2022 年臺灣國際科學展覽會
優勝作品專輯

作品編號 **050016**

參展科別 **動物學**

作品名稱 **The Reproduction success of the Cyprinidae and a Claridae fish species and its impact on small- scale fisheries**

得獎獎項

國　　家 **South Africa**

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關鍵詞

作者照片

Introduction:

In the following research project, the reproductive success and natural recruitment of 4 Cyprinid fish species,moggel (*L. umbratus),* common carp (*C. carpio),* orange river mudfish (*L. capensis),* smallmouth yellowfish (*L. aeneus)* and Claridae fish species which for this investigation will be the sharp-toothed catfish (*C. gariepinus).* Natural recruitment refers to the transition of young fish to adult fish. Reproduction success refers to the individual or species' production of offspring per spawning/breeding season.

This research is important as it helps determine whether or not the Cyprinidae fish species such as the moggel (*L. umbratus),* common carp *(C. carpio),* orange river mudfish (*L. capensis)*, smallmouth yellowfish (*L. aeneus)* and sharp-toothed catfish (*C. gariepinus)* fish species have healthy populations or if there had been a disturbance in their environment that may have negatively impacted the fish species.

This research is necessary as it will provide the grounds for investigation into potential fishery species which would possibly be able to sustain a small-scale fishery, (Isaacs and Hara, 2015).

It provides information on how successful their reproduction and natural recruitment is. It is important to investigate which species has the most successful spawning season so that it can be determined whether or not they would be a good species for a small or large scale fishery (Jakobsen *et al.,* 2009).

Furthermore the South African cabinet has approved a National Freshwater wild capture fisheries policy during 2021. This new policy will guide the development of an inland fisheries sector in the country inland fisheries have the potential to contribute to government's imperatives of job creation, poverty alleviation, better food security and rural development. Critical to this is to determine the reproductive success and natural recruitment of all potential fisheries species.

Literature Review

Natural recruitment is the process of small, young fish that transition to an older, larger life stage. Reproduction success refers to the individual or species' production of offspring per spawning/breeding season.

Being dependent on aquatic respiration, strategies for iono-osmotic regulation, and maternal transfer of contaminants to eggs are all factors that create additional ways in which fish are exposed to EDCs (Van Der Kraak *et al.,* 2012).

The density-dependent mortality that occurs during early fish life stages is one of the most important factors that affect a fish population (Camp *et al.,* 2020). This can affect their

mortality in means that occur over a large numbers of eggs spawned. The numbers of fish that are recruited to subadult populations can be similar through time (Camp *et al.,* 2020).

Density-dependent recruitment processes are also the reason for populations sustaining themselves despite the death of a large number of adults that may have died from fishing or natural causes (Camp *et al.,* 2020). However, overfishing or reductions in suitable habitat can cause a reduction in the numbers of recruits and as a result decrease the population of certain fish species (Camp *et al.,* 2020).

Fisheries are a major cause of mortality in fish populations as it is size selective and impacts the population dynamics and the reproductive resilience (Saborido-Rey, 2016). There have also been studies that have shown the negative impact that pollution has had on several fish processes. It has shown that the frequency of courtship displays and its duration have decreased (Jones *et al.,* 1997).

Dams are impacting fish in a direct manner as they create hazards and or prevent fish from migrating upstream and downstream. The mortality rate increases and damage to certain fish species increases when fish pass through dam discharge structures (Bernacsek, 2000). Dams can affect the biodiversity of fish, fish stocks and fisheries indirectly by altering or degrading the upstream and downstream aquatic environments (Bernacsek, 2000).

It has been found that drops in water levels can increase the mortality of dewatered eggs and impact the reproductive success of different fish species (Logez *et al.,* 2016). Fish who primarily occupy the littoral zone for shelter and when water levels fluctuate this compromises their habitat and may induce a behavioral response in the fish such as stress which may trigger death or decreased reproduction (Logez *et al.,* 2016).

The change in temperature due to the seasons has a profound impact on the reproduction in fish (Pankhurst *et al.,* 2011). Temperatures that are increased result in reproductive development in spring-spawning species, and falling temperatures trigger the reproduction in autumn- spawners (Pankhurst *et al.,* 2011). Higher levels of temperatures trigger spring spawning, and delay autumn spawning (Pankhurst *et al.,* 2011). Larval fishes have been found to be more sensitive than adults to environmental fluctuations as well as having direct effects on embryonic duration and egg survival, size at hatching, developmental rate, pelagic larval duration and survival (Pankhurst *et al.,* 2011). Recently research as found that there is an increase in the demand for fish in South Africa, this is due to change in diet (Isaacs and Hara, 2015).

Table 1: Ecology, biology and life strategies of moggel (*Labeo umbratus),* common carp *(Cyprinus carpio),* orange river mudfish (*Labeo capensis),* smallmouth yellowfish *(Labeobarbus aeneus)* and sharp-toothed catfish *(Clarias gariepinus).* Adapted from Barkhuizen, (2015)

	Smallmouth yellowfish (*Labeobarbus aeneus)*	**Orange river mudfish (*Labeo capensis)***	**Moggel (*Labeo umbratus)***	**Common carp (*Cyprinus carpio)***	**Sharp-toothed catfish (*Clarias gariepinus)***
Length at sexual maturity	Males- 300mm Females-390mm [1]	Males- 330-350mm Females-370-400mm [1]	Males- 260-300mm Females-340- 370mm [1]	Males- 300mm Females-350mm [1]	Males- 460-600mm Females-410- 450mm [1]
Age at sexual maturity	Males- four years Females-five years [1]	Males- four years, Females-five years [1]	Males-three years 4, Females-four years [1]	Males- four years, Females-five years [1]	Males- two years 8,22, Females-one to two years [1]
Number of eggs	on average 15 277 [1]	on average 133 474 [1]	on average 173 591 [1]	on average 509 353 [1]	on average 50 173 [1]
Time until eggs hatch	Two to five days [1]	Three to four days [1]	40 hours [1]	Four to eight days [1]	25 to 40 hours [1]
Required habitat for spawning	Has a good amount of oxygen in the water in logic systems along with gravel beds [1]	Shallow rocky lotic areas and floodplains [1]	Lentic system and pools and floodplains [1]	Submerged plants in littoral zone [1]	Flooded vegetative zones [1]
Maximum age	Males- 19 years, Females-16 years [1]	Males- 12 years, Females- eight to nine years [1]	five to six years [1]	Males- 20 years Females- three to 28 years [1]	eight years or longer [1]
Maximum length	Males- 427mm Females-496- 500mm[1]	Males- 370-400mm Females-400- 450mm [1]	500mm [1]	438-1037mm [1]	1.4m [1]
Maximum weight	7.8kg ,9kg [1]	3kg, 3.8kg [1]	2.8kg [1]	36kg [1]	59kg [1]
Preferred habitat	Lotic and lentic; prefer lotic systems with clear water [1]	Lotic and lentic; with rocks and large flowing rivers and impoundments[1]	Lentic [1]	Lentic [1]	Lentic [1]
Growth rate	Slow with around 120mm growth a year[1]	Fast with around 80-90mm a year [1]	Fast with 100mm in a year [1]	Fast [1]	Rapid with around 200mm in a year [1]

Problem Statement:

Successful spawning seasons of certain fish species are vital for their use as potential fish for small scale fisheries.

Research Question:

What is the reproduction success and natural recruitment of Cyprinidae and Claridae fish species in allemanskraal dam after the 2020/2021 spawning season?

Aim of Research:

To investigate the reproduction success and natural recruitment of the following cyprinidae species ie moggel *(Labeo umbratus)* common carp *(Cyprinus carpio)*, orange river mudfish *(Labeo capensis)*, smallmouth yellowfish (*Labeobarbus aeneus)* as well as the clardiae species, the sharptooth catfish *(Clarias gariepinus)* in allemanskraal dam after the 2020/2021 spawning season based on results to be obtained, determine which species are suitable to be utilized in a small-scale fishery.

Hypothesis:

The cyprinidae and claridae fish species had a successful spawning season during 2020/2021, with the highest recruitment levels in the moggel *(Labeo umbratus)* common carp *(Cyprinus carpio)* and orange river mudfish *(Labeo capensis)* populations expected.

Method:

Proceeded to the study site, Allemanskraal dam. Sections of 10m were measured along the shoreline. A 100mm seine net was used, (A seine net is a long net, with or without a bag in the centre, which is set either from the shore or from a boat for surrounding a certain area and is operated with two long ropes that are attached to its ends which is used to haul or herd the fish (www.fao.org, n.d.))The ends of the seine nets were attached to one foot while the top line was held in hand. The net was then pulled for a distance of 10m in the littoral zone. After the 10m the person in the deep end moved forwards towards the shallow shore in a semi circle ensuring that the bag in the middle of the net stayed in the middle. When in position one volunteer would pull the bottom of the net while the other pulled the top on each side simultaneously onto the shore. The net was opened and the juvenile fish were collected from the net and the bag. This process was repeated four times.

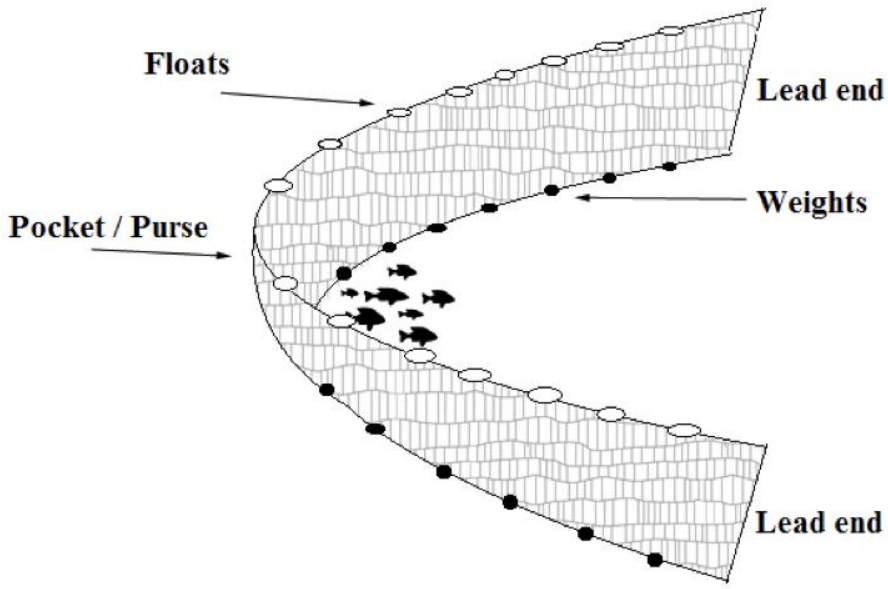

Figure 1 : Image showing an example of a seine net

Image supplied by: **https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.researchgate.net%2Ffigure%2FDiagram-of-beach-seine_fig4_308309566&psig=AOvVaw0cwZ5tuoQPi34Xz9hn068s&ust=1627675563386000&source=images&cd=vfe&ved=0CAsQjRxqFwoTCKD535iKifICFQAAAAAdAAAAABAD**

Variables:

Independent: The type of fish species being studied, the smallmouth yellowfish (*L. aenus)*, orange river,mudfish (*L. capensis),* moggel (*L. umbratus),* common carp (*C. carpio)*, sharp-toothed catfish (*C. gariepinus)*

Dependent: the reproduction success and natural recruitment of each fish species being studied.

Controlled/Fixed: the same type of nets will be used which will be 10m measured along a shoreline using a 100mm seine net.

The same measurement instrument will be used to measure each fish.

The sampling of the fish will happen within the same time period.

Study Site:

The study site of the following investigation is the Allemanskraal Dam. It is located in the Free State province of South Africa. The Allemanskraal Dam is found on the sand River in the quaternary catchment C42E. The Allemanskraal Dam is a 61-year-old impoundment that is surrounded by the Willem Pretorius Nature Reserve. The Allemanskraal Dam's purpose is for the irrigations of plant life via its canals. The Allemanskraal Dam also allows for large-scale fisheries and sport and recreational activities.

The Allemanskraal Dam is nearest to Ventersburg in the Free State and is 22 kilometres away from it. It supplies water to Virginia via a pipeline. This water is also purified at the Virginia Water Purification Works and transferred to the Upper Orange (Modder River Catchment) by a gravity pipeline which also leads to a storage reservoir in Brantfort where the water is puriefied and supplied to its users (Barkhuizen, 2015).

The Allemanskraal Dam has a total mass gravity concrete section and an earth embankment that is found on the right flank. The Allemanskraal Dam has a full water supply level of 1,368.7 m, a dead storage level of 1,355.9 m and the level at the bottom of the reservoir is at 1,353.0 m.The total surface area of the Allemanskraal Dam is 2667 hectares as well as a total capacity of 178 136 000 square metres. The average depth at full supply level (FSL) is 6.7 metres, and the catchment area is 3628 cubic kilometers. The Allemanskraal Dam's wall type is Earthfall and Gravity. The height of the Allemanskraal Dam is 37.7 metres with a crest length of 1 347 metres (Barkhuizen, 2015).It was noted that the Allemanskraal Dam was at 100% capacity during the sampling period of the investigation on the 10th April 2021.

The next 3 figures indicate the localities of the study site:

Figure 2: The map of Africa Image supplied by:
https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.britannica.com%2Fplace%2FAfrica&psig=AOvVaw3Fc2Mt5JRyqF42ct5rGtTi&ust=1622555782224000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCLDr-cCJ9PACFQAAAAAdAAAAABAD

Figure 3: Map of South Africa
Image supplied by: https://cdn.britannica.com/30/4230-050-B944C675/South-Africa.jpg

Figure 4: Map of South Africa indicating the location of Allemanskraal Dam
Image supplied by: http://wis.orasecom.org/content/study/UNDP-GEF/InfrastructureCatalogue/Documents/Reservoirs/Allemanskraal%20Dam.pdf

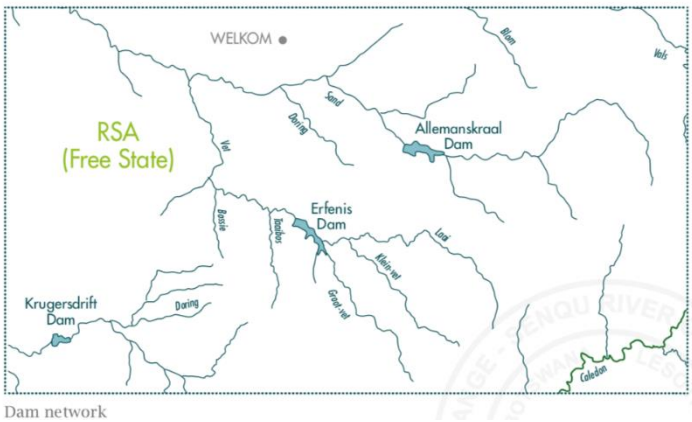

Figure 5: Map showiing the Dam network of Allemanskraal Dam and surrounding Dams

Image supplied by: http://wis.orasecom.org/content/study/UNDP-GEF/InfrastructureCatalogue/Documents/Reservoirs/Allemanskraal%20Dam.pdf

The following figures indicate the fish species that will be studied:

<table>
<tr><td>  </td><td>  </td></tr>
<tr><td>Figure 6
Photograph of a juvenile orange river mudfish (Labeo capensis)
Taken by Jessica De Freitas</td><td>Figure 7
Photograph of a juvenile common carp (C. carpio)
Taken Jessica De Freitas</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>Figure 8
Photograph of a juvenile smallmouth yellowfish (L. aeneus)
Taken by Jessica De Freitas</td><td>Figure 9
Photograph of a juvenile moggel (L. umbratus)
Taken by Jessica De Freitas</td></tr>
</table>

Results

Table 2: Table showing the number of juvenile fish of each species caught in a 10 m seine net at Allemanskraal Dam:

Fish Species	Number of fish species caught in a 10 m seine net
Moggel (*Labeo umbratus)*	78
Smallmouth yellowfish (*Labeobarbus aeneus)*	9
Common carp (*Cyprinus carpio)*	54
Orange river mudfish (*Labeo capensis)*	35
Sharp-toothed catfish (*Clarias gariepinus)*	2

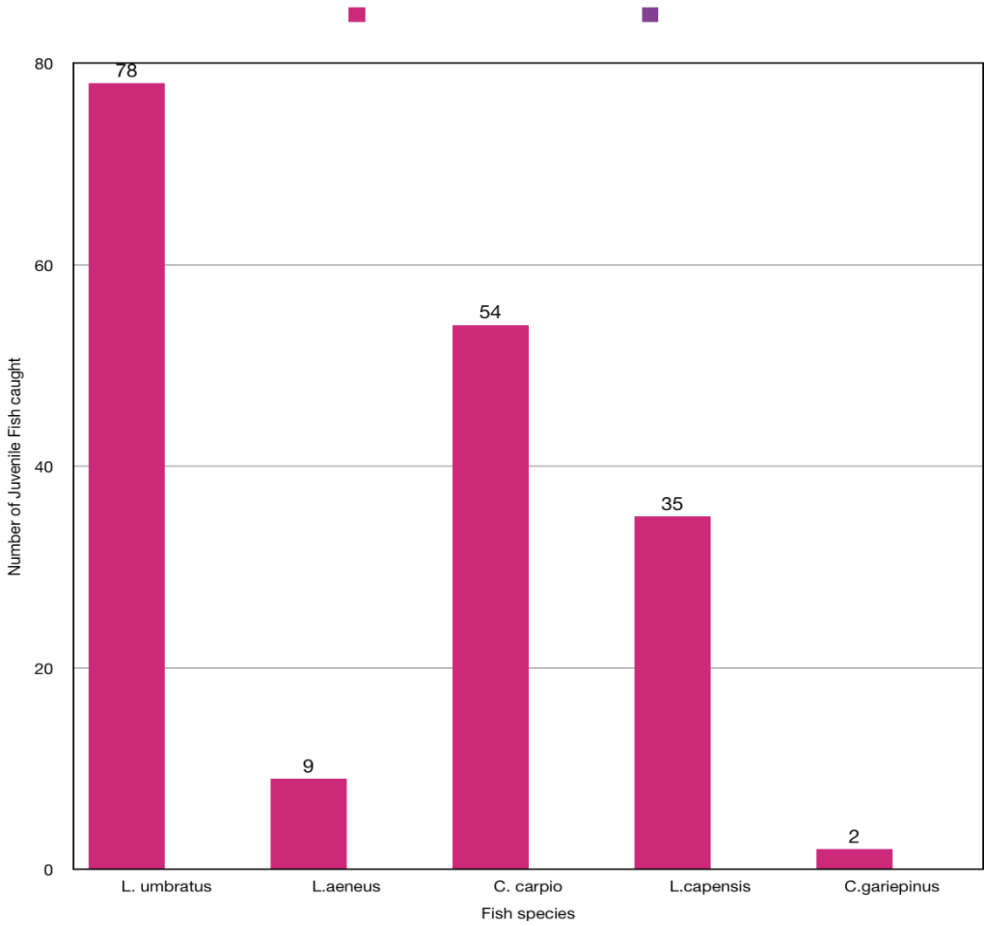

Figure 10: Bar Graph showing the number of juvenile fish of each species caught in a 10 m seine net at Allemanskraal Dam:

N-178

Analysis:

The catch composition of the 10m seine net consisted of moggel (Labeo umbratus) (n=78) common carp (cyprinus caprio) (n=54) orange river mudfish (Labeo capensis) (n=35) smallmouth yellowfish (Labeo aeneus) (n=9) and sharp-toothed catfish (Clarias gariepinus) (n=2). In total 178 young of year (juveniles) of all species were caught.

Discussion of results:

The moggel (*L.umbratus)* and the common carp (*C. carpio) were* found to have the highest numbers of juvenile fish caught. While the sharp-toothed catfish (*C. gariepinus)* and smallmouth yellowfish (*L. aeneus)* fish species had the lowest number of juvenile fish caught. The orange river mudfish (*L. capensis)* had a relatively average amount of juvenile fish caught in comparison with the numbers of the other fish species. The high numbers of the moggel (*L. umbratus)* and the common carp (*C. carpio)* indicate that these fish species had a successful spawning season whereas species such as orange river mudfish (*L. capensis)* had an average spawning season and species such sharp-toothed catfish (*C. gariepinus)* and smallmouth yellowfish (*L.aeneus)* had an unsuccessful spawning season due the low number of juvenile fish caught. The relatively successful spawning season of the smallmouth yellowfish (*L. capensis)* may be attributed to the dam being at full capacity as the species requires local flooding in order to start the spawning as the elevated water levels are needed to ensure that the juveniles survive.(Froese and Pauly, 2019).

The low numbers of the smallmouth yellowfish (*L. aeneus*) may be attributed to the fact they have a slow growth rate while in comparison with the moggel (*L. umbratus),* common carp (*C. carpio),* orange river mudfish (*L. capensis) and* sharp-toothed catfish (*C. gariepinus)* which all grow at a rapid rate.(Barkhuizen, 2015).The low numbers of the smallmouth yellowfish *(L. aeneus)* may also be due to the slow and late maturity rate of the species, meaning that there will be an extended period of time before they are able to reproduce (Barkhuizen et al., 2015). The large amount of juvenile moggel (*L. umbratus*) can be attributed to the high number of eggs laid by the species as well as the short duration of time taken for the eggs to hatch (Barkhuizen, 2015). The high numbers of moggel (*L. umbratus)* common carp (*C. carpio)* suggest that they would be good fish species for a small scale fishery due to their large numbers however overall the best species for a small-scale fishery would be the, *C. carpio* (common carp), as they are a large fish species whereas the moggel (*Labeo umbratus)*, is a relatively small fish species in comparison with the the common carp (*C. carpio).*

Recommendations for future research:

The individual fish species may be studied over a longer period of time to determine what would be the best fish species overall for a small scale fishery based on their reproduction success. In addition to this the individual fish species may also be studied in different areas of the country.

The study may be conducted over a period where the dam was not at full capacity, could be done over the different seasons to see if it is a reliable source year round instead of when the dam is at full capacity.

Additional questions posed concerning the environmental impacts on the fish species and their habitats should also be investigated as South Africa has frequent droughts. What would the effect of continued and worsting global warming have on our already frequent droughts and what would that mean for our water systems and the species that live there and as a results what would it mean for small and large scale fisheries.

Errors and Limitation:

The project had a few challenges. One being that it was difficult to tell the orange river mudfish (*L. capensis)* apart from the mogel which made it challenging to capture the number of species of juvenile fish accurately.

Many of the juvenile fish had damaged tail fins which resulted in difficulty capturing the true fork length of the juvenile fish and this resulted in estimation while measuring and this may have resulted in inaccurate readings of the fork length.

It had been found that the Allemanskraal Dam does not have tremendous potential regarding fisheries as there are major fluctuations in the water which causes a continuous decrease in the populations of the various fish species as the fish will not be able to spawn and this may have affected the results as the fluctuating water levels may have impacted the spawning of the fish species studied. The common carp (*C. carpio)* may have impacted the numbers of the young of year and juvenile fish species of the other fish and so it will never be known if the other fish species could be reliable for a fishery had there been no carp.

Due to the nature of this project, having an expert to assist was a necessity and without an expert this project would not have been able to be completed. The need for an expert on a frequent basis is limiting in terms of progress and the amount of research able to be conducted out in the field.

Being a matric learner has been both immensely challenging as well as limiting with regards to the project, in terms of finding time to balance both schoolwork and completing the project. This paired with the COVID-19 pandemic has limited the amount of testing able to be conducted for this project.

Conclusion:

In conclusion, the hypothesis was accepted due to the fact that the moggel *(L. umbratus)* had the most successful spawning season with a total of 78 out of the 178 juvenile fish caught. These high numbers can be attributed to the large amount of eggs laid by the species and the short amount of time that it takes for them to hatch. Furthermore the the common carp (*C.*

carpio) also had a successful spawning season with a total of 54 young of year fish caught out of the total of 178.

The orange river mudfish (*L. capensis)* had an average spawning season with a total of 35 juvenile out of the total of 178. This is due to the fact that the species requires local flooding to spawn and at the time the time of investigation the dam was at full capacity.

The smallmouth yellowfish (*L. aeneus)* and sharp-toothed catfish (*C. gariepinus)* both had the lowest numbers of juvenile fish caught with a total of 9 and 2 respectively out of the 178 and this therefore indicates that these species had an unsuccessful spawning season in comparison with the other species who had relatively successful spawning seasons. The low numbers of the smallmouth yellowfish (*L. aeneus)* may be due to their slow growth rate in addition to this the low numbers may also be due to their slow growth and maturity rate.

Therefore the high numbers of young of year fish of both the moggel (*L. umbratus)*, and common carp (*C. carpio)* suggest that they would be a good fish species for a small scale fishery. However, overall the best species for a small scale fishery would be the, common Carp (*C. carpio)* as they are a large fish species whereas the moggel (*L. umbratus)* is a relatively small fish species in comparison with the the common carp (*C. carpio)* and would not be as suitable for a small scale fishery.

Acknowledgements

Thank you to Dr Leon Barkhuizen for his expertise and guidance on the subject and throughout the completion of the project

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Appendix

Summary of the questions and answers from the expert interviewed
General questions and answers regarding the procedure of catching the fish and recording findings:

Q: Should the temperature, the TDC and ECD level in the water where the fish were caught be taken into account?
A: No we will not be taking it into account, only the numbers of the juvenile fish are important.

Q: When is a fish regarded as a juvenile?
A: The juvenile fish will be between the lengths of 0-10 cm (young of year which refers to fish born within the past year) and 11-20 cm (juvenile fish) those will be the lengths of the juvenile except for the catfish which was noted that their set length would be 20 cm.

Questions and answers on factors affecting spawning and the spawning season of fish:

Q: How will it be known if the species had a successful spawning season?
A:The numbers of the juvenile fish caught from each species will be compared with one another to determine which species had the most successful spawning season.

Q: Have the droughts negatively impacted the spawning of fish?
A: The droughts impact the water levels and as a result this negatively impacts the spawning of many fish species as many fish species spawn in the littoral zone and if that is compromised then their spawning will also be compromised.

Q: Do the common carp (*Cyprinus carpio)* impact the numbers of the other juvenile fish?
A: Yes the alien and invasive common carp (*C. carpio)* do impact the numbers of the other juvenile fish species. They impact them in negatively as they compete with other indigenous fish species for food.

Q: Why is having a successful spawning season important?
A: It is important as it helps to determine whether or not the particular species would be considered as a good candidate for a small or large scale fishery.

Photographs of Project

Figure 11
Image of learning how to use the seine nets
Image taken by Kudzi Nhiwatiwa

Figure 12
Image of using the seine nets and collecting the fish in the dam
Image taken by Kudzi Nhiwatiwa

Figure 13
Image of using the seine nets and collecting fish in the dam
Image taken by Kudzi Nhiwatiwa

Figure 14
Image of using the seine nets to collect fish
Image taken by Kudzi Nhiwatiwa

Figure 15
Image of collecting the fish from the seine nets
Image taken by Kudzi Nhiwatiwa

Figure 16
Image of collecting fish from the seine nets
Image taken by Kudzi Nhiwatiwa

Figure 19
Image of collecting the fish from the seine nets
Image taken by Kudzi Nhiwatiwa

Timeline

Project will commence on the 15 February 2021

Discussion with Dr Leon Barkhuizen – external study mentor 18 February 2021

Project reviewed by mentor 5 March 2021

Research project carried out 9-11 April 2021

Project reviewed by mentor 12 June 2021

Project submitted for Eskom Expo 30 July 2021

destea
department of
Economic, Small Business Development,
Tourism and Environmental Affairs
FREE STATE PROVINCE

Reference: Aquatic Research / Ichthyology

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21 July 2021

To whom it may concern

Mini-research projects on freshwater fish, small-scale fisheries and water quality of Grade 12 learners from St. Andrew School, Welkom

I, Dr. Leon M. Barkhuizen, Aquatic Scientist and Ichthyologist from the Free State Department of Economic, Small Business Development, Tourism and Environmental Affairs (FS DESTEA), and Research Associate, Department of Zoology and Entomology, University of the Free State, hereby confirms that the Grade 12 Life Science learners from St. Andrew School, Welkom, implemented various mini-research projects on freshwater fish, small-scale fisheries and water quality under my guidance and mentorship at Allemanskraal Dam in the Free State Province.

The mini-research projects done by the learners, form part of Provincial level research projects on the occurrence, distribution and relative abundance of freshwater fish, investigations in to small-scale fisheries development, and water quality parameters in aquatic systems in the Free State under supervision of Dr. Barkhuizen. The research is done under authorisation of an approved Research permit, Permit number NC.8679/2018 issued by the FS DESTEA on 17 November 2018 with an expiry date of 31 December 2021. All fish caught during the mini-research projects at Allemanskraal Dam were treated humanely according to guidelines and most were released back into the dam after biological data were collected.

Yours sincerely.

Dr. L.M. Barkhuizen *Pri.Sci.nat*

21/07/21

【評語】050016

This study is to investigate the reproduction success and natural recruitment of the following cyprinidae species ie moggel (Labeo umbratus) common carp (Cyprinus carpio), orange river mudfish (Labeo capensis), smallmouth yellowfish (Labeobarbus aeneus) as well as the clardiae species, the sharptooth catfish (Clarias gariepinus) in allemanskraal dam after the 2020/2021 spawning season based on results to be obtained,

1. This is interesting project. However, this study only selected one site (Allemanskraal Dam) and performed four catches during one day was not enough to reflect the real situation of fish reproduction. Base on one year result is also very difficult to draw a conclusion.
2. The result of number of juvenile fish is not enough to determine which species are suitable to be utilized in a small-scale fishery.
3. Additionally, more factors, such as environmental effects and adult fish number, were suggested to include in the project.