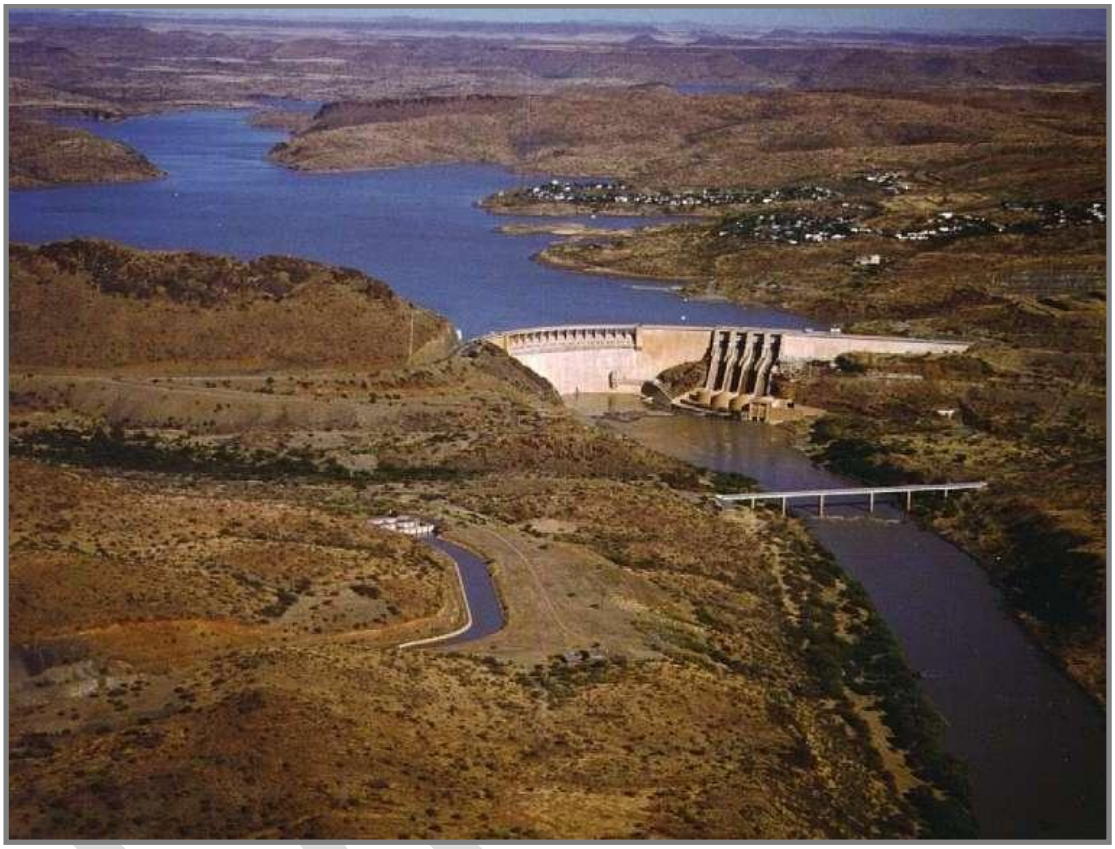
DRAFT EXPERIMENTAL FISHERY MANAGEMENT PLAN FOR THE DEVELOPMENT OF A SMALL-SCALE COMMERCIAL CAPTURE FISHERY ON VANDERKLOOF DAM, NORTHERN CAPE PROVINCE, SOUTH AFRICA



Internal working document for review by EFMP advisory committee

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1. PROJECT OUTLINE

Vanderkloof Dam as it is situated within a priority area for development. The nearby towns of Keurtjieskloof, Petrusville and Phillipstown have high levels of unemployment and poor food security. The Northern Cape Department of Agriculture, Land Reform & Rural Development (NC–DALRRD) has recognized the potential that inland fisheries may have for local rural communities in the area. NC–DALRRD wishes to explore possibilities to develop a potential small-scale commercial capture fishery on Vanderkloof Dam and has mandated the Rural Fisheries Programme (undertaken by the Department of Ichthyology and Fisheries Science, Rhodes University) to assess this potential. In order to make an informed decision the Department intends to develop a small-scale experimental fishery. The experiment will produce baseline catch data for the determination of sustainable harvest levels and current trends in catch rates, which are needed for the development of future management actions. Biological, economic and social data created in the experiment will be used to assess its biological and economic feasibility and to make a decision on whether to implement the next phase (small–scale commercial fishery).

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4. ACRONYMS AND ABBREVIATIONS

CBLE	Community Based Legal Entity
CPUE	Catch Per Unit Effort
CSIR	Council for Scientific and Industrial Research
DAFF	Department of Agriculture, Forestry and Fisheries
NC-DALRRD	Northern Cape Department of Agriculture Land Reform & Rural Development
DEAT	Department of Environmental Affairs and Tourism
NC-DENC	Northern Cape Department of Environment and Nature Conservation
DIFS	Department of Ichthyology and Fisheries Science
DWS	Department of Water and Sanitation
EFMP	Experimental Fishery Management Plan
FS-DETEA	Free State Department of Economic Development, Tourism and Environmental Affairs
GTAC	Government Technical Advisory Centre
HDI	Historically Disadvantaged Individuals
IUCN	International Union for Conservation of Nature and Natural Resources
NCNC	Northern Cape Nature Conservation
NEMA	National Environmental Management Act
NEMBA	National Environmental Management: Biodiversity Act
NWU	North-West University
RFP	Rural Fisheries Programme
SAMSA	South African Maritime Safety Authority
SANBI	South African National Biodiversity Institute
SASACC	South African Sport Anglers and Casting Confederation
TAC	Total Allowable Catch
TOPS	Threatened or Protected Species

5. DEPARTMENTS AND MANDATES RELATED TO THE PROJECT

Table 1. Departments and mandates related to the Vanderkloof Dam experimental fishery project.

Department	**Mandate**
Department of Agriculture, Forestry and Fisheries (DAFF)	To provide expert advice on the development of the EFMP.
Rural Fisheries Programme, Department of Ichthyology and Fisheries Science, Rhodes University	EFMP development, implementation, monitoring and assessment.
Department of Water and Sanitation (DWS)	Responsible for the use and zonation of the surface water of the Dam.
Northern Cape Department of Agriculture, Land Reform & Rural Development (NC-DALRRD)	The development of inland fisheries in the province.
Northern Cape Department of Environment and Nature Conservation (NC-DENC)	Responsible for the management of State owned land around the Dam. Responsible for the management of land between the high water mark and the purchase boundary. Responsible for compliance monitoring and control of the experimental fishery.
Free State Department of Economic Development, Tourism and Environmental Affairs (FS-DETEA)	Responsible for the management of State owned land around the Dam. Responsible for the management of land between the high water mark and the purchase boundary.
Department of Environmental Affairs	Responsible for biodiversity management within the Dam.
South African Maritime Safety Authority (SAMSA)	Administers and executes maritime related legislation and regulations.
Renosterberg Municipality	Still to add mandate.
South African Sport Anglers and Casting Confederation (SASACC)	To provide expert advice on the development of the EFMP, and to represent the views, concerns and recommendations of recreational fishers.
GTAC Government Technical Advisory Centre	Still to add mandate.
Masifundise Development Trust	To represent small-scale fisher rights; formation of rural fishers into a community-based legal entity; assist in experimental right allocations.
Vanderkloof Angling Club	To represent the views, concerns and recommendations of the Vanderkloof Angling Club and town residents.

6. EXPERIMENTAL FISHERY MANAGEMENT PLAN ADVISORY COMMITTEE

The following advisory committee (Table 2), made up of resource stakeholders and fishery researchers, was established to advise NC-DALRRD on recommendations for the development of the Experimental Fishery Management Plan (EFMP), and to provide input on the development of a research framework and operational protocol.

Table 2. Vanderkloof Dam EFMP advisory committee.

Name	Organisation	Email
Dr. Andy Cockcroft	DAFF	**andrewC@daff.gov.za**
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7. EXECUTIVE SUMMARY

Despite the importance of inland fisheries to rural communities, especially in developing countries, little attention has been paid to this sector in recent years (Welcomme et al. 2014). As a result there has been a lack in management of inland fisheries resources (Welcomme et al. 2014). Inland fishery statistics are generally very poor and the state of fish stocks in many inland waters are unknown because of the low level of research (Welcomme et al. 2014). Although knowledge of the actual contribution of the sector to food security is unknown, inland fisheries employ about 56 million people directly and indirectly (Welcomme et al. 2014).

In South Africa inland fisheries are poorly developed and fish populations in many dams are under-utilized (McCafferty *et al.* 2012). Although the primary purpose of South African dams is to supply water for domestic and agricultural use, there has been an increasing realisation that their fish populations could make a contribution to food security through the establishment of capture fisheries (McCafferty *et al.* 2012). Historically South African dams have primarily been utilized for recreational fishing purposes, as subsistence use was criminalized by the apartheid regime in all waters except in the former homeland areas (McCafferty *et al.* 2012). This legacy persists today as many of South Africa's rural communities do not have a fishing tradition and there is a lack of an institutional framework to facilitate managed and sustainable/equitable access to the fish resource in inland waters (McCafferty *et al.* 2012). With the lack of an inland fisheries policy at national level, provincial governments have been the driving force in the development of freshwater fisheries in South Africa (Field & Rouhani 2013). It is suspected that interest in developing inland fisheries will continue to increase to address major national policy objectives, which include food security, economic empowerment, optimal economic benefit from water, and poverty eradication (RSA 1998a, 1998b).

The Vanderkloof Dam is the second largest (133 km²/13 300 ha) and longest (114 km) water body in South Africa and was built as part of the Orange River Scheme. The main aim of the scheme is to provide a solution to chronic water shortages and to generate hydro-electricity. The Dam is primarily used for irrigation but also supplies the urban requirements of Koffiefontein, Ritchie, Jacobsdal, Vanderkloof, Keurtjieskloof and Petrusville (DWS 2014). The electricity generated at Vanderkloof Dam feeds into the Eskom National Grid to supply power for peak and emergency demand periods, as well as base load energy when excess water might pose a flood risk (DWS 2014).

The Dam is used by the informal Vanderkloof Angling Association and Vanderkloof Boat Club as well as adventure kayakers and other water sport enthusiasts. Most of the recreational use of the Dam is relatively informal with no national affiliation of any clubs. The Vanderkloof boat club has approximately 72 members who use the Dam (DWS 2014). In addition, angling is very popular in the Dam. This includes shore angling and light boat angling for species such as common carp (*Cyprinus carpio*), sharptooth catfish (*Clarias gariepinus*), mudfish (*Labeo capensis*), moggel (*Labeo umbratus*), smallmouth yellowfish (*Labeobarbus aeneus*) and largemouth yellowfish (*Labeobarbus kimberleyensis*). The Dam is primarily used during the December and April holidays where a number of users travel from and around the country (DWS 2014). To a lesser extent, some users also travel to the Dam for

weekends. The majority of the land surrounding the Dam is used for conservation purposes. There are two nature reserves on the Northern Cape side of the Dam (Doornkloof and Rolfontein Nature Reserve) both of which are managed by the Northern Cape Department of Environment and Nature Conservation (NC-DENC). Although subsistence fishing by local rural communities is illegal and currently criminalized at the Vanderkloof Dam, it continues to take place.

Previous studies has indicated that fish stocks in the Vanderkloof Dam has great value as an alternative and cheap protein source for rural communities (Allanson & Jackson 1983; Britz & Hecht 1997). The utilization of fish resources in the dam may also accrue economic benefits for subsistence and small-scale commercial harvesters (Allanson & Jackson 1983; Britz & Hecht 1997). The Rural Fisheries Programme has completed a pre-feasibility study of a small-scale capture fishery at the Vanderkloof Dam and has found that there may be a opportunity for rural community fishermen (Field & Rouhani 2013). This would create an income and also provide a form of protein to a number of families. In addition, the recent Vanderkloof Dam Final Resource Management Plan indicated that a small-scale commercial capture fishery may be a possibility for socio-economic development in the area, but that the economic feasibility and biological sustainability of such a venture need to be assessed (DWS 2014).

The principles of fisheries management are well established. It is widely recognised that the long-term sustainable use of fish resources, which promotes the economic and social well being of the fishers, is the overriding objective of fisheries management (Weyl *et al.* 2007). The development of new inland fisheries at major water bodies like Vanderkloof Dam requires the development of Fishery Management Plans (FMP's) and must be guided by Operational Protocols and an institutional environment in order to ensure biological sustainability and optimization of economic benefits for local rural communities (Weyl *et al.* 2007). Decisions on resource allocation should be guided by national policy, although at present, the lack of an inland fisheries policy is a major stumbling block for sustainable inland fisheries development in South Africa (Ellender 2010). Abrahams (2000) suggested the development of new fisheries in large impoundments such as the Vanderkloof Dam should involve initial experimental operations, trial periods of fishing, appropriate research and monitoring.

The Northern Cape Department of Agriculture, Land Reform & Rural Development (NC-DALRRD) intends to investigate the potential of a small-scale commercial capture fishery on Vanderkloof Dam by implementing and assessing the success of an experimental fishery. One of the goals of the experimental fishery is to test its economic feasibility. However, the primary objective is to obtain enough scientific information about fish resources in order to determine biologically sustainable catch and effort levels. Only if proven to be biologically sustainable and economically feasible, will information generated in the proposed experimental fishery lead to the development of a FMP for the structuring of a subsequent small-scale commercial fishery in line with the Government's objectives for fisheries sector development.

8. AIMS AND OBJECTIVES

The main aim of any experimental fishery is to determine the status of the resource and establish safe levels for sustainable exploitation (King 1995). Experimental catch and effort surveys give a good indication of what is removed from a resource, which can subsequently be used to determine how fish populations respond to harvesting (Reid & Montgomery 2005).

8.1 Experimental Fishery Management Plan aims

The aim of this EFMP is to investigate the economic feasibility and biological sustainability of a small-scale experimental fishery on Vanderkloof Dam. Results of the experiment will be used to make a decision on whether to implement the next phase (small-scale commercial fishery).

8.1.1 Specific biological aims are to:

- Assess seasonal catch and effort
- Determine total yield from the experimental fishery
- Determine seasonal species, sex and size composition of different experimental gears
- Determine what effects exploitation rates may have on species caught

8.1.2 Specific economic aims are to:

- Assess whether it is possible to achieve sustainable catch rates for economically efficient production
- Explore demand and market potential for harvested fish
- Determine if income allows a sustainable business framework
- Determine if replacement/maintenance of capital items are possible through profits generated in the experimental fishery or if ongoing government subsidy would be required

8.2 Government objectives

The establishment of new small-scale fisheries are a government priority in terms of several of its key objectives (DEAT 2003):

- Job creation.
- Food security and food production.
- Poverty alleviation.
- Socio-economic development.
- Human resource development – skills enhancement through new economic activities, particularly those associated with small business.
- Social sector service delivery – expanding the commercially exploitable resource base, broadening access and prioritizing the poor and disadvantaged.
- Rural development programmes – focusing particularly on previously neglected areas.

NC-DALRRD is committed to the development of new inland fisheries in the province with the aim of achieving economic growth within previously neglected rural areas. The initial focus will be on exploring the development of a small-scale

experimental capture fishery on Vanderkloof Dam, thereby creating employment opportunities within the Vanderkloof and Petrusville rural community sections.

8.3 Experimental Fishery Management Plan objectives

8.3.1 Biological Objectives

- To assess the long-term biological sustainability of the proposed experimental fishery.
- To apply the Precautionary Principle with respect to the utilization of previously underutilized fish resources where little or no data is available.
- To provide for the protection of fish species diversity and aquatic habitats.

8.3.2 Economic Objectives

- To assess the potential of sustainable development of economically efficient commercial production through experimentation with different fishing gear, seasons and areas.
- To assess the long-term economic feasibility of the proposed experimental fishery.

8.3.3 Social Objectives

- To assess the possibility of a fishery to provide employment opportunities for the local rural community.

8.3.4 Governance Objectives

- To suggest a structured governance framework for the development of small-scale inland fisheries.

9. OPERATIONAL PROTOCOL

The following operational protocol is recommended for the development of small-scale inland fisheries in South Africa (adapted from Oosthuizen et al. 2007). Although Figure 1 illustrates a three-phased protocol the focus of this EFMP is only on Phase 0 and Phase 1 (i.e. the development of the experimental fishery). Phase 2 is purely added for forecast purposes in the case that the experimental fishery proves economically feasible and biologically sustainable.

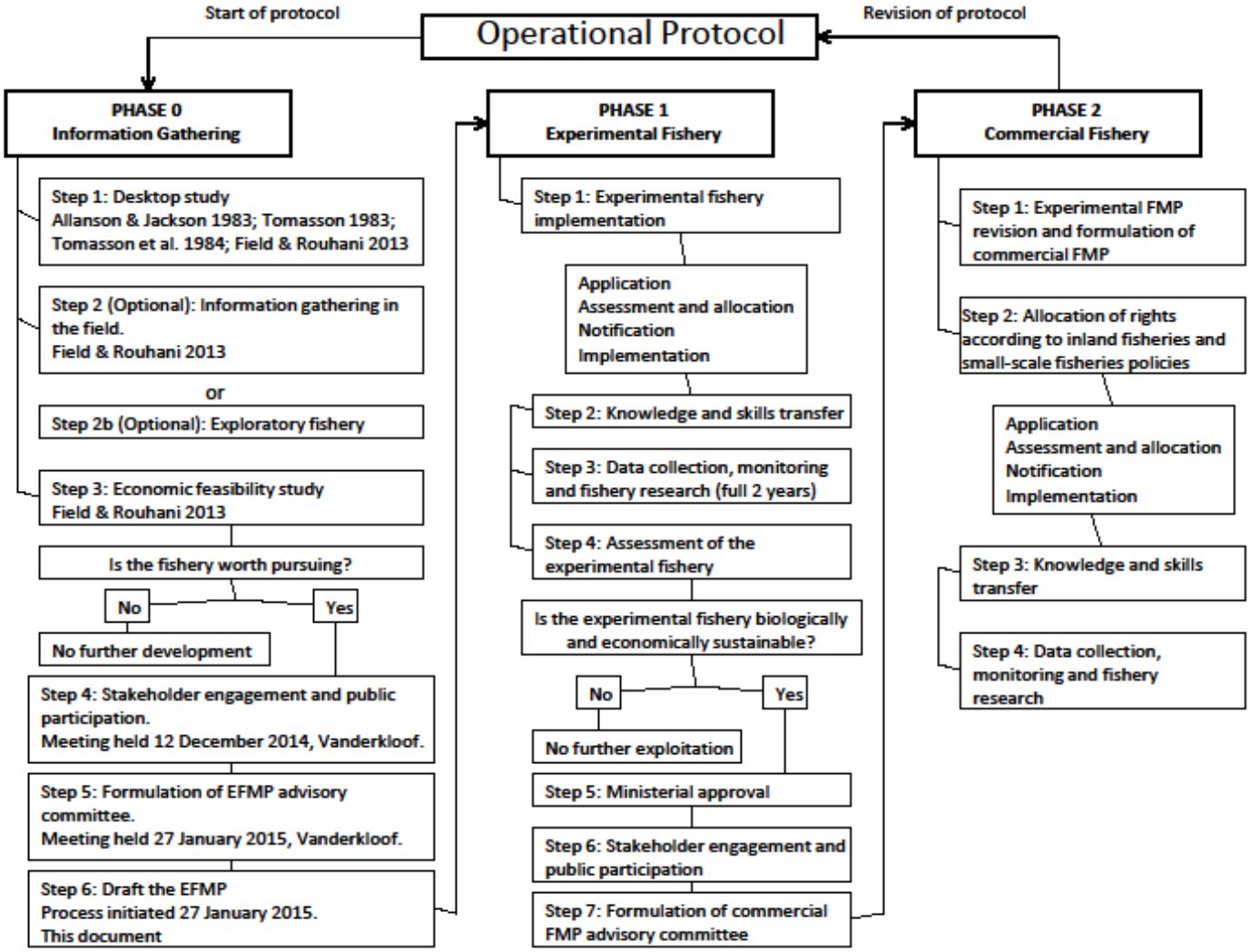

Figure 1. Operational protocol for development of the Vanderkloof experimental fishery (adapted from Oosthuizen et al. 2007)

10. EXPERIMENTAL FISHERY MANAGEMENT PLAN PROCESS

The following 15 step process is recommended for the development of the EFMP:

Step 1: Stakeholder engagement and public participation (meeting held 12 December 2014, Vanderkloof).

Step 2: Formulation of the EFMP advisory committee (meeting held 27 January 2015, Vanderkloof).

Step 3: Draft the preliminary EFMP (released 23 March 2015).

Step 4: Present the preliminary draft EFMP to the advisory committee for feedback (meeting held 26 March 2015, Vanderkloof).

Step 5: Revision of the preliminary draft EFMP.

Step 6: Present the draft EFMP to the advisory committee for feedback.

Step 7: Revision of the draft EFMP.

Step 8: Submit the final draft EFMP to the advisory committee for approval.

Step 9: Submit the final draft EFMP to NC-DENC and DAFF national for assessment and subsequent permit application.

Step 10: If approved and permits issued, implement the experimental fishery as outlined in the Final EFMP.

Step 11: Data collection and monitoring as outlined in the Final EFMP.

Step 12: Adapt the EFMP as new information becomes available.

Step 13: Assess the biological sustainability and economical feasibility of the experimental fishery.

Step 14: If results prove the experimental fishery to be biologically sustainable and economically feasible, recommendations for the development of a subsequent small-scale commercial FMP will be provided.

Step 15: If results prove the experimental fishery to be biologically unsustainable and economically unfeasible, no further commercial exploitation of fisheries resources will be recommended.

11. EXPERIMENTAL FISHERY DESIGN

11.1 Health risks [34]

Aquatic environments can be polluted by contaminates that are accumulated by freshwater fish (du Preez et al. 2003). This may pose a health risk to consumers of contaminated fish (du Preez et al. 2003). Unsafe levels of heavy metal concentrations in the tissue of fish species is a possibility and therefore need to be assessed. Independent testing laboratories as well Eco-Analytical laboratories at the Council for Scientific and Industrial Research (CSIR) and North-West University (NWU) are currently being approached to test for heavy metal concentrations in samples and whether fish present in the dam are safe for human consumption.

11.2 Experimental approach

A combination and adaptation of experimental approaches recommended by Oosthuizen (2003) is suggested for the collection of information from the proposed experimental fishery:

11.2.1 A base scientific fishery experiment - comprised of fishing with a specified number of different gear types and configurations. This will allow for:

- The determination of potential sustainable yield and to determine if the resources are large enough to support commercial exploitation.
- The determination of the effects of different gear types, gear restrictions, areas and season on catch per unit effort (CPUE) and mean mass.
- The determination of catch rates needed for economic forecasts, gear efficiency assessment and gear type effects on unwanted bycatch.

11.2.2 An exploratory processing and marketing approach - where fishers are given freedom to experiment with processing, value-adding and markets. This will allow for:

- Market-related research information.
- Establishment of demand and possible markets for harvested fish.

11.3 Current legislation [1]

Experimental fishery assessments and surveys in South African inland waters have been granted permits exempt from regulations against illegal gears and catches (example Rouhani 2004; Weyl et al. 2007; Richardson et al. 2009; Weyl et al. 2010; Ramollo 2011; Wepener et al. 2011; Ellender et al. 2012; Winker et al. 2012; Field & Rouhani 2013 and Crafford et al. 2014). Although legal issues regarding gears and protected species are only dealt with in the commercial fishery phase (if the experiment proves successful), the new TOPS regulations complicates the planned use of illegal gears and catches of protected species in the proposed experimental fishery. These legalities need to be taken into account and sorted out before the EFMP can be finalized.

11.4 Species

The following species will comprise the catch:

11.4.1 Target species

- Smallmouth yellowfish *Labeobarbus aeneus* [2]
- Sharptooth catfish *Clarias gariepinus* [3]
- Mudfish *Labeo capensis* [4]

11.4.2 Bycatch species

- Moggel *Labeo umbratus*
- Largemouth yellowfish *Labeobarbus kimberleyensis* [5]
- Common carp *Cyprinus carpio*

11.5 Duration of the experiment

The experimental fishery will run for a minimum of 2 full years. [6]

11.6 Harvest limitations and number of participants [7]

The following conservative catch and effort limits should be adequate to allow for the economic feasibility assessment of the experiment as well as ensuring adherence to a precautionary approach.

11.6.1 Total Allowable Catch

A annual TAC limit of 60 tons (5 tons per month) is recommended for the experimental fishery.

11.6.2 Participants

18 participants could run the base experimental fishery:

- 4 boat fishers (gill nets and longlines)
- 10 shore fishers (hand line, rod & line, electro fisher, seine nets, feike nets)
- 4 processing plant and multipurpose shop workers (fish processing, marketing and sales)

11.7 Number of vessels and vessel type [8]

A 7 - 9 m open deck aluminium vessel is recommended to set/retrieve all fishing gear and transport catches ashore. A vessel of this size could be powered by 115 – 200 hp.

11.8 Vessel safety and safety equipment

Safety is a very important aspect and the experimental fishery has to be compliant to national safety regulations. There are combination training courses available for participants (skippers/fire fighting/first aid).

The following safety equipment should be stored onboard during all fishing operations:

- life jackets
- emergency flares
- personal locator beacon (PLB)
- fire extinguisher
- oars

11.9 Skipper

Mr. Sydney Kramer, a rural community member and experienced skipper has been identified for participation as skipper in the experimental fishery.

11.10 Gear types and configurations

It is important to test a range of different gear types, sizes, seasons and areas in order to determine its effects on catch rates of target and bycatch species. The restrictions and configurations recommended below are for the proposed **base** experimental gears, and should only be seen as a starting point when initiating the experimental fishery. Although configurations should remain the same for the base experimental gears (to ensure standardized long term data), it may be necessary to cease with particular gears/configurations if the harvest of certain species exceeds those biological reference points stipulated.

11.10.1 Gill Nets [9]

The following conservative gill net configurations would allow for the experimental design needed to assess catch rates of target and bycatch species in different seasons, areas and with different mesh sizes (Table 3). [Mesh sizes < 60 mm (due to high selectivity for immature smallmouth yellowfish) and > 100 mm (due to high selectivity for large largemouth yellowfish) are excluded]

Table 3. Gear configurations proposed for the base experimental gill net fleets.

Gear specifications	Restrictions
total gill net length	240 m
fleet #	6
fleet length	40 m
fleet depth	3 m
mesh panels per fleet	4
panel length	10 m
mesh sizes	60, 70, 80, 90 mm
marker buoy intervals	10 m

Therefore, Table 3 above proposes 6 base experimental gill net fleets, each fleet 40 m long x 3 m deep consisting of 4 randomly distributed 10 m long mesh panels.

11.10.2 Longlines [10]

The following conservative longline configurations would allow for the experimental design needed to assess catch rates of sharptooth catfish in different seasons and areas:

Table 4. Gear configurations proposed for the base experimental longline fleets.

Gear specifications	Restrictions
longline width	12 mm rope
total longline length	180 m
fleet #	6
fleet length	30 m
hook type	circle
hook size	5/0
# hooks	15/30 m
# total hooks	90
float intervals	1m
hook trace from top rope	1 m
trace strength	50 kg
marker buoy intervals	30 m

Therefore, Table 4 above proposes 6 base experimental longline fleets, each fleet 30 m long consisting of 15 hooks.

11.10.3 Hand lines and rod & line [11]

These methods will be tested with 10 shore fishers. A preliminary minimum size limit of 360 mm (female length at 50% maturity in Lake Gariep) and maximum size limit of 440 mm ('trophy' fish) are recommended for smallmouth yellowfish. A preliminary minimum size limit of 323 mm (female length at 50% maturity in Lake Gariep) and a maximum size limit of 400 mm (brood stock) are recommended for mudfish catches. All largemouth yellowfish must be released alive.

11.10.4 Fyke nets [12]

Shore fishers will test this method with 3 fyke nets. If it appears practical in the areas zoned for experimentation this gear type should be permitted for use in the base experimental gears. A preliminary minimum size limit of 360 mm (female length at 50% maturity in Lake Gariep) and maximum size limit of 440 mm ('trophy' fish) are recommended for smallmouth yellowfish. A preliminary minimum size limit of 323 mm (female length at 50% maturity in Lake Gariep) and a maximum size limit of 400 mm (brood stock) are recommended for mudfish catches. All largemouth yellowfish must be released alive.

11.10.5 Seine nets [13]

Shore fishers will test this method with 1 seine net (50 m). If practical beaching areas for the use of a seine net can be identified within the sites zoned for experimental fishing then this gear type should be permitted for use in the base experimental fleets. It is important to take spawning habits, seasons and sites of certain species into account when choosing areas for the use of seine nets. Yellowfish and mudfish may have adapted to spawn in the dam (Tómasson et al. 1984) and their choice of spawning sites may depend on the availability of suitable habitat such as shallow banks, newly inundated vegetation in flooded riparian areas and tributaries. Care should be taken not to destroy habitats important to spawning. A preliminary minimum size limit of 360 mm (female length at 50% maturity in Lake Gariep) and maximum size limit of 440 mm ('trophy' fish) are recommended for smallmouth yellowfish. A preliminary minimum size limit of 323 mm (female length at 50%

maturity in Lake Gariep) and a maximum size limit of 400 mm (brood stock) are recommended for mudfish catches. All largemouth yellowfish must be released alive.

11.10.6 Electro fishing

Shore fishers will test this method. A preliminary minimum size limit of 360 mm (female length at 50% maturity in Lake Gariep) and maximum size limit of 440 mm ('trophy' fish) are recommended for smallmouth yellowfish. A preliminary minimum size limit of 323 mm (female length at 50% maturity in Lake Gariep) and a maximum size limit of 400 mm (brood stock) are recommended for mudfish catches. All largemouth yellowfish must be released alive.

11.11 Access to the dam [14]

Access to the dam for launching a vessel could be gained via an existing slipway located near the dam wall.

or

Via the existing boat club slipway where washing facilities exist.

Practical areas for the use of certain fishing gears (especially seine and feike nets) are apparently limited on Vanderkloof Dam and identification of suitable areas could be problematic. Shallow banks and sandy beaches are needed to use seine and feike nets, and access to different areas of the dam may be needed for the use of other gears such as hand lines, rod & line and electro fishers.

11.12 Zonation of base experimental fishing sites [15]

Appendix 1 - 3 provides an overview of the water surface zonal plan proposed by DWS (2014). This plan has demarcated zone A (zone closest to the town) for a combination of activities including recreational shore fishing, recreational boat fishing, small-scale experimental fishing and other waters sports. For the base experiment harvesting will be limited to 18 experimental sites (split into 6 longline, 6 gill net, 1 rod & line, 3 fyke net, 1 seine net and 1 electro fishing experimental sites) within zone A. CPUE data generated from the experimental catches will ultimately be used to determine which of the experimental sites and gears prove most efficient in terms of catch efficiency and bycatch concerns.

Figure 2 below illustrates 17 catch locations tested during the pre-feasibility survey and gives an indication of possible experimental fishing sites and distances to travel within zone A (Field & Rouhani 2013).

Figure 2. Catch locations tested during the pre-feasibility survey (taken from Field & Rouhani 2013).

11.13 Experimental fishing operation

Heads and intestines collected from fish caught in gill nets and other shore fishing methods will be used to bait longlines.

The base experimental gill net and longline configurations will remain the same throughout the entire experimental fishery, unless stipulated biological reference points are exceeded. [16] As new data about gear selectivity/efficiency becomes available from the experimental fleets, the addition of other gears, configurations and catch areas should be permitted. Each of the base experimental sites will remain stationary for the duration of the entire experiment. [16] Gill nets and longlines will be fished simultaneously, each in a different area (exact experimental sites still to be identified). Gill net and longline gears will be set at roughly the same depth. [18] Both gears will be set parallel to the shoreline [19]

Both gill nets and longlines could be set to soak for 12 - 18 hours overnight (set between 16:00 pm – 20:00 pm and hauled between 06:00 am – 09:00 am). [20]

or

Soak for 24 hours (haul and set from 08:00 am). [20]

During the retrieval of gill nets and longlines all fish will be separated according to fleet and mesh size by placing them into separate labelled bins. [21] Any largemouth yellowfish landed alive (low probability) during the hauling of these gears will be released unharmed immediately if possible. Importantly any fish released alive will be recorded, measured, weighed and included in the total catch.

Practical areas for the use of seine nets and feike nets are apparently limited at Vanderkloof. Access to suitable areas for the use of hand lines, rod and line and electro fishers are also limited. The identification of shallow banks, areas to beach

seine nets and access to different areas of the dam need to be explored to determine the experimental design for these methods.

In order to harvest enough volume to allow for the assessment of the experiment's economic feasibility it is recommended that fishing experiments be repeated at least 16 days per month (4 days per week) weather permitting, for a minimum of 2 years (two seasonal cycles). The actual number of expected fishing days per month cannot be determined at present as there are no long term data on expected catch rates or gear selectivity. Number of fishing days will also depend on the size of catches, processing capabilities/volumes and market demands of products.

11.14 Landing of fish

Catches from gill nets and longlines will be landed at a designated slipway near the dam wall?

or

At the boat club slipway?

and directly transported to a processing plant in Keurtjieskloof. Once at the processing plant catches will be taken into cooling facilities where scientific data collection will take place. Thereafter fish will be processed for market and all waste collected for use in a fish composting plant.

How will shore fishers transport catches from shore fishing sites to processing plant?

11.15 Data collection

Hand-held instruments will be used to collect the following information at each experimental fishing site before setting gill nets, longlines and fyke nets, and before starting hand line, rod & line, seine net and electro fishing sessions:

- GPS position
- depth
- temperature before setting and hauling gear
- pH
- turbidity (Secchi depth)
- total dissolved solids
- electrical conductivity
- dissolved oxygen
- fishing effort (gear type, mesh size, net/line length, number of hooks, soak time/fishing session length)

Further scientific data collection and fish processing of catches will take place at a fish processing plant to be constructed in Keurtjieskloof. A fisheries biologist will sample catches for the following data:

- species

- fork length
- mass
- sex
- gonad mass
- eviscerated mass (gut removed)
- maturity
- Otoliths

11.16 Fish processing and distribution

After scientific data collection fish will be processed for sale and distribution.

11.17 Waste disposal

All fish waste will be used in a fish composting side project still to be developed (standard fish composting method to be tested).

11.18 Data analysis [22]

Scientific data analysis will be the responsibility of the Rural Fisheries Programme and a Scientific Working Group still to be established at Rhodes University. They will assess the economic feasibility and biological sustainability of the proposed experimental fishery at the end of the 1st and 2nd year of experimental fishing.

Trends in CPUE and maturity proportions (per species per gear type) will be assessed on a annual basis. This will allow for the identification of seasonal impacts on catch rates.

Catch data generated in the experimental fishery can be used to simulate the response of fish stocks to different exploitation strategies on a annual basis. A per-recruit approach is considered appropriate as they can be used to assess biological reference points (BRPs) to achieve management targets. Specifically, biological reference points (BRPs) or indicators will be derived, which will provide an indication of how much fishing effort it takes to compromise the biological sustainability of fish stocks. Because one of the aims of the experimental fishery is to ascertain the sustainability of its biological harvest, and not to maximize yield, a spawner biomass-per-recruit (SBR) approach could be used to assess the response of SBR to different levels of fishing mortality and age at selection.

11.19 Infrastructure required

The following basic infrastructure should be in place before the proposed experimental fishery can be implemented:

- Access to the dam (slipway to launch a vessel and suitable areas for shore fishing methods).
- Wash bays for boat and fishing gear.
- Garage and storage facility for boat and fishing gear.
- Cooling and freezing facilities for fish and products.

- Fish processing plant including standard necessary equipment.
- Multipurpose shop including standard necessary equipment.
- Water and electricity.
- Ablutions.
- Fish waste disposal infrastructure (composting plant).
- Transportation to and from the dam for boat, gear, fish and fishers.
- Transportation of fish products to various points of sale.

12. EXPERIMENTAL BUSINESS PLAN

12.1 Multipurpose processing facility and shop

A processing facility and multipurpose shop will be constructed in Keurtjieskloof by Provincial Government.

12.2 Supply of product

Due to the lack of long-term catch data, estimates of fish production and expected catch rates cannot be determined at present. [28] It is the aim of the experimental fishery to provide long term catch data in order to determine expected catch rates per gear type and catch location.

12.3 Expected catch rates

Due to the lack of long term catch data accurate estimates of fish production and expected catch rates cannot be determined at present. It is however possible to provide a rough estimate of expected catches using results from Field and Rouhani (2013).[28] According to their results a 5 day fishing week using gill net and longline gears proposed in this experimental FMP could produce a harvest of 207 kg yellowfish and mudfish, and a further 323 kg (90 hooks vs. 150 hooks used in Field & Rouhani 2013) sharptooth catfish. This equals to 530 kg fish harvested per week (5 day fishing week), and 2120 kg per month (20 day fishing month). Catch rates of additional gears such as seine nets, feike nets, hook & line and electro fishing are unsure, but it is felt that their addition could allow for the harvesting of extra tonnage to achieve a total monthly harvest of 5 tons. Therefore 60 t per year.

It is important to bear in mind that the study of Field & Rouhani 2013 was conduct over a very short (5 day) sampling period and catch rates in the proposed experimental fishery may differ according to gear types, catch locations, and seasons. Fishing days will also depend on weather conditions and the processing capabilities/volumes of the proposed processing plant.

12.4 Expected price/kg [29]

Initial expected sales at R10-R18/kg whole fish (Field & Rouhani 2013).

12.5 Economic forecast

Reliable economic analysis and forecasts of expected profit cannot be calculated as there are no long term catch data to estimate accurate expected catch rates. However, if following the expected catch rates as estimated from Field and Rouhani (2013), and a minimum expected price of R10/kg whole fish, it could be possible to generate a total monthly income of R50,000 if 5 tons per month can be harvested using the proposed experimental gears, and if markets can be established for this volume. This could provide a monthly income of R2,777.78 per participant (for 18 participants).

12.6 Potential markets

12.6.1 Local markets

- Vanderkloof
- Keurtjieskloof
- Petrusville
- Luckhoff
- School feeding scheme

12.7 Potential products

- Whole fish (yellowfish/carp/mudfish/moggel)
- Fillets (yellowfish/carp/catfish)
- Boerewors (carp/catfish/mudfish/moggel)
- Cooked fish (yellowfish/carp/catfish)

12.8 Product distribution

The method of transport and product distributing still need to be explored.

12.9 Initial start-up cost (minimum capital investment)

Table 5. Draft initial start-up cost for the proposed experimental fishery.

Items	Description	QTY	Total cost
Fishing gear			
boat	Kingfisher 750 Maxi (7.5m aluminium; console)	1	R 145 750.00
trailer	heavy duty galvanized with extras	1	R 48 700.00
motor	Suzuki DFATL115 (115 hp 4-stroke)	1	R 107 017.00
hydraulic steering system	single ram with stainless steel wheel	1	R 13 350.00
motor installation	supply of cables, battery and battery box	1	R 6 150.00
passenger seating	standard frame seat with rip-stop canvass	1	R 1 887.00
electric bilge pump		1	R 2 226.00
fuel & oil	for boat motors		
spare & maintenance equipment			
safety equipment	fire extinguisher, life jackets, oars, flares, PLB		
gill nets			
longlines			
fyke nets			
seine nets			
electro fisher			
rods & reels			
hand lines			
fish bins	to separate fish onboard and transport		
camera	to document fishery and catches		
GPS	Garmin Etrex 10		
uniforms	overalls, oil skins, gloves		
storage facility/unit	undercover gear and boat storage		
contingency			

Product health

Fish heavy metal concentrations	NWU can test if fish safe for human consumption	18	R 9 450.00

Processing

processing plant building	to process fish and stock
freezers	stock
mincer	to produce boerewors and grind waste
scale	to weigh catch
vacuum sealer	product packaging
industrial aluminium table	product preparation
cleaning and filleting knives etc.	various equipment for fish processing
uniforms and protective clothing	overalls, gloves, boots, etc.
packaging materials	processing
cleaning equipment	
contingency	

Transport

ice machine	to chill catch onboard vessel
fuel	to transport fish & products
vehicle	to transport fish & products
contingency	

Retail

multipurpose shop	to sell fish products and other general items
stock? (drinks, snacks etc.)	
freezer	stock
fridge	stock
industrial aluminium table	product preparation
scale	sales
till	sales
stove and cooking utensils	food preparation
uniform	
fishery logo	design for product packaging
cleaning equipment	
stationary	
contingency	

Public communication

website design	design as comms platform for small-scale fishers

Training courses

first aid	for fishers and other participants
fire fighting	for fishers and other participants
marketing and business	for fishers and other participants
skippers license	for skipper/s

S & T	training trip to Disaneng Dam
Data collection	
data collection equipment	measuring boards, scales, tools & instruments
contingency	

Sub total
Vat (14%)
TOTAL

13. MONITORING AND CONTROL

Monitoring of the experimental fishery will be accompanied by stringent control measures to ensure that the data collection requirements and permit conditions are met and compliance with regulations adhered to.

13.2 Monitoring and control measures

Suggested control measures to be implemented before, during and after fishing operations are listed below (adapted from Bergh & Davies 2002):

13.1.1 During vessel launching

- Vessel launching site limited to one specific slipway only.
- Vessel inspections to ensure compliance with regulations e.g. vessel type, size, engine power, gear type, gear number, fishers etc.

13.1.2 While fishing

- Fisheries observer/biologist deployed to implement continues monitoring and scientific data collection.

13.1.3 During landing

- Vessel and initial fish landing site limited to one specific slipway only (same as launching slipway)
- Vessel inspections to ensure compliance with regulations e.g. vessel type, size, engine power, gear type, gear number and catch composition and mass.
- Fish landing site (processing plant) limited to one specific site only.
- Fisheries observer/biologist deployed to implement continues monitoring, scientific data collection and logbook data entries.

13.1.4 Monthly catch returns

- Catch return logbooks accurately filled in and submitted.

13.2 Monitor and control responsibilities

Enforcement of control measures will be the responsibility of the Northern Cape Department of Environment and Nature Conservation (NC-DENC). NC-DENC will inspect all infrastructure, fishing gear and fishing activities on a *ad hoc* basis in order to ensure compliance with regulations as set out in this EFMP. They will also evaluate and monitor any additional environmental impacts that might arise from the proposed experimental fishery activities.

Scientific monitoring of all aspects of the experimental fishery will be the responsibility of the Rural Fisheries Programme (through the deployment of a trained fisheries biologist/observer). The onsite fishery biologist will collect all scientific data required for the feasibility assessment. In addition, NC-DENC will collect data in the form of compulsory monthly catch returns and product sales, submitted by the experimental fishery.

14. PERFORMANCE INDICATORS TO MEASURE ACHIEVEMENT OF OBJECTIVES

14.1 Biological indicators [31]

Table 6 lists the performance indicators and reference points recommended for the main biological objectives. It is important to note that these reference points are suggestions only and may be adjusted as the experimental fishery proceeds.

Table 6. Performance indicators recommended for the main biological objectives of the experimental fishery.

Species	Gear type	Criteria to be measured	Management objective	Indicator	Measurement	Action	Time frame
largemouth yellowfish	Gill nets	Sustainability of fish stocks	Productive capacity sustained into future with low risk	Numbers and size	Fork length	Abandon mesh size if more than number? fish > 390 mm (first female length at maturity in Lake Gariep) and number? < 390 mm is captured annually	Monthly assessment of gill net bycatch
Largemouth yellowfish	Shore fishing gears	Sustainability of fish stocks	Productive capacity sustained into future with low risk	Live captures	Occurrence	Release all largemouth yellowfish captured alive	Daily
smallmouth yellowfish, mudfish, sharptooth catfish	Gill nets	Sustainability of fish stocks	Productive capacity sustained into future with low risk	Maturity	Proportion of maturity at selection	Abandon gear type (mesh size) if age/length at selection is below 50% maturity	Annual assessment of monthly trends
smallmouth yellowfish	Shore fishing gears	Sustainability of fish stocks	Productive capacity sustained into future with low risk	Size limits	Fork length	Release fish < 360 mm (female length at 50% maturity in Lake Gariep) and > 440 mm (brood stock)	Daily
mudfish	Shore fishing gears	Sustainability of fish stocks	Productive capacity sustained into future with low risk	Size limits	Fork length	Release fish < 323 mm (female length at 50% maturity in Lake Gariep) and > 400 mm (brood stock)	Daily
sharptooth catfish	Shore fishing gears	Sustainability of fish stocks	Productive capacity sustained into future with low risk	Size limits	Fork length	Release fish < ? mm (? At 50% maturity?)	Daily

All species	All gears	Sustainability of fish stocks	Productive capacity sustained into future with low risk	Catch per unit effort (CPUE)	Catch per trip per gear	Abandon gear type if CPUE drops below 40-50% of initial CPUE	Annual assessment of monthly trends
All species	All gears	Resource response to harvesting and assessment of biological sustainability	Productive capacity sustained into future with low risk	Yield per recruit model	Biological reference points (BRP's)	Maintain Spawner Biomass Recruit (SBR) above 40% of pristine biomass	Annual assessment

14.2 Economic indicators [32]

Table 7 lists the performance indicators and reference points recommended for the main economic objectives. It is important to note that these reference points are suggestions only and may be adjusted as the experimental fishery proceeds.

Table 7. Performance indicators recommended for the main economic objectives of the experimental fishery.

Economics	Indicator	Measurement	Action	Time frame
Capital expenditure	Cost of capital (building infrastructure, equipment, boat, engines etc.)	Final costing of all capital items and equipment	Assess replacement costs of capital against profits. Assess within business plan	Annual assessment
Labour	Cost of labour	Detailed labour costs, including UIF etc.	Assess within business plan	Annual assessment
Monthly operational costs and revenue	Breakdown of monthly operational expenses and revenue	Full cost breakdown per item	Assess within business plan	Annual assessment
Capital and equipment maintenance/ replacement costs	Maintenance and refurbishments required per month	Full cost breakdown per item	Assess within business plan	Annual assessment
Viability of business	Rent excluding capital expenditure and including capital	Viability of business with/without government subsidy	Assessment of viability	Annual assessment

15. MANAGEMENT APPROACH [35]

Traditional management measures in the form of the following regulations will be used to control and monitor the experimental fishery activities:

15.1 Regulation 1: Restrictive licensing [23]

One experimental fishing permit will be issued.

15.2 Regulation 2: Harvest limitation [7]

A total annual catch of 60 tons (5 tons per month) is recommended.

15.3 Regulation 3: Effort limitation [7]

A total of 18 full-time participants is recommended.

15.4 Regulation 4: Gear limitation [24]

The base experiment will be limited to 27 fleets consisting of 6 gear types (6 longlines, 6 gill nets, 10 hand line/rod & line, 3 fyke nets, 1 seine net and 1 electro fisher) with configurations as stipulated. Additional gear types with different configurations should be allowed as more information about catch rates, gear efficiency and bycatch concerns become available.

15.5 Regulation 5: Restrictive vessel launching and landing points

Vessel launching and landing will be restricted to one slipway site:

The existing slipway located near the dam wall.

or

The existing boat club slipway where washing facilities exist.

15.6 Regulation 6: Area closures [25]

Initial experimental fishing will take place in zone A. Experimental fishing in other zones should however be permitted at a later stage as more spatial and temporal information becomes available.

15.7 Regulation 7: Closed season [26]

A closed season may be enforced during peak spawning periods in summer (January) if gill nets are found to be selective in catching large upstream reproductive migrations (or even possible spawning aggregations) of largemouth yellowfish during that period.

15.8 Regulation 8: Avoidance of intersectoral conflict with recreational users [27]

No harvesting will take place on public holidays and over weekends. All fishing gears must be removed from the water on these days.

15.9 Regulation 9: Size limits

- A preliminary minimum size limit of 360 mm (female length at 50% maturity in Lake Gariep) and maximum size limit of 440 mm for smallmouth yellowfish catches in shore fishing gears (hand lines, rod & line, feike nets, seine nets, electro fishers) is recommended.
- A preliminary minimum size limit of 323 mm (female length at 50% maturity in Lake Gariep) and a maximum size limit of 400 mm for mudfish catches in shore fishing gears is recommended.

15.10 Regulation 10: Biological indicators/reference points [24]. [31]

- Abandon mesh size if more than number? largemouth yellowfish > 390 mm (First female length at maturity in Lake Gariep) and number ? < 390 mm is captured.
- Abandon gear type if age/length at selection is below 50% maturity.
- Abandon gear type if CPUE drops below 40-50% of initial CPUE.
- Release all largemouth yellowfish caught alive in shore fishing gears (hand lines, rod & line, feike nets, seine nets, electro fishers).
- Maintain Spawner Biomass Recruit (SBR) above 40% of pristine biomass.

16. EVALUATION CRITERIA AND NOMINATION PROCESS OF PARTICIPANTS

The Small-Scale Fisheries Policy has outlined a process for the allocation of small-scale fishing rights to fishing communities in the marine sector. This process could be adapted and applied to the allocation of rights in the Vanderkloof Dam experimental fishery.

16.1 Proposed process to allocate experimental fishing rights

- Masifundise Development Trust to assist in a skills audit to identify skills needed.
- Masifundise Development Trust to assist in the identification of potential participants and eligible fishers with the capacity for development.
- Masifundise Trust to work with rural fishers and organise them into a community based legal entity (CBLE) within which they can operate.
- The FMP committee will assess experimental fishing rights applications and recommend potential participants to NC-DALRRD.
- Before NC-DALRRD makes a final decision on the successful applicants for experimental fishing rights, a provisional list of successful applicants will be issued.
- The provisional list will be made available to the community. Interested and affected parties in the community may then be invited to comment on the list and, in particular, inform the delegated authority if any applicant has been excluded from the provisional list or whether any applicant included on the provisional list should be excluded.
- The commitments of the successful participants will be established in terms of a contract or permit conditions and by signature of a Code of Conduct.

It is important to note that participants in the experimental phase will not be entitled to fishing rights in a subsequent commercial phase. They will simply be issued with an experimental permit. If rights are ultimately allocated in a small-scale commercial fishery, applicants will be evaluated on a case-by-case basis, where performance in the experimental phase will be taken into account in the scoring system.

To qualify for experimental fishing rights, applicants should meet certain criteria. [30]

16.2 Proposed criteria to qualify for experimental fishing rights

- Only Historically Disadvantaged Individuals (HDI's) may apply.
- Acceptance and commitment of the applicant to develop the venture within the EFMP guidelines.
- Only South African citizens may apply (ID document).
- Applicants must have at least attained the age of 18 at time of submitting application.
- Applicants must have the capacity for learning new skills.
- Preference will be given to applicants who can demonstrate that they are dependent on fish resources for their basic needs (subsist from catch or engaged in the sale or barter thereof).
- Applicants who are unemployed and those with no other sources of regular income should be considered.
- Preference should be given to applicants living within closest proximity of the Vanderkloof Dam.

- Applicants will be required to demonstrate that, during experimental fishing, they are able to personally exercise the right. Only applicants incapable of participating due to a permanent physical disability will be exempted from this requirement. In case of such a disabled person, a family member, to be approved by the Department, will be permitted to exercise the right on behalf of the Right Holder. The name of the family member will appear on the permit.
- An application will not be considered if it is received after the closing date.
- An application will not be considered if it is not signed by the applicant or if the applicant provided false information or false documents.

17. ADMINISTRATION PROCESS

17.1 Code of conduct agreement

This will be a signed contract agreement between NC-DALRRD, NC-DENC and the prospective fishers, and will include the following:

- Permit conditions
- Code of conduct for experimental fishers stipulating requirements such as:
    - Adherence to experimental design
    - Accurate collection and reporting of data
    - Fisheries observer/biologist assistance
    - Willingness to attend workshops
    - Disciplinary procedures

17.2 Notification

Permit-holders will be notified in writing and through personal communication regarding any changes in the management regulations and/or permit conditions.

17.3 Penalties for non-compliance

Strict penalties will be applied to fishers who transgress any permit conditions or management regulation. These will range from fines for the less-serious incidents to the loss of experimental fishing permits for serious offences and refusal of any further allocations.

17.4 EFMP committee feedback, review and amendment [33]

During the first 6 months of experimental fishing monthly committee feedback meetings will be held. Thereafter once every two months. During these feedback meetings management strategies/measures and experimental design/approach will be reviewed.

At the end of the 1st and 2nd year of experimental fishing the EFMP will undergo full review as new data will be available for the estimation of catch rates, sustainable harvest levels and economic forecasts. Management strategies/measures and experimental design/approach will also be reviewed during this process.

17.5 Public communication

A public communication strategy still needs to be developed and added to the EFMP.

NC-DALRRD will initiate public communication via "Volksblad" and other media, and the Rural Fisheries Programme is currently in the process of developing a website **(**www.vanderklooffisheries.co.za**)** which will act as a communication portal for small-scale fishers. The website will include their views and opinions as well as information on the development and progress of the experimental fishery. The Final EFMP will be distributed and advertised to all stakeholders and interested and affected parties.

17.6 Infrastructure development

Local tenders for the building of infrastructure.

17.7 Finances and oversight of procurement

The committee can oversee finances (procurement of equipment, fishing gear, infrastructure, and services).

or

If Rhodes University receives the implementation budget then the University will oversee finances. But, committee members will have access to financial reports.

17.8 Interested and affected parties

Suggestions, recommendations and concerns regarding the experimental fishery must be presented to the EFMP committee through the various representatives. It is the EFMP committee's responsibility to make sure the views, concerns and issues of all organisations represented are included and discussed.

17.9 Addition of new members to the EFMP advisory committee

The addition of new representatives to the EFMP committee must undergo an application process. The application must be accompanied by a motivation letter submitted to the EFMP committee as well as NC-DALRRD for consideration.

17.10 EFMP advisory committee decisions

A committee representative cannot make a decision on the way forward alone. The Rural Fisheries Programme cannot make any decisions alone. They only provide recommendations and facilitate the development of the experimental fishery management plan. Only the committee as a whole can make joint decisions on the way forward.

18. CONCLUSION

The draft EFMP presented here is a theoretical approach to the development of a small-scale rural community fishery on Vanderkloof Dam. Although it provides a basis for the implementation of the experimental fishery, the practical realisation of such implementation may have financial, institutional, legal, and time costs not all accounted for here. Nevertheless, this draft EFMP outlines the important factors to be considered in the development and management of the proposed experimental fishery. Furthermore, this draft EFMP should be subject for review from both government and stakeholder bodies (i.e. the EFMP advisory committee).

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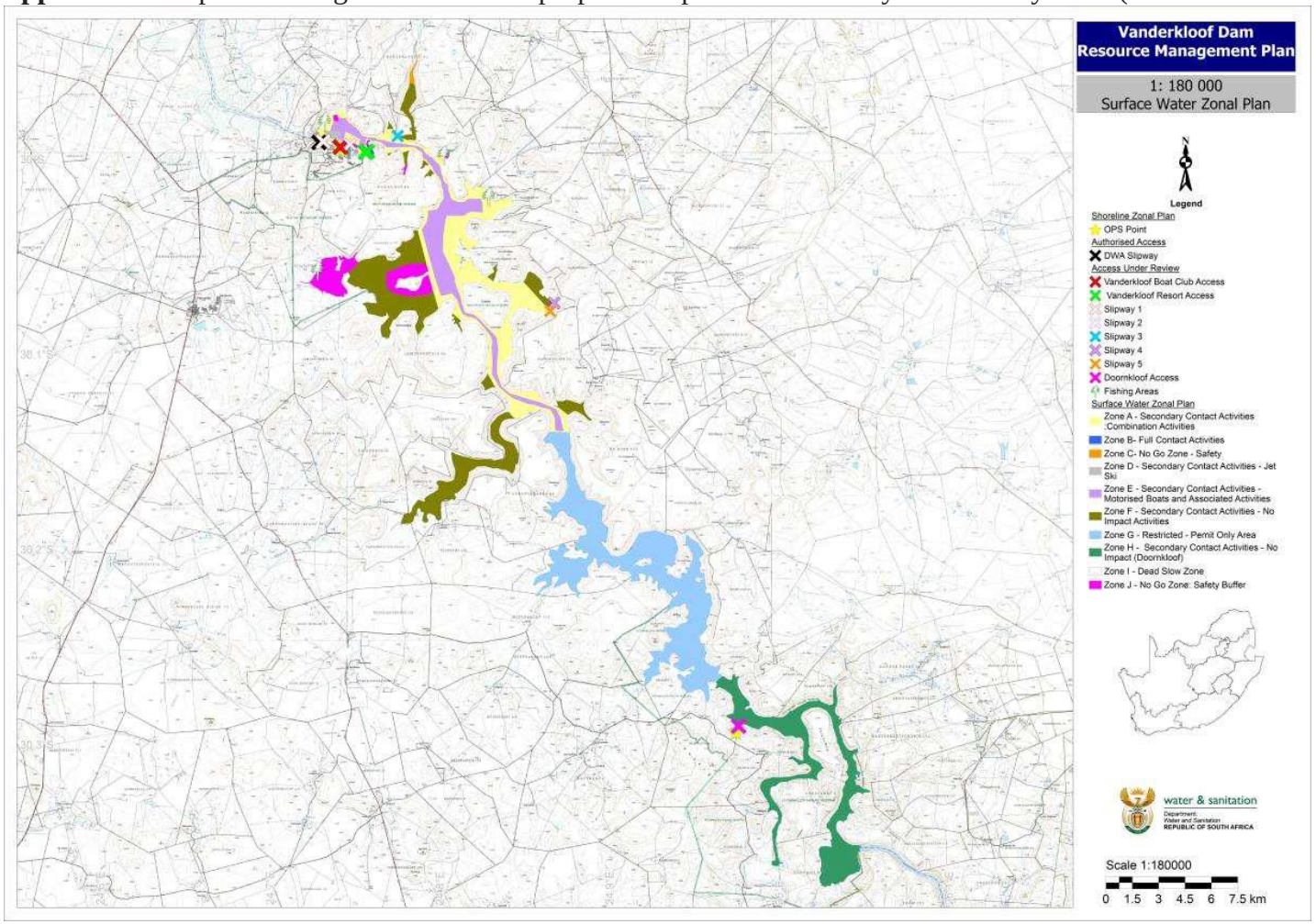
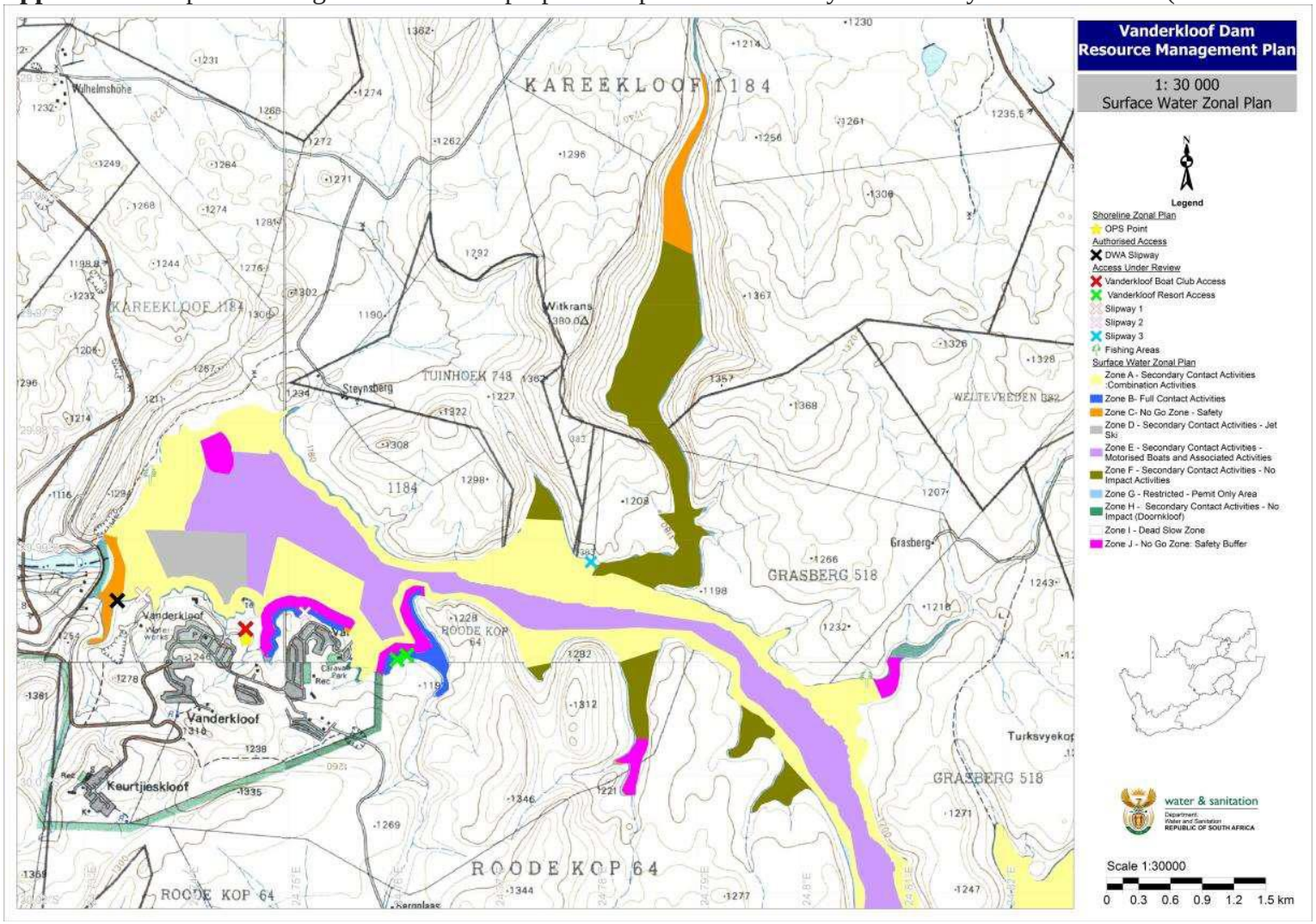
APPENDICES

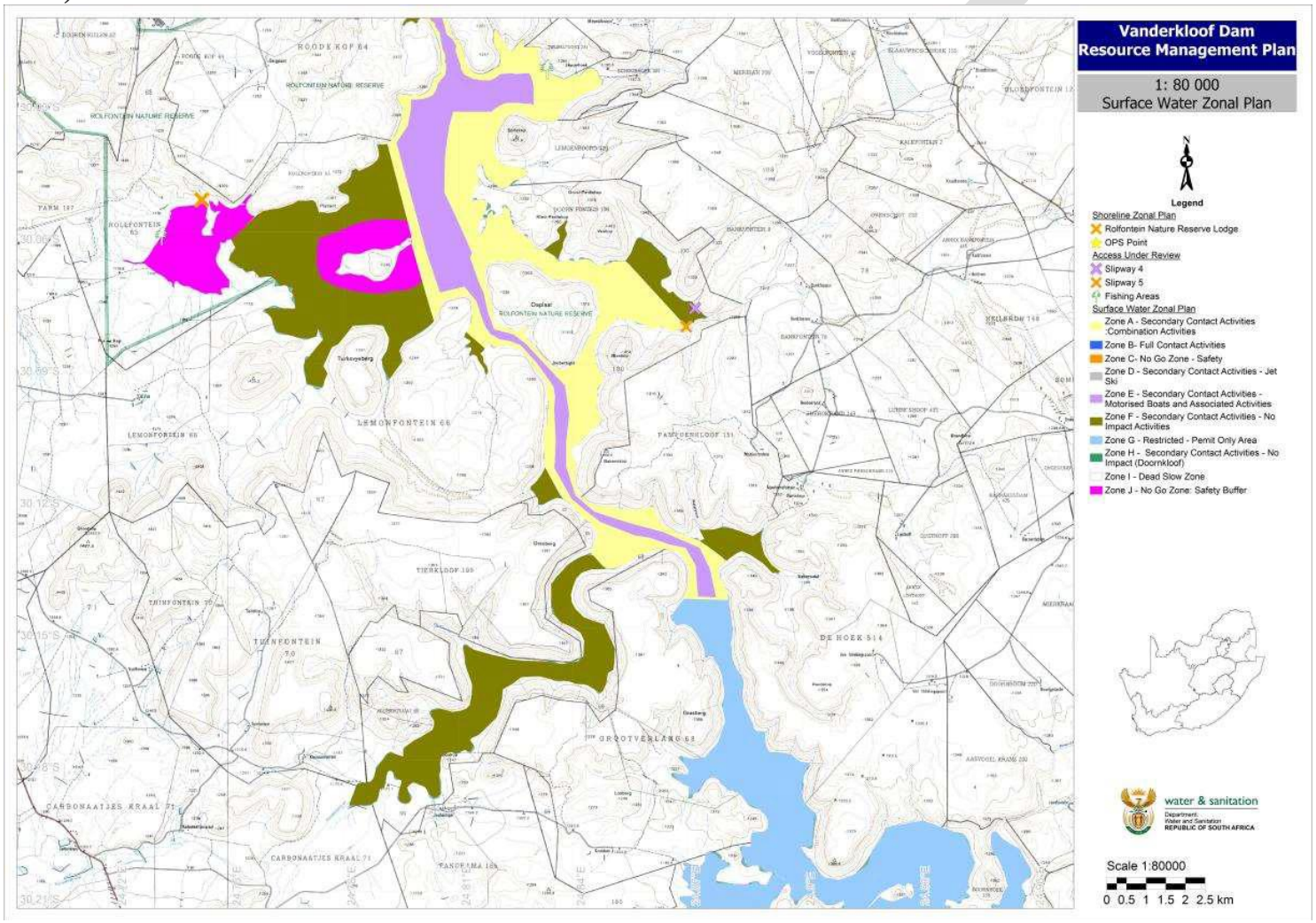
Appendix 1. Map illustrating zonation of the proposed experimental fishery in Zone A/yellow (taken from DWS 2014).



Appendix 2. Map illustrating zonation of the proposed experimental fishery in Zone A/yellow: Section 1 (taken from DWS 2014.)



Appendix 3. Map illustrating zonation of the proposed experimental fishery in Zone A/yellow: Section 2 (Zone A = yellow) (taken from DWS 2014.)



Appendix 4. Explanatory notes to be read in conjunction with the draft Experimental Fishery Management Plan.

1) The following legislation complicates the harvesting of some of the proposed target and bycatch species:

Target species:

Smallmouth yellowfish *Labeobarbus aeneus*

- SPECIALLY PROTECTED. Schedule 1 and 2 of Northern Cape Nature Conservation (NCNC) Act 9 of 2009. TOPS Notice No. R152 (23 February 2007), published in Government Gazette No. 29657.
- CATCH & RELEASE ONLY. Schedule 1b of the NCNC Act. Proclamation No. 3 of 2012 published in Provincial Gazette Extraordinary No. 1656 dated 19 December 2012.

Mudfish *Labeo capensis*

- PROTECTED. Schedule 1 and 2 of NCNC Act 9 of 2009. TOPS Notice No. R152 (23 February 2007), published in Government Gazette No. 29657.

Bycatch species:

Largemouth yellowfish *Labeobarbus kimberleyensis*

- NEAR THREATENED. IUCN 2010.
- SPECIALLY PROTECTED. Schedule 1 and 2 of NCNC Act 9 of 2009. TOPS Notice No. R152 (23 February 2007), published in Government Gazette No. 29657.
- VULNERABLE. Notice No. R151 in Government Gazette No. 29657 (23 Feb 2007) in accordance with Section 56(1) the NEM:BA.
- CATCH & RELEASE ONLY. Schedule 1b of the NCNC Act. Proclamation No. 3 of 2012 published in Provincial Gazette Extraordinary No. 1656 dated 19 December 2012.

Moggel *Labeo umbratus*

- SPECIALLY PROTECTED. Schedule 1 and 2 of NCNC Act 9 of 2009. TOPS Notice No. R152 (23 February 2007), published in Government Gazette No. 29657.

2) The biology of smallmouth yellowfish *Labeobarbus aeneus* has been documented in a number of South African inland waters including the Vanderkloof Dam (Mulder 1971; Hamman 1981; Tómasson 1983; Weyl et al. 2009). The life history of *L. aeneus* is characterised by slow growth rates, longevity of approximately 15 years, late maturity and moderate to low fecundity. Abundance and recruitment success is variable and highly dependent on environmental conditions (Tómasson et al., 1984). Locality specific differences in the life history of the species has been reported (Weyl et al. 2009). The exploitation strategies of long lived (10 – 20 yrs), slow growing and late maturing intermediate strategist species such as *L. aeneus* should be conservative as they are vulnerable to overfishing (Jennings et al. 1999; King & McFarlane 2003). According to King and McFarlane (2003) it is important to maintain a critical spawning biomass. A rapid experimental fisheries assessment has shown that a small

gill net fishery for *L. aeneus* could be biologically feasible on the Xonxa Dam, although the near threatened *L. kimberleyensis* (associated with bycatch in the Vanderkloof Dam) were not present in this dam (Richardson et al. 2009).

L. aeneus relies heavily on visually selecting zooplankton and has been reported to favour less turbid conditions (Dorgeloh 1995; Eccles 1986; Gaigher & Fourie 1984). In Vanderkloof Dam, the abundance of *L. aeneus* increased from low abundance at the inflowing river to increased abundance nearest the dam wall. This was postulated to be as a result of a turbidity gradient between the inflowing river and the dam wall (Tómasson et al. 1985).

3) Although a indigenous species, sharptooth catfish *Clarias gariepinus* is not a high conservation priority species, and the exploitation of large populations in reservoirs has been recommended (Andrew et al. 2000; Weyl et al. 2007; Richardson et al. 2009). A rapid experimental fisheries assessment has shown that a small longline fishery for *C. gariepinus* in the Xonxa Dam could be biologically feasible (Richardson et al. 2009). The species can grow very large (max reported length 170 cm and weight 60 kg) and it is considered to have a rapid growth rate depending on ambient conditions and habitat (Bruton & Allanson 1980, Hecht & Appelbaum 1987, Britz & Pienaar 1992). In females, the growth rate decreases after 3 years resulting in the males reaching larger sizes (Skelton 2001). Individuals of this species are known to live for eight or more years (Bruton & Allanson 1980). *C. gariepinus* is considered to be omnivorous displaying scavenging and predatory behaviour, with an extremely varied diet consuming fruits and seeds, all types of aquatic invertebrates and small vertebrates, small mammals and even plankton (Bruton 1979; Skelton 2001). Larger individuals show a specific dietary shift towards fish as they grow bigger (Willoughby & Tweddle 1978). However, inactive foods are generally preferred (Bruton 1979a, Skelton 2001).

4) Biological studies on mudfish *Labeo capensis* occurring in Vanderkloof Dam (Tómasson et al. 1984) and Lake Gariep (Winker et al. 2012) reported female dominated adult populations with males attaining 9 years and females 12 years of age. *L. capensis* is highly fecund with egg incubation time only lasting for to three days (Tómasson et al. 1984). A large female of 400 mm is able to produce 100 000 eggs (Winker et al. 2012). The species seem to spawn in the Vanderkloof Dam and their choice of spawning sites may depend on the availability of suitable habitat such as shallow banks, newly inundated vegetation in flooded riparian areas and tributaries (Tómasson et al. 1984). During the breeding season spawning events may be a response to cues such as rainfall and associated run-off from temporary tributaries and the availability of temporary floodplain habitat (Tómasson et al. 1984).

In Lake Gariep *L. capensis* have retained a life history strategy that is considered to be well adapted to seasonal riverine environments (Winker et al. 2012). The species is most likely a periodic strategist, which typically refers to a group of fishes that inhabit seasonal environments and where adults delay their maturation to a large size to synchronously spawn large clutches of eggs when conditions are favourable (Winker et al. 2012). Periodic strategists are considered to be the least adapted to habitats that have become temporally stable and that are subject to low resource availability due to decreased inundation of floodplains from damming (Winker et al. 2012). In addition, the exploitation strategies of long lived (10 – 20 yrs), slow growing and late maturing

intermediate strategist species such as *L. capensis* should be conservative as they are vulnerable to overfishing (Jennings et al. 1999; King & McFarlane 2003). According to King and McFarlane (2003) it is important to maintain a critical spawning biomass.

5) The biology of largemouth yellowfish *Labeobarbus kimberleyensis* has been studied on various inland waters in South Africa (Hamman 1981; Mulder 1971; Tómasson 1983; Ellender 2008; Ellender et al. 2012). *L. kimberleyensis* has a slow growth rate and attains 82.5 cm and 22.7 kg (Skelton 2001; Ellender 2008). Maturity for *L. kimberleyensis* in Lake Gariep is reached late, with first male maturity at 337 mm FL and 4 years, and female first maturity at 390 mm FL and 6 years of age (Ellender 2008). Harvest rates of long lived (10 – 20 yrs), slow growing, late maturing and moderate to low fecundity equilibrium strategist species such as *L. kimberleyensis* should be low as they are vulnerable to stock collapse as a result of overfishing (Jennings et al. 1999; King and McFarlane 2003, Ellender 2008). According to King and McFarlane (2003) It is important to maintain harvest limits of this species to a critical minimum.

6) A minimum of 2 years of experimental fishing will allow for the assessment of catches over two seasonal cycles. This would ensure a solid scientific outcome and encourage investment and commitment from fishers and participants.

7) Inland fisheries are limited by the natural productive capacity of freshwater fish resources. To ensure that biological and economic sustainability is achieved during the experimental fishery, and that fish resources are not overfished in this phase, it is necessary to set sustainable harvest limits (through total allowable catch and effort limitation). The estimation of sustainable harvest limits are, unfortunately, only possible in the presence of an already established fishery (Richardson et al. 2009). In such a situation, where catches and catch-rates have been monitored over time, the population dynamics of the fish stocks can be modelled using the most appropriate stock-assessment methods. However, in new fisheries such as the proposed experimental fishery, the choice of assessment methods is constrained by the long-term data-limited nature of fish resources in the dam. Therefore the need for long-term experimental catches to generate data for stock assessment and the estimation of sustainable harvest levels.

   The general principle is that the less information about a resource available, the more conservative the approach should be. Due to the lack of long-term data on the fisheries potential of the Vanderkloof Dam only small quantities and a small number of participants should be allowed in the experimental phase as a precautionary approach.

   Abrahams (2000) recommended a 150 – 250 t annual total allowable catch (TAC) for the Vanderkloof Dam. At the time of their study this TAC was directed at ensuring that fishing pressure would be within sustainable limits of what resources could sustain, and income generated per harvester would be such to offset high input costs such as boats, safety equipment, fishing gear and refrigeration facilities. This recommendation could however be out of date as conditions within the dam may have changed over time (31 years). Although their recommendations may therefore no longer be accurate/applicable, their study is the only one of its kind so far completed on Vanderkloof Dam, and could be used as a starting point.

It is important to bear in mind that the experimental TAC needs to be large enough to test the economic feasibility of a small-scale business venture, but also small enough to ensure adherence to a precautionary approach during resource harvesting.

It is recommended that participants are kept at a minimum to ensure that income above the minimum wage is achieved per participant. It is recommended that participants are split into 3 groups:

- Boat fishers (gill nets and longlines)
- Shore fishers (seine nets, feike nets, rod & line, hand lines and electro fishers)
- Processing plant and multipurpose shop workers (fish processing, marketing and sales)

8) The size of the boat and motor to be used will depend on the final zonation of experimental fishing sites. Distances expected to travel to some sites may be far and the transport of heavy fishing gear with at least 4 fishers onboard is suggested. A medium sized boat with a larger engine for longer distances (and possible rough weather) may therefore be required.

Figure 3 and 4 illustrates recommended vessel options. Both are available for purchase through T-Craft boat manufacturers in Port Elizabeth (www.tcraft.co.za). Each vessel option could be powered by 115 – 200 hp.

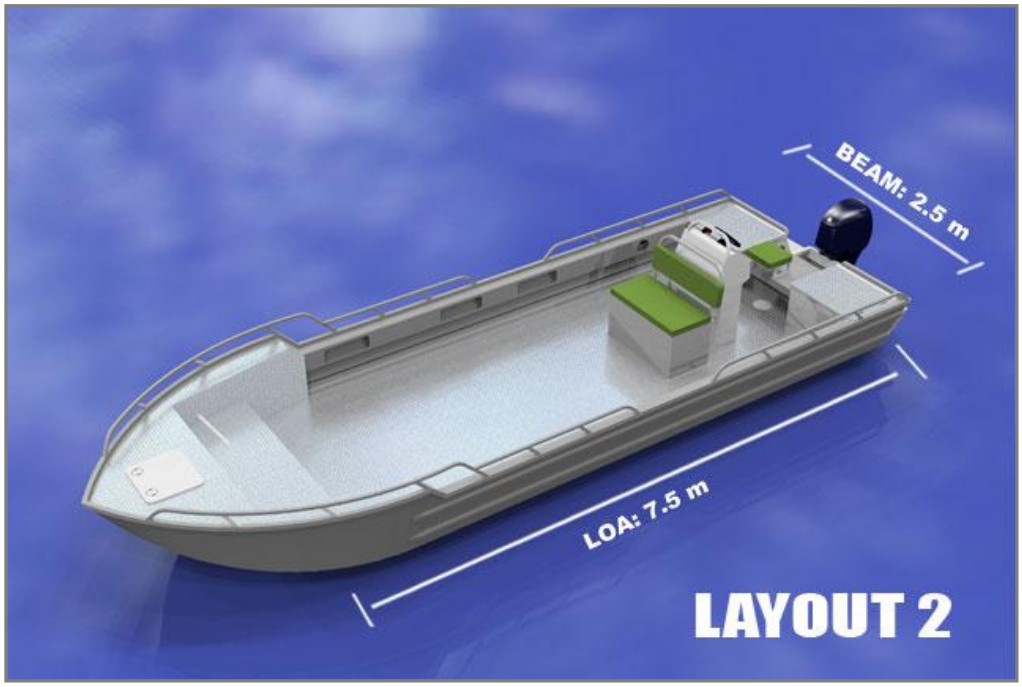


Figure 3. Kingfisher 750 Maxi (taken from www.tcraft.co.za).

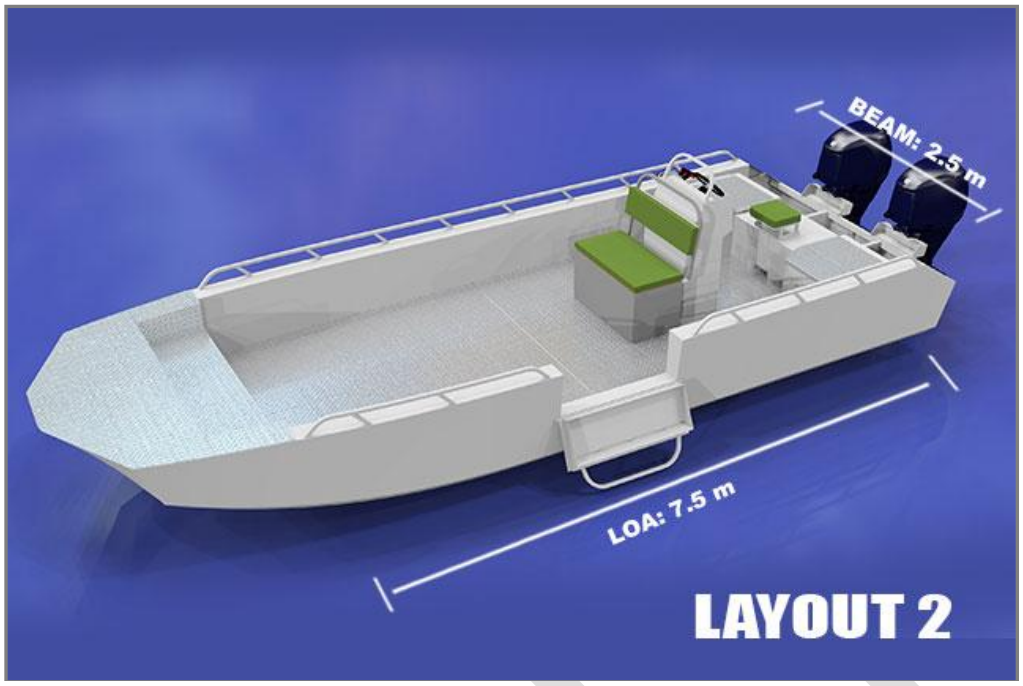


Figure 4. KFX 250 (taken from www.tcraft.co.za**)**.

The hulls are fabricated from 5083/5754 Marine Grade Aluminium ensuring that whilst the boats are relatively light they are extremely robust, standing up to years of use (and in some cases abuse) in a multitude of countries such as Angola, Botswana, DRC, Ethiopia, Kenya, Lesotho, Madagascar, Malawi, Mozambique, Namibia, Nigeria, Rwanda, Serra Leonie, South Africa, Sudan, Tanzania, Uganda, Zambia, and Zimbabwe, without the common maintenance problems found in glass fibre and inflatable boats. Their success in commercial markets are well known and they are regularly purchased by the United Nations, Petroleum Companies, Fish Farms, Conservation, Police and Defence Departments as well as Mining and Construction Companies where they have earned a reputation for quality of build and toughness.

9) Gill net gear restrictions as recommended by Abrahams (2000), and those used in previous experiments (Weyl et al. 2007; Ellender 2008; Ellender et al. 2012) are summarised in Table 8 below.

Table 8. Gill net gear restrictions recommended for Vanderkloof Dam by Abrahams (2000) and configurations used in other fisheries assessments (Weyl et al. 2007; Ellender 2008; Ellender et al. 2012).

Gear specifications	Abrahams (2000) For Vanderkloof Dam	Weyl et al. (2007) Taung Dam	Ellender (2008) Lake Gariep	Ellender et al. (2012) Lake Gariep
total net length (m)	1000	150-300	225	225
fleet #	20	3 to 6	5	5
fleet length (m)	≤ 50	50	45	45
fleet depth (m)	–	2	3	3
mesh panels per fleet	–	5	5	5
panel length (m)	–	10	9	9
mesh sizes (mm)	100-145	44, 60, 75, 100, 144	44, 60, 75, 100, 144	47, 65, 77, 105, 152
marker buoy intervals (m)	25	–	–	–

During gill net experiments in South Africa's largest impoundment, Lake Gariep, largemouth yellowfish constituted a small bycatch by number (Ellender *et al.* 2012). The study showed that gill nets were not effective in catching largemouth yellowfish (2%), carp (3%), sharptooth catfish (1%) and moggel (1%) but were highly effective in catching mudfish (61%) and smallmouth yellowfish (32%) (Table 9). However, during gill net experiments in the Taung Dam gill nets were more effective in catching smallmouth yellowfish (45%), sharptooth catfish (26%) and largemouth yellowfish (20%) whereas mudfish (6%), carp (2%) and moggel (2%) formed a small percentage of the total catch (Table 9).

Table 9. Summary of species composition in Lake Gariep and Taung Dam experimental gill net catches (Weyl et al. 2007; Ellender 2008; Ellender et al. 2012).

	Lake Gariep (Ellender 2008)	Lake Gariep (Ellender et al. 2012)	Taung Dam (Weyl et al. 2007)
Species	% of gill net catches by weight	% of gill net catches by number	% of gill net catches by weight
mudfish *Labeo capensis*	41	61	6
smallmouth yellowfish *Labeobarbus aeneus*	38	32	45
sharptooth catfish *Clarias gariepinus*	7	1	26
largemouth yellowfish *Labeobarbus kimberleyensis*	8	2	20
carp *Cyprinus carpio*	5	3	2
moggel *Labeo umbratus*	1	1	2

As part of a pre-feasibility study Field and Rouhani (2013) conducted a small gill net survey on Vanderkloof Dam. The survey took place over 5 days (8 – 12 April 2013) using a total gill net length of 186 m with a variety of mesh sizes (32, 40, 50, 75 mm) at 6 different catch locations. Results are shown in Table 10 below:

Table 10. Species composition in the Vanderkloof Dam gill net survey catches (Field & Rouhani 2013).

Species	% of gill net catches by number	number of gill net catches
Smallmouth yellowfish *Labeobarbus aeneus*	65.4	306
Mudfish *Labeo capensis*	21.4	100
Moggel *Labeo umbratus*	9	42
Largemouth yellowfish *Labeobarbus kimberleyensis*	3.2	15
Sharptooth catfish *Clarias gariepinus*	1.1	5

Gill nets do not allow for the release of unintended bycatch species as most fish are found dead or too damaged upon removal from gear. Due to the results of previous experiments (Weyl et al. 2007; Ellender 2008; Ellender et al. 2012; Field & Rouhani 2013) it is presumed that a small percentage of largemouth yellowfish will be "harvested" as bycatch in the proposed experimental gill net catches. Ellender (2008) showed that in Lake Gariep smallmouth yellowfish were mostly caught with smaller mesh sizes (44 – 100 mm) and largemouth yellowfish were only represented sufficiently in the larger mesh sizes (100 and 144 mm). If gill nets are permitted for use in the proposed experimental fishery, their effects on the bycatch rates of

largemouth yellowfish should be monitored in order to determine the most sustainable mesh sizes with the least impact on this near threatened (IUCN 2010) species.

Richardson et al. (2009) advised against the use of smaller mesh sizes (< 44 mm) in Xonxa Dam because of per recruit effects of harvesting considerably more, but smaller, immature fish. Their results showed that a 60 mm mesh size would be a sustainable option for use in a future fishery. Harvest strategies for the Vanderkloof experimental fishery should be developed in such a way as to avoid growth overfishing where recruits are caught before they can contribute significantly to the biomass. It is therefore suggested to exclude mesh size smaller than 60 mm as they may catch mostly immature fish. If less fish are targeted before maturity has been reached, individuals may at least be given a chance to spawn successfully before capture, thus reducing the chance of stock failure.

In Lake Gariep Ellender (2008) and Ellender et al. (2012) showed that mesh sizes of 140 mm caught large largemouth yellowfish almost exclusively. Ellender et al. (2012) clearly illustrated the vulnerability of this species to mesh sizes larger than 100 mm (Figure 5). In addition, large *L. kimberleyensis* individuals are predominantly made up of females as a result of a sex ratio skewed toward females in the larger size classes (Mulder 1973). Removing large female fish from a population can have dire consequences for the exploited species (Birkeland & Dayton 2005). Ellender (2008) has shown that in Lake Gariep large females display a number of traits, such as increased fecundity, better egg quality, larval survival and increased spawning frequency, which would make their removal problematic (Birkeland & Dayton 2005; Froese et al. 2008). In addition, large largemouth yellowfish are highly valued as 'trophy' fish in the recreational fishery. It is not known whether largemouth yellowfish spawn in Vanderkloof Dam, but this can be determined by maturity stage assessments on largemouth yellowfish caught as bycatch in the experimental gill nets.

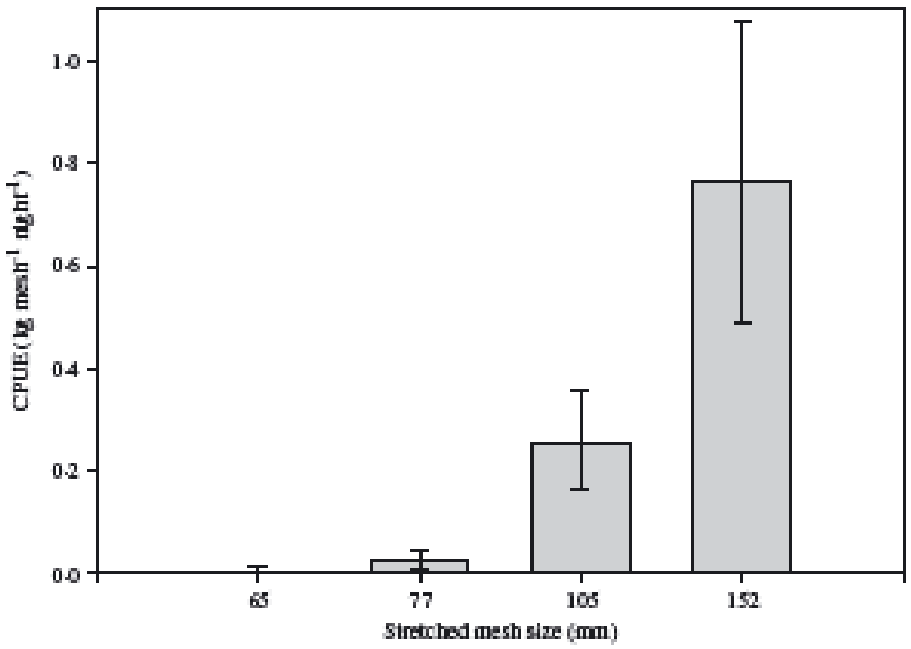


Figure 5. Mean gillnet catch per unit effort (CPUE) per mesh size for *Labeobarbus kimberleyensis* by mass from Lake Gariep (2007–2008), illustrating the vulnerability of the species to larger mesh sizes (taken from Ellender 2008).

10) Longlines are a good gear choice as they can be very effective at catching sharptooth catfish, with some possible bycatch of common carp and mudfish. Due to the type of bait used (fish heads and intestines) there are no expected bycatch of largemouth yellowfish.

Table 11. Longline gear restrictions recommended for Vanderkloof Dam by Abrahams (2000) and SASACC (2015), and configurations used in other fisheries assessments by Weyl et al. (2007).

Gear specifications	Abrahams (2000)	SASACC (2015)	Weyl et al. (2007)
longline width	–	–	12 mm rope
total longline length	400 m	140 m	20 - 60 m
fleet #	8	7	1 to 3
fleet length	≤ 50 m	≤ 20 m	20 m
# hooks	25/50 m	10/20 m	10/20 m
# total hooks	200	70	10 to 30
hook trace from top rope	1 m	–	–
marker buoy intervals	25 m	–	–

As part of a pre-feasibility study Field and Rouhani (2013) conducted a small longline survey on Vanderkloof Dam. The survey only took place over 5 days (9 – 13 April 2013) using 15 longlines and 150 hooks at 6 different catch locations (Dam Wall, the Wall, Battle Bay, Island Long, Big Water Island and the Gap). During the survey longlines caught sharptooth catfish exclusively. Results are shown in Table 12 below:

Table 12. Species composition in the Vanderkloof Dam longline survey catches (Field & Rouhani 2013).

Species	% of longline catches by number	number of longline catches
sharptooth catfish	100	148

11) SASACC is willing to provide rod & line training courses and workshops for experimental fishers. If the rod & line method produces enough volume and proves economically feasible then the project could possibly do away with expensive gears and equipment such as boats and motors.

12) Fyke nets can catch a variety of species and bycatch of largemouth yellowfish can be released alive. Fyke nets were considered in the a recent fisheries survey (Field & Rouhani 2013), but due to the depth and rocky banks associated with the area studied this gear type was deemed inappropriate.

13) Seine nets can catch a variety of species and bycatch of largemouth yellowfish can be released alive. Seine nets were considered in the recent fisheries survey (Field & Rouhani 2013), but due to the depth and rocky banks associated with the area studied this gear type was deemed inappropriate as areas to beach a seine net were limited.

14) Practical areas and access for the use of shore fishing methods (rod & line, hand line, seine nets, feike nets and electro fishers) are limited and could be problematic in the experimental fishery. Shallow banks, sandy beaches and access to different areas of

the dam are needed for the use of some of these fishing gears. DWS will investigate the possibility of opening up the "Freestate side" near the dam wall for experimental fishing purposes.

15) The location of the combination activities Zone A (DWS 2014) would be the most economically viable area to zone the experimental fishing sites. The closer to the dam access point the fishing sites are zoned the less fuel expenses would be needed to fish.

    The final zonation of experimental fishing sites are an important part of this EFMP as it should be designed to deal with and minimize intersectoral conflict. Local tourism through recreational shore fishing, boat based recreational fishing, kayaking tours and other water sports (water skiing, wakeboarding, tubing and jet skiing, rowing regattas, canoe sprints, swimming) is a growing industry at Vanderkloof. It should be one of the aims of the EFMP to ensure that these tourism industries are not damaged by the proposed experimental fishing sites. Ultimately the choice of experimental fishing site zonation would have to be made in consultation with recreational fishers and waters sport industries to minimize conflict over areas important to the growing local tourism industry (such as popular recreational fishing sites and suitable areas for water sports).

16) By ensuring the base experimental fleet numbers and configurations remain the same throughout the entire experimental fishery, standardised long term scientific data for accurate catch and effort estimates can be generated.

17) By fishing different gears simultaneously in different areas, and ensuring experimental sites remain stationary for the duration of the entire experiment, standardised long term scientific data for accurate catch and effort estimates per experimental gear and site can be generated.

18) By setting experimental gears at roughly the same depth each fleet will have the same probability of capturing fish.

19) By setting gill nets and longlines parallel to the shoreline the safe passage of boat anglers and other recreational users in the area will be maximized.

20) By setting gill nets and longlines between 16:00 – 20:00 in the afternoon and hauling the following morning between 06:00 – 09:00 some conflict with the existing recreational sector may be avoided. Two separate trips will need to be made daily in order to retrieve and then later set gears. However, if gears are soaked for 24 hours (haul and set from 08:00 am) then only one trip per day will be necessary, saving on fuel expenses. The impact of longer gear soak times on the quality of captured fish would need to be assessed.

21) By separating captured fish in labelled bins onboard the vessel (according to fleet and mesh size), accurate experimental catch data can be collected back on shore.

22) In data limited situations, where no long term fisheries data exists (such as at Vanderkloof Dam), fisheries managers in developing countries have focused on the application of per-recruit models (Beverton and Holt 1957) as a cost-effective stock assessment technique (Thompson and Allison 1997, Booth and Weyl 2004, Kanyerere

et al. 2005, Weyl et al. 2005a, 2005b). These models have been suggested to give an indication of the effect of exploitation on the spawning stock biomass of species (Booth & Buxton 1997; Butterworth et al. 1989; Punt et al. 1996). The application of per recruit models allows for the assessment of biological reference points (BRPs) to achieve management targets. Specifically, biological reference points (BRPs) or indicators are derived, which provide an indication of how much fishing effort it takes to compromise the biological sustainability of the fish stock (Allan et al. 2005; Mace 1994; Sparre & Venema 1997). Because one of the aims of the proposed experimental fishery is to ascertain the sustainability of its biological harvest, and not to maximize yield, a spawner biomass-per-recruit (SBR) approach may be recommended to assess the response of SBR to different levels of fishing mortality and age at selection.

Ellender (2008) used a per-recruit analysis to determine the impact of fishing on yellowfish resources in Lake Gariep. The proposed experimental design and biological data to be collected on Vanderkloof Dam would allow for the application of the same statistical methods to determine the impact of harvesting on fish resources here. It is therefore suggested that a similar per recruit analysis be performed on data at the end of the first year of experimental fishing, and again at the end of the second year.

23) Restrictive licensing is a precautionary measure to prevent overexploitation by other operators realising an economic opportunity. Only one small-scale business permit is proposed for the experimental fishery.

24) Gear limitations should be amendable as the more information becomes available about gear efficiency during the experimental fishery, the more additions/changes will be made and alternatives tested with regards to economic feasibility and bycatch concerns. The base experimental gear types suggested may prove highly selective for intended target species (such as sharptooth catfish and smallmouth yellowfish), but some gear types may reach stipulated bycatch limits of near threatened largemouth yellowfish with the result of exclusion of those gears. Therefore an adaptive management approach is suggested regarding gear limitations.

25) Initial experimental fishing will only take place in a small area near the town within zone A (according to DWS 2014), as it is the most economically feasible option with regards to fuel expenses associated with travelling distances to experimental fishing sites. Zones B – J (not zoned for commercial fishing) may in effect act as buffer zones (precautionary measure) against uncertainty of the resource response to harvesting.

26) Summer months coincides with the peak (January) spawning seasons of smallmouth and largemouth yellowfish (Ellender 2008). There is circumstantial evidence of smallmouth and largemouth yellowfish spawning aggregations in Lake Gariep during this period, where it was proposed to implement a closed season from January to June during peak spawning if aggregations are targeted in future fisheries (Ellender 2008). According to Tómasson et al. (1983) smallmouth yellowfish made a distinct reproductive migration to the upper reaches of the dam during spawning seasons (moving into the inflowing Orange River to spawn), thus migrating away from the proposed experimental fishing sites in the lower reaches of the dam (zone A).

27) This regulation should minimize the potential of intersectoral/user conflict when sport fisheries and other recreational users are most active. During these periods all experimental fishing gear must be removed from the water.

28) Different gear types, configurations, seasons and areas will be tested during the experimental fishery, which will all impact on fish production, catch rates and species selectivity. It is therefore not possible to determine accurate expected catch rates for the proposed experimental fishery using short term data generated in the pre-feasibility assessment by Field and Rouhani (2013).

The pre-feasibility survey by Field and Rouhani (2013) only provides an indication of gill net and longline catch rates during a 5 day survey conducted in April 2013 (Table 13 and Table 14 below). The gear configurations and catch locations used may differ in the proposed experimental fishery and therefore produce different catch rates.

Table 13. Catch and CPUE summary of gill net catches in 6 locations on Vanderkloof Dam (taken from Field & Rouhani 2013).

Location	Date	Hours	Gear	Meters	Ave Size (mm)	Total Weight (g)	CPUE g/m/hour
Corner	09-Apr	18.00	Gill Net	36	628	13190	20.35
Corner	10-Apr	23.50	Gill Net	36	715	10410	12.30
Far Bay	10-Apr	21.80	Gill Net	100	470	26250	12.04
Far Bay	11-Apr	24.20	Gill Net	100	400	19093	7.89
Island Gill	08-Apr	15.25	Gill Net	50	428	7420	9.73
Island Gill	09-Apr	27.50	Gill Net	50	354	12770	9.29
Island Gill	10-Apr	24.25	Gill Net	50	458	14200	11.71
Island Gill	11-Apr	18.00	Gill Net	50	346	7958	8.84
Island Gill	12-Apr	24.00	Gill Net	50	339	10950	9.13
River Gill	08-Apr	18.25	Gill Net	100	415	18118	9.93
River Gill	09-Apr	22.75	Gill Net	100	410	16530	7.27
Second Bay	11-Apr	23.25	Gill Net	36	348	22120	26.43
The Point	12-Apr	27.00	Gill Net	36	349	28351	29.17
	Totals	**287.75**		**794.00**	**435.38**	**207360.00**	

Table 14. Catch and CPUE summary of longline catches in 6 locations on Vanderkloof Dam (taken from Field & Rouhani 2013).

Location	Wall	Island Long	Gap	Battle Bay	Dam Wall	Big Water	Total
Hours	90.25	66.75	93.25	69.75	48	25.5	**393.5**
Hooks	30	30	30	30	10	20	**150**
Barbell (g)	121901	142438	80926.63	168076.86	11260	14500	**539102**
Total weight (kg)	121.90	142.44	80.93	168.08	11.26	14.50	**539.10**
Total Number	42	31	31	34	1	9	**148**
Ave Weight (kg)	2.90	4.60	2.61	4.94	11.26	1.61	**4.65**
Ave Size (mm)	694.00	828.00	699.31	842.00	1060.00	654.00	**796.22**
CPUE (g/hr/hook)	45.02	71.13	28.93	80.32	23.46	28.43	**46.22**

29) Current rural fisheries programme sales achieved at Disaneng Dam:

Carp (head on): R25/kg
Carp Fillets : R30/kg
Catfish gutted: R25/kg
Catfish fillets: R30/kg
Carp sausage: R50/kg
Cooked carp fillets: R65/kg

30) It is impossible to accommodate the entire rural community in the experimental fishery. The natural availability of resources in the dam is not adequate to meet the

livelihood needs of all community members. To qualify for experimental fishing rights, applicants should meet certain criteria which are intended to identify the most deserving and suitable applicants. These criteria are meant to ensure that fishing rights are allocated in an efficient, effective, orderly and transparent manner.

31) Richardson et al. (2009) indicated that the effect of harvesting rates per species has to be monitored, as once CPUE drops below 40–50% of initial CPUE, harvesting levels could depress the intrinsic rate of increase in fish populations. It is however important to note that seasonality may impact on catch rates, and this needs to be taken into account when assessing monthly or bi-annual CPUE trends. Ellender (2008) recommended that should a gill net fishery develop on Lake Gariep, it should be assessed on a bi-annual basis for changes in CPUE and size composition of the catch.

    To maintain the biological sustainability of *L. aeneus* in future gill net fisheries in Lake Gariep (Ellender 2008) and Xonxa Dam (Richardson et al. 2009) it was recommended to maintain age at selection above 50% maturity. This should allow individuals the opportunity to spawn successfully before entering the fishery.

32) Oosthuizen (2003) recommended that economic benchmarks should be set according to both the business plan and the economic projections made by the EFMP (economic feasibility study). The economic achievements by the experimental fishery in terms of income/profitability and sales/tonnage should be compared to these.

33) In the case that future gill net fisheries are developed on Lake Gariep Ellender (2008) recommended continued monitoring and reassessment to establish whether utilisation patterns change over time, and to make changes to management strategies accordingly. This could be achieved by bi annual monitoring to asses changes in *CPUE* and the size composition of catches. Situations within any fishery are bound to change through time and it is important that the EFMP accommodate these changes. It is necessary to review management strategies/measures and experimental design/approach developed in this EFMP periodically, so as to be able to react to and provide for these changes within the experimental fishery (Die 2002). Changes in biological stock or in the socio-economic status of the proposed experimental fishery may occur, necessitating a review of the EFMP. The EFMP should allow for changes in long-term as well as urgent short-term measures.

34) Aquatic environments can be polluted by contaminates that are accumulated by freshwater fish (du Preez et al. 2003). This may pose a health risk to consumers of contaminated fish (du Preez et al. 2003). The bioaccumulation of heavy metals has been shown in African sharptooth catfish *Clarias gariepinus* (Kotze et al. 1999; Olaifa et al. 2004; Desta et al. 2007; Farombi et al. 2007; Crafford & Avenant-Oldewage 2011; Eneji et al. 2011), largemouth yellowfish *Labeobarbus kimberleyensis* (Retief et al. 2009), smallmouth yellowfish *L. aenues* (Wepener et al. 2011) and mudfish *Labeo capensis* (van Aardt & Erdmann 2004). Independent testing laboratories as well Eco-Analytical laboratories at CSIR and NWU are available to test for heavy metal concentrations in samples and whether fish present in Vanderkloof Dam are safe for human consumption.

35) Traditional approaches adopted in inland fisheries management include limitations on access, closed seasons, minimum sizes of landed fish and limitations on the type and

mesh size of fishing gear (Welcomme et al. 2014). In some larger inland systems these limitations have been unsuccessful, mainly due to the spatially dispersed nature of their fisheries, the large number of fishers involved, the distance from major urban centres and poor enforcement of regulations (Welcomme et al. 2014). In addition, the drivers of change and productivity in many inland fish populations arise from outside the fishery, usually in the form of environmental impacts arising from other users of the aquatic resource (Welcomme et al. 2014). Traditional management approaches do however appear to work well in the case of a smaller lakes where fishing activities can be closely monitored and controlled (Welcomme et al. 2014).