout fundies particularly Rob Karssing and Jake Alletson are acknowledged and thanked.

The present committee has been functional since 2005. They have faced all the problems of their predecessors including episodes of losses due to water blockages, maintenance of the hatchery and trying in vain to get better records of number of fishermen and their catches. An important decision was taken to buy trout eggs instead of buying fingerlings of 6 inches. This decision was taken in 2012 and it has changed our process considerably and has allowed us to increase our numbers substantially. The resources have been documented earlier in this article as well as the process of rearing the trout through the various phases of development. The venture has been successful. We researched the process carefully and introduced scientific measures to measure temperature and oxygen content in the water accurately.

We have improved the management of moving of trout and have got this down to a fine art. There has also been an improvement in all record keeping both monitoring growth and general running costs. The driving principle was to improve the fishing at Mbona primarily and secondly to sell fish of 30cms in size to neighbouring facilities. This has proved quite successful and we will continue to have frequent meetings, hoping to improve all of our ventures. We also took the decision to open Crystal to limited bass fishing as previously mentioned and to allow floating tubes on Laughter. The latter decision resulted in an exciting afternoon?s fishing producing over 20 nice sized fish. The committee is very active and meets regularly and would welcome new members, especially some younger enthusiasts.

There are a number of issues that we would really appreciate help with and suggestions one of these is record keeping, despite the website facility, still leaves much to be desired. This is so important for us to know whether we are being successful or not and will guide in future plans. The Easter and Christmas fishing competitions are not as well supported as we would like. We are planning to supply trout to shareholders by an ordering system and would like to hear whether there is enough of a demand for them.

In conclusion, all previous contributors to this facility are to be saluted and thanked. The present committee has been active since 2005. It has been a great journey together of enthusiastic members doing research and development. This has been a shared experience. Each member has brought to the committee something special and all have been willing to attend meetings and especially to carry out tasks that they have undertaken to do.

Jacko Jackson brought a wealth of scientific know how and expertise,

Pierre Olivier has been a tower of strength with his practical experience and unrelenting service of maintenance, development and even deliveries is invaluable.

Bernard McDonald always willing, contributed much knowledge and was always prepared to be hands on.

Pete Barbour was our marketer and has established a nice clientele which has now been taken over by Ronnie Ritchie who is already producing results.

It has been my privilege to work with this fine group of people. It must be said that Gareth Powell and Dave Forsyth have given us every support and assistance whenever we have asked and have made their contributions to what we have.

We thank the boards over the years for their support and guidance. We believe that Mbona can be proud of our facility. We have as a first class entity that is functional and productive and that will continue to bring to shareholders a treasured resource. Any shareholders are welcome to come and see what we have in the hatchery and to be further informed of the process. We need some of our younger members to join us and take over.

We wish you great moments as you enjoy the unique and precious delights of Mbona and that you will at times be rewarded with a Rainbow trout of note.

Figure 1: Fly Fishing on Rainbow dam.

Dennis Dyer

Fishing Committee Chairman

Chapter 1

Introducing Rainbow Trout

1.1 Trout Species

There are 206 species in the family of *Salmonidae*. Salmonids (salmon, trout, char and whitefish) are found in practically all continents, partly because they are indigenous there and partly because they have been introduced.

Among trout, brook trout, brown trout, lake trout, sea trout and rainbow trout are the most widely known species.

1.1.1 Brown Trout

Brown Trout are native to Europe and West Asia. An important market and sport fish, it has been introduced to many different countries all over the world, see figure 1.1

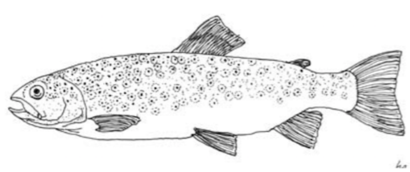

Figure 1.1: Brown Trout.

According to their habitat, taxonomists distinguish three forms of Brown Trout. They are the actual brown trout *Salmo trutta m. fario*, the lake trout *Salmo trutta m. lacustris* and sea trout *Salmo trutta m. trutta*,

1.1.2 Brook Trout

Brook Trout, together with Lake Trout *Salvelinus namaycush*, belongs to the *char* subgroup of salmonids, which distinguishes it from trout and salmon, see figure 1.2

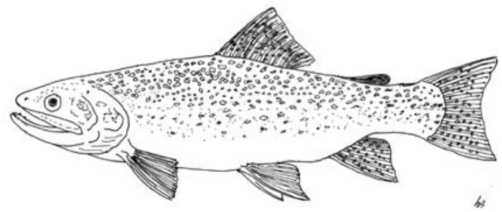

Figure 1.2: Brook Trout.

The Brook Trout is one of the most well-known sport fish and is native to the northeast of the United States of America and the east region of Canada. It has been introduced to many countries of South America, Oceania and Asia, and to practically all of the countries of Europe and the former Soviet Union.

1.1.3 Rainbow Trout

Rainbow Trout, *Oncorhynchus mykiss*, is a highly commercial sport and market fish. A normal adult rainbow trout weighs about 2-3 kg, while its maximum size, weight and age are 120 cm total length (TL), 25.4 kg and 11 years, respectively. Rainbow Trout live in the upper, cold water sections of rivers and seas, see figure 1.3

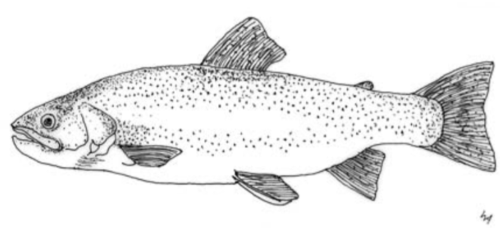

Figure 1.3: Rainbow Trout.

As in the case of other trout, the habitat and food of rainbow trout determine both their actual colour and shape. The Rainbow Trout has many local strains, which have developed in the different river systems. Out of these, numerous improved commercial strains have been bred. The widely cultured commercial strains have been improved from those original rainbow trout populations that possessed advantageous qualities, such as hardiness, fast growth, resistance to diseases and reliable reproduction under farm conditions.

1.2 Rainbow Trout in the Wild

In the wild, there are rainbow trout populations that spawn in autumn and there are other populations that spawn in spring. From these populations, two different commercial strains have been bred. Their qualities are similar, only their spawning seasons differ from each other. This enables the production capacities of a rainbow trout farm to be increased.

1.2.1 Habitat

There are many habitat factors that basically influence the growth of rainbow trout. These include basic water qualities and the abundance of natural food.

A Rainbow trout is a typical cold water fish see the optimal temperature ranges in figure 1.4

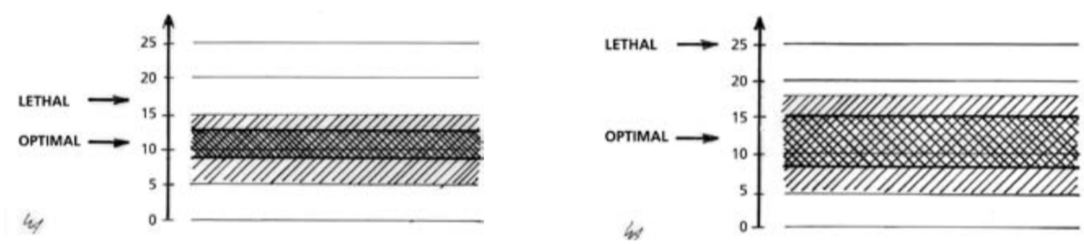

Figure 1.4: Optimal Temperature ranges for Rainbow Trout at different development stages: **left:** during the incubation of eggs and sac fry, **right:** during the growth.

Apart from temperature the other factors that influence growth are:

Clear water: Keen eyesight is crucial for efficient feeding.

Dissolved oxygen: Water should sustain dissolved oxygen (DO) in high concentrations, in order to ensure smooth respiration.

Clean water: Water should be free of harmful solid and gaseous waste materials produced during metabolism and respiration.

1.2.2 Natural food

The natural food of rainbow trout depends on the age and size of fish, on the size of food item and on the habitat occupied. Rainbow trout are aggressive and greedy in feeding. They are opportunistic feeders that grab and eat almost anything. Figure 1.5 summarises the most frequent natural food items of rainbow trout.

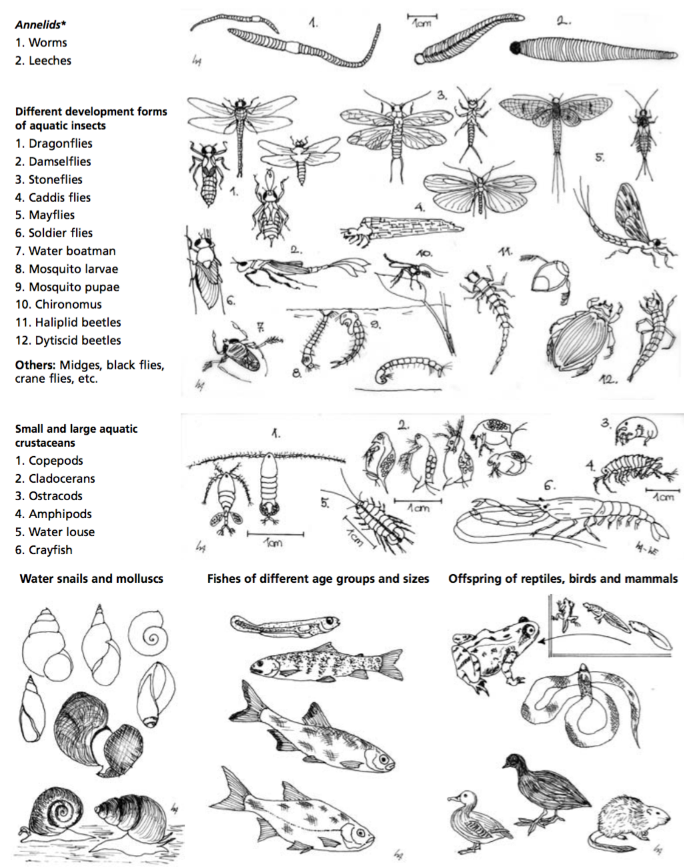

Figure 1.5: Natural Food Sources for Rainbow Trout.

Terrestrial insects are also consumed when they fall into the water. These insects are adult beetles *Coleoptera*, flies *Diptera*, ants *Formicidae* and larvae of moths and butterflies, *Lepidoptera*.

1.2.3 Life Cycle and Development Phases

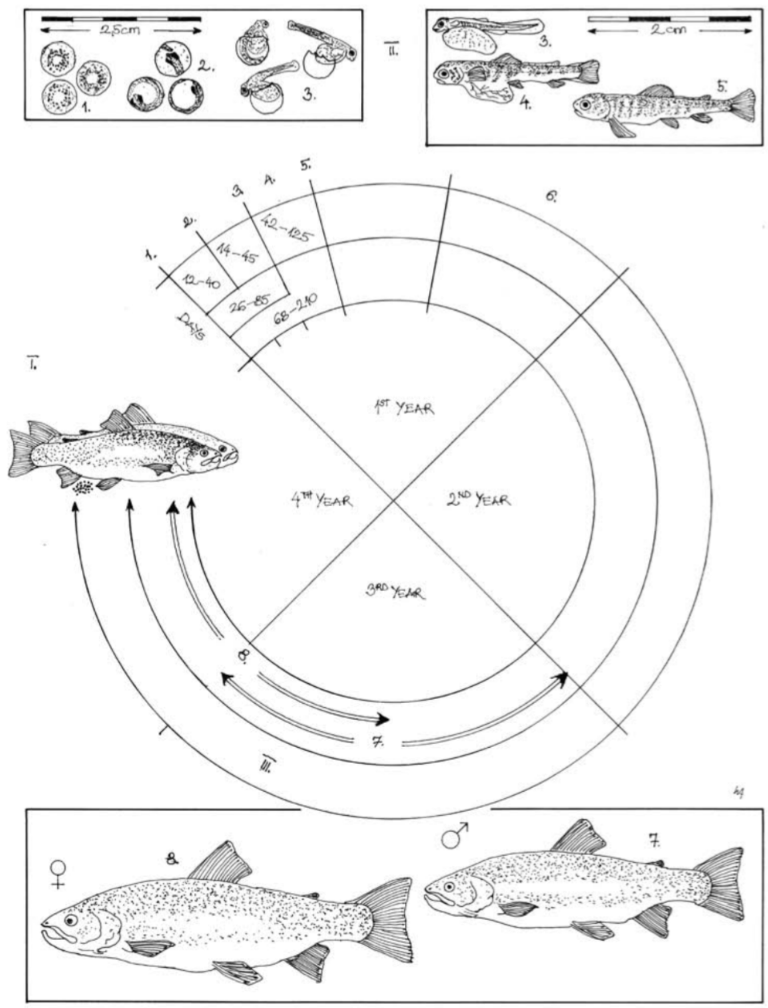

Figure 1.6: Rainbow Trout Development Stages: 1. Fertilized eggs. 2. Eyed egg. 3. Hatched sac fry. 4. Swim-up fry. 5. Fry. 6. One-summer fish. 7. Sexually mature male and 8. female ready to spawn

Figure 1.6 shows the life cycle and development stages for rainbow trout in the wild. The actual start and duration of the different development phases depend on the water temperature, the genotype as well as the quantity and quality of available natural fish food.

1.2.4 Body Parts

Figure 1.7 and 1.8 shows the body parts of a rainbow trout and the standard length measurements.

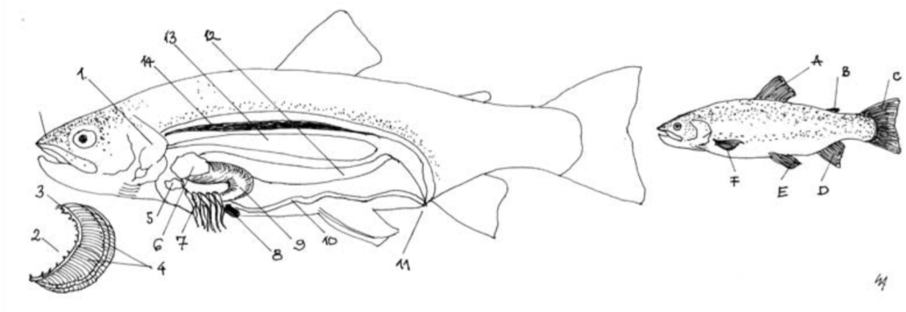

Figure 1.7: Rainbow Trout Body Parts: 1. Opercula (gill cover). 2. Gill raker. 3. Gill arch. 4. Gill filaments. 5. Heart. 6. Liver. 7. Pyloric caecae and pancreas. 8. Spleen. 9. Stomach. 10. Intestine. 11. Anus and urogenital papilla. 12. Gonad. 13. Swimming bladder. 14. Kidney. A. Dorsal fin. B. Adipose fin. C. Caudal fin. D. Anal fin. E. Pelvic fin. F. Pectoral fin.

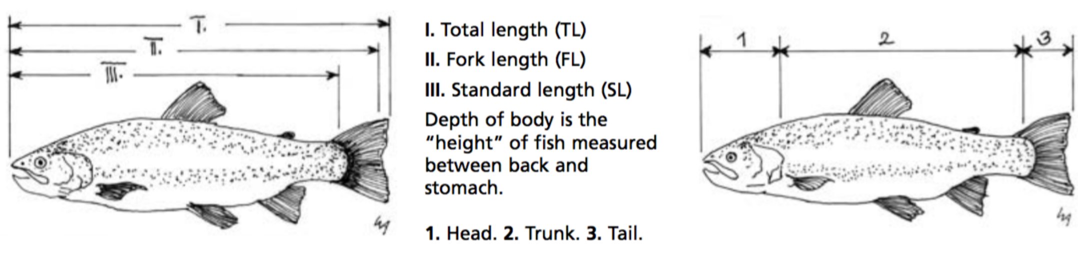

Figure 1.8: Rainbow Trout Standard Length Measurements.

1.2.5 Length versus Weight

Figure 1.9 shows the correlation between its total length and weight.

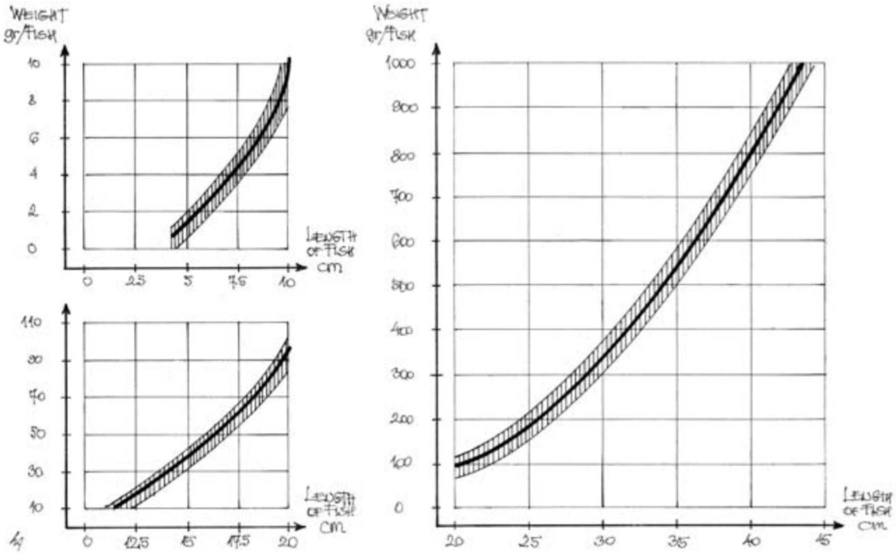

Figure 1.9: Rainbow Trout Standard Length versus Weight Correllations.

1.2.6 Duration of development stages

Water temperature is a major determining factor of fish production. This is because the body temperature of embryos, fry and developing fish equalise their temperature to that of the water they are in. Along with the body temperature, the intensity of the metabolism also changes.

The developing embryos and fry feed from the yolk sac and receive oxygen through the entire body surface. When the water temperature is higher, the embryos and fry develop more rapidly, while at lower water temperatures the speed of development reduces. Outside of a certain range of water temperature development stops.

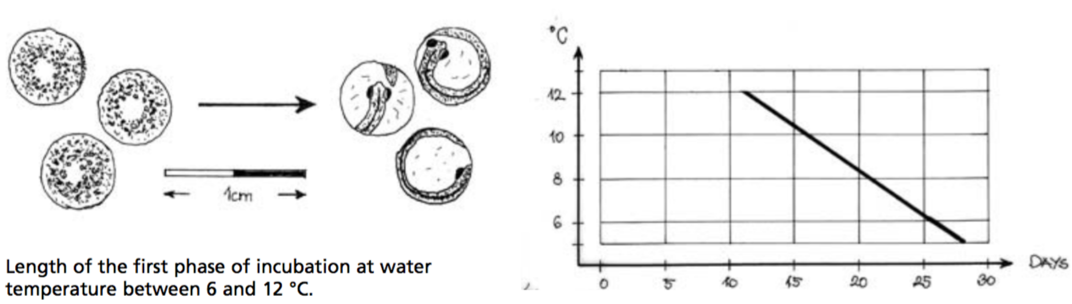

Figure 1.10: Duration of First Phase of Incubation.

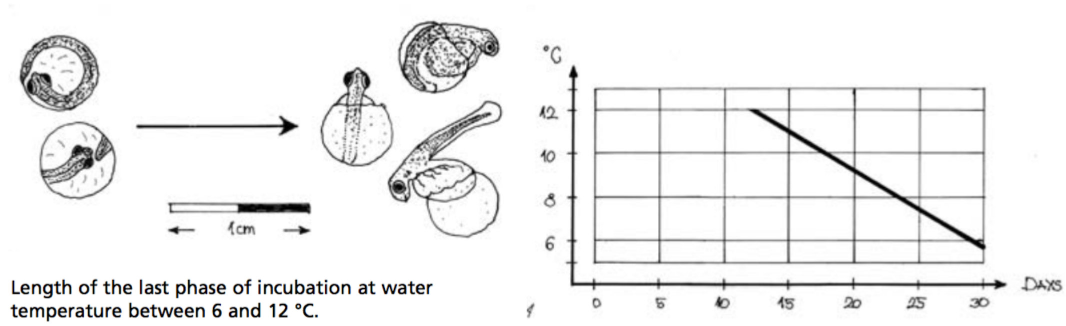

Figure 1.11: Duration of Last Phase of Incubation.

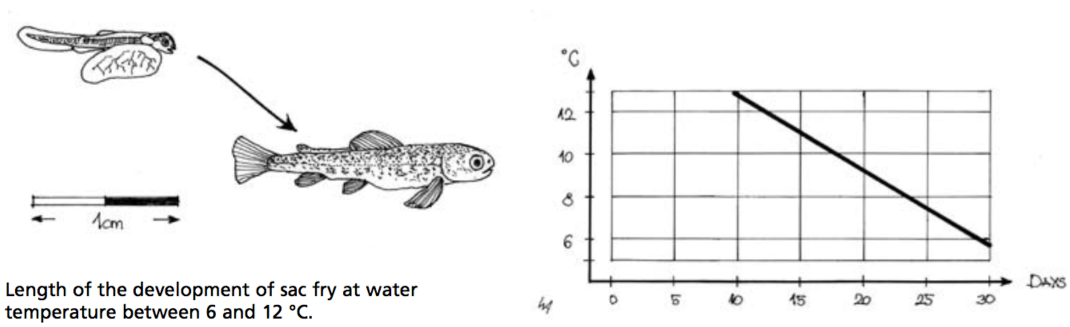

Figure 1.12: Duration of Sac Fry Development.

The total length of the development of embryo and fry from fertilisation to swim-up is about 37-83 days at water temperatures between 6 °C and 12 °C.

After starting external feeding, the actual length of the development of the different age groups depends not only on the temperature and oxygen content of water but also on the quality and quantity of consumed feed. Here, it has been assumed that trout is adequately fed with commercial feeds.

Development of fry from swim-up fry takes 1.5-3 months, see figure 1.12. Here. *fry* refers to a total length of 5 cm and to an average body weight of 2 g.

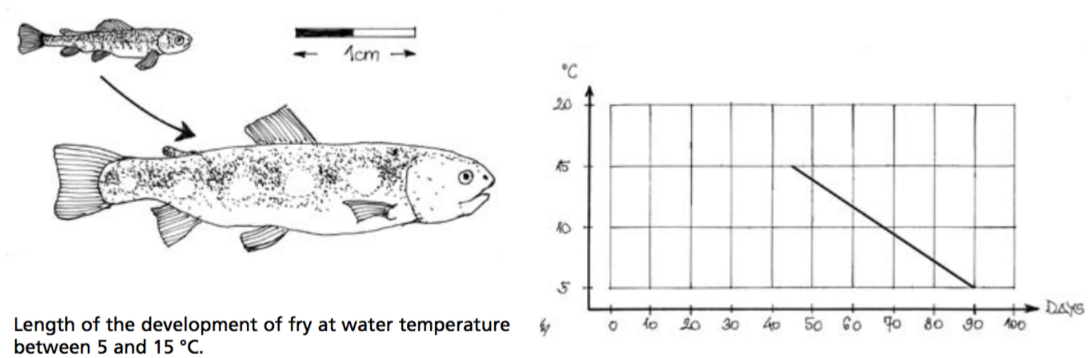

Figure 1.13: Duration of Fry Development.

Development of fingerlings from fry takes 3-4.5 months, see figure 1.13. Here, *fingerling* refers to a total length of 12.5 cm and to an average body weight of 25 grams.

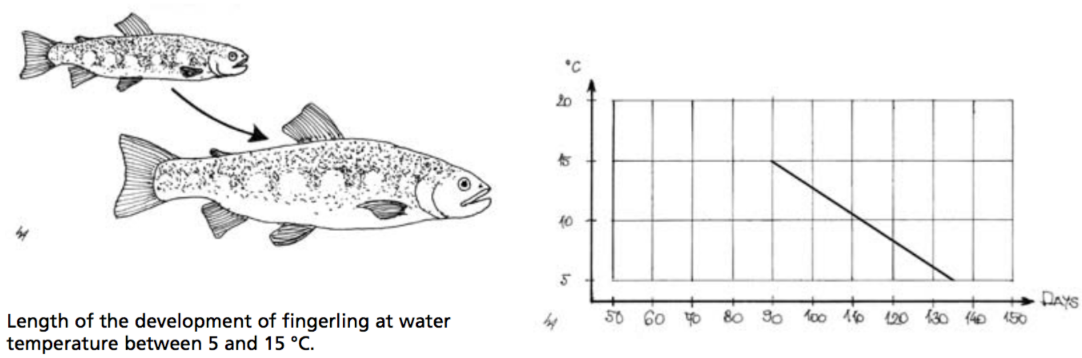

Figure 1.14: Duration of Fingerling Development.

Development of table fish from fingerling takes 4-6.5 months, see figure 1.14 . Here, *table fish* refers to the desired minimum body weight of 250 g.

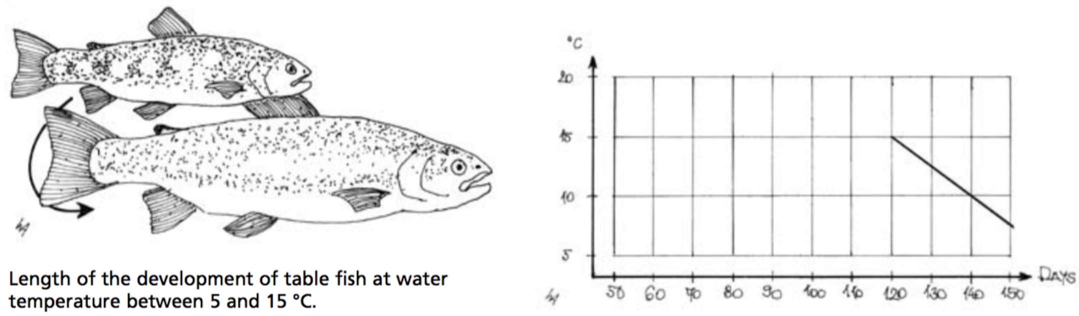

Figure 1.15: Duration of Table Fish Development.

Growth of large table fish from 250 g to 500 g takes a further 2.5-4.5 months (75-135 days) when the water temperature is between 5 °C and 15 °C.

1.3 Production Conditions

In this section we outline the optimal or near to optimal conditions that should be ensured during production of the different age stages of Rainbow Trout.

1.3.1 Water pH

Rainbow Trout tolerates unfavourable pH conditions differently during the various development phases of the fish. The optimal and acceptable ranges of pH of rearing water also differ. For developing embryos and fry, the range of optimal pH is narrow, and varies between 6.5 and 8, but the range of acceptable pH is also narrow. For older fish, both the optimal and acceptable ranges of pH are wider, as demonstrated in figure 1.16.

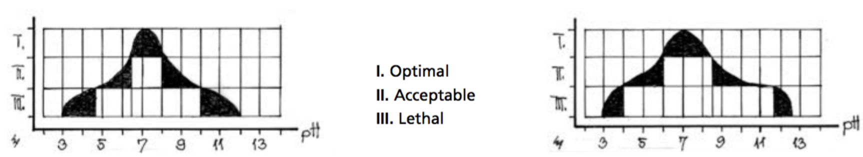

Figure 1.16: Optimal pH ranges for embryos and swim-up fry on the left and growing fish on the right.

1.3.2 Water Temperature

The optimal, acceptable and lethal ranges of water temperature also vary according to the development stages of the fish, as demonstrated in figure 1.17.

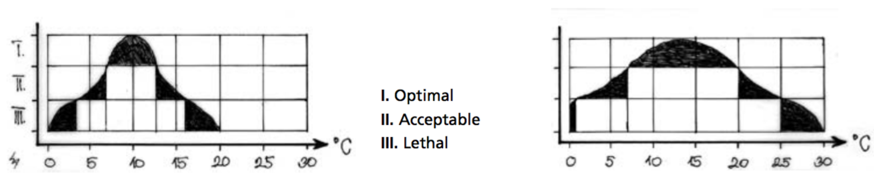

Figure 1.17: Optimal temperature ranges for embryos and swim-up fry on the left and growing fish on the right.

There is a range of water temperature, about 7 °C to 18 °C, where the appetite of feeding rainbow trout is optimal, see figure 1.18. Outside of this range, at lower and higher water temperature, fish lose appetite. Finally, at too low or too high water temperature, fish stop feeding.

Feed intake of rainbow trout intensifies as the water temperature increases. However, this behaviour continues only up to about 18 °C. Above this temperature, the appetite of and feed intake by the fish sharply decreases and stops.

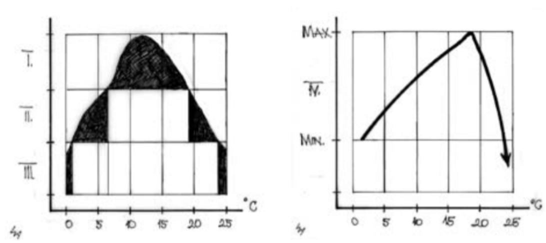

Figure 1.18: I. Optimal range of appetite. II. Losing appetite. III. Feeding stops. IV. Intensity of feeding..

It is important to be aware that there is an inverse correlation between the intensity of feeding and the utilisation of consumed feed. Thus, at about 18 °C, rainbow trout are willing to feed very intensively, but the digestion of consumed feed will be less complete at this temperature. The water temperature where the different trout species make the best growth out of the consumed feed varies from 13 °C to 15 °C.

1.3.3 Water Oxygen Content

Oxygen dissolved in water ensures the respiration of the different aquatic plants and animals. Most frequently, the DO content of water is expressed in milligrams of oxygen per litre of water (mg/litre). The maximum oxygen content of water depends on the water temperature. This is because water can dissolve only a certain quantity of oxygen, which is determined by the partial pressure of oxygen in the atmosphere. Figure 1.19 shows the inverse correlation between temperature and DO content of water. At a higher temperature of water, the DO content is lower. At maximum oxygen content, water is 100 percent saturated with oxygen and the oxygen in excess soon leaves to the atmosphere.

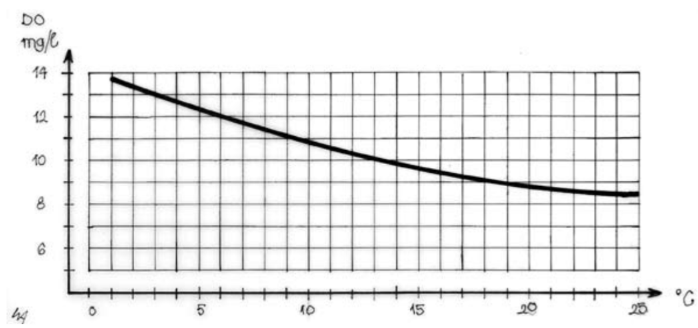

Figure 1.19: Correlation between temperature and maximum oxygen saturation.

The optimal and acceptable concentrations of oxygen in water vary according to the actual development stage of the fish. The optimum is when the oxygen content of rearing water is near to saturation (100 percent). The acceptable range of oxygen content of rearing water is lower. It ranges between 5 and 6 mg/litre during incubation of eggs and the first development stages of fry. For older age groups, the acceptable low oxygen content of water may be about 4.5 mg/litre.

It is important to know that the oxygen consumption of fish increases considerably during and after feeding. During these periods the demand for oxygen will temporarily increase.

1.3.4 Water Supply

In order to ensure the replacement of used water in the rearing devices, a continuous supply of fresh, clean and oxygen-rich water is essential. The necessary quantities of water supplied depend on the age and actual quantity of the developing fish.

The quantity of eggs, fry and growing fish per unit area of rearing device is determined by the oxygen content of supplied water. In colder water, the metabolism and, hence, respiration slows, while in warmer water they intensify. Accordingly, the actual quantity of water needed for the same number of developing embryos, fry and fish will be different. At low water temperature, the quantity of water supplied may be less but at higher water temperature it should be more. See figure 1.20

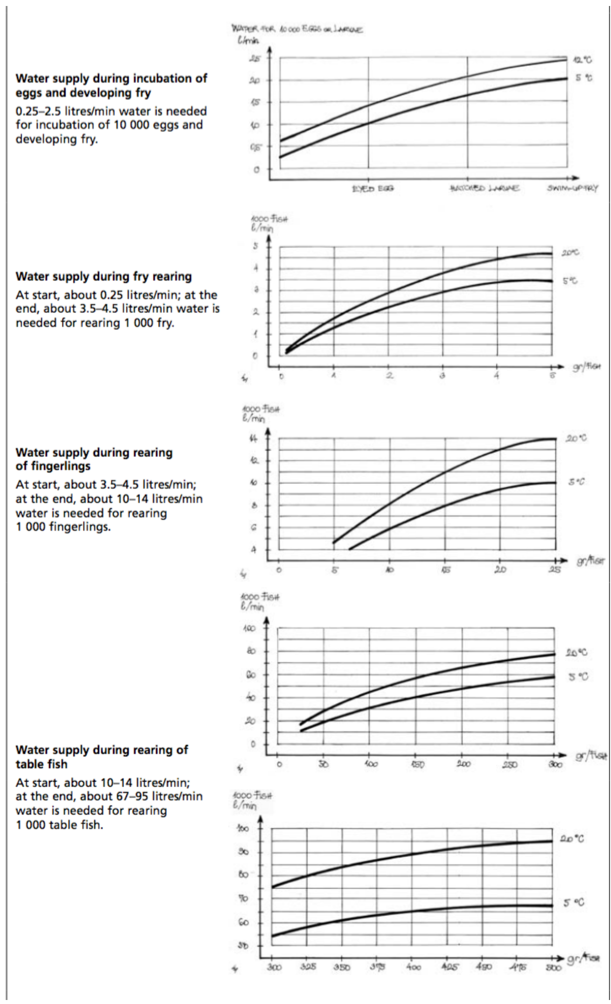

Figure 1.20: Water supply in tanks required according to development stage of fish.

Water supply is expressed by the flow rate, which is the quantity of water needed for 10 000 specimens of eggs or 1 000 specimens of fry or fish. It is expressed either in litres per second (litre/s) or litres per minute (litres/min).

Frequency of water exchange is another way to specify the quantity of supplied water. It is expressed by the exchange rate of water per hour or day.

The water supply in concrete or lined tanks can be more intensive than in earth ponds, hence the density of fish can also be higher in these devices.

1.3.5 Aeration Principles

In the practice of pond fish farming oxygen deficiency has been regarded as dangerous mainly because of mass losses of fish. But recent investigations have shown that decreased oxygen saturation can have serious effects on the economy of a fish farm as well.

Keeping the dissolved oxygen content of the pond water nearly at the saturation level makes it possible not only to avoid mass losses of fish but ensures better conversion rates and higher yields in intensive culture.

Most trout farms use flow-through systems, whereby grow-out tanks are continuously refreshed with large quantities of new water, usually gravity-fed from nearby streams or rivers. Whether rectangular raceways or self-cleaning circular tanks are employed, the essentials remain the same; rapid removal of wastes and continuous replenishment of the system with highly oxygenated water.

Chapter 2

Mbona Hatchery

2.1 Infrastructure.

At the Mbona Hatchery we make use of Baths, Tanks and Ponds for the production of fry, fingerlings and table fish, see 2.1 for the layout of the Mbona Hatcheries operation.

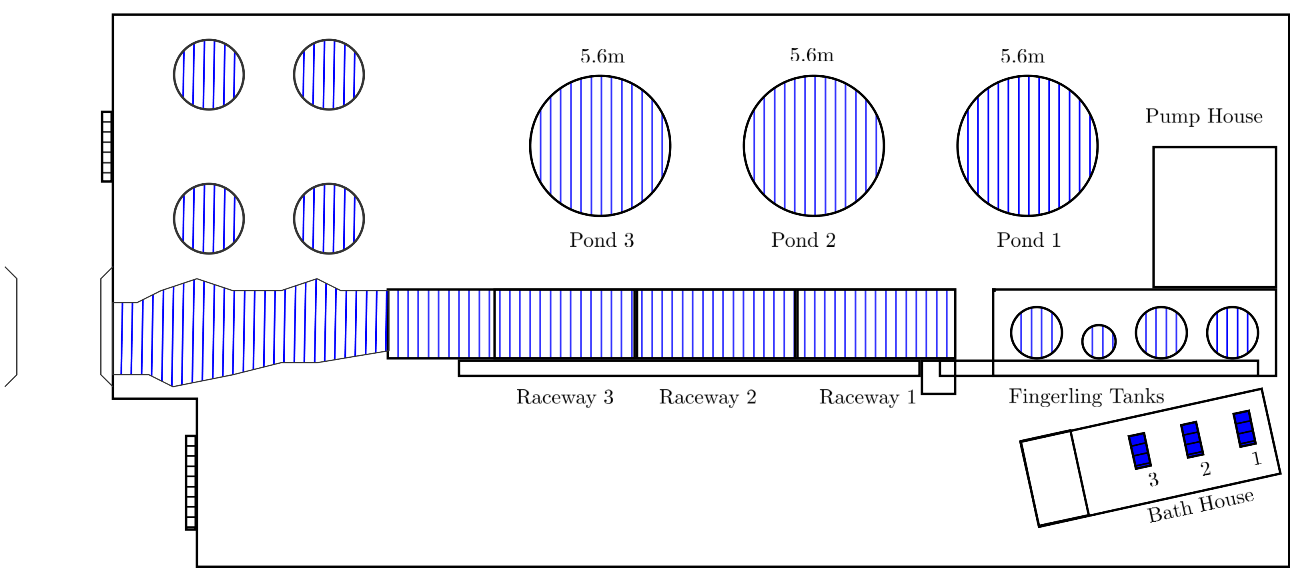

Figure 2.1: Mbona Hatcheries Layout.

2.1.1 Hatching Baths

At the Mbona Hatchery we use a California hatching tray which is a screened, flat-bottomed tray that fits horizontally inside the rearing bath and is arranged so that water is forced through the eggs from below.

The tray is a container for incubation of eggs and sac fry. The bottom of the tray is a sieve material, on which the eggs and sac fry rest. They are placed in a Hatching Bath and they receive freshwater through the sieve from under the tray, as illustrated in figure 2.2.

Figure 2.2: Mbona incubator baths have one California type tray (size: 0.5 m 0.4 m = 0.2 m2). When hatching trays are removed, the bath is used for rearing the fry.

Although the material, shape and size of hatching trays may vary, the quantities of eggs and sac fry that can be incubated on them are similar. A hatching tray about 0.2 meter squared is needed for the incubation and hatching of 10 000 rainbow trout eggs. Later, the required space increases, because 10 000 swim-up fry need 5 times more space (about 1 meter squared) with about 0.5 m depth. The required quantity of water in these devices should be ensured and adjusted as presented in the graphs of the previous chapter.

2.1.2 Fry Tanks

Figure 2.3: Mbona fry tanks are plastic jojo type tanks used for rearing the fry till they are old enough to move to the tanks. The flow rate through the tank is controlled by an inlet valve and the depth of water in the tank is determined by the height of the overflow outlet pipe.

2.1.3 Growing Ponds

Figure 2.4: Mbona growing ponds are of concrete construction and used for growing the fingerlings to sellable fish of length greater than 6 inches. The flow rate through the pond is controlled by an inlet valve and the depth of water in the tank is determined by the height of the overflow outlet pipe. The ponds are covered with netting to prevent the fish from escaping.

2.1.4 Raceway

Figure 2.5: The Mbona raceway is used as an exit for the water after it has passed through the baths, tanks or ponds. It is also used to grow trophy and table fish for select customers.

2.2 Water Reticulation

Water is siphoned from Lake Crystal and passed through an aeration tower before being piped to the baths, tanks, ponds and pools in the Mbona hatchery, see figure 2.6.

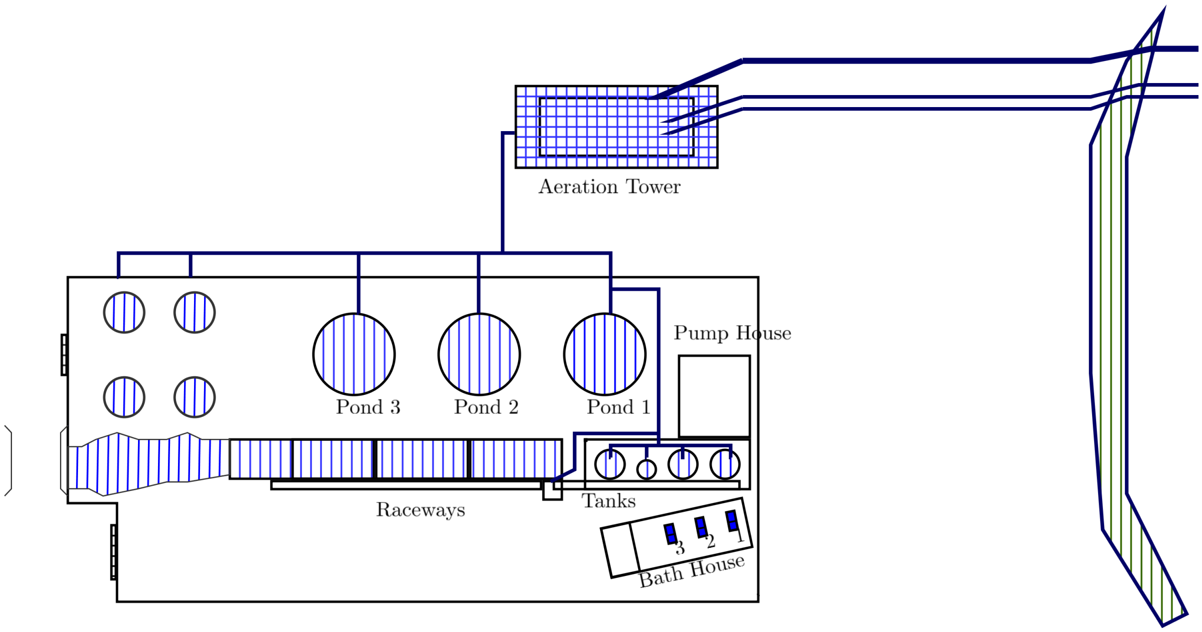

Figure 2.6: Mbona Hatcheries Water Reticulation System.

2.2.1 Aeration Tower

Aerated water is critical to the survival of live fish so The Mbona system used three different siphons to provide water to the aeration tower and on to the hatchery, see photgraph 2.7.

Figure 2.7: The Mbona aeration tower is fed by **three** siphons from Lake Crystal that must run continuously, see text for flow estimates.

The flow of water from the three siphons can be computed using a formula outlined in the appendix of **WaterPAK**, an Australian manual on best practices for the irrigation of cotton fields, see [3].

The formula is based on Bernoulli's principle but adjusted for velocity loss due to friction between the water and the pipe. The flow rate for a siphon can be approximated by:

$$Q = \frac{\pi D^2}{4}\sqrt{\frac{2DH}{1.9 + 0.019\frac{L}{D}}}$$

where

- Q is the flow rate in $m^3 s^{-1}$
- D is the diameter of the siphon pipe in m
- H is the height differential between the outlet and the lake surface in m.
- L is the length of the siphon pipe in m.

Using this formula we compute daily discharge in litres expected from each of the 3 siphon pipes leading to the aeration tower. The results are presented in table 2.1.

	Diam (mm)	height (m)	length (m)	friction correction	Velocity (m/s)	Flow (litres/sec)	Flow (litres/day)
siphon 1	75	7	125	33,6	2,02	8,92	770688
siphon 2	75	7	125	33,6	2,02	8,92	770688
siphon 3	110	7	125	23,5	2,42	23	1987200

Table 2.1: Siphon discharge in litres per day

These figures are supported by an experiment Pierre carried out when he use a bucket and stop watch to estimate the total consumption of the Hatchery with just the two smaller siphons feeding the aeration tower. The results of this experiment are presented in table 2.2.

	litres / minute	litres / hour	litres / day	litres / year
pond 1	266	15960	383040	139809600
pond 2	357	21420	514080	187639200
pond 3	320	19200	460800	168192000
green tanks	25	1500	36000	13140000
hatching baths	15	900	21600	7884000
total consumption	**983**	**58980**	**1415520**	**516664800**

Table 2.2: Water consumption in the Hatchery as measured with a bucket and stopwatch.

Chapter 3

Mbona Hatcheries Procedures

3.1 Procedures

In this section we track the progress of trout from eyed-eggs to fry to fingerlings, see figure 3.1.

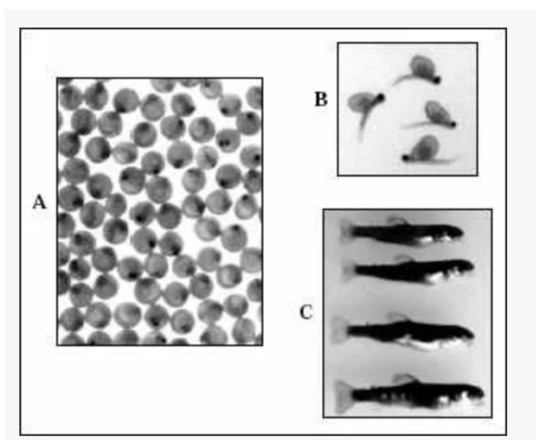

Figure 3.1: What to look for: A) Eyed-Eggs, B) Sac-Fry, C) Fingerlings

After this they spend the rest of their time in in the hatchery ponds as pre-sale growing fish. In what follows we track the trout from Haching to sale giving feeding and cleaning schedules that must be followed.

3.1.1 Preparation of Hatchery for new batch of eggs

Make sure the fish food store is replenished. Purchase replacements from AVI feeds in Pinetown, see contact details A.2, who will deliver to Hopewell in Howick. The current food range is outlined in the feed table 3.1. This table is just a suggestion, The suppliers of the feed should be consulted for their recommendation.

Size (inches)	Weight (grams)	Location	Feed	Bags to buy (@25kg)
<1	0,2	Bath	Dust No 0	0.2
2	5	Tank	Starter Crumble No 1	2
3	20	Tank	Starter Crumble No 3	2
4	60	Pond	Starter 2mm Pellet	4
6	200	Pond	Grower 3mm Pellet	4
8	500	Raceway	Finisher 5mm Pellet	4

Table 3.1: Fish Feed: showing feed type to match different stages

Two weeks before the eggs arrive start with the following repairs and maintenance:

-2 𝕎

- Scrub three baths with abrasive pads & Handy Andy
- Clean & service in-feed pipes
- Clean & service out-flow filters
- Check drain plugs & safety locks
- Check & repair mini vacuum cleaner
- Check the following equipment:
  - 220 volt light globes in hatching room
  - Roller blinds & window covering
  - Egg tweezers & dead egg removal pipe & bird feathers
  - Head lamps & batteries

- Digital scale
- Thermometers
- **V** channel egg counter
- PVC gloves
- Egg transporting box

Two or three days before arrival of eggs: -0.5 𝕎

- Scrub down all baths & equipment again with Hibitane
- Position square egg trays in baths & start water flow

On the day of collection 0 𝕎

- Take egg transporting box, thermometer & note pad.
- Buy ice in Howick, load transporting box & pack spare ice in cool bag

3.1.2 Transportation of eggs

At the end of May about 10000 **Eyed Eggs** are purchased from a Hatchery in Underberg, see the contact details table A.2 .

Eggs are transported in a polystyrene box with trays of ice above and below the tray of eggs. The temperature in the box should be about 4 °C.

Eggs at 4 °C can be boxed for as long as 96 hrs (4 days). The hatch-out-rate guarantee should be about 90%. The expected time to hatch out at 10 °C should be between 6 and 7 days.

Once the eggs have arrived at **0** 𝕎 (weeks after arrival) they progress from hatching baths to fingerling tanks to fish ponds the schedule of which is outlined below:

3.1.3 Egg handling on arrival

On arrival at Mbona Hatcheries the eggs have to be tempered and counted. 0 𝕎 1^{st}June

The tempering process requires increases the temperature of the eggs to the temperature of the water in the incubation trays in a slow and regular manner. The recomendation is 1 °C per hour. The temporing is accomplished as follows:

Measure boxed eggs temperature.

Half fill a bucket.

Add ice or iced water to bring down bucket water temperature to egg temperature.

When the two temperatures are equalised remove the ice from the bucket.

Carefully add eggs to bucket and rehydrate eggs.

Slowly bring the bucket temperature up to incubation tray temperature by adding small amounts of Mbona water from the baths to the bucket.

aim for an increase of 1 °C per hour.

Once the eggs have rehydrated the counting of the eggs can be accomplished by weighing a batch of 200 eggs, W_B, that are counted from a pharmacy tablet-counting device and then weighing the remaining eggs, W_R, in the rehydration bucket and computing the number of eggs received according to:

$$N_{eggs} = 200(1 + \frac{W_R}{W_B})$$

In the past counting was done by the supplier in the presence of the customer so there was no need to recount on arrival at Mbona.

3.1.4 Hatching Bath Procedures

3.1.5 Hatching of Eyed Eggs

Once the eggs have been transferred to the hatching trays they will take two weeks to hatch. During this time white eggs (eggs that have died) must be removed from the hatching tray by means of a suction straw. If this is not done regularly then the dead eggs will contaminate the live ones. 2 $\mathbb{W}$

After about two weeks, depending on water temperature, the eggs will hatch to produce sac-fry which will float away from the egg clutch and possibly spill out of the hatching tray into the hatching bath. These sac-fry will feed from their sac for another two weeks.

After this the fry must be taught to feed. This is done by sprinkling food dust, see table 3.1, on the water surface with a "plastic" water flow inhibitor in place so that the food dust does not get expelled from the bath before the fry have fed. 4 $\mathbb{W}$

In the beginning this feeding must occur at least **SIX** times a day whilst the fry are still in the baths. After 2 weeks of feeding the feeding rate can be reduced to **FOUR** times a day for another 2 weeks. Note that when the fry are young they must be fed small amounts and often so as to maintain equal growth rates amongst the fry and thus reduce canabalism.

After feeding, some food dust will sink to the bottom of the bath and this sediment must be cleaned regularly by vacuuming the bottom of the bath with the mini vacuum machine.

3.1.6 Relocation of fry from Baths to Tanks

As soon as the fry learn to feed by themselves the Tanks must be prepared to receive the fry. All four tanks must be cleaned with diluted Chlorhexiden Gluconate, (Hibitane). Read the instructions to get the dilution proportions. The sides of the tanks must be brushed and broomed and flushed repeatedly. The water must be running a few days before the fish arrive. 6 𝕎

When the mortality rises in the Baths move the fry to tanks, Use tanks 2 and 4 with **runts** in tank 3. Use tank 1 for overflow from 2 and 4. Use buckets and the displacement method to count and record the number of fry moved. 8 𝕎

The fry will remain in the tanks for two months. During this time they must be fed with starter crumble, see the feed table 3.1.

- twice daily for 4 weeks using starter crumble no 1
- twice daily for 4 weeks using starter crumble no 3

The amount of food to feed can be estimated from the following entry in the Trout in the Classroom website [4]. Assuming 1000 baby fish feed them approximately the following amount of food each day:

- fish starting to swim up: feed very little (use dust number 0).
- fish just out of hatch box: 1.5 grams. (use dust number 0)
- fish approx. 1 inch: 6 grams. (use starter crumble 1)
- fish approx. 1.5 inch: 17 grams of food (use starter crumble 3).
- fish approx. 2.25 inch: 55 grams of food (fish ready for transfer to ponds).

3.1.7 Relocation of fingerlings from Tanks to Ponds

1 week before the fry reach fingerling stage the ponds must be prepared to receive them. Use the same technique to clean the ponds. Make sure the ponds are clean and water has been running for at least two days before transferring the fingerlings. 15 $\mathbb{W}$

Use the gutters and count and transfer the fingerlings to the ponds. measure the average length using a 10% sample of the fingerlings transfered. Transfer into pond 1 and 2 with overflow to pond 3 16 $\mathbb{W}$

feeding schedule, see the feed table 3.1.

- twice daily for 4 weeks using 2mm pellets
- twice daily for 4 weeks using 3mm pellets

after this the fish are ready to move to dams 24 $\mathbb{W}$

3.1.8 Feeding Schedule for growing fish

When the fish are in the ponds they should be fed according to their total weight per day. Assuming optimal temperatures between 12 °C and 18 °C, they should be fed 2.5% of their body mass. This amount should be split in two and the growing fish should be fed twice daily.

Below 10 °C the daily food allowance should be droped to 1.5% of total body mass and below 5 °C it should be reduced further to 1% of body mass.

Above 20 °C the daily food allowance should also be reduced since at this temperature the fish become too lethargic to feed.

The weight, W, of a fish can be estimated from its length and girth as follows

Imperial W in pounds, L and G in inches: $W = \frac{1}{800} \times L \times G^2$

Metric W in grams, L and G in centimetres. $W = \frac{450}{800} \times L \times G^2$

In table 3.2 you will find example computations for various fish dimensions

Computing Weight from length and girth

	length (inches)	length (cm)	girth (inches)	girth (cm)	weight (pounds)	weight (grams)
	6	15	4,0	10,0	0,1	54
	7	18	4,5	11	0,2	80
	8	20	5,0	13,0	0,3	113
	9	23	5,5	14	0,3	153
	10	25	6,0	15,0	0,5	203
	11	28	6,5	17	0,6	261
	12	30	7,0	18,0	0,7	331
	13	33	7,5	19	0,9	411
	14	36	8,0	20,0	1,1	504
	15	38	8,5	22	1,4	610
	16	41	9,0	23,0	1,6	729
	17	43	9,5	24	1,9	863
	18	46	10,0	25,0	2,3	1013

Table 3.2: Computing weight from length and girth, $W \approx L \times G^2$

3.1.9 Moving Stock Fish to Dams

When the fish in the ponds reach an average length of 6 to 7 inches they are ready to be sold to customers or used to restock Mbona dams. Customers must be contacted timeously so that orders can be taken and expected delivery dates agreed upon and the fishing committee must meet to decide on which dams are to be restocked.

Prices for live fish are set annually. Since the Mbona operation is **non-profit**, prices are kept just below market value and sales are limited so that Mbona can stock their own dams adequately. Current prices are shown in table 3.3.

size in inch	6	7	8	9	10	11	12	13	14	15	16
2018 price per inch	R1,62	R1,78	R1,87	R1,96	R2,06	R2,17	R2,27	R2,39	R2,51	R2,63	R2,76
2018 price per fish	R10,00	R12,00	R15,00	R18,00	R21,00	R24,00	R27,00	R31,00	R35,00	R39,00	R44,00
2019 price per inch	R1,77	R1,94	R2,04	R2,14	R2,25	R2,36	R2,48	R2,60	R2,73	R2,87	R3,01
2019 price per fish	R11,00	R14,00	R16,00	R19,00	R22,00	R26,00	R30,00	R34,00	R38,00	R43,00	R48,00

Table 3.3: Selling Price for Mbona Fish, the six inch price is set annually and the price of the larger fish increases 10% per inch and the price per fish is rounded to the nearest rand.

Stock fish are counted and transported using a 600 litre tank mounted on an Mbona Isuzu with oxygenator attached. The number of fish the tank can accommodate depends on the average size of the fish as outlined in the table 3.4.

length	number
7 inch	700
8 inch	400
9 inch	300
10 inch	250

Table 3.4: Numbers versus Length for 600 litre vessel.

Live fish that are not sold are used to stock the Mbona dams. The number of live fish a dam can support depends on the surface area of the dam and the size of the fish. In table 3.5 we show dam capacities for a range of fish sizes. In the last column we show suggested proportional stocking figures assuming 1000 fish were available for dam stocking. Naturally these numbers are not cast in stone as dams may not be in a fit condition to receive stock fish. For example,Holbeck may be silted up and Emerald may be empty.

DAM	SIZE/HA	4 inch	6 inch	8 inch	10 inch	12 inch	Proportional
Cap/Ha		200	160	120	100	80	1000
Crystal	21	4200	3360	2520	2100	1680	680
Evergreen	4,1	820	656	492	410	328	133
DeepPool	0,3	60	48	36	30	24	10
Laughter	1,7	340	272	204	170	136	55
Rainbow	1,3	260	208	156	130	104	42
Amber	0,4	80	64	48	40	32	13
PatEric	1	200	160	120	100	80	32
Emerald	1	200	160	120	100	80	32
Holbeck	0,1	20	16	12	10	8	3
Total Capacity	30,9	6180	4944	3708	3090	2472	1000

Table 3.5: Dam Capacities on Mbona, Each column shows the dam capacities dependent on the current size of the stock fish. The last column shows suggested proportional allocation assuming 1000 stock fish are available

3.1.10 Hatchery Staff Duties

In preparation for egg arrival

- When informed of a pending fish delivery, lay out & check & clean all delivery equipment.
- Pack all fish transporting equipment way after use
- Report any damaged or lost equipment to management.

During Incubation and sac-fry growth

- remove white eggs **three** times per day.
- make sure baths are clean, just sweep in preparation for hatching.
- when teaching fry to eat, use very small amounts of dust and fry must be seen breaking the water surface when feeding.
- Baths must be vacumed a half hour after each feed.

During Growth Period

- Feed fish daily according to Size - Quantity - frequency chart.
- Vacuum clean tanks and ponds after each feed.
- Keep pond nets in good repair
- Inspect all fencing & keep grass cut under & around electric fence.
- Keep large & small catch nets in good repair.
- Cut grass and keep hatchery area & hatchery room neat & tidy at all times.
- All long catch net & vacuum poles to be cleaned & stored on racks

At all times

- Keep all fish transporting equipment clean & stored under cover
- Report any broken or damaged equipment to management same day.
- Report any predator activity, otter or birds of prey, to management same day.

Chapter 4

Possible Fertilisation of Mbona Trout Eggs

Currently, Mbona purchases pre-fertilised eyed eggs for their hatching trays. However it may be possible to strip and fertilise our own fish if we have a reasonable collection of mature female and male trout. These brood fish should ideally be about 3 years old. In this chapter we outline what would be required in order to accomplish this operation. These recommendations come from Gavin Chin.

4.1 Infrastructure

4.1.1 Housing

Fertilised Eggs must be incubated in a ”tower” that remains undisturbed in the dark for at least 25 days. To accommodate this tower the Mbona hatcheries must purchase another shed to house the incubation tower. This shed can be small as only one tower is envisaged. Probably a ”guard hut” residing on a concrete base will do.

4.1.2 Egg towers

The newly fertilised eggs must reside undisturbed in a **tower** for about 25 days. This tower has the following properties, see diagram in figure 4.1.

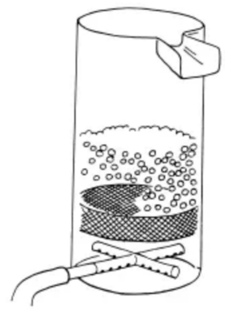

Figure 4.1: Fertilisation Tower.

- Egg towers to stand on concrete base set through cabin floor.
- 75mm PVC tube, castellated top with light-proof lid set in 35mm thick concrete base
- gravel chip diffuser, stainless steel mesh above,
- 1/2inch inlet with tee for vertical anti bubble pipe.
- Hypodermic needle set into clear plastic inlet pipe for Malachite infusion.

4.2 Stripping Equipment

- table
- towel
- paper towel
- 2 large bowls
- 2 jars
- wet cloth
- smooth anorak
- one teaspoon
- one long feather
- 2 large nets

- recovery tank with good oxygenated water
- 2l malachite solution
- egg tower with constant supply of oxygenated water.

Malachite solution:

- 2l water (preferably preboiled)
- 1 x heaped teaspoon Zink free Malachite powder (Supplier details from Gavin)
- Keep solution in sealed bottle.

4.3 Workers

- fish catcher
- runner
- fish stripper
- an assistant
- fish recoverer

4.4 Method

4.4.1 Stripping the Hens

- Make sure both stripping bowls are completely dried using paper towel. Any water mixed into the eggs at this stage would result in the eggs not being fertilised.
- Presuming the stripper is right handed, use the wet cloth to hold fish by the tail in left hand.
- Tuck the fish's head under your left arm hiding its eyes, (vent away from yourself).
- Using the towel, ask the assistant is to dry the nipple area of the fish in the direction of the tail.

- Strip each hen into the smaller dried bowl so that ova can be assessed.
- Only when seen to be NOT haloed add ova to larger bowl.
- Using the right hand the stripper milks the fish on the underbelly to expel the eggs.
- It may take a few strokes before the eggs appear.
- If the belly is hard and no eggs appear, then the fish is not ready and goes in the recovery tank.
- If the eggs are haloed (ie translucent with an orange dot), then the eggs are too old and must not be mixed in with the other eggs. If even one egg in a batch is haloed, throw the entire batch away, but continue to strip the fish or she may become egg-bound and die.
- If last years eggs are expelled with good eggs, they must be removed with the teaspoon. They appear as a whitish shell.The eggs should be uniform orange in colour.
- Strip the fish until all eggs are out. If the fish defecates during stripping (black in colour), remove the faeces using the teaspoon.
- If the fish tenses, allow her to relax before continuing stripping.
- If she struggles, allow her to drop gently to the table then continue with the process.

4.4.2 Recovery

- Take fish to recovery tank as soon as possible
- Hold her upright under the water and closest to oxygenated water while cleaning off her body the slime that has built up during stripping.
- Only the slime that occured during stripping to be removed to prevent her getting a fungus.
- Keep holding her upright until she swims away out of your hands.
- Do not pull her backwards through the water.
- The person aiding fish to recover must stand at the tank and check for fish turning on their side.

- The fish must be helped to remain upright to make a full recovery.
- Return recovered fish to their own tank within a couple of hours.

4.4.3 Stripping the Cocks

- Once the females have been stripped, the catcher sends a male to be held in the same way.
- The milt from the male is to be stripped into one of the jars.
- Remove faeces if necessary.
- One or two males may be enough for fertilisation.

4.4.4 Fertilisation

- Pour the milt into the eggs.
- Stir very gently with a feather until eggs are coated with milt.
- Leave for about 10 minutes
- Add water to the bowl until the bowl is a third to a half full.
- Leave for half an hour.
- Cover to prevent light entering.
- Flush eggs with clean water and remove dead (white) eggs.
- Add to the tower, through which a constant supply of oxygenated water is flowing.
- Leave in tower overnight.
- Next morning, pour ova into bowl with water and remove all dead eggs and replace in tower.
- Leave for 4 days undisturbed.
- After 4 days treat eggs by injecting 10ml of malachite solution daily to prevent fungal infection.
- When eyed after about 25 days transfer to egg trays.

Chapter 5

Mbona Hatcheries Records

5.1 Record Keeping

The various record keeping forms appear in the appendix of this document. The forms are self explanatory. Eventually the Appendix will also contain records from years gone by if they still exist.

5.1.1 Season starting June 2018

The 2018 season started with the arrival of 10000 eyed Rainbow Trout eggs from the Underberg Hatchery. The temperature of the water at the Underberg hatchery was approximately 12 °C. The eggs arrived at Mbona at14h30 in two trays with one ice tray on the bottom and another ice tray on the top of the transportation cooler box.

On arrival at Mbona the temperature of the eggs in the top tray was 12 °C which was brought up to the Mbona water temp of 14.6 °C by 16h00 and these eggs were then moved to bath B.

On arrival at Mbona the temp of the bottom tray was 10 °C which was brought up to Mbona water temp of 14.6 °C by 16h30 and these eggs were placed in bath A.

Once the eggs had been transferred to the incubation baths, the process of removing dead eggs began. In table 5.1 we show how many dead eggs were removed from each bath per day during the incubation period.

Feeding the Rainbow fry with fish food starter powder commenced on Tuesday the 12^{th} of June.

On Thursday the $14th$ of June a further 3000 brown trout eyed eggs from the Trova

Trout company in Sabie arrived at the Mbona Hatchery. These ova were packed in iced trays and air freighted to PmB. They arrived at Mbona at 9am at a temperature of 5.1 °C. The temperature of the eggs was gradually increased to 13.1 °C over a period of 5 hours. The ova were transferred to a hatching tray in bath C at 14h00 when the water was at temperature 13.4 °C. Removal of dead ova from Bath C commenced on Friday the 15th of June, see table 5.1 for daily mortality counts.

	temperature (centegrade)		survival and mortality		
date	morning	afternoon	bath A rainbow trout	bath B rainbow trout	bath C brown trout
			5000	5000	
Sun, Jun 3, 2018	14,6	14,8	400	812	
Mon, Jun 4, 2018	14,0	14,4	302	142	
Tue, Jun 5, 2018	13,6	14,0	156	122	
Wed, Jun 6, 2018	13,5	13,7	157	119	
Thu, Jun 7, 2018	13,4	14,1	190	100	
Fri, Jun 8, 2018	13,6	13,8	206	164	
Sat, Jun 9, 2018	13,6	14,0	149	130	
Mon, Jun 11, 2018	13,3	13,7	430	289	
Tue, Jun 12, 2018	13,2	13,6	109	88	
Wed, Jun 13, 2018	13,0	13,4	95	80	
Thu, Jun 14, 2018	13,0	13,6	50	49	3000
Fri, Jun 15, 2018	12,8	13,6	49	38	0
Sat, Jun 16, 2018	13,0	13,4	0	0	13
Sun, Jun 17, 2018	13,0		61	39	2
Mon, Jun 18, 2018	13,0	13,5	127	162	8
Tue, Jun 19, 2018	12,6	13,6	32	28	32
Wed, Jun 20, 2018	12,8	13,4	62	71	63
	Total mortality to date		2575	2433	118
	Estimated survivors		2425	2567	2882
	7874				

Table 5.1: Temperature and mortality records for 2018 incubation period.

Assuming that the number of eggs at purchase was accurate and that dead eggs were counted accurately table 5.2 suggests that we could expect approximately 5000 surviving Rainbow fry ready for relocation to the fry tanks. So we were pleasantly surprised when the Relocation counts as shown in table 5.2 indicated approximately 8000 surviving Rainbow fry.

Transfer	Date	length (in)	girth (in)	weight (gr)	from	to	number	mortality	weight kg
Fry	2018/06/26	0,8	0,4	0,0720	Bath 1	Tank 1	559		0,0402
	2018/06/27	0,8	0,4	0,0720	Bath 1	Tank 1	1562		0,1125
	2018/06/28	0,8	0,4	0,0720	Bath 1	Tank 1	2395		0,1724
	2018/06/28	0,8	0,4	0,0720	Bath 2	Tank 2	3619		0,2606
							8135		0,5857
Fingerlings	2018/10/23	2,5	1	1,4063	Tank 2	Pond 1	3414	5,7%	4,8009
	2018/10/30	2,5	1	1,4063	Tank 1	Pond 3	3857	14,6%	5,4239
							7271	10,6%	10,2248

Table 5.2: Counts for 2018 relocation of fry from baths to tanks.

This 40% discrepancy is either due to receiving more eggs than expected or due to the counting of hatched egg shells as dead eggs or to both.

Rearing the fry in the tanks

Two weeks after relocation of fry from baths to tanks we carried out length and weight measurements on the fry. The results can be seen in table 5.3 where the recommended feeding schedule is given as computed from the suggestions given in chapter 3.

Date	tank	number of fish	length (in)	weight (grams)	daily feed	grams per 1000	grams per day
2018/07/10	1	4500	1,0	0,22	crumble 1	6	27
2018/07/10	2	3600	1,25	0,49	crumble 1	6	21,6

Table 5.3: Weight and Length measurements of growing fry

5.1.2 Disposal of 2017 Trout

During the 2018-19 season we sell 2017 fish live to local customers and when available, dressed fish to Mbona shareholders. We use the remainder to stock our dams at Mbona. see tables, 5.4, 5.5 and 5.6 below.

Transfer	Date	length (in)	girth (in)	weight (gr)	delivered to	number	weight kg	quote per fish	value	sub-total
external sales	2018/06/01	6	4	54	Brendon Raw	250	14	R10	R2500	
of 2017 batch	2018/07/27	8	6	162	Ambers	100	16	R16	R1600	
	2018/08/14	12	8	432	UCL Friedel	100	43	R34	R3400	
	2018/08/22	10	7	276	St. Johns	60	17	R24	R1440	
	2018/08/22	10	8	360	Brendon Raw	150	54	R24	R3600	
	2018/08/31	12	8	432	Month End Braai	16	7	R50	R800	
	2018/08/04	12	8	432	Rockwood Lodge	100	43	R34	R3400	
	2018/08/04	12	8	432	Rob Haesloop	50	22	R34	R1700	
	2018/11/30	12	8	432	Bret Bower	50	22	R34	R1700	
	2019/01/13	14	10	788	Sitka	100	79	R39	R3900	
						976	315			R24040
external sales	2019/03/20	6	4	54	Glen Cairn	500	27	R10	R5000	
of 2018 batch										
						500	27			R5000

Table 5.4: 2018-19 sales of live fish to external customers.

Transfer	Date	length (in)	girth (in)	weight (gr)	delivered to	number	weight kg	quote per fish	value	sub-total
shareholders	2018/08/31	12	8	432	shareholders	16	7	R50	R800	
	2018/10/12	12	8	432	shareholders	15	6	R50	R750	
	2018/11/30	12	8	432	shareholders	9	4	R50	R450	
	2018/12/05	12	8	432	shareholders	14	6	R50	R700	
	2018/12/12	12	8	432	shareholders	11	5	R50	R550	
	2019/01/11	12	8	432	shareholders	3	1	R50	R150	
	2019/01/18	12	8	432	shareholders	5	2	R50	R250	
	2019/01/19	12	8	432	shareholders	5	2	R50	R250	
	2019/01/21	12	8	432	shareholders	2	1	R50	R100	
	2019/01/22	12	8	432	shareholders	2	1	R50	R100	
	2019/01/24	12	8	432	shareholders	1	0	R50	R50	
	2019/01/25	12	8	432	shareholders	3	1	R50	R150	
	2019/02/08	12	8	432	shareholders	2	1	R50	R100	
	2019/02/21	15	11	1021	shareholders smoked	50	51	R60	R3000	
	2019/02/22	15	11	1021	shareholders	8	8	R50	R400	
	2019/02/26	15	11	1021	shareholders smoked	19.5	20	R80	R1560	
	2019/03/12	15	11	1021	shareholders	6	6	R50	R300	
	2019/03/12	15	11	1021	shareholders smoked	3.5	4	R80	R280	
						175	127			R9940

Table 5.5: 2018-19 sales of dressed trout to Mbona shareholders.

Transfer	Date	length (in)	girth (in)	weight (gr)	delivered to	number	weight kg	quote per fish	value	sub-total
Mbona dams	2018/08/03	11	8	396	Crystal	256	101	R29	R7424	
		11	8	396	Crystal	158	63	R29	R4582	
		11	8	396	Evergreen	150	59	R29	R4350	
		11	8	396	Rainbow	154	61	R29	R4466	
		11	8	396	Laughter	154	61	R29	R4466	
		11	8	396	PatEric	205	81	R29	R5945	
	2018/08/06	11	8	396	Crystal	346	137	R29	R10034	
		11	8	396	Crystal	252	100	R29	R7308	
		11	8	396	Rainbow	172	68	R29	R4988	
		11	8	396	PatEric	170	67	R29	R4930	
	2018/08/30	11	8	396	Crystal	324	128	R29	R9396	
		11	8	396	Amber	50	20	R29	R1450	
		11	8	396	Deep Pool	50	20	R29	R1450	
		11	8	396	Laughter	150	59	R29	R4350	
		11	8	396	Evergreen	200	79	R29	R5800	
	2018/10/22	12	9	547	Crystal	200	109	R34	R6800	
		12	9	547	Evergreen	520	284	R34	R17680	
		12	9	547	Deep Pool	80	44	R34	R2720	
		12	9	547	Amber	50	27	R34	R1700	
	2018/10/24	12	9	547	Laughter	150	82	R34	R5100	
		12	9	547	Rainbow	210	115	R34	R7140	
		12	9	547	Emerald	25	14	R34	R850	
	2018/12/03	12	9	547	Crystal	100	55	R34	R3400	
		12	9	547	Evergreen	85	46	R34	R2890	
	2019/02/21	15	11	1021	Holbeck	26	27	R57	R1482	
		15	11	1021	Crystal	17	17	R57	R969	
		15	11	1021	Emerald	30	31	R57	R1710	
						4284	1956			R133380

Table 5.6: 2018-2019 stocking of Mbona dams from eggs hatched in 2017.

5.2 Mbona Hatcheries Maintenance and Repair

Maintainance and repair projects as of March 2019 (completed projects marked ✓).

5.2.1 Hatching room

- Repair bath 2 in-feed pipe
- Make good all three bath outlets and make adjustable drains.
- Make 3 PVC/F-glass mesh filter curtains
- Stop leaks in drain out-pipes
- Sort 220v lighting in hatching room

5.2.2 Main pond area

- Complete clay repair and gravel of raceway pond.
- Complete fencing and gates to new extension ✓
- Reroute electric fencing ✓
- Run water feed pipe to new area off main 3 pond feed ✓
- Replace small fingerling tank with larger model.

5.2.3 Shade cloth cover

- Replace and reset gum poles ✓
- Replace shadecloth ✓
- Replace swimming pool hose sections where necessary ✓
- Build, using old fencing standards, adjustable drain pipe stands
- Do 12 volt night light bug catch test with white plastic ✓(not successful)

5.2.4 Syphon water feed from Crystal

- Pull up 2 x 70mm syphon pipes and replace filters ✓
- Move 3 syphon inlets and main water inlet 18 meters further from wall
- Build mud anchor and substantial top float with nylon rope-pulley lifting system for maintenance.
- Box and cover 3 x vacuum break valves at Crystal edge for quick access

5.2.5 Oxygenator

- Reseat IBR roof ✓
- Remove T from North 70mm pipe and extend ✓
- Sort distributor tray or trays ✓
- Check bottom of bath outlet drain ✓
- Re-concrete beneath oxygenator to prevent undermining ✓
- Box and lid 2 x 70mm syphon pipe taps and hose connect points for quick access
- Extend and secure steel inspection ladder
- Gravel South side walk area against wall
- Paint oxygenator

5.3 Budget proposal

This section requires further development by the fishing committee.

			Current			Proposed		
	Item	Category	Count	@	Cost	Count	@	Cost
Expenses	Eggs	Rainbow	10000	R0,20	R2000,00			
		Brown	3000	R1,00	R3000,00			
	Food	Powder	1					
		small pellets	5					
		large pellets	5					
	Labor							
	Equipment							
	Transport							
Income	Brendan Raw		500		R6000,00			
	Ambers		100		R3000,00			
	Dressed Trout							

Table 5.7: Possible Budget proposal for next season.

Chapter 6

Trout Recipes

In this chapter we intend to publish Trout Recipes for dishes that have been attempted at Mbona. Please email your trout recipes to the editor at:

hugh.murrell@gmail.com

Your recipe can be in plain text with an **ingrediants** section and an **instructions** section. Please attach a photo of the resulting dish just before eating commences. See our braai trout recipe for an example.

6.1 Robertson's Braai Trout (by Hugh Murrell)

ingredients

- 2 Whole Trout, gilled and gutted.
- Robertsons Spice for Fish
- 2 lemons
- 1 Fennel Bulb
- 1 lemon
- For the Yogurt Dressing:
  - 250ml Greek Yogurt, double cream
  - 45ml mayonnaise
  - 1 lemon, juiced
  - 10ml Wholegrain Mustard
  - Robertsons Coarsely Ground Black Pepper

instructions

- Get your fire ready to braai the fish over medium hot coals.
- Oil the inside of your grid to ensure that the fish doesn't stick to the grid.
- Rinse the trout well under cold water, then pat dry with a tea towel.
- Season the fish, inside and outside, with Robertsons Spice for Fish.
- Use lemon and sliced fennel slices to stuff into the cuts and cavity, then drizzle the stuffed parts with lemon juice.
- Place the fish inside a large hinged grid (without any foil) using a few lemon slices to protect the fish, see figure 6.1
- braai over medium hot coals on both sides for about 30 minutes in total, see figure 6.1.
- For the dressing, mix all the ingredients together.

- Transfer the fish to a large serving platter and serve with a bowl of yogurt dressing, see figure 6.2

results

Figure 6.1: Robertson's Braai Trout, prepared (left image) and on the coals (right image)

Figure 6.2: Robertson's Braai Trout, served and ready to be eaten.

6.2 Whole Baked Trout with Herb Salsa (by Natasha Russo)

thanks to, http://eatdrinkpaleo.com.au/whole-baked-trout-recipe/

ingredients for two trout

- 2 Whole Trout, gilled, gutted and heads and tails removed.
- For the salsa
  - 1 medium red onion, peeled and roughly diced
  - A handful of fresh basil leaves
  - A handful of fresh parsley
  - A few mint leaves
  - 1 garlic clove, peeled
  - Zest of 1 lemon
  - Juice of half lemon
  - half cup olive oil
  - 2 teaspoon sea salt
  - half teaspoon black pepper

instructions

- Preheat the oven to 200 centegrade
- Combine the salsa ingredients in a food processor or a blender and process into a salsa like consistency.
- Remove Heads and Tails and place the whole fish in a large roasting tray.
- Cover the fish with the herb marinade on both sides and a little inside the fish cavity.
- Bake in the oven for 20-25 minutes, on the middle shelf.
- Remove and transfer to a platter or serve right in the roasting tray.
- Best with Spinach, Cranberry and Roast Almond Salad

results

Figure 6.3: Whole Trout, gutted (left image) and prepared (right image)

Figure 6.4: Natasha's Whole Baked Trout, served and ready to be eaten.

Appendices

Appendix A

Tables

A.1 Contact Details

A.1.1 Local Mbona Knowledge

Person	Position	email
Dave Forsyth	manager	manager.mbona@iuncapped.co.za
Guy Reen	assist manager	assist.mbona@iuncapped.co.za
Dennis Dyer	trout chairman	dennisd@surfafrica.net
Pierre Olivier	shareholder	pierre@pierrecraft.co.za
Bernard McDonald	shareholder	jmcdonaldh7@gmail.com
Hugh Murrell	shareholder	hugh.murrell@gmail.com
Ronnie Ritchie	shareholder	karklooflady@iuncapped.co.za
Justin Pinington	shareholder	justingwc@gmail.com
Gareth Powell	consultant	gpsafari@gmail.com

Table A.1: Local Knowledge, Contact Details

A.1.2 Suppliers

Item	Contact	Company / district / email	phone
trout eggs	Wolf Auni	Giant's Cup Hatchery Underberg troutcup@vodamail.co.za	Underberg 033 7011511
	Renier	Lunsklip Lydenberg	013 2351287 082 4546017
	Simon Bunn	Peak Trout Cathedral Peak Hotel	083 3755571
trout food	Ntoko or Phumi	AVI feeds, Pinetown with deliveries to Hopewell	0317660016
grass carp	Francious Classen	De Rust Hatchery Swllendam info@outdoorarena.co.za R150 - R300 per fish	023 6162444
chubby head barbs	Rudolf duToit	private farm Karkloof	083 2784848
chemicals			

Table A.2: Suppliers of trout eggs, trout feed, chemicals and other fish

A.1.3 Customers

contact	district	phone	email
Brendan Raw	Jettison Timbers	083 6832039	bblraw@mweb.co.za
Douglas Benson	Glenrock Estate	087 8085757	douglas@glenrock.co.za
Neville	Siteka Estate	083 4522241	
Alan Bailey	Amber Valley		em@ambervalleybc.co.za
Mr. Farhaad	Rainbow Retreat	082 5510247	
Friedel Eggers	UCL		eggers@ucl.co.za
Wendy Curle	Rietvlie		wendycurle@vodamail.co.za
Rex Fey	Kokstad		
Whispering Water	Dargle		
Sunset Farm	Mooiriver	079 6244030	fam@mweb.co.za
Justin Pinington	fishing club		
Nick Nolden	Nyamvubu		nick@noldenbros.co.za
Judy Cole	Siteka	083 4522241	rbdservices1@gmail.com
Juanita	Kambrook Farm		Juanita@iconstruction.co.za
Gareth Powell	Glen Cairn		gpsafari@gmail.com

Table A.3: Potential customers for live trout

A.2 Record Forms:

A.2.1 Mbona Hatchery Counting Aid

Date:	From:	To:	Size (inch)	Count

5	10	15	20	25	30	35	40	45	50	total
/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	50
/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	100
/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	150
/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	200
/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	250
/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	300
/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	350
/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	400
/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	450
/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	500
/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	550
/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	600
/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	650
/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	700
/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	750
/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	800
/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	850
/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	900
/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	950
/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	/ / / / /	1000

A.2.2 Mbona Hatchery Trout Relocation Record

Date	Quantity	Size (inches)	From	To

A.2.3 Trout Return Form

	MBONA, TROUT RETURNS		
Share		Date Arrived	
Name		Date Departing	
		Number of Days	
	Number Caught	Number Released	Number Kept
Crystal			
Rainbow			
Laughter			
Evergreen			
DeepPool			
PatEric			
Amber			
Holbeck			

Figure A.1: Return Form to be filled in by visitors on departure at the main gate.

A.2.4 Mbona Trout Ladder

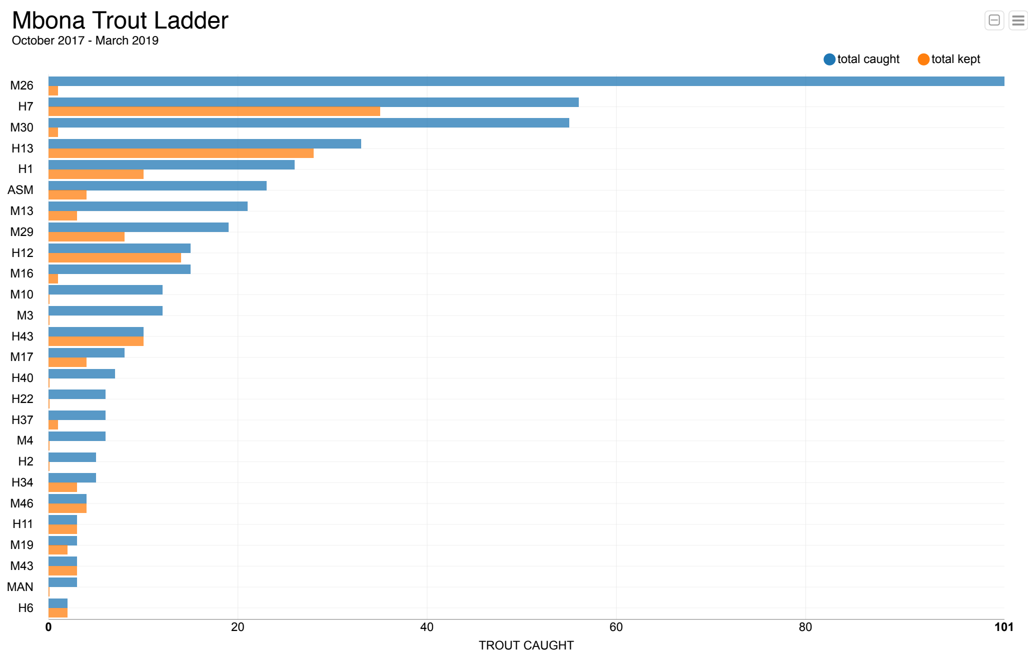

Figure A.2: Ladder showing catch and keep records for each share since web based trout returns were introduced.

A.2.5 Trout Catches by Dam

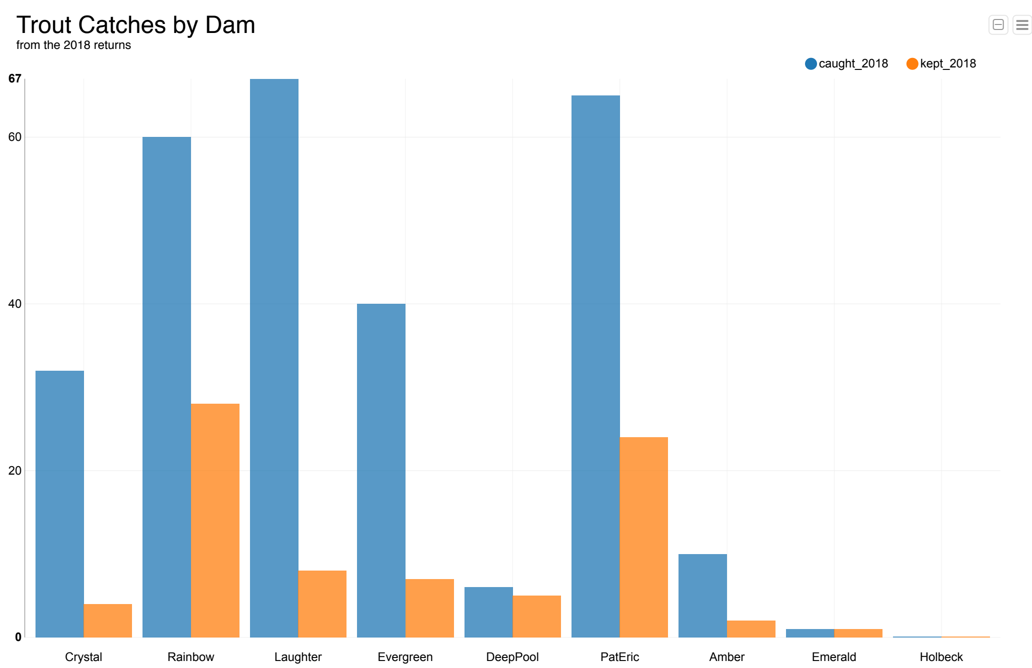

Figure A.3: Bar chart showing catch and keep records for each dam for 2018.

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