USE OF FRESHWATER FISH TO EVALUATE THE WELLBEING OF SELECTED RIVERS IN KWAZULU-NATAL, SOUTH AFRICA

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ABSTRACT

Freshwater makes up just 0.01 % of the total water on earth but the fish species inhabiting it make up around 20 % of all vertebrate species. For centuries, human settlements have relied upon freshwater fish for food, recreation and the ecosystem services they provide. As a water-short country, South Africa has been unable to keep up with the increasing water demands from the ever-growing population. This has resulted in increased abstraction from rivers and the construction of instream barriers such as dams. The impacts of these are relatively poorly known for most South African fish species.

Fish species are good indicators of river wellbeing as they are relatively easy to collect and identify, they are responsive to changes in environmental quality and they are mobile and long living. Fish have globally been established as ecological indicators and scientists and managers use attributes of fish related to various levels of biological organisation from cellular to community level. The ecologically relevant evaluations of community structures of fish can be used to evaluate the condition of many determinant factors of riverine ecosystems. Numerous multi-variate statistical analysis techniques have been established to allow for a robust statistical evaluation of sifts in community structures of fishes and relate changes in associated ecosystem variables to characterise causality. Additional community metric measure tools such as the Fish Response Assessment Index (FRAI) is being used throughout South Africa successfully to evaluate the wellbeing of fish communities and identify causes of probable shifts in communities. The FRAI is based on fish species intolerances and preferences, and their response to drivers of change in riverine ecosystems. By comparing the community structure changes of fish communities to outcomes of community metric measures the lines of evidences can be used to validate outcomes and reduce uncertainty in the application of the approach for the region.

Labeobarbus natalensis, locally known as the KwaZulu-Natal (KZN) yellowfish or scaly, is ubiquitous in KZN, South Africa. Populations that have historically been found in most rivers within the province but have apparently declined in response to increased use of water resources. Major determinants of their decline include habitat loss, altered water quality and quantity, and the establishment of barriers such as dams and weirs that hinders migrations. The probable occurrence of *Labeobarbus natalensis* in KZN rivers and environmental factors and anthropogenic determinants affecting their presence/absence were evaluated.

Assessments were carried out at 40 sites on 23 river systems in KZN, South Africa. Four seasonal surveys were undertaken between January 2015 and April 2016. The rapid assessments included monitoring fish communities, water quality and habitat availability/conditions. Fish were collected using a range of sampling techniques appropriate to the habitats observed in the rivers. Sampling methods included the use of electrofishing and passive and active netting techniques. Fish collected were identified, measured to total length (TL) and then released alive at their capture location. The diversity, abundance and population structures of fishes were evaluated and compared with known historical distributions. Community structure analyses were carried out using multivariate statistical procedures for the fish community structures in relation to the drivers of community structure changes. In addition to the two community-based structure analyses which were done, a population-level analysis was carried where TL was used to assess the shape and wellbeing of populations.

Outcomes includes significant shifts in fish communities between catchments and within catchments and between seasons. Many communities were observed to have been significantly correlated with water quality, quantity and habitat variability associated with different land use scenarios. The FRAI results varied representing communities in a largely natural to critically modified condition that were closely correlated to changes in community structures analysed statistically. The general reduction in the wellbeing of many communities throughout KZN were partially attributed to the drought that took place during the study period. Additional stressors identified included the increase in range of alien predators and competing fish species and a range of land use activities. The FRAI scores indicated that study sites where agricultural activities were the dominant land use type were of most concern, as the fish communities occurred in severely and critically modified conditions. Sedimentation impacts affecting instream habitats and water quality from poor agricultural practices likely resulted in shifts in the dominant substrate type from cobbles/gravel to sand/silt.

It was found that the semi-rheophilic KZN yellowfish had a preference for fast flowing water and cobbles/boulders as a substrate type and as a cover feature. Furthermore, invasive fish, abstraction and industrial use all had negative impacts on the state of the rivers and the KZN yellowfish population wellbeing. The drought, which was impacting the northern parts of KZN the most, likely accelerated the decline in fish populations. The vulnerability of substrates such as gravel, cobbles, and boulders to sedimentation has the potential to result in a population shift, away from *L. natalensis* and towards species like *Oreochromis mossambicus* and *Micropterus spp*. The KZN yellowfish populations in the Mkuze and Mlazi River systems

in particular were observed to be in a poor state with low abundances and poor population structures of the species in the Mkuze River and no yellowfish were observed in Mlazi River system. Contrastingly, the KZN yellowfish populations in the Thukela and uMngeni River systems in particular, were in good health. They showed good population structure and good recruitment. The overall wellbeing of KZN yellowfish populations in many river systems has declined in response to consistent increases in stressors observed in the province due to increasing use of water resources and expansion of alien fish distributions.

Increased conservation efforts are required to curb the overall decline of the wellbeing of freshwater fishes in KZN observed during the study. The spread of alien species of fish is of particular concern, along with habitat loss which is of high ecological importance to native fish species. The river catchments which are situated in areas of high anthropogenic use were found to be the most impacted, followed by areas with intense agricultural utilisation. The drought during the study period likely exacerbated the aforementioned drivers of change, an area which requires further study. This study investigated specific threats and environmental driving factors that impact freshwater fish populations in KZN. The outcomes of the study include information on fish communities that can facilitate the identification of key conservation areas for local riverine conservationists and demonstrate the successful use of multiple lines of evidence to monitor and evaluate fish community wellbeing in KZN.

PREFACE

The data described in this thesis were collected in KwaZulu-Natal, Republic of South Africa, from January 2015 to April 2016 while registered at the School of Life Sciences, University of KwaZulu-Natal, Pietermaritzburg, under the supervision of Dr. Gordon O'Brien, and Prof Colleen T. Downs.

This thesis, submitted for the degree of Masters in Science (Ecological Sciences) in the College of Agriculture, Engineering and Science, University of KwaZulu-Natal, School of Life Sciences, Pietermaritzburg campus, represents original work by the author and has not otherwise been submitted in any form for any degree or diploma to any University. Where use has been made of the work of others, it is duly acknowledged in the text.

Evans

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Wesley Evans

December 2017

I certify that the above statement is correct and as the candidate's supervisor I have approved this thesis for submission.

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Dr Gordon O'Brien

Supervisor

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DECLARATION 1 - PLAGIARISM

I, Wesley Evans, declare that

1. The research reported in this thesis, except where otherwise indicated, is my original research.

2. This thesis has not been submitted for any degree or examination at any other university.

3. This thesis does not contain other persons’ data, pictures, graphs or other information, unless specifically acknowledged as being sourced from other persons.

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DECLARATION 2 - PUBLICATIONS

DETAILS OF CONTRIBUTION TO PUBLICATIONS that form part and/or include research presented in this thesis:

Publication 1 (Formatted for submission to African Journal of Aquatic Sciences)
Multiple lines of evidence to evaluate the wellbeing of fish communities on a regional scale in KwaZulu-Natal, South Africa

W Evans, CT Downs, & G O'Brien
Author contributions:
WE conceived paper with CTD and GO. WE collected and analysed data, and wrote the paper. CTD and GO contributed valuable comments to the manuscript and contributed to editing the paper.

Publication 2 (Formatted for submission to African Journal of Aquatic Sciences)
The state of the KwaZulu-Natal yellowfish populations in KwaZulu-Natal, South Africa
W Evans, CT Downs, & G O'Brien
Author contributions:

WE conceived paper with CTD and GO. WE collected and analysed data, and wrote the paper. CTD and GO contributed valuable comments to the manuscript and contributed to editing the paper.

Signed: ……………………………………………………

Wesley Evans

December 2017

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INTRODUCTION

1.1 Importance of rivers

Freshwater systems have for centuries been a primary requirement of human settlement; it lends itself to mankind’s domestic, industrial, agricultural and recreational needs (FAO 1997; Karr 1999; FAO 2014). Economically, the fishing industry provides employment for at least 60 million people world-wide (Bartley et al. 2015). Globally, the use of freshwater resources has increased noticeably along with human population growth, with their conservation and management being critical to human development (Dudgeon et al. 2006). The many services that the rivers have provided have long been abused and if they continue to be abused, by 2025 two thirds of the population could be faced with severe water stress and shortage issues (Karr 1999; Saunders et al. 2002).

The extensive abstraction and pressure on rivers has had a severe impact diversity and well-being of fish populations (Vidal 2008). Fish species inhabiting inland waters make up around 20% of all vertebrate species while inland waters make up approximately 0.01% of the total volume of water on earth (Stiassny 1996; Helfman et al. 2009). Freshwater fishes are widely regarded as the second most threatened group of vertebrates, behind the amphibians which are another group that are reliant upon the wellbeing of freshwater ecosystems (Baillie et al. 2004).

In contrast to terrestrial conservation practices where a plot of land can be allocated for conservation, riverine ecosystems are connected along the length of a river. Here for example, the construction of dams (impoundments) that occur outside the boundaries of protected areas can have dire effects on the fish residing within the protected areas (Skelton et al. 1995). The impacts potentially stops the migration of fish species and alters their emergence and growth cues (Petts 1984; Drinkwater and Frank 1994). A review by Bednarek (2001) examined studies on the ecological impacts of the removal of thirteen dams across the United States of America between 1963 and 1999. Dams physically stop sediment from flowing downstream with the current; when a dam wall is removed and natural flow is resumed, the backlog of sediment is then washed downstream causing short-term suffocation and abrasion of biota and habitats (Bednarek 2001). More than half of the river systems suffered such short term effects of the removal of a dam wall but once the increased sediment load had passed, many rivers showed an improvement in fish diversity, fish movement and water quality (Bednarek 2001). Unfortunately, the movement towards dam removal appears to be one that is restricted to developed nations, with most developing nations still building dams in order to fulfil the water requirements of the growing human populations and the associated industries and agriculture (Bednarek 2001). Dams and other instream barriers impact on the flow of a river in many ways, which in turn have the potential to result in an adverse response from the inhabiting fish communities (Table 1.1).

Table 1.1: Effects of altering flow regimes on freshwater fish communities. Adapted from Anania (2015).

Alteration in flow	Response of fish communities
Magnitude	• Alteration of flow results in the loss of rheophilic species (Poff and Zimmerman 2010). • Reduction in the magnitude of flow reduces the amount of sediment carried away by flow (Poff et al. 2010).
Duration	• Reducing the duration of high flows would be expected to have a negative effect on native fish (Poff et al. 2010). • Increasing the duration of low flows could result in loss of habitat and damage native species (Poff et al. 2010).
Timing	•Altered timing can aid the establishment of non-native fish (Poff et al. 2010). • Loss of seasonal flow peaks disrupts cues for spawning (Poff et al. 2010).

River wellbeing and diversity is best conserved on a catchment scale, where the land and the river are conserved together (Nel et al. 2007). Reserves and parks can protect terrestrial animals effectively but have their drawbacks for freshwater species (Skelton et al. 1995; Lawrence et al. 2011). The construction of a reservoir can occur outside the boundaries of the park or protected area but have dire effects on the fish residing within the park (Skelton et al. 1995). The connectivity of riverine ecosystems and the associated threats that affect the connectivity of populations of fishes must be considered to affectively protect important populations.

1.1.1 Alien species

Introduction of non-native fish species can be intentional or accidental (e.g. escape from aquaculture facilities). However, where the introduction happens, it has the potential to impact the natural diversity and even cause a collapse in the food web (Vander Zanden 1999; Rahel 2000). A list of the 100 most invasive alien species (Lowe et al. (2000) listed eight freshwater fish species; *Oncorhynchus mykiss, Salmo trutta, Clarias batrachus, Cyprinus carpio, Gambusia affinis, Lates niloticus, Micropterus salmoides, Oreochromis mossambicus*.

An example of how destructive the introduction of an invasive fish species can be to the native biota was observed in Lake Victoria from the 1950s (Ogutu-Ohwayo 1990). Lake Victoria was home to over three hundred species of haplochromine cichlid (Witte et al. 1992). The Nile perch (*Lates niloticus*), Nile tilapia (*Oreochromis niloticus*), and several other non-native species were introduced to Lake Victoria with the goal to improve the fishing industry in the area (Ogutu-Ohwayo 1990; Witte et al. 1992). The abundance and average catch size of *L. niloticus* sharply increased in the early 1980's, which coincided with a sharp decline in overall abundance of the haplochromine cichlids (Witte et al. 1992). A region of Lake Victoria, called Mwazana Gulf, was home to around 123 species of haplochromine cichlids prior to 1980 (Witte et al. 1992). After the explosion in *L. niloticus* in the early 1980's, approximately eighty of the 123 species of haplochromines was locally extinct (Witte et al. 1992). It was estimated that of the 300+ species of haplochromines that were once found in Lake Victoria, over 200 are now either extinct or severely threatened (Witte et al. 1992).

In South Africa, the leading cause of the spread of extra-limital and alien freshwater fish species is angling (35% of introductions)(Ellender and Weyl 2014). Research on the impacts of extra-limital and alien species in South Africa has predominantly been focused on predatory and competitive aspects, with only a few studies focussing on the potential genetic impacts of some species being introduced (Ellender and Weyl 2014). Nile tilapia are known to alter food webs by competing for food with other fish species and by consuming juveniles of other fish and amphibian species (Morgan et al. 2004; Zambrano et al. 2006). They have a high tolerance to environmental variation so it is capable of inhabiting a broad geographical range (Zambrano et al. 2006). Furthermore, their high tolerance makes them an attractive choice for aquaculture, contributing to their rapid distribution across the globe (Canonico and Arthington

2005). They were originally found in the Nile and Niger River basins, as well as many large lakes across Africa (Trewavas 1983). It is thought that in the 1930s, the Nile tilapia was taken to Java (Indonesia) as an aquarium species (Canonico and Arthington 2005). In the 1970s, it's potential as a good aquaculture species was recognised and it was then translocated to Latin America, through-out Africa and to parts of Asia (Canonico and Arthington 2005). The extensive use of the Nile tilapia in aquaculture resulted in many accidental releases into nearby river systems (Canonico and Arthington 2005). In a study, by Zengeya et al. (2011), on the stomach contents of exotic and native tilapine cichlids in the Limpopo River, South Africa, it was found that the invasive Nile tilapia and the native *Oreochromis mossambicus* consistently had similar stomach contents through-out the year. This similarity of the stomach contents suggests that they are directly competing with one another for food (Zengeya et al. 2011).

As mentioned only a few studies have focused on the potential genetic impacts of some introduced fish species (Ellender and Weyl 2014). The Nile tilapia, which is alien to South African freshwater rivers, is known to hybridise with the Mozambique tilapia (Cambray and Swartz 2007). It was predicted by Cambray and Swartz (2007) that the Mozambique tilapia would be extirpated from several systems in southern Africa as a result of hybridisation and competition from the Nile tilapia. The Nile tilapia was found in several small coastal rivers in KwaZulu-Natal (KZN), overlapping with the range of the native Mozambique tilapia (Ellender and Weyl 2014). Six of the eight most aggressive alien fish species are found in KZN, South Africa, with one of them being native to southern Africa (*O. mossambicus*) (Lowe et al. 2000). Of the five that are alien to KZN, four were deliberately introduced for sport (*M. salmoides, O. mykiss, S.trutta, C. carpio*) while *G. affinis* was introduced as a form of biocontrol for mosquitoes (Lowe et al. 2000). Instead of feeding on mosquito eggs, *G. affinis* rather feeds of the eggs of native freshwater fish (Lowe et al. 2000). In addition to the freshwater fish found on the list by Lowe et al. (2000), several other alien invasive species are found in KZN with varying impacts.

1.1.2 Trout and *Micropterus spp.* in KZN

Both brown trout (*S. trutta*) and rainbow trout (*O. mykiss*) were introduced as a target species for anglers in South Africa in the 1800's following their successful introductions in Australia and New Zealand (Crass et al. 1964; Crass 1986). Despite two species of trout being on the list of the 100 most invasive species in the world by Lowe et al. (2000), they are protected in South Africa due to their recreational value. *Salmo trutta*, native to Europe, western Asia and Morocco (Crass et al. 1964; Welcomme 1981) feeds on a wide variety of aquatic insects, crustaceans, molluscs, salamanders, frogs and many species of fish (Scott and Crossman 1973). The rainbow trout is native to the west coast of North America where it primarily feeds upon invertebrates, other fish and their eggs (Scott and Crossman 1973).

An example of the impact of alien invasive fish species was done by Karssing et al. (2012) and examined the importance of waterfalls in uKhahlamba Drakensberg Park, KZN, South Africa, in the conservation of the indigenous Natal cascade frog (*Hadromophryne natalensis*). It was thought that alien fish, brown trout and rainbow trout preyed upon the native frog. Relative abundances of the frog and trout were assessed and compared above and below waterfalls at two separate sites (Karssing et al. 2012). Neither species of trout were found above the waterfalls, acting as natural barriers. It was concluded that trout are the most likely cause in the severe decline in the abundance of *H. natalensis* below the waterfalls at both sites (Karssing et al. 2012).

Micropterus salmoides was introduced into South African waters in 1928 for recreational purposes and quickly spread due its popularity amongst anglers (Van Rensburg et al. 2011). *Micropterus salmoides*, as well as *M. dolomieu* and *M. punctulatus*, remains a highly sought after target species for anglers in KZN, especially in lentic systems (De Moor and Bruton 1988). *Micropterus salmoides* expanded their range by 1500 km in 10 years throughout east coast of South Africa (De Moor 1996).

1.1.3 Yellowfish in KZN

The most widespread and well known of native fish in KZN is *Labeobarbus natalensis* (Castelnau, 1861), otherwise known as the KZN yellowfish or scaly (Karssing 2008). It ranges from headwaters to lowland streams, from the Mkuze River to the Mtamvuna River and all major systems in between in KZN. Tolerant of a range of temperatures and to moderately polluted water, *L. natalensis* can be found in a variety of habitats (Karssing 2008). The KZN yellowfish is commonly targeted by subsistence and recreational fishermen due to its relatively large size and broad distribution in KZN (Karssing 2008). Migrating long distances on a yearly basis to spawn on open gravel beds in shallow water, the KZN yellowfish is most vulnerable at their spawning grounds where they congregate in large groups (Karssing 2008). Often illegal netting takes place at spawning grounds before the fish have had an opportunity to spawn (Karssing 2008).

The rising threat of alien fish species on native fish species in KZN is of particular concern. Alien fish species such as *M. salmoides* (largemouth bass) and extralimital species such as *Labeobarbus aeneus* (Vaal-Orange smallmouth yellowfish), from the Vaal-Orange system, are out competing the KZN yellowfish for food. Furthermore, it is thought that *L. aeneus* may be hybridising with *L. natalensis* (Karssing 2008). *Micropterus salmoides* poses a serious threat to *L. natalensis* as the largemouth bass competes for the KZN yellowfish for food and habitat as well as the preying on juvenile yellowfish (Karssing 2008). The common carp (*Cyprinus carpio* Linnaeus, 1758), is also found within the range of *L. natalensis,* and is yet another competitor for food but it has the tendency to alter the habitat of a riverbed in an unfavourable way (Koehn 2004).

Poor land management poses a serious threat to the wellbeing of *L. natalensis*. Poor agricultural practices lead to erosion which in turn result in the silting up of rivers (Karssing 2008). This silt would ordinarily be washed away with a flood but the construction of instream dams and weirs at regular intervals in KZN have slowed floods down, therefore they no longer remove silt (Karssing 2008). Silt then remains in the system, burying the gravel beds which act as spawning grounds for *L. natalensis* (Karssing 2008) and reduce other important feeding habitats.

1.2 Rivers

Rivers provide food and water for humans and animals alike, they hold cultural importance, aid in transport and navigation as well as serving as biodiversity hotspots. A countries economy is intricately linked to the wellbeing of its rivers, and the services they can provide. These services, however, are not limitless and overuse can lead to a collapse in the ecosystem (Rodriguez et al. 2006). There is a trade-off between use of ecosystem services and the protection of the ecosystem. Rivers must be monitored in order to ensure that healthy ecosystems are being maintained (Rodriguez et al. 2006). There are three general approaches used to identify a healthy ecosystem including; (1) the use of biotic and abiotic indicators to describe the wellbeing of ecosystems, (2) measuring a system's resilience to understand the capacity of the ecosystem to change and, (3) the identification of risk factors and their management to reduce threats to ecosystem wellbeing (Rapport 1989; Karr 1991). Use of indicators has long been the most popular amongst the three approaches, making use of biological, chemical and physical indicators (Rapport 1989).

Monitoring chemical indicators has its drawbacks as it does not account for anthropogenic-induced alterations such as loss of habitat (Whitfield and Elliott 2002). Conversely, monitoring just physical indicators does not account for chemical alterations that are likely to negatively impact on the inhabitants of the river. Biological monitoring is preferred to chemical monitoring because the latter often misses many of the anthropogenic-induced perturbations of aquatic ecosystems, e.g. habitat degradation. If the physical aspects of a freshwater system (hydrology, geomorphology etc.) are in an unhealthy state, the biotic components of the system would be compromised (Rapport 1989). It is thus important for us to monitor all aspects of the river (Burt et al. 2008). Several biotic indices have been created, based on the different living organisms found in and around rivers- fish, macro-invertebrates, riparian vegetation and diatoms. Each biotic indicator has its own strengths and weaknesses.

In the early 1970s, scientists developed indices for macroinvertebrates and diatoms and used them as indicators of ecosystem wellbeing (Karr 1981). Macroinvertebrates and diatoms are seen as excellent indicators, usually less mobile than fish, and they are easy to sample (López-López and Sedeño-Díaz 2015). The use of macroinvertebrates and diatoms as indicators has some downfalls; such as high levels of expertise is often required to differentiate between taxa (Karr 1981). Fish can be used to good effect as indicators of system wellbeing for various reasons (Roset et al. 2007; Herman and Nejadhashemi 2015), such as:

1. Fish have been well studied- a large amount is known about their habitat preferences and intolerances.
2. Fish can usually be identified in the field and it is relatively easy to do so- limited training is required.
3. Fish are more relatable for the general public than diatoms and macroinvertebrates
4. Due to their mobility, fish represent the wellbeing of a larger portion of the river.
5. Fish are relatively long-lived, meaning that they represent the wellbeing of an ecosystem over a longer period (Fausch et al. 1990).

1.2.1 Use of communities vs individual species

Some species of fish may be more tolerant to certain environmental factors than others. Therefore, using a single species of fish as an indicator of ecosystem wellbeing may provide a restricted view of the environmental factors that all species of fish in the system may face (Kwak and Peterson 2007). Making use of entire communities to assess the wellbeing of an ecosystem ensures that more environmental variables are taken into account (Kwak and Peterson 2007). Patrick (1949) utilised a community-based approach to biological monitoring, recognising the advantage of monitoring multiple species at a community level rather than an individual species.

Since the early 1900s fish were used as indicators of biotic integrity but it was only in 1981 that the first biological index was developed (Karr 1981; Simon 1998). The Index of Biotic Integrity (IBI) was developed in the USA where biological integrity as “the ability to support and maintain a balanced, integrated, and adaptive community of organisms having a species composition, diversity and functional organization comparable to those of natural habitats within a region" (Karr and Dudley 1981). The use of a fish-based index slowly spread across North America and in 1992 the first article on IBI from outside of North America was published (Oberdorff and Hughes 1992; Vidal 2008). Hocutt et al. (1994) foresaw that the internationally developed methods of biomonitoring did not work well in Africa due to social, economic and cultural differences. Assessments of African rivers using an index developed for a first world country usually failed to meet their objectives due to unforeseen impacts associated with a developing nation (Hocutt et al. 1992; Hocutt et al. 1994). In developing countries, many local communities depend upon their nearby aquatic system for food and water yet the rivers are being altered heavily by fast developing industry, impacting water quality and quantity (Hocutt et al. 1994). The IBI was adapted to better suit African freshwater ecosystems and guidelines for the development of a purpose-built index were described (Hocutt et al. 1994).

Sections of the IBI require large amounts of historical and ecological data for completion which are not always available, especially in Africa (Hocutt et al. 1994; Kleynhans 1999). Furthermore, the IBI requires a larger selection of equipment and the running costs are high (Kleynhans 1999). In 1999, the Fish Assemblage Integrity Index (FAII) was developed, which aimed “to measure the biological integrity of a river based on the attributes of the fish assemblages native to the river” (Kleynhans 1999). FAII considers the following:

- The intolerance of the expected indigenous fish community
- The frequency of occurrence
- Frequency of parasite-infested individuals (Kleynhans 1999)

FAII computes an expected value for the reference conditions and an observed value for the actual value that were input; from these two values, one can calculate the relative FAII score as a percentage (Kleynhans 1999). The relative FAII score can be translated to a class rating (A-F), indicating the level to which the river has been modified. In 2007, the Fish Response Assessment Index (FRAI), an update to FAII, was developed in order to strengthen the relationship between cause and effect (Kleynhans and Louw 2007). FRAI is based on known environmental intolerances and preferences of reference fish species (Kleynhans and Louw 2007). Although based on FAII, FRAI does have numerous differences. The FRAI is more of a habitat based, cause-and-effect based index, which explains and deciphers the current fish assemblage, in comparison with the reference condition (Kleynhans 2007). It is the assessment of the response of freshwater fish species metrics to changing environmental conditions occur either through direct measurement or are inferred from the condition of the habitat (Kleynhans 2007). The FRAI is based on fish sample data and fish habitat data combined; knowledge of fish species' ecological requirements is used to evaluate the derived response of species metrics to habitat changes (Kleynhans 2007). The FRAI samples all available habitats effectively. By following the standardised FRAI protocol at each site, the FRAI scores are spatially and temporally comparable (Table 1.2).

The FRAI does have several limitations. It provides a rapid assessment of a site for situations where a more extensive assessment is not viable due to time constraints or finances. For some fish species, the environmental tolerances and preferences are based on expert opinion and inferred knowledge. Alien and extra-limital freshwater fish species are considered by the FRAI; they impact the FRAI score of a site according to their known impacts on fish habitat or predacious behaviour. However, there is potential for alien fish species to act as good indicators of freshwater wellbeing (Kennard et al. 2015). Brown trout and Rainbow trout can be of use when assessing the wellbeing of a river as they are well studied and their tolerances and preferences are known (Molony 2001; Kennard et al. 2015).

Table 1.2: Protocol for the calculation of FRAI, adapted from Kleynhans (2007)

Step	Procedure
Determine reference fish list and frequency of occurrence for each site	• Use historical data & expert knowledge • Model: use ecoregional and other environmental information • Use fish reference frequency of occurrence database (FROC) if available
Determine present state for drivers	Using: •Hydrology • Physico-chemical • Geomorphology • Index of habitat integrity
Site selection	• Field survey • Desktop assessment
Determine the condition of the fish habitat	• Assess the habitat potential • Assess the habitat condition
Representative fish sampling at site	• Sample all velocity depth classes per site where possible • Sample at least three stream sections per site
Capture and analyse fish sampling data per site	• Transform fish abundances to frequency of occurrence ratings
Execute FRAI model	• Rate the FRAI metrics in each metric group • Enter species reference frequency of occurrence data • Enter species observed frequency of occurrence data • Determine weights for the metric groups • Obtain FRAI value and category • Present both modelled FRAI & adjusted FRAI

1.2.2 River Health Programme

The River Health Programme (RHP) was developed by the Department of Water and Sanitation, (DWS) South Africa, with the main goal of expanding the basis of ecological information on aquatic resources, in order to support the national management of these systems (Roux 1997). The RHP makes use of biological response monitoring in order to characterise the response of the aquatic environment to various disturbances (Schreiner 2010). The rationale behind the RHP is that the integrity of the biota inhabiting the river provides a direct, holistic and integrated measure of the integrity of the river as a whole (Karr and Chu 1997). The RHP makes use of FRAI for the fish component and in conjunction with similar indices for other biotic and abiotic factors, produces an overall measure of the biotic integrity of the river.

1.2.3 Study area

The study area included forty sites in KZN, South Africa on 23 major river systems. The sites were selected based on historical sampling sites for the River Health Programme, as selected by the Department of Water and Sanitation, South Africa. The sites were selected to be representative of the river reach in which they are located, with consideration for ease of access. Sites with good perennial flow, with a wide range of available biotopes or habitats were selected. Where possible, sites were situated away from man-made instream structures such as weirs and bridges with instream support. These structures create unnatural flow regimes and habitat structures.

Two sites were selected in the T-catchment, one site on the Mzimkulu River and one site on the Mtamvuna River. A total of 13 sites were in the U-catchment, four of these being on the economically important uMgeni River. Eight sites were selected within the V-catchment, including two sites on the largest river in the province, the Thukela River. The remaining six sites were located on rivers which feed into the Thukela River. A total of 17 sites were selected to represent the W-catchment, the northern most portion of the province. This includes four study sites on the Phongola River and its tributaries. A further 5 sites were selected on the Mfolozi River and its tributaries.

1.3 Aims and objectives

The primary aim of the study was to infer the overall state of rivers in KZN, South Africa, based on the sampling of 40 sites between February 2015 to May 2016. The secondary aim of the study is to update the state of the *Labeobarbus natalensis* or KZN yellowfish in KZN, South Africa.

To achieve the aims, the following objectives were established:

- Implement seasonal surveys (n = 4) to sample fish communities at sites (n = 40) on the major rivers (n = 23) throughout KZN.
- Implement the fish component of the RHP monitoring programme in the major rivers in KZN. This includes the application of the Fish Response Assessment Index (FRAI) to evaluate fish communities within the 40 sites on rivers in KZN.
- Statistically evaluate potential shifts in community structures of fish communities of the major rivers in KZN using multivariate analysis techniques.
- Statistically correlate environmental driver variability with fish community structures of the major rivers in KZN to identify potential causes of shifts in communities.
- Update the 2008 wellbeing of yellowfish populations in KZN.

This thesis is structured with stand-alone data chapters that are intended to be submitted to international peer review journals for publication. Some duplication was therefore unavoidable. The chapters are:

Chapter 1: Introduction chapter

Chapter 2: Multiple lines of evidence to evaluate the wellbeing of fish communities on a regional scale in KwaZulu-Natal, South Africa.

Chapter 3: The state of the KwaZulu-Natal yellowfish populations in KwaZulu-Natal, South Africa

Chapter 4: Conclusions chapter.

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CHAPTER 2:

MULTIPLE LINES OF EVIDENCE TO EVALUATE THE WELLBEING OF FISH COMMUNITIES ON A REGIONAL SCALE IN KWAZULU-NATAL, SOUTH AFRICA

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2.1 Abstract

Freshwater ecosystems are one of the most diverse types of ecosystems on the planet but represent a fraction of the total surface water on the planet. Although these ecosystems are limited compared with the main environment, approximately one third of all vertebrate species live in freshwater ecosystems. For decades, freshwater fish have been used as indicators of ecosystem wellbeing through multiple lines of evidence. The Fish Response Assessment Index (FRAI) is an assessment-based index that was developed in South Africa. It is based on the preferences and intolerances of fish and their response to drivers of change. The aim of this study was to apply established community metric measures and multivariate statistical techniques to infer the overall state of rivers based on the wellbeing of fish communities in KwaZulu-Natal, South Africa. The study area included forty sites in KwaZulu-Natal, South Africa on 23 major river systems. The sites were surveyed four times in 2015 and 2016 as a part of the River Health Programme. The FRAI was used to assess the state of the rivers using a rapid assessment of fish communities, water quality and habitat condition/availability. Community structure evaluations were carried out using a multivariate statistical procedure for the fish community structures in relation to drivers of community structure changes. The FRAI scores showed that five sites were found to be in a 'Seriously Modified' and unacceptable ecological state. The FRAI scores indicated that the areas of most concerns were the areas of intensive agricultural activity. Furthermore, invasive fish, abstraction and industrial use all had negative impacts on the state of the rivers. The drought, which was impacting the northern parts of KwaZulu-Natal the most, accelerated the decline in fish community wellbeing. The vulnerability of substrates such as gravel, cobbles, and boulders to sedimentation has the

potential to result in a population shift, away from *Labeobarbus natalensis* and towards species like *Oreochromis mossambicus* and *Micropterus spp.*

Keywords: freshwater ecology, indicators of ecosystem wellbeing, fish, freshwater

2.2. Introduction

Rivers, world-wide, provide a plethora of services including food and water for people and animals alike (Vorosmarty et al. 2010). Furthermore, they hold cultural importance, aid in transport and navigation as well as serving as biodiversity hotspots (Vorosmarty et al. 2010). A country's economy is intricately linked to the wellbeing of its rivers, and the services they can provide. These services, however, are not limitless and overuse can lead to a collapse in the ecosystem (Rodriguez et al. 2006). A trade-off between use of ecosystem services and the protection of the ecosystem is required. For years it has been recognised that human activities pose a major threat to the ecological integrity of rivers (Allan et al. 1997). An increase in urban development around a river results in the restructuring of fish communities (Scott et al. 1986). Increased use of freshwater ecosystem services has the tendency to result in an increase in tolerant and invasive species while there is a downward trend in sensitive species (Onorato et al. 2000; Scott and Helfman 2001). The growing economy in South Africa has resulted in an unsustainable increase in the demand on freshwater ecosystems (King and Louw 1998), potentially resulting in a relatively undocumented shift in fish community structure. Freshwater is often described as the most threatened ecosystem on the planet, in addition to it declining at a far greater rate than all other ecosystems (Sala et al. 2000; Dudgeon et al. 2006; Hermoso 2017). The reason why freshwater ecosystems are under such threat is manifold; freshwater makes up just 0.01% of the world's water while being home to more than one third of all vertebrate species (Gleick 1996; Dudgeon et al. 2006). The major threats to freshwater ecosystems include over-exploitation, water pollution, habitat degradation, invasive species and flow modifications (Dudgeon et al. 2006; Vorosmarty et al. 2010).

There are three general approaches used to characterise a healthy ecosystem: 1. use of biotic and abiotic indicators, 2. measuring a system's resilience, and 3. the identification of risk factors (Rapport 1989). Use of indicators has long been the most popular of the three approaches, making use of biological, chemical and physical indicators (Rapport 1989). If the physical aspects of a freshwater system (hydrology, geomorphology etc.) are in an unhealthy state, the biotic components of the system would be compromised (Rapport 1989). It is thus important to monitor all aspects of the river. Several biotic indices have been created, based on the different living organisms found in and around rivers- fish, macro-invertebrates, riparian vegetation and diatoms (Kleynhans and Louw 2007).

The use of multiple validated lines of evidence to evaluate the wellbeing of the ecosystem is considered best scientific practice as it provides a greater level of certainty. Each individual LoE is perhaps not completely robust by itself but when integrated with other lines of evidence, the uncertainty of the outcomes are generally reduced. In this study, the LoEs implemented were Fish Response Assessment Index (FRAI) (Kleynhans and Louw 2007) and Multivariate statistics (Redundancy Analysis). The multivariate analysis was used to validate the FRAI results and to provide insight into what the main drivers of change were.

Macroinvertebrates and diatoms were seen as excellent indicators, usually less mobile than fish, and they are easy to sample. Although, the use of macroinvertebrates and diatoms as indicators has some downfalls; high levels of expertise is often required to differentiate between taxa (Karr 1981). In the early 1970s, macroinvertebrates and diatoms were used as indicators of ecosystem wellbeing (Karr 1981). Fish were first used as indicators of ecosystem wellbeing in the 1950s (Doudoroff and Warren 1957). It was not until the early 1970s that indices were created, after it was discovered that their presence, absence or abundance could be used to indicate physical, chemical or biological wellbeing of ecosystems (Karr 1981; Hughes and Gammon 1987; Ganasan and Hughes 1998). Fish can be used to good effect as indicators of system wellbeing for many reasons. They have been well studied and a large amount is known about their habitat preferences and intolerances (Karr 1981). They can usually be identified in the field and it is relatively easy to do so as limited training is required (Karr 1981). Furthermore, they are mobile meaning that they represent the wellbeing of a greater portion of the river (Karr 1981).

Since the early 1900s fish have been used as indicators of biotic integrity but it was only in 1981 that the first biological index was developed (Karr 1981; Simon 1998). The Index of Biotic Integrity (IBI) was developed in the USA where biological integrity as “the ability to support and maintain a balanced, integrated, and adaptive community of organisms having a species composition, diversity and functional organisation comparable to those of natural habitats within a region" (Karr and Dudley 1981). The concept of a fish based index slowly spread across North America and in 1992 the first article on IBI from outside of North America was published (Oberdorff and Hughes 1992; Vidal 2008). Hocutt et al. (1994) foresaw that the internationally developed methods of biomonitoring did not work well in Africa due to social, economic and cultural differences. Assessments of African rivers using an index developed for a first world country usually failed to meet their objectives due to unforeseen impacts associated with a developing nation (Hocutt et al. 1992; Hocutt et al. 1994). In developing countries, many local communities depend upon their nearby aquatic system for food and water yet the rivers are being altered heavily by fast developing industry, impacting water quality and quantity (Hocutt et al. 1994). The IBI was adapted to better suit African freshwater ecosystems and guidelines for the development of a purpose-built index were described (Hocutt et al. 1994).

Sections of the IBI require large amounts of historical and ecological data for completion which is not always available, especially in Africa (Hocutt et al. 1994; Kleynhans 1999). Furthermore, the IBI requires a larger selection of equipment and the running costs are high (Kleynhans 1999). In 1999, the Fish Assemblage Integrity Index (FAII) was developed, which aimed "to measure the biological integrity of a river based on the attributes of the fish assemblages native to the river" (Kleynhans 1999). FAII considers the intolerance of the expected indigenous fish community, their frequency of occurrence and the frequency of parasite-infested individuals (Kleynhans 1999). FAII computes an expected value for the reference conditions and an observed value for the actual value that were input; from these two values, one can calculate the relative FAII score as a percentage (Kleynhans 1999). The relative FAII score can be translated to a class rating (A-F), indicating the level to which the river has been modified. In 2007, the Fish Response Assessment Index, an update to FAII, was developed in order to strengthen the relationship between cause and effect (Kleynhans and Louw 2007). FRAI is based on known environmental intolerances and preferences of reference fish species (Kleynhans and Louw 2007). The FRAI makes use of a Microsoft® Excel based multi-criteria decision model that was developed by the Department of Water Affairs (Kleynhans and Louw 2007; Kleynhans 2007). The index is designed to characterise the present ecological state of fish communities at each site and assess the impacts of the fish community (Kleynhans 2007).

Fish community structures and drivers of change can be evaluated using a Redundancy Analysis ordination technique (RDA) using Canoco version 4.5 software (ter Braak and Šmilauer 2002). A RDA allows for the direct interpretation of the community structures of fish in terms of the taxa obtained during detailed surveys. Furthermore, when combined with Monte Carlo permutation testing, the statistical significance of the hypothesised differences in the community structure can be tested (Van den Brink et al. 2003). This approach allows the habitat drivers of change in fish community structures of riverine ecosystems to be statistically evaluated.

The aim of this study was to apply established community metric measures and multivariate statistical techniques to infer the overall state of rivers based on the wellbeing of fish communities in KwaZulu-Natal (KZN), South Africa. It was hypothesised that the respective KZN river fish community structures were affected by river quality. It was predicted that freshwater fish communities in KZN would be found in a degraded state, particularly in the study sites in areas with extensive anthropogenic activity.

2.3. Methods

Four fish collection surveys were undertaken at 40 sites across KZN (Fig. 2.1, Appendix 2.1 Table A 1) from February 2015 to April 2016, which consisted of two high- and two low- flow surveys at each site (Fig. 2.2). During the surveys, some sites were dry and not sampled. Fish were sampled using an array of techniques, including electrofishing, casts nets, and seine nets. Surveys were carried out with approval from Ezemvelo KZN-Wildlife with permit numbers: OP713-2015, OP715-2015, OP911-2016, and OP913-2016.

The KZN sites were selected based on historical sampling sites for the River Health Programme, as selected by the Department of Water and Sanitation, South Africa. The sites were selected to be representative of the river reach in which they are located, with consideration for ease of access. Sites with good perennial flow, with a wide range of available biotopes or habitats were selected. Where possible, sites were situated away from man-made instream structures such as weirs and bridges with instream support. These structures create unnatural flow regimes and habitat structures. Two sites were selected in the T-catchment, one site on the Mzimkulu River and one site on the Mtamvuna River. A total of 13 sites were in the U-catchment, four of these being on the economically important uMgeni River. Eight sites were selected within the V-catchment, including two sites on the largest river in the province, the Thukela River. The remaining six sites were located on rivers which feed into the Thukela River. A total of 17 sites were selected to represent the W-catchment, the northern most portion of the province. This included four study sites on the Phongola River and its tributaries. A further five sites were selected on the Mfolozi River and its tributaries.

Reference fish assemblage was determined using historical data, expert knowledge and the PESEIS database for each site, based on the sub-quaternary code. The fish habitat potential and current condition was then determined at each site, followed by the sampling of fish using the appropriate methods. Sampling was carried out in all available velocity depth classes (Kleynhans 2007; Appendix 2.1 Table A 2) where possible. Fish sampling data were collated and transformed into frequency of occurrence ratings. Historical distribution of all freshwater fishes known to occur in KZN were considered. Distribution maps using the Present Ecological State, Ecological Importance (PESEIS, DWS, 2014) assessment and freshwater fish distribution and Atlas of Southern African Freshwater Fishes Distribution in KwaZulu-Natal (Scott et al. 2006).

The assessment of the ecological wellbeing of freshwater fishes were carried out using the FRAI (Kleynhans 2007). The FRAI results in an automated and an adjusted score; the former is based on the model's automated assessment based on the state of the drivers and the differences between expected and observed species in the assessment alone. This does not account for the availability of habitat and other fish attribute features that the automated FRAI score assumes are affected due to the community of fishes observed in relation to reference communities. The index then allows the user to alter the automated FRAI scores by manually evaluating the state of the drivers in the systems. The impacts that the FRAI considers are the available substrate types, available cover features, velocity and depth, the physical-chemical state of the water, presence of introduced species and barriers for migration in the river (Kleynhans 2007). The FRAI calculates the ecological category for each site based on these impacts and fish data. Ecological categories range from A to F, where "A" is "Unmodified, natural" (90-100%) and "F" is "Critically/extremely modified" (0-19%) (Table 2.1; (Kleynhans et al. 2005).

Table 2.1: Summary of the name and description of the six ecological categories used in the Ecoclassification procedure for the Water quality, Habitat, Fish, Invertebrates and Ecostatus (Kleynhans et al. 2005)

Ecological Categories	Name	Description
A	Natural	Unmodified natural
B	Good	Largely natural with few modifications
C	Fair	Moderately modified
D	Poor	Largely modified
E	Seriously modified	Seriously modified
F	Critically modified	Critically or extremely modified

Electrofishing was performed using a Samus electrofisher (SAMUS 725M Electrofisher, SAMUS Special Electronics, Poland) or a generator (Honda EG 3000 portable generator). Sampling effort and results were recorded per velocity-depth class. Where a combination of velocity-depth classes existed, the dominant velocity-depth class was recorded for the sampling effort. The following apparatus were used for catching fish in the different velocity-depth classes, adapted from the Kleynhans (2007):

- Fast-deep: An electrical shocking apparatus with one operator and one dip net handler was used in such habitat types. A cast net (diameter = 1.85 m, mesh size = 2.5 cm) was used in rapids not suitable for electrofishing. Where possible, a block net was erected downstream of the sampling area. Capture results were recorded as number of fish caught during each effort.

- Fast-shallow: An electrical shocking apparatus with one operator and one dip net handler was used in such habitat types. Where possible, a block net was erected downstream of the sampling area. Capture results were recorded as number of fish caught during each effort.

- Slow-deep: An electrical shocking apparatus with one operator and one dip net handler was used in such habitat types. A small seine net (5 m long, 1.5 m deep, mesh size = 1 mm) was used to sample fish. A cast net, (diameter = 1.85 m, mesh size = 2.5 cm) was used in pools not suitable for beach seining. Capture results were recorded as number of fish caught during each effort.

- Slow-shallow: An electrical shocking apparatus with one operator and one dip net handler was used in such habitat types. A small seine net (5 m long, 1.5 m deep, mesh size = 1 mm) was used to sample fish. An electrical shocking apparatus should preferably be used. Capture results were recorded as number of fish caught during each effort.

Electrofishing was performed for up to 60 min. per site when suitable, the cast net was thrown up to 20 times per site where suitable while the small seine net was used up to three times per site where suitable. Current strength and settings and the electrofishing gear were optimised to sample different species and conditions in the study area (Bohlin et al. 1989). All available habitats were sampled effectively at each site.

Fish were transferred to 20 l buckets containing river water to be counted, identified, and measured (total length, TL). The TL was measured for all fish collected in the study for analysis of the population structure, allowing for the consideration of age groups/classes of individuals in a population which are useful indicators of the state of fish populations (Russell and Skelton 2005). Following identification and measuring, fish were returned to the river alive at nearest point to capture. Voucher specimens for validation were preserved in 10 % Formaldehyde and stored at the University of KwaZulu-Natal, South Africa. A catch per unit effort (CPUE) was determined based on the number of fish sampled per unit. Units varied based on equipment type used for the sampling effort.

The physico-chemical characteristics of the rivers being samples were measured *in situ* at the time of biotic sampling. Water quality variables included temperature, pH, oxygen concentration and saturation and conductivity using a calibrated Eutech PCD 650 multimeter (EUTECH Instruments Ltd, Singapore) and water clarity was measured using a clarity tube (Kilroy and Biggs 2002). Additional sub-surface water samples were collected for laboratory analyses of nutrients, salts, system variables and some toxicants. The samples were kept on ice until they were delivered to Umgeni Water's Laboratory (Pietermaritzburg, South Africa) for analyses who provided certificated results. The available habitat was visually assessed and described as either marginal vegetation, aquatic vegetation, undercut banks, root wads, substrate, depth/column or open (Kleynhans 1999). The available substrate type for each effort was categorised as either fines/silt, mud, sand, gravel, cobbles, boulders or bedrock (Kleynhans 1999). The velocity/depth for each effort was measured using a Transparent Velocity Head Rod (GroundTruth, Hilton, South Africa) (Fonstad et al. 2005). Furthermore, each biotope was placed into a velocity/depth class, as outlined in Kleynhans (2007).

The availability and state of instream and riparian habitat features is an important driver of ecosystem wellbeing. In this study, the habitat quality and diversity were assessed by applying the Index of habitat integrity (IHI) (Kleynhans 1996). This index was completed at the site using established score sheets. The values of the index were then calculated and a rating system for the index describes the habitat quality of the given site.

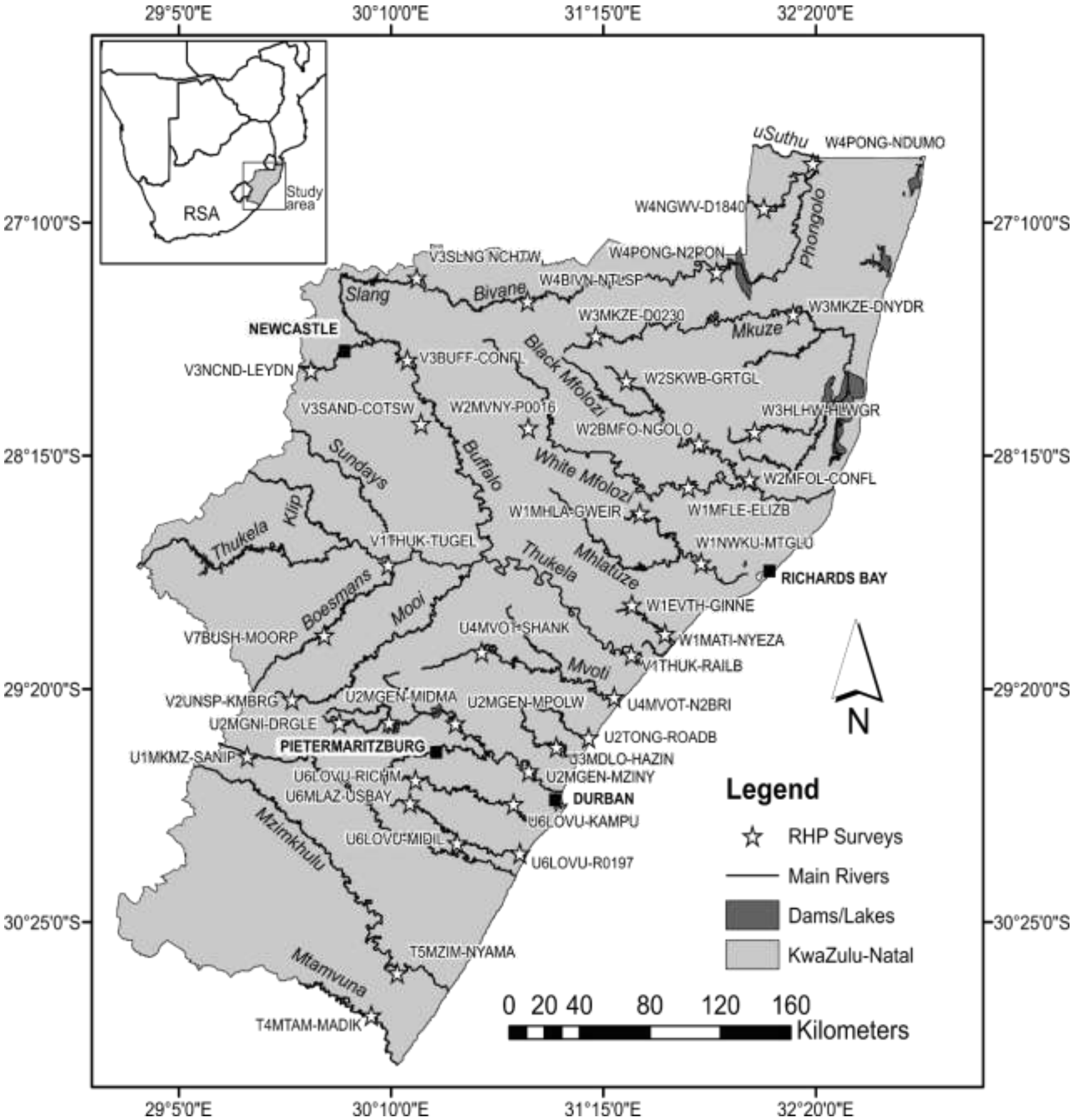


Fig 2.1: Geographic distribution of the River Health Programme sites surveyed 2015-2016 in KZN, South Africa. (Sites according to Appendix 2.1 Table A 1).

Multivariate statistical evaluation of fish community structures were performed using the Canoco version 4.53 software (ter Braak and Šmilauer 2002). This allows for the direct interpretation of the community structures of fish in terms of the taxa obtained during detailed surveys (O'Brien et al. 2009). When combined with Monte Carlo permutation testing, the statistical significance of hypothesised differences in the community structures can be tested (ter Braak and Šmilauer 2002; Van den Brink et al. 2003). This approach allows for constrained analyses of the community structures to be undertaken, which involves overlaying captured variance of explanatory environmental variables such as habitat and water quality variables onto fish sample and species ordinations (O'Brien et al. 2009). A principal component analysis (PCA) approach, using Canoco for Windows version 4.53, is based on a linear response model relating species and environmental variables (Van den Brink et al. 2003). Results of the ordination are produced as two-dimensional maps of the samples being analysed, where the placements of the samples reflect the similarities or dissimilarities between fish assemblages and abiotic parameters recorded at the sampling sites. Redundancy analyses were performed in order to determine which species or environmental factors were the main drivers being the groupings seen in the PCA ordination. An RDA is a derivative of a PCA which allows for the selection of the driving variables that are intended to be overlaid onto the PCA.

2.4. Results

Of the expected 59 indigenous freshwater fish species within KZN, 38 were collected with a further six invasive species (Appendix 2.1 Table A 3). In excess of 5500 fish were collected in over 800 efforts, using seine nets, cast nets, scoop nets and electrofishing (Appendix 2.1 Table A 3). Summer 2015 (high flow) was found to have the greatest diversity of species while the survey in summer 2016 had the greatest abundance of individuals. Of the six alien fish species that were collected in KZN, the bass (*Micopterus spp*.) was the most widespread and abundant, with over 350 individuals being collected at twelve sites in all four surveys (Appendix 2.1 Table A 3). In the Tongati River system, both the Mozambique (*Oreochromis mossambicus*) and Nile tilapia (*O. niloticus*) were collected. The FRAI scores displayed a worsening in ecological wellbeing in 2015 with a slight recovery being observed in the summer 2016 survey. Twelve sites were calculated to be in a lower ecological category in the spring 2015 survey when compared with the summer 2015 survey. A slight recovery in FRAI scores was observed in the summer 2016 survey, with five sites having an improved ecological category. Of the five sites that were calculated to be in an ‘E’ ecological category, four of them were located in the

Mvoti to Mzimkhulu water management catchment. There are two large urban and multiple rural settlements are located in this catchment, which largely contributed to lowered ecological categories of these sites. Just one site was recorded to be in a 'Largely Natural with Few Modifications' state (EC = B), being W2SKWB-GRTGL. This site is situated in the upper reaches of the Sikwebezi River, a tributary of the Black Mfolozi River. This site was displaying a decrease in ecological wellbeing, predominantly due to the severe drought. In the spring 2015 survey, this site had a FRAI score of 73.2%, placing it in an Ecological Category of "C". At the time of sampling, the river had almost stopped flowing and the majority of the available habitat was left functionless. The site did, however, show signs of recovery due to improved flows in summer 2016.

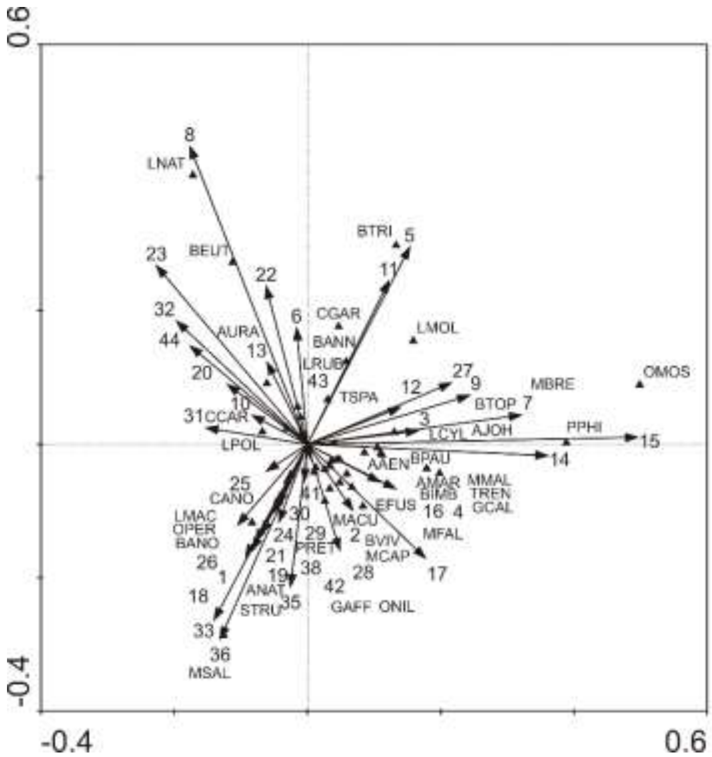
Overall there was a significant difference (p = 0.002) between all the sites based on fish communities, while sites 8, 15, 28, and 5 were significantly different (p = 0.002) from each other, and each accounted for 13-14% of the variation (Fig. 2.2). Grouped around LNAT were *Enteromius eutaenia* and *Amphilius uranoscopus* (BEUT and AURA), and sites such as W2SKWB-GRTGL (Sikwebezi River) and V7BUSH-MOORP (Bushmans River) received consistently high FRAI scores during the study period. The FRAI scores displayed a decrease in 2015 with a slight recovery being observed in the summer 2016 survey. Twelve sites were calculated to be in a lower ecological category in the spring 2015 survey when compared with the summer 2015 survey. A slight recovery in FRAI scores was observed in the summer 2016 survey, with five sites having an improved ecological category. Of the five sites that were calculated to be in an 'E' ecological category, four of them were located in the Mvoti to Mzimkhulu water management catchment. There are two large urban and multiple rural settlements located in this catchment, largely contributing to lowered ecological categories of the sites. Just one site was recorded to be in a 'Largely Natural with Few Modifications' state (EC = B), being W2SKWB-GRTGL. This site is situated in the upper reaches of the Sikwebezi River, a tributary of the Black Mfolozi River. The FRAI scores at this site decreased in survey two and three of 2015, predominantly due to the severe drought. In the spring 2015 survey, this site had a FRAI score of 73.2%, placing it in an Ecological Category of "C". At the time of sampling, the river had almost stopped flowing and the majority of the available habitat was left functionless. The site did, however, show signs of recovery due to improved flows in summer 2016.

Table 2.2: Adjusted FRAI Scores and Ecological Categories from all KwaZulu-Natal River Health Programme sites, 2015-2016. (See Appendix 2.1, Table A 1 for site names).

	Summer 2015		Autumn 2015	
Site name	FRAI Score	EC	FRAI Score	EC
T4MTAM-MADIK	-	-	74.4	C
T5MZIM-NYAMA	-	-	68.5	C
U1MKMZ-SANIP	-	-	70.7	C
U2MGEN-MIDMA	58.1	C/D	59.1	C/D
U2MGEN-MPOLW	66.0	C	69.9	C
U2MGEN-NINAW	59.4	C/D	58.5	C/D
U2MGNI-DRGLE	-	-	74.8	C
U2TONG-ROADB	38.9	D/E	36.0	E
U3MDLO-HAZIN	52.9	D	47.1	D
U4MVOT-N2BRI	31.0	E	29.0	E
U4MVOT-SHANK	56.9	D	63.1	C
U6LOVU-R0197	37.4	E	36.0	E
U6LOVU-RICHM	48.4	D	52.5	D
U6MLAZ-P0502	50.8	D	53.6	D
U6MLAZ-USBAY	48.5	D	54.7	D
V1THUK-RAILB	62.3	C	63.3	C
V1THUK-TUGEL	75.2	C	72.4	C
V2UNSP-KMBRG	-	-	70.9	C
V3BUFF-CONFL	68.9	C	66.1	C
V3NCND-LEYDN	65.5	C	60.0	C/D
V3SAND-COTSW	56.7	D	55.7	D
V3SLNG NCHTW	65.3	C	63.8	C
V7BUSH-MOORP	70.7	C	68.9	C
W1EVTH-GINNE	66.7	C	67.7	C
W1MATI-NYEZA	55.4	D	53.4	D
W1MFLE-ELIZB	65.3	C	63.3	C
W1MHLA-GWEIR	62.4	C	63.4	C
W1NWKU-MTGLU	69.6	C	65.6	C
W2BMFO-NGOLO	63.3	C	69.1	C
W2MFOL-CONFL	65.8	C	71.2	C
W2MVNY-P0016	58.3	C/D	55.5	D
W2SKWB-GRTGL	86.9	B	82.3	B
W2WMFO-DINDI	66.3	C	63.3	C
W3HLHW-HLWGR	-	-	59.1	C/D
W3MKZE-D0230	71.3	C	68.3	C
W3MKZE-DNYDR	59.7	C/D	47.3	D
W4BIVN-NTLSP	70.7	C	71.7	C
W4NGWV-D1840	58.6	C/D	49.1	D
W4PONG-N2PON	64.2	C	57.9	C/D
W4PONG-NDUMO	63.5	C	-	-

	Spring 2015		Summer 2016	
Site name	FRAI Score	EC	FRAI Score	EC
T4MTAM-MADIK	67.0	C	73.0	C
T5MZIM-NYAMA	67.4	C	66.5	C
U1MKMZ-SANIP	68.7	C	74.1	C

U2MGEN-MIDMA	53.6	D	63.6	C
U2MGEN-MPOLW	61.2	C/D	62.7	C
U2MGEN-NINAW	51.9	D	50.5	D
U2MGNI-DRGLE	74.3	C	70.3	C
U2TONG-ROADB	33.8	E	36.4	E
U3MDLO-HAZIN	43.0	D	38.4	D/E
U4MVOT-N2BRI	35.4	E	30.6	E
U4MVOT-SHANK	-	-	53.9	D
U6LOVU-R0197	37.2	E	39.2	D/E
U6LOVU-RICHM	45.2	D	43.4	D
U6MLAZ-P0502	51.1	D	50.6	D
U6MLAZ-USBAY	51.4	D	57.0	D
V1THUK-RAILB	68.8	C	63.2	C
V1THUK-TUGEL	74.4	C	74.6	C
V2UNSP-KMBRG	71.0	C	69.5	C
V3BUFF-CONFL	72.4	C	68.1	C
V3NCND-LEYDN	54.5	D	51.5	D
V3SAND-COTSW	36.5	E	38.5	D/E
V3SLNG NCHTW	60.5	C/D	66.5	C
V7BUSH-MOORP	60.5	C/D	58.7	C/D
W1EVTH-GINNE	57.8	C/D	58.8	C/D
W1MATI-NYEZA	57.8	C/D	56.9	D
W1MFLE-ELIZB	-	-	64.5	C
W1MHLA-GWEIR	-	-	70.9	C
W1NWKU-MTGLU	63.8	C	68.6	C
W2BMFO-NGOLO	-	-	72.7	C
W2MFOL-CONFL	-	-	56.4	D
W2MVNY-P0016	-	-	49.7	D
W2SKWB-GRTGL	72.5	C	69.9	C
W2WMFO-DINDI	-	-	64.3	C
W3HLHW-HLWGR	-	-	57.1	D
W3MKZE-D0230	58.1	C/D	60.9	C/D
W3MKZE-DNYDR	-	-	-	-
W4BIVN-NTLSP	66.9	C	68.7	C
W4NGWV-D1840	-	-	-	-
W4PONG-N2PON	-	-	49.1	D
W4PONG-NDUMO	-	-	53.4	D



Number	Code	River, Catchment
1	W4BIVN-NTLSP	Bivane, Phongolo
2	W4PONG-N2PON	Phongolo
3	W4NGWV-D1840	Ngwavuma, Phongolo
4	W4PONG-NDUMO	Phongolo
5	W3MKZE-D0230	Mkuze
7	W3HLHW-HLWGR	Hluhluwe, Mkuze
6	W3MKZE-DNYDR	Mkuze
8	W2SKWB-GRTGL	Sikwebezi, Black Mfolozi, Mfolozi
9	W2BMFO-NGOLO	Black Mfolozi, Mfolozi
10	W2MVNY-P0016	Mvunyana, White Mfolozi, Mfolozi
11	W2WMFO-DINDI	White Mfolozi, Mfolozi
12	W2MFOL-CONFL	Mfolozi
13	W1MFLE-ELIZB	Mfule, Mhlathuze
14	W1MHLA-GWEIR	Mhlathuze
15	W1NWKU-MTGLU	Nwaku, Matikulu
16	W1EVTH-GINNE	Vutha/Matikulu, Matikulu
17	W1MATI-NYEZA	Matikulu
18	V3SLNG-NCHTW	Slang, Buffalo, Thukela
19	V3NCND-LEYDN	Ncandu, Buffalo, Thukela
20	V3BUFF-CONFL	Buffalo, Thukela
21	V3SAND-COTSW	Mzinyashana, Buffalo, Thukela
22	V1THUK-TUGEL	Thukela
23	V7BUSH-MOORP	Bushmans, Thukela
24	V2UNSP-KMBRG	Mooi/Mfulankomo, Mooi, Thukela
25	V1THUK-RAILB	Thukela
26	U4MVOT-SHANK	uMvoti
27	U4MVOT-N2BRI	uMvoti
28	U2TONG-ROADB	Tongati, Tongati
29	U3MDLO-HAZIN	Mdloti
30	U2MGNI-DRGLE	uMngeni
31	U2MGEN-MIDMA	uMngeni
32	U2MGEN-MPOLW	uMngeni
33	U2MGEN-NINAW	uMngeni
35	U6MLAZ-USBAY	uMlazi
36	U6MLAZ-P0502	uMlazi
38	U6LOVU-RICHM	Lovu
41	U6LOVU-R0197	Lovu
42	U1MKMZ-SANIP	Mkhomazana, Mkomazi
43	T5MZIM-NYAMA	Mzimkhulu
44	T4MTAM-MADIK	Mtamvuna, Mtamvuna

Fig 2.2: Redundancy analysis plot showing dissimilarity based on the fish communities among sites from rivers sampled in the study area with sites overlaid as explanatory variables. 22.7% of the variability is displayed on axis 1 with 62.6% of the total variation being displayed on all four axes.

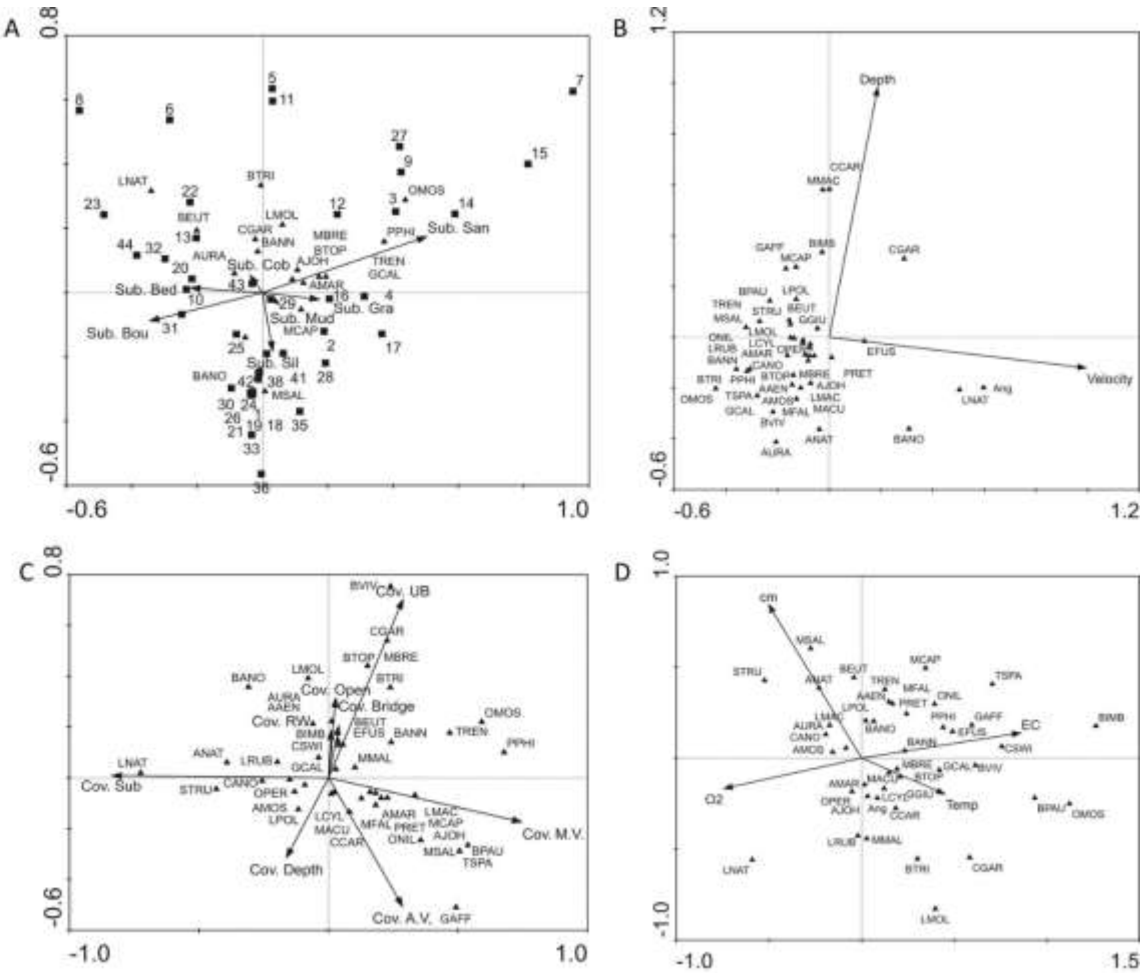


Fig 2.3: Redundancy analysis plot showing dissimilarity based on the fish communities among sites from rivers sampled in the study area with substrate types (A), velocity and depth (B), cover features (C) and four water quality components (D) as explanatory variables.

Substrate was found to be a significant driver of community structure (p = 0.002). 94.5% of the variation seen in the fish communities was explained by substrate types (Fig. 2.3A). Of all of the substrates, sand accounted for the greatest variation in fish community structure (F = 14.04, p = 0.002). *Pseudocrenilabrus philander* and *O. mossambicus (*PPHI and OMOS) were shown to have a strong preference for a sandy substrate while *Amphillius uranoscopus* and *Labeobarbus natalensis* (AURA and LNAT) showed a preference for cobbles as a substrate type.

Velocity-depth was found to be a significant driver of community structure (p = 0.002, Fig. 2.3B). 100% of the variation seen in the fish communities is displayed in the first two axes of the ordination (Fig. 2.3B). *Labeobarbus natalensis* (LNAT), is known to have a preference for moderately fast flowing water despite being able to tolerate stagnant water (Karssing 2008). *Labeobarbus natalensis* is quite closely linked with velocity, along with 'Ang', juvenile *Anguillid* species (Fig. 2.3B) were *Cyprinus carpio* (CCAR) and *Marcusenius macrolepidotus* (MMAC). The latter was caught on just one occasion and it was in deep water while *C. carpio* was caught on numerous occasions, almost always in deep water. Multiple species displayed a slight preference for deeper water while the vast majority showed more cosmopolitan preferences, i.e. they showed no preference. Species found opposite to where the vector is placed showed the opposite preference to the species found on the same side of the vector. As such, it can be said that *Amphillius uranoscopus* and *A. natalensis (*AURA and ANAT) showed a strong preference for shallow water. Likewise, it can be said that *Micropterus spp.* showed a preference for slow flowing water.

Cover type was found to be a significant driver of community structure (p = 0.002). 86.3% of the variation seen in the fish communities is explained by cover features (Fig. 2.3C). Of all of the features, substrate accounted for the greatest variation in fish community structure (F = 8.57, p = 0.002). *Labeobarbus natalensis* (LNAT) showed a strong preference for substrate as a cover feature, along with *Salmo trutta* and *Amphillius natalensis* (Fig. 2.3C). *Clarias gariepinus* and *Enteromius viviparous* displayed a strong preference for undercut banks while *Labeobarbus polylepis* and *Anguilla mossambica* showed a small preference for depth as a cover feature.

Water quality was found to be a significant driver of community structure (p = 0.002) in the study area. One hundred percent of the variation seen in the fish communities can be explained by water quality (Fig. 2.3D). Of all of the features, electric conductivity accounted for the greatest variation in fish community structure (F = 9.61, p = 0.002) while clarity accounted for the second most variation in fish diversity (F = 6.33, p = 0.002). *Brycinus imberi*, *Chiloglanis swierstrai*, *Poecilia reticulata* and *Eleotris fusca* all showed tolerance for water with high electric conductivity.

The FRAI scores at U2MGEN-NINAW (uMngeni River) were low due to a multitude of issues. An invasive fish bass (*Micropterus spp.*) dominated the system, and in addition the invasive bluegill (*Lepomis macrochirus*) was found there. Furthermore, heavy sedimentation was taking place above the weir at the site. The site was penalised relatively heavily as it is in the same reach as a weir and a large impoundment. The site did, however, show some signs of recovery in the summer 2016 survey, predominantly due to the improved flows and large KZN yellowfish (*L. natalensis*) population sampled at the time of survey. Issues at U2TONG-ROADB (Tongati River) included alien vegetation along the riparian zone, infestation by alien fish, sedimentation due to erosion, and poor water quality. The Nile tilapia, found at this site, is an aggressive alien species of fish which hybridises with the native Mozambique tilapia.

U3MDLO-HAZIN (Mdloti River) is heavily impacted by water abstraction, solid waste, chemical waste and alien vegetation in the riparian zone. The low scores at U4MVOT-N2BRI (Mvoti River) were heavily linked to water quality and quantity. The lower Mvoti River is heavily used by industry and the river had completely dried up for one survey (pers. obs.). U6LOVU-R0197 (Lovu River) is situated at relatively deep part of the river, quite close to the estuary. As such, River Health Programme methods are not suited to sampling this site effectively. Impacts at this site include extensive sand mining in the riparian zone. Impacts at U6LOVU-RICHM (Lovu River) include altered flows via a weir upstream and extensive agricultural activity. The agricultural activity has resulted in loss of riparian vegetation, sedimentation and water quality concerns (pers. obs.). V3SAND-COTSW (Sand River) is severely impacted by a recently constructed weir. Initially, the weir had completely prevented water from flowing past in an attempt to increase the water level above the weir for abstraction purposes. The site was heavily impacted by poor water quality, sedimentation and alien fish during the surveys.

The main driver of the decline in FRAI score was the drought in conjunction with the rapid spread of alien species of fish. The sites situated further away from anthropogenic activity tended to be more stable than the sites that were heavily impacted by anthropogenic activity (Table 2.2) The drought in northern KZN caused many rivers to stop flowing or even to completely dry which were observed in the study.

Ecologically important sites for the KZN yellowfish (*L. natalensis*) were identified across the province at sites which were home to fish of multiple size classes. Sites on the uMngeni River displayed relatively good recruitment of KZN yellowfish as well as larger specimens during high flow. The Mtamvuna River (T4MTAM-MADIK) showed signs of recruitment, as did the Bushman's River (V7BUSH-MOORP) for KZN yellowfish. Water quality specialists, such as *Amphillius spp.*, and habitat specialists, such as *Labeo spp.*, were relatively uncommon, being found at few sites. Large KZN yellowfish specimens were somewhat rare; this is partly due to the low levels of water in the province during the study period.

Extralimital species were found at 21 sites, with bass (*Micropterus spp.*) being caught at ten of these. A large population of *O. niloticus* was found in the Tongati River (U2TONG-ROADB), where it is thought to be hybridising with the "near-threatened" native species *O. mossambicus.*

Certain fish species were expected to have a wide distribution in KZN, such as *Enteromius gurneyi* and *Clarias theodorae*, but were not found during any of the four surveys. According to the Atlas of Southern African Freshwater Fishes (Scott et al. 2006), *E. gurneyi* is expected in almost all river systems from the Mtamvuna River to the Matikulu River (See Supplementary Data Appendix 2.1). *Enteromius gurneyi* is known to prefer open pools in clear streams in an altitudinal range of 300-1000 m a.s.l (Skelton 2001). Despite 18 of the study sites falling in the expected range of *E. gurneyi*, it was not recorded during the study period. Similarly, *C. theodorae* has a broad expected range in southern Africa, including lowland regions in KZN (Appendix 2.1; 4.1). Approximately eight sites fall in the expected distribution range of *C. theodorae* but it was not recorded once at any of the study sites during the study period. While not absent completely, *Micralestes acutidens* was found at just one site during the study period of the eight sites falling in its distribution range (Appendix 2.1; 4.1). This may too be attributed to the drought at the time of sampling in the study area.

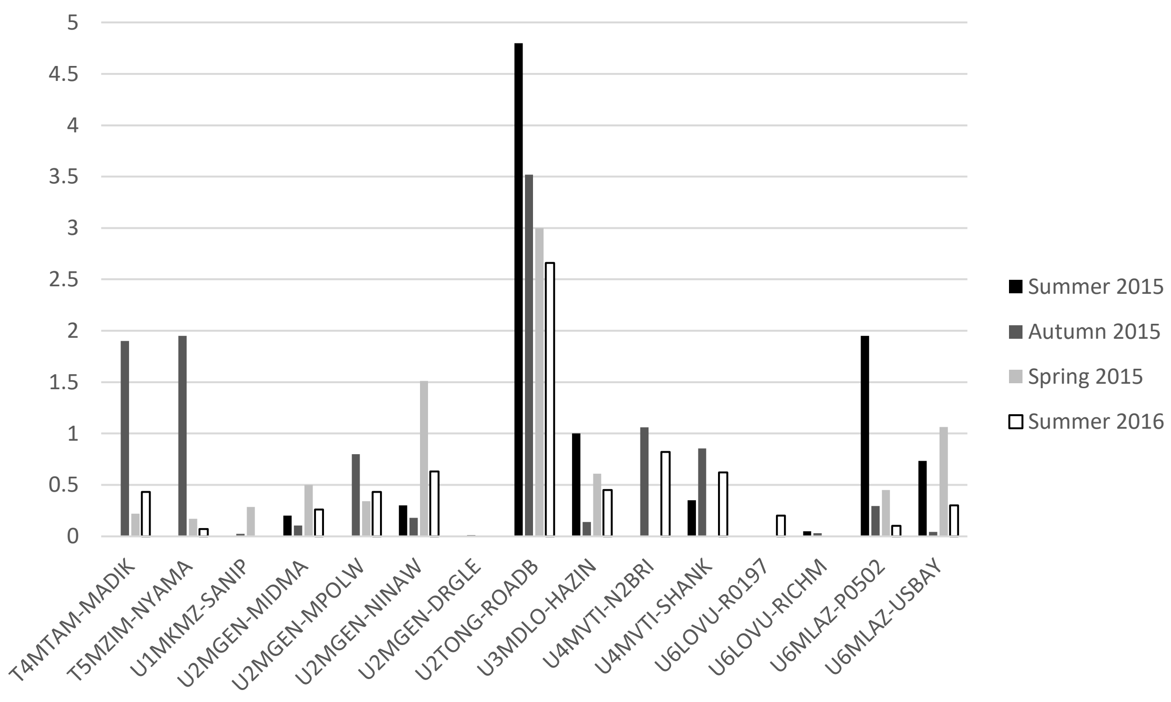


Fig 2.4: Catch per unit effort for RHP sampling sites in the U and T catchment areas of KwaZulu-Natal, South Africa

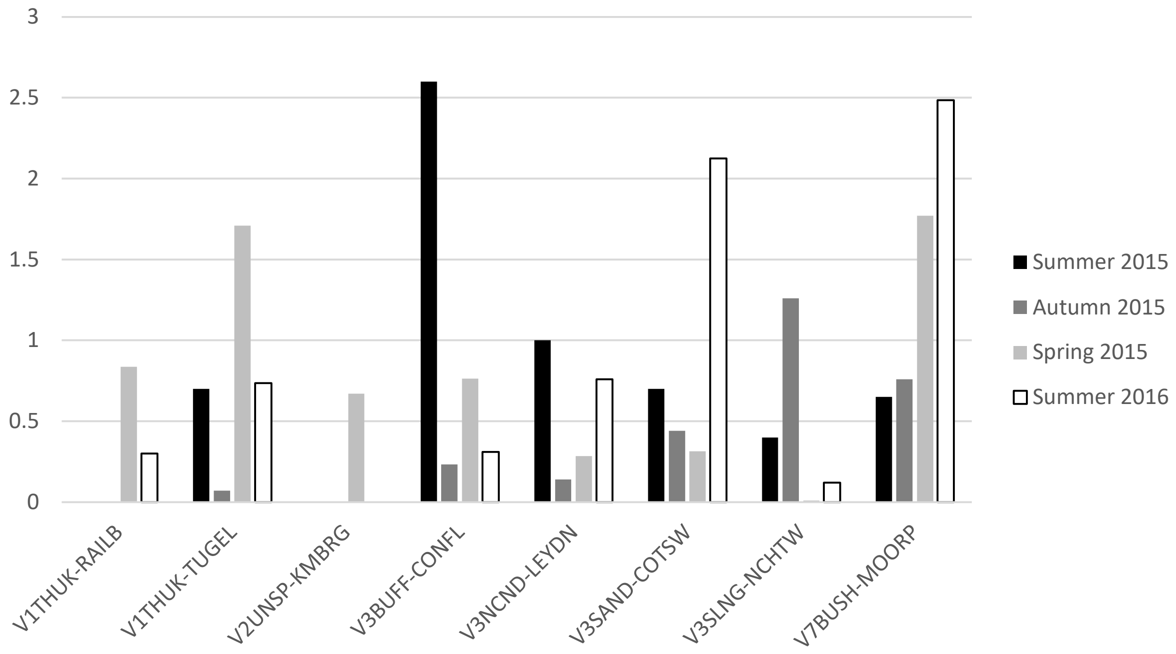


Fig 2.5: Catch per unit effort for RHP sampling sites in the V catchment area of KwaZulu-Natal, South Africa

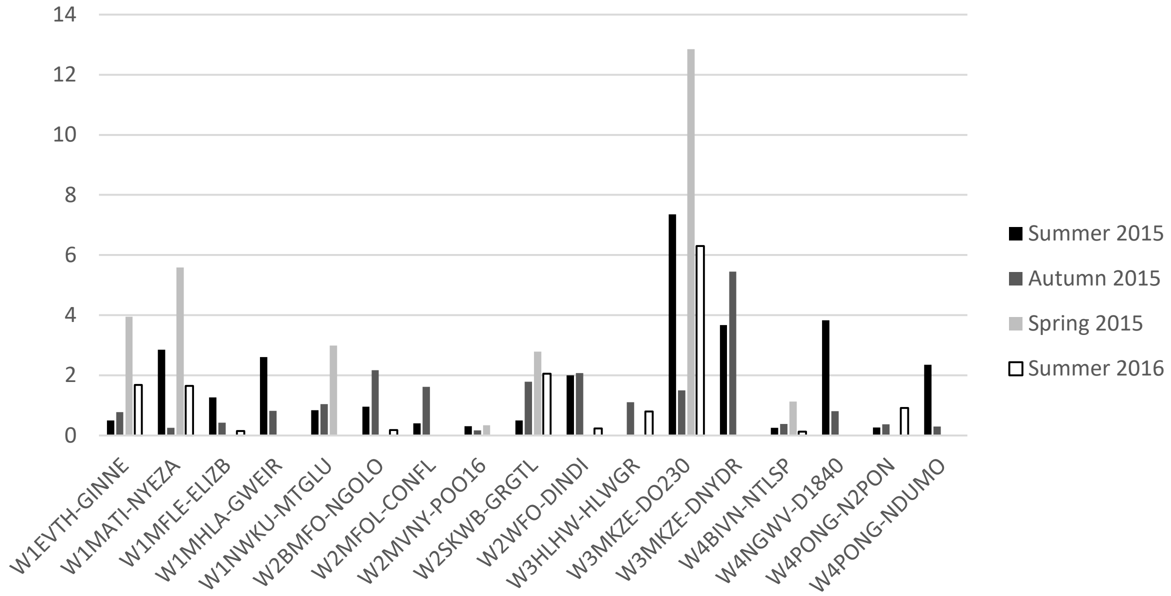


Fig 2.6: Catch per unit effort for RHP sampling sites in the U and T catchment areas of KwaZulu-Natal, South Africa

The catch per unit effort showed a decrease in many sites (U2TONG-ROADB, V7BUFF-CONFL and U6MLAZ-P0502) in the autumn and spring 2015 surveys when compared with the summer 2015 and 2016 surveys (Fig. 2.4 – Fig. 2.6). Several sites (both sites on the Mvoti River and V7BUSH-MOORP) showed signs of recovery from the spring 2015 to the summer 2016 survey, once there was some relief from the drought in parts of KZN (pers. obs.). The highest CPUE was recorded on the Mkuze River in the spring 2015 survey at a time where the river was not flowing and it was only possible to sample in pools where several *Tilapia sparrminii* had recently spawned. The CPUE in the lower Thukela River site (V1THUK-RAILB) was zero for the first two surveys of 2015 as the site was in flood for both surveys and sampling was only possible with a cast net. It was unsafe to sample as the water level was too high.

2.5 Discussion

Of the forty KZN river sites sampled, five were found to be in a 'Seriously Modified' state (Ecological Category = E) during the study period, which is deemed unacceptable by the Department of Water and Sanitation (Kleynhans and Louw 2007). All five of these sites were lowland rivers, in areas of high anthropogenic use. These rivers were all heavily utilised by local communities and industry and the impacts included dominant alien fish populations, water quality concerns, sedimentation and alien riparian vegetation.

The ecological state of freshwater fish communities in KZN showed signs of decline in the autumn and spring 2015 surveys, based on the FRAI scores. The majority of the sites in a 'Seriously Modified' or 'Largely Modified' states were located near large informal settlements, cities or industrial areas. The balance between use and protection is rarely obtained. Furthermore, the sites located near areas of high anthropogenic use were usually characterised by alien fish populations.

The hybridisation threat between *O. mossambicus* and *O. niloticus* led to *O. mossambicus* being placed on the IUCN red list as "Near-threatened" in 2007. According to a study by the IUCN, hybridisation is occurring in the Limpopo system and pure *O. mossambicus* are likely to become lost in those systems through competition and hybridisation (Cambray and Swartz 2007). It is possible that this same process is taking place in the Tongati River (U2TONG-ROADB). *Oreochromis niloticus* is spreading rapidly throughout southern Africa as a result of anglers and aquaculture, adding further threat to *O. mossambicus* (Ellender and Weyl 2014).

The uMngeni River is of great economic importance as it provides water for Pietermaritzburg and Durban, the two largest cities in KZN. As such, the river is highly utilised but significant efforts are being made to balance this with protection. Of the four sites on the uMngeni River, just one is in a ‘Largely modified’ state (EC = D) while the other three sites are in a ‘Moderately modified’ state (EC = C). *Labeobarbus natalensis* was expected to be found at three of the four sites on the uMngeni River, with the fourth site being outside of its temperature tolerance range. Large, healthy populations were found at all three of these expected sites which is encouraging as *L. natalensis* is commonly used as an indicator of ecosystem wellbeing.

A reduction in the velocity of the water at the study sites would result in a shift in the community structure. Fish which are strongly linked with high velocity (such as *Anguillids* and *L. natalensis*) would decline and the community structure would shift to fish which are associated with slow flowing water (eg. *Micropterus spp.* and *Coptodon rendalii*). *Amphilius uranoscopus* and *L. natalensis* both showed preference for cobbles as substrate type while *O. mossambicus* and *Micropterus spp.* showed preference for sand and silt, respectively. Gravel, cobbles and boulders all serve as spawning and feeding grounds for many KZN fishes (Skelton 2001). Sedimentation of gravel, cobbles and boulders are all susceptible to inundation by sediment, resulting in ecologically important substrate being lost.

The major sources of sediment are agriculture, forestry, urban development, and road construction (Waters 1995). Dudgeon (2000) found that the removal of forest near a river has the potential to increase turbidity and sedimentation which results in decreased fish abundance and biodiversity. Furthermore, agricultural activity has an inversely proportional relationship with fish biodiversity, as the agricultural activity near a river increases, so does the amount of sedimentation, while the fish diversity in the river decreases (Walser and Bart 1999). In addition to feeding and breeding, certain substrate types can act as a form of cover for fish to hide from predators (Kleynhans 2007). Sand, gravel, cobbles and boulders all have the potential to act as cover for fish and when these substrates get inundated with fine silt or mud, they lose their effectiveness as a cover feature (Kleynhans 2007). *Labeobarbus natalensis*, *S. trutta* and *A. natalensis* all showed a preference for substrate as a cover feature. Loss of substrates such as gravel, cobbles and boulders to sedimentation would likely result in a community shift, resulting in a decline in populations of *L. natalensis* and *A. natalensis*.

Of the water quality parameters included in the analysis, electric conductivity was found to be the greatest driver of community change. The main sources of conductivity include sedimentation, clay soil results in increased conductivity and increased agricultural activity results in increased sedimentation (Walser and Bart 1999). Water quality was a significant driver of community structure, explaining one hundred percent of the variation. This was expected as *B. imberi* is a predominantly pan based species, *P. reticulata* is known to have high tolerance (Shikano and Fujio 1997), while *E. fusca* is an estuarine straggler. *Micropterus spp.*, *Salmo trutta*, and *Amphillius natalensis* all showed a preference for water with good clarity. It was surprising that *Micropterus spp.* showed this preference as it is has been shown in a study by Reid et al. (1999), that *Micropterus spp.* gains no advantage from being in clear water over being in turbid water.

Furthermore, run-off from agricultural activity has the potential to result in increased conductivity in water. Strongly linked with high electric conductivity were estuarine- and pan-tolerant species, as well as three of the cichlids (*T. sparrminii, Pseudocrenilabrus philander* and *O. mossambicus*) while indicator species such as *L. natalensis* showed a preference for water with a low electric conductivity. A shift in the electric conductivity would result in a decline in *L. natalensis* and an increase in the aforementioned cichlids.

In conclusion, the fish populations of KZN appear to be in a state of decline, largely driven by the agricultural activity, abstraction for anthropogenic and industrial use and exacerbated by the drought. While the population structure analysis suggested that the cohorts are equally represented for the most part, the concern arises when one looks at the diversity and abundances within KZN. Fish communities have long been used successfully as indicators of ecosystem wellbeing because of their predictable responses to most anthropogenic disturbances (Li et al. 2010). Furthermore, the FRAI has been successfully implemented in South Africa for the purpose of assessing the wellbeing of freshwater ecosystems since 2007. Four rapid provincial-scale surveys were carried out from February 2015 to April 2016. With several notable absent species and the decline in populations of others, it is clear that the rivers of KZN are not in a healthy state. While not comprehensive, these surveys provided sufficient evidence to support this claim. Several sites showed a decline during the study period, primarily due to loss of habitat and unsustainable use of freshwater, exacerbated by the drought, particularly during the spring 2015 survey. The decline and general poor health of many rivers in KZN during the study period illustrates the lack of balance between use and protection of freshwater ecosystems. Sustained over-use without an increase in protection will result in a loss of structure (biodiversity and physical ecosystem features) and function (ecosystem processes) and have socio-economic consequences. The conservation status of many of the species in KZN needs to be revisited, particularly the species which were not found to have a reduced distribution range or not found during the study period.

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Appendix 2.1

Table A 1: River Health Programme site number, name and river catchment in KwaZulu-Natal, South Africa where I sampled from February 2015 to April 2016.

Site No:	RHP Name	River catchment	Latitude	Longitude
1	W4BIVN-NTLSP	Bivane, Phongolo	-27.529370	30.861440
2	W4PONG-N2PON	Phongolo	-27.395193	31.826608
3	W4NGWV-D1840	Ngwavuma, Phongolo	-27.097892	32.068882
4	W4PONG-NDUMO	Phongolo	-26.890038	32.318026
5	W3MKZE-D0230	Mkuze	-27.692560	31.211290
6	W3MKZE-DNYDR	Mkuze	-27.592270	32.217950
7	W3HLHW-HLWGR	Hluhluwe, Mkuze	-28.138560	32.019950
8	W2SKWB-GRTGL	Sikwebezi, Black Mfolozi, Mfolozi	-27.900330	31.365220
9	W2BMFO-NGOLO	Black Mfolozi, Mfolozi	-28.191223	31.737514
10	W2MVNY-P0016	Mvunyana, White Mfolozi, Mfolozi	-28.118986	30.866828
11	W2WMFO-DINDI	White Mfolozi, Mfolozi	-28.393483	31.683031
12	W2MFOL-CONFL	Mfolozi	-28.359600	31.994340
13	W1MFLE-ELIZB	Mfule, Mhlathuze	-28.515890	31.436140
14	W1MHLA-GWEIR	Mhlathuze	-28.746950	31.747450
15	W1NWKU-MTGLU	Nwaku, Matikulu	-28.941420	31.394160
16	W1EVTH-GINNE	Vutha/Matikulu, Matikulu	-29.067085	31.505883
17	W1MATI-NYEZA	Matikulu	-29.076547	31.563093
18	V3SLNG NCHTW	Slang, Buffalo, Thukela	-27.420670	30.296810
19	V3NCND-LEYDN	Ncandu, Buffalo, Thukela	-27.851440	29.756630
20	V3BUFF-CONFL	Buffalo, Thukela	-27.803441	30.247932
21	V3SAND-COTSW	Mzinyashana, Buffalo, Thukela	-28.098820	30.318530
22	V1THUK-TUGEL	Thukela	-28.756331	30.150376
23	V7BUSH-MOORP	Bushmans, Thukela	-29.08337	29.825037
24	V2UNSP-KMBRG	Mooi/Mfulankomo, Mooi, Thukela	-29.380814	29.660522
25	V1THUK-RAILB	Thukela	-29.172622	31.391921
26	U4MVOT-SHANK	Mvoti	-29.159860	30.628690
27	U4MVOT-N2BRI	Mvoti	-29.370004	31.304341
28	U2TONG-ROADB	Tongati, Tongati	-29.559913	31.174085
29	U3MDLO-HAZIN	Mdloti	-29.602083	31.009018
30	U2MGNI-DRGLE	uMngeni	-29.488805	29.903036
31	U2MGEN-MIDMA	uMngeni	-29.488134	30.156002
32	U2MGEN-MPOLW	uMngeni	-29.491252	30.492632
33	U2MGEN-NINAW	uMngeni	-29.714520	30.868058
35	U6MLAZ-USBAY	Mlazi	-29.756000	30.289000
36	U6MLAZ-P0502	Mlazi	-29.809722	30.500000
38	U6LOVU-RICHM	Lovu	-29.861446	30.261955
41	U6LOVU-R0197	Lovu	-30.096890	30.822200
42	U1MKMZ-SANIP	Mkhomazana, Mkomazi	-29.645765	29.431339
43	T5MZIM-NYAMA	Mzimkhulu	-30.652236	30.197692
44	T4MTAM-MADIK	Mtamvuna, Mtamvuna	-30.849236	30.064003

Table A 2: Velocity-depth classes as defined by (Kleynhans 2007)

Velocity/Depth Class	Velocity	Depth
SS	<0.3m/s	<0.5m
SD	<0.3m/s	≥0.5m
FS	≥0.3m/s	<0.3m
FD	≥0.3m/s	≥0.3m

Table A 3: Indigenous and invasive freshwater fish abundance and diversity from February 2015 to April 2016, in KZN, South Africa

Table Code	AAEN	AJOH	AMAR	AMOS	ANAT	AURA	Ang	BANN	BANO	BEUT	BIMB	BPAU	BTOP	BTRI	BVIV	CANO	CCAR	CGAR	CSWI	EFUS	GCAL	GGIU	LCYL	LMAC	LMOL	LNAT	LPOL	LRUB	MACU	MBRE	MCAP	MFAL	MMAL	MSAL	OMOS	ONIL	OPER	PPHI	PRET	STRU	TREN	TSPA	Abundance	Diversity
W4BIVN-NTLSP Su15																										1								2			1						4	3
W4BIVN-NTLSP Au15															3	9																		1								2	15	4
W4BIVN-NTLSP Sp15						1										13									1		15						2	2			1						35	7
W4BIVN-NTLSP Su16																											1							8									9	2
W4PONG-N2PON Su15																		2																	7						3		12	3
W4PONG-N2PON Au15																		2			11																				9		22	3
W4PONG-N2PON Su16																		1	1		13		3						81						1						6	11	117	8
W4NGWV-D1840 Su15						2								23	10			1							3										5								44	6
W4NGWV-D1840 Au15												1																							2			15					18	3
W4PONG-NDUMO Su15											7	3			27			1	3		1				6										20			2					70	9
W4PONG-NDUMO Au15											2																								18								20	2
W4PONG-NDUMO Su16																																											0	0
W3MKZE-D0230 Su15								54						7									1		28	58									5							1	154	7
W3MKZE-D0230 Au15																		6																	61						3		70	3
W3MKZE-D0230 Sp15														27												8									49								84	3
W3MKZE-D0230 Su16								19										6																	1							308	334	4
W3MKZE-DNYDR Su15													1	26	15										55					1					20						7		125	7
W3MKZE-DNYDR Au15												3									4														71			1					79	4
W3HLHW-HLWGR Au15												4		8				1		1						2									4								20	6
W3HLHW-HLWGR Su16																		5								8																	13	2
W2SKWB-GRTGL Su15									1					1				1							1	20																	24	5
W2SKWB-GRTGL Au15	2					10				35				43				1								17																	108	6
W2SKWB-GRTGL Sp15						9				19				2				2			2					83																	117	6
W2SKWB-GRTGL Su16	1									29				32													8															26	96	5
W2BMFO-NGOLO Su15														3																					16								19	2
W2BMFO-NGOLO Au15	4											1		16				4							13	2									26								66	7
W2BMFO-NGOLO Su16																																			9								9	1
W2MVNY-P0016 Su15																										6																	6	1
W2MVNY-P0016 Au15																										3																	3	1
W2MVNY-P0016 Sp15																		6																									6	1
W2MVNY-P0016 Su16																																											0	0
W2WMFO-DINDI Su15	1													8											1	3									13								26	5
W2WMFO-DINDI Au15	1													38				12							8	73									25								157	6
W2WMFO-DINDI Su16	1																								1	1									2								5	4
W2MFOL-CONFL Su15														3												1									6						1		11	4
W2MFOL-CONFL Au15	6		1											2				3		3	2				11	4									19						1		52	10
W2MFOL-CONFL Su16																																											0	0
W1MFLE-ELIZB Su15																										26															17		43	2
W1MFLE-ELIZB Au15								3				2		5												11									8								29	5
W1MFLE-ELIZB Su16																		1																								9	10	2
W1MHLA-GWEIR Su15												6		17							5												25		7			9			15		84	7
W1MHLA-GWEIR Au15	1																	1							2										15			2					21	5
W1MHLA-GWEIR Su16		2																			6					1									7			11					27	5
W1NWKU-MTGLU Su15				1																						2									5			9			14		31	5
W1NWKU-MTGLU Au15															8			1																	24			11					44	4
W1NWKU-MTGLU Sp15																		3								1									68			44					116	4
W1NWKU-MTGLU Su16			2									1						1								1									60			25					90	6
W1EVTH-GINNE Su15												1						1			3					30					1							4			14	1	55	8
W1EVTH-GINNE Au15														2	4					1																		5	7			1	20	6
W1EVTH-GINNE Sp15												35									2										1			12	13						41		104	6

Table A 3 cont.: Indigenous and invasive freshwater fish abundance and diversity from February 2015 to April 2016, in KZN, South Africa

Table Code	AAEN	AJOH	AMAR	AMOS	ANAT	AURA	Ang	BANN	BANO	BEUT	BIMB	BPAU	BTOP	BTRI	BVIV	CANO	CCAR	CGAR	CSWI	EFUS	GCAL	GGIU	LCYL	LMAC	LMOL	LNAT	LPOL	LRUB	MACU	MBRE	MCAP	MFAL	MMAL	MSAL	OMOS	ONIL	OPER	PPHI	PRET	STRU	TREN	TSPA	Abundance	Diversity
W1EVTH-GINNE Su16												9		2																								2				105	118	4
W1MATI-NYEZA Su15																					1										10			16	19						60		106	5
W1MATI-NYEZA Au15	1																					1													3								5	3
W1MATI-NYEZA Sp15	4													7							5										11	80		16	12						1		136	8
W1MATI-NYEZA Su16																				6	2										5			2				1				78	94	6
V3SLNG-NCHTW Su15									13																																		13	1
V3SLNG-NCHTW Au15									30																																		30	1
V3SLNG-NCHTW Sp15															1																												1	1
V3SLNG-NCHTW Su16									6																																		6	1
V3NCND-LEYDN Su15					9				8																																		17	2
V3NCND-LEYDN Au15					3										9																			1									13	3
V3NCND-LEYDN Sp15					11	11		13																																			35	3
V3NCND-LEYDN Su16					1				22																																		23	2
V3BUFF-CONFL Su15												1					1	3								6													51				62	5
V3BUFF-CONFL Au15																		1																					5				6	2
V3BUFF-CONFL Sp15												17						1								12													3		1		34	5
V3BUFF-CONFL Su16																	1	21								14													1				37	4
V3SAND-COTSW Su15									19									2																								1	22	3
V3SAND-COTSW Au15															9			1																								3	13	3
V3SAND-COTSW Sp15								17				2																															19	2
V3SAND-COTSW Su16									133																																		133	1
V1THUK-TUGEL Su15															8			4								3		3										1					19	5
V1THUK-TUGEL Au15												1		1				3							1																		6	4
V1THUK-TUGEL Sp15				1										40											35	31									2			1					110	6
V1THUK-TUGEL Su16							1							4	1			5							3	27												3					44	7
V7BUSH-MOORP Su15						1																				21																	22	2
V7BUSH-MOORP Au15						2												1								26																	29	3
V7BUSH-MOORP Sp15																										35																	35	1
V7BUSH-MOORP Su16																										148																	148	1
V2UNSP-KMBRG Au15																																											0	0
V2UNSP-KMBRG Sp15																																								29			29	1
V2UNSP-KMBRG Su16																																											0	0
V1THUK-RAILB Au15																																											0	0
V1THUK-RAILB Sp15	1																	1		1					6	4																14	27	6
V1THUK-RAILB Su16																																											0	0
U4MVOT-SHANK Su15															1											5								2								4	12	4
U4MVOT-SHANK Au15						2									65											1								2								23	93	5
U4MVOT-SHANK Su16										1																								18								2	21	3
U4MVOT-N2BRI Au15														3				2								6									12				2				25	5
U4MVOT-N2BRI Su16	1													4				2																	21								28	4
U2TONG-ROADB Su15																																			4	26			4				34	3
U2TONG-ROADB Au15																																			4	3		1	135				143	4
U2TONG-ROADB Sp15	1											19			1			2		8											18					6			52				107	8
U2TONG-ROADB Su16	2											3			2					10																			216				233	5
U3MDLO-HAZIN Su15				1																						18								7	2						11		39	5
U3MDLO-HAZIN Au15																										7								1	1								9	3
U3MDLO-HAZIN Sp15				1																						3								5	8								17	4
U3MDLO-HAZIN Su16																		2								3								11	7								23	4
U2MGNI-DRGLE Au15															1																												1	1
U2MGNI-DRGLE Su16																																								1			1	1

Table A 3 cont.: Indigenous and invasive freshwater fish abundance and diversity from February 2015 to April 2016, in KZN, South Africa

Table Code	AAEN	AJOH	AMAR	AMOS	ANAT	AURA	Ang	BANN	BANO	BEUT	BIMB	BPAU	BTOP	BTRI	BVIV	CANO	CCAR	CGAR	CSWI	EFUS	GCAL	GGIU	LCYL	LMAC	LMOL	LNAT	LPOL	LRUB	MACU	MBRE	MCAP	MFAL	MMAL	MSAL	OMOS	ONIL	OPER	PPHI	PRET	STRU	TREN	TSPA	Abundance	Diversity
U2MGEN-MIDMA Su15																										1								1									2	2
U2MGEN-MIDMA Au15																		1								4								1									6	3
U2MGEN-MIDMA Sp15																		2								10								12									24	3
U2MGEN-MIDMA Su16																										20								4									24	2
U2MGEN-MPOLW Su15																		1								11								9								5	26	4
U2MGEN-MPOLW Au15																										29															2	6	37	3
U2MGEN-MPOLW Sp15																										17									4								21	2
U2MGEN-MPOLW Su16																		2								38								6	1			3			2	8	60	7
U2MGEN-NINAW Su15	5																																	10									15	2
U2MGEN-NINAW Au15	5		1																					1										3				1					11	5
U2MGEN-NINAW Sp15	1			2																						3								61				2				1	70	6
U2MGEN-NINAW Su16	3																									5								24								3	35	4
U6MLAZ-USBAY Su15																																		23									23	1
U6MLAZ-USBAY Au15																																		3									3	1
U6MLAZ-USBAY Sp15																																		6	7								13	2
U6MLAZ-USBAY Su16																																		6	6								12	2
U6MLAZ-P0502 Su15				1																														46									47	2
U6MLAZ-P0502 Au15																																		13									13	1
U6MLAZ-P0502 Sp15																																		9									9	1
U6MLAZ-P0502 Su16																																		5									5	1
U6LOVU-RICHM Su15																		1																								2	3	2
U6LOVU-RICHM Au15																																			2								2	1
U6LOVU-RICHM Sp15																																											0	0
U6LOVU-RICHM Su16																																											0	0
U6LOVU-R0197 Su15																																											0	0
U6LOVU-R0197 Au15																																											0	0
U6LOVU-R0197 Sp15																																											0	0
U6LOVU-R0197 Su16																																			1								1	1
U1MKMZ-SANIP Au15																																								2			2	1
U1MKMZ-SANIP Sp15																																								5			5	1
U1MKMZ-SANIP Su16																																											0	0
T5MZIM-NYAMA Au15														3												7									6								16	3
T5MZIM-NYAMA Sp15																		1								6					1				3								11	4
T5MZIM-NYAMA Su16																		2								2									3								7	3
T4MTAM-MADIK Au15									1																	153									1								155	3
T4MTAM-MADIK Sp15															6											2																	8	2
T4MTAM-MADIK Su16									7																	31								6									44	3

CHAPTER 3:

THE STATE OF THE KWAZULU-NATAL YELLOWFISH POPULATIONS IN KWAZULU-NATAL PROVINCE, SOUTH AFRICA

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3.1 Abstract

Labeobarbus natalensis, colloquially known as the KwaZulu-Natal (KZN) yellowfish or scaly, is ubiquitous in KZN, South Africa. Populations that have historically been found in almost all rivers within the province have declined in response to increased use of water resources. Major determinants of the decline include habitat loss, altered water quality and quantity, and the establishment of barriers such as dams and weirs that hinders migrations. In this study the wellbeing of the KZN yellowfish populations was evaluated at 40 sites sampled quarterly between February 2015 and March 2016 within 16 major rivers in KZN as a part of the regional 2015/6 River Health Programme study. In this study fish were collected using a range of sampling techniques appropriate to the habitats observed in the rivers sampled and included the use of electrofishing and passive and active netting techniques. Fish collected were identified, total length (TL) measured and then released. The occurrence of yellowfish and the population structures were evaluated and compared with known historical distributions of yellowfish. This allowed for an update of the 2008 "state of KZN yellowfish wellbeing assessment". Considering that genetic diversities of KZN yellowfish are known the ecological importance of each population is considered to be high. The study was undertaken during a severe drought in the region which was partially attributed to the general reduction in the wellbeing of yellowfish throughout KZN. Additional stressors identified include the increase in range of alien precious and competing fishes and a range of land use activities. The yellowfish populations in the Mkuze and Mlazi Rivers in particular were observed to be in a poor state with low abundances and poor population structures of the species in the Mkuze River and no yellowfish observed in Mlazi River system. Thereafter populations in reaches of rivers associated with urban and industrial use were poor, and populations in northern KZN in particular seemed to have been negatively affected by the recent drought. Populations in southern KZN rivers of the Mkomazi, Mzimkhulu and Mtamvuna Rivers appeared to be intact. High frequencies of occurrence, healthy population structures and good recruitment of yellowfish were observed in these rivers. Populations in the uMngeni, and upper and middle Thukela rivers were observed to occur in a suitable condition although high abundances were not consistently observed. In the last ten years the overall wellbeing of yellowfish populations in KZN has declined in response to consistent increases in stressors observed in the province due to increasing use of water resources and expansion of alien fish distributions. River rehabilitation and conservation measures proposed in 2008 have not been implemented. It is recommended that the genetic diversity of yellowfish in KZN be urgently addressed to identify unique populations, and that if any unique populations include those identified here to be in a poor condition, urgent conservation action should be undertaken. The yellowfish of KZN represent an important socio-ecological resource of the province that is generally out of sight and out of mind, so more is needed to promote this species and their contributions to regional ecosystem services.

Keywords: *Labeobarbus natalensis*, KwaZulu-Natal, ecological wellbeing, ecologically important

3.2 Introduction

The southern African yellowfish (Genera *Labeobarbus*) form part of the Cyprinidae family (Skelton 2001). *Labeobarbus spp.* are long living and grow to large sizes, reaching up to 800 mm (total length) and 22 kg (Skelton 2001). The most widespread and well known of yellowfish in KZN is *Labeobarbus natalensis* (Castelnau, 1861), otherwise known as the KwaZulu-Natal yellowfish or scaly (Karssing 2008). *Labeobarbus natalensis* attains a maximum length of ~640 mm and weight of ~4.6 kg (Skelton 2001) and ranges from headwater streams to lowland rivers, from Mkuze to Mtamvuna and all major systems in between (Supplementary Data Appendix 3.1). *Labeobarbus natalensis* is replaced by *L. polylepis* in the Phongolo River system, the most northern river system in KZN. In the Phongolo River system *L. polylepis*, the Bushveld smallscale yellowfish (*Labeobarbus polylepis* Boulenger 1907) and Lowveld Largescale Yellowfish (*Labeobarbus marequensis* (A. Smith 1841)) occur (Crass et al. 1964).

KZN yellowfish are opportunistic feeders, they are known to feed on filamentous algae, diatoms, organic detritus, insect larvae, and crabs (Roux 2007). The mouth parts of *L.*

natalensis vary considerably, predominantly according to their staple diet (Karssing 2008). The mouth parts range from enlarged and rubbery to thin, scraping lips (Skelton 2001). In addition to this, is morphologically variable with colouration, body, and head (Karssing 2008). This considerable variation in the morphology of *L. natalensis* has resulted in the many historical synonyms of *L. natalensis* (Supplementary Data Appendix 3.1). Many aspects of its morphology show large variation across its geographical range, from the shape and form of its mouth parts to the body shape. Karssing (2008) found that specimens from the lowland stretches of rivers are usually more thick-set and deep bodied whereas specimen from the upper reaches generally had a more elongated body shape. Furthermore, the last dorsal spine of KZN yellowfish found near the upper reaches of rivers tended to be thin and flexible, where those found in lowland rivers tend to be thick and rigid (Karssing 2008).

KZN yellowfish are capable of thriving in pools and impoundment habitats throughout their range and migrate upstream into rivers for spawning and feeding (Karssing 2008). The KZN yellowfish is a facultative seasonal migrating species that migrates upstream from the low and middle reaches of rivers in late spring presumably for spawning and feeding activities (Karssing 2008). Migrations are undertaken by juvenile, sub-adults and mature breeding adults (Wright and Coke 1975a). When impassable barriers are not present, *L. natalensis* have been known to use the upper reaches of rivers to spawn which usually takes place in October/November when temperatures and habitats are favourable (Wright and Coke 1975a; Karssing 2008). Females choose coarse gravel beds in water with high oxygen content for spawning (Wright and Coke 1975a).

Wright and Coke (1975b) carried out a study on the artificial propagation of *L. natalensis* and found that juveniles are susceptible to high silt loads in rivers. Fertilised eggs are deposited on gravel beds and approximately three days later, they hatch (Wright and Coke 1975b). Shortly after hatching, the larvae burrow head first into the gravel and remain there, almost motionless for a week; the larvae display negative phototropism by moving in the opposite direction of the light (Wright and Coke 1975b). After this week, larvae use up their yolk sacs, emerge and then remain hidden amongst the gravel for another 10 days feeding on phytoplankton and zooplankton (Wright and Coke 1975b). If the gravel is inundated with silt, the burrowing phase is not possible, potentially leaving them vulnerable to predation or displacement (Wright and Coke 1975b).

In the Karssing (2008) technical report, it was noted that there was a decline in KwaZulu-Natal yellowfish populations and that frequent surveys were necessary in order monitor the its state, especially in areas where it was threatened most. The River Health Programme was seen as the best way to carry out the monitoring of KZN yellowfish, especially in systems where they are most threatened (Karssing 2008). According to Karssing (2008), the rivers where the KZN yellowfish is threatened most include the upper Thukela River, the uMngeni River and the Mfolozi River where the KZN yellowfish is threatened by hybridisation and competition.

There are at least 15 species of non-native species of freshwater fish found in KZN (trout (*Oncorhynchus mykiss* and *Salmo trutta*), bass (*Micropterus salmoides, M.punctulatus, M. dolomieu*), bluegill (*Lepomis macrochirus*), mosquito-fish (*Gambusia affinis*), guppy (*Poecilia reticulata*), Nile tilapia (*Oreochromis niloticus*), goldfish (*Carassius auratus*), grass carp (*Ctenopharyngodon idella*), common carp (*Cyprinus carpio*), swordtail (*Xiphophorus helleri*) and Orange River mudfish (*Labeo capensis*) (Skelton 2001; Karssing 2008; Zengeya et al. 2011; Ellender and Weyl 2014). Of these 15 non-native species, the South African National List of Invasive Freshwater Fish Species lists just eight (NEMBA 2004). Due to its extensive range in KZN, the KZN yellowfish is impacted in some way by most of these non-native species. Trout (*O. mykiss* and *S. trutta*) and *Micropterus spp.* pose a serious threat to *L. natalensis* by competing for food and habitat and direct predating of juvenile KZN yellowfish (Karssing 2008). The common carp (*C. carpio* Linnaeus, 1758), also found within the range of *L. natalensis*, is yet another competitor for food but *C. carpio* has the tendency to alter the habitat of a riverbed in an unfavourable way (Koehn 2004). In addition to the infestation of alien fish species in KZN rivers, *L. natalensis* has to contend with rapid loss and alteration of habitat (Karssing 2008). It would seem that the successful conservation of *L. natalensis* would rely upon the protection of water quality, availability and quality of habitats and food (Coke 1997).

Labeobarbus natalensis is tolerant to a moderate amount of water pollution but is known to develop disfigured fins, scales and mouth parts as a result of pollution (Coke 1999; Karssing 2008). Furthermore, *L. natalensis* with the fungal infection *Saprolegnia* (a sign of stress) are commonly found in polluted waters, especially towards the end of winter (Oldewage 1987; Coke 1999). In the Msunduzi River, a particularly polluted river running through the city of Pietermaritzburg, South Africa, several large fish kills have been documented in the recent past, predominantly due to an accumulation of waste products which depletes the oxygen supply in the river (Karssing 2008). The Msunduzi River runs through the Msunduzi Local Municipality, which is serviced by two waste water treatment works, both flowing into the

Msunduzi River. According to a DWS (2011) report, neither of these waste water treatment facilities were compliant with governmental effluent quality discharge standards meaning that partially treated effluent was being returned to the Msunduzi River and eventually on to the uMngeni River.

Although *L. natalensis* is currently listed on the IUCN Red Data list as "Least Concern", the genetic diversity of all of the populations is under investigation (Bloomer 2007). Further investigation may result in some populations being separated into sub-species to represent the genetic diversity of the species complex. Some of these isolated populations are threatened by multiple stressors affecting water quantity, quality and habitat of rivers in KZN (Skelton 2001; Karssing 2008).

Labeobarbus natalensis has long been targeted by fishermen as a source of protein. Its remains that have been dated to originate from 2000 BC were discovered in parts of the Thukela River basin, along with primitive hooks (Mazel 1989). Since 2000 BC, people have continued to make use of *L. natalensis* as a source of protein (Mazel 1989). As angling for KZN yellowfish has grown in more recent times, so has the need for proper protection. It is a relatively slow growing and long lived fish, reaching maturity after two years (Skelton 2001) The daily bag limit for anglers is 10 fish with a minimum length of 20 cm but it is suggested that a daily bag limit of 2 fish with a length between 30 cm and 50 cm is required for proper protection (Karssing 2008).

KZN yellowfish populations can be divided into at least two groups based on differences in their mitochondrial DNA (Bloomer 2007). While work is currently undergoing, preliminary results indicate that there is a clustering of alleles according to the river system (Bloomer 2007). The populations north and south of the Thukela River were found to be genetically different from the populations found in the Thukela River (Bloomer 2007). Legislation in SA (NEMBA 2004) requires that genetic diversity be considered as diversity and protected as unique species. This suggests that the population should be managed and protected separately to protect diversity. The aim of this study was to update the wellbeing of the KZN endemic *L. natalensis* using available population wellbeing information and threats to yellowfish in KZN. An update of the state of the KZN yellowfish is presented and incorporates seasonal sampling of the fish communities and associated threats to river health in KwaZulu-Natal through the River Health Programme assessment undertaken between February 2015 and April 2016.

3.3 Methods

Four fish collection surveys were undertaken at 33 sites across KZN (Fig. 2.2; Chapter 2) from February 2015 to April 2016, which consisted of two high- and two low- flow surveys at each site (Fig. 2.2). During the surveys, some sites were dry and not sampled. Fish were sampled using an array of techniques, including electrofishing, casts nets, and seine nets (Chapter 2). Surveys were carried out with approval from KZN-Ezemvelo Wildlife with permit numbers: OP713-2015, OP715-2015, OP911-2016, and OP913-2016.

The KZN sampling sites were selected based on historical sampling sites for the River Health Programme, as selected by the Department of Water and Sanitation, South Africa (Chapter 2). The sites were selected to be representative of the river reach in which they are located, with consideration for ease of access. Sites with good perennial flow, with a wide range of available biotopes or habitats were selected. Where possible, sites were situated away from man-made instream structures such as weirs and bridges with instream support. These structures create unnatural flow regimes and habitat structures. Two sites were selected in the T-catchment, one site on the Mzimkulu River and one site on the Mtamvuna River. A total of 12 sites were in the U-catchment, three of these being on the economically important uMgeni River. Six sites were selected within the V-catchment, including two sites on the largest river in the province, the Thukela River. The remaining six sites were located on rivers which feed into the Thukela River. A total of 13 sites were selected to represent the W-catchment, the northern most portion of the province. This included five sites on the Mfolozi River and its tributaries (Chapter 2).

Reference fish assemblage was determined using historical data, expert knowledge and the PESEIS database for each site, based on the sub-quaternary code (Chapter 2). The fish habitat potential and current condition was then determined at each site, followed by the sampling of fish using the appropriate methods. Sampling was carried out in all available velocity depth classes (Kleynhans 2007) where possible. Fish sampling data were collated and transformed into frequency of occurrence ratings. Historical distribution of all freshwater fishes known to occur in KZN were considered. Distribution maps using the Present Ecological State, Ecological Importance (PESEIS, DWS, 2014) assessment and freshwater fish distribution and Atlas of Southern African Freshwater Fishes Distribution in KwaZulu-Natal (Scott et al. 2006; Chapter 2).

The assessment of the KZN yellowfish was carried out using the FRAI procedure (Kleynhans 2007; Chapter 2). The FRAI results in an automated and an adjusted score; the former is based on the model's automated assessment based on the state of the drivers and the differences between expected and observed species in the assessment alone. This does not account for the availability of habitat and other fish attribute features that the automated FRAI score assumes are affected due to the community of fishes observed in relation to reference communities. The index then allows to user to alter the automated FRAI scores by manually evaluating the state of the drivers in the systems. The impacts that the FRAI considers are the available substrate types, available cover features, velocity and depth, the physical-chemical state of the water, presence of introduced species and barriers for migration in the river (Kleynhans 2007). The FRAI calculates the ecological category for each site based on these impacts and fish data. Ecological categories range from A to F, where "A" is "Unmodified, natural" (90-100%) and "F" is "Critically/extremely modified" (0-19%) (As per Table 2.1) (Kleynhans et al. 2005).

Electrofishing was performed using a Samus electrofisher (SAMUS 725M Electrofisher, SAMUS Special Electronics, Poland) or a generator (Honda EG 3000 portable generator) (Chapter 2). Sampling effort and results were recorded per velocity-depth class. Where a combination of velocity-depth classes existed, the dominant velocity-depth class was recorded for the sampling effort. The following apparatus were used for catching fish in the different velocity-depth classes, adapted from the Kleynhans (2007, Chapter 2). Electrofishing was performed for up to 60 min. per site when suitable, the cast net was thrown up to 20 times per site where suitable while the small seine net was used up to three times per site where suitable. Current strength and settings and the electrofishing gear were optimised to sample different species and conditions in the study area (Bohlin et al. 1989). All available habitats were sampled effectively at each site (Chapter 2). Captured fish were transferred to 20 l buckets containing river water to be counted, identified, and measured (total length, TL). The TL was measured for all fish collected in the study for analysis of the population structure, allowing for the consideration of age groups/classes of individuals in a population which are useful indicators of the state of fish populations (Russell and Skelton 2005). Following identification and measuring, fish were returned to the river alive at nearest point to capture. Voucher specimens for validation were preserved in 10 % Formaldehyde and stored at the University of KwaZulu-Natal, South Africa. A catch per unit effort (CPUE) was determined based on the number of KZN yellowfish sampled per unit. Units varied based on equipment type used for the sampling effort (Chapter 2).

The available habitat was visually assessed and described as either marginal vegetation, aquatic vegetation, undercut banks, root wads, substrate, depth/column or open (Kleynhans

1999; Chapter 2). The available substrate type for each effort was categorised as either fines/silt, mud, sand, gravel, cobbles, boulders or bedrock (Kleynhans 1999). The velocity/depth for each effort was measured using a Transparent Velocity Head Rod (GroundTruth, Hilton, South Africa) (Fonstad et al. 2005). Furthermore, each effort was placed into a velocity/depth class, outlined in Kleynhans (2007). The availability and state of instream and riparian habitat features is an important driver of ecosystem wellbeing. In this study, the habitat quality and diversity were assessed by applying the Index of habitat integrity (IHI) (Kleynhans 1996). This index was completed at the site using established score sheets. The values of the index were then calculated and a rating system for the index describes the habitat quality of the given site (Chapter 2).

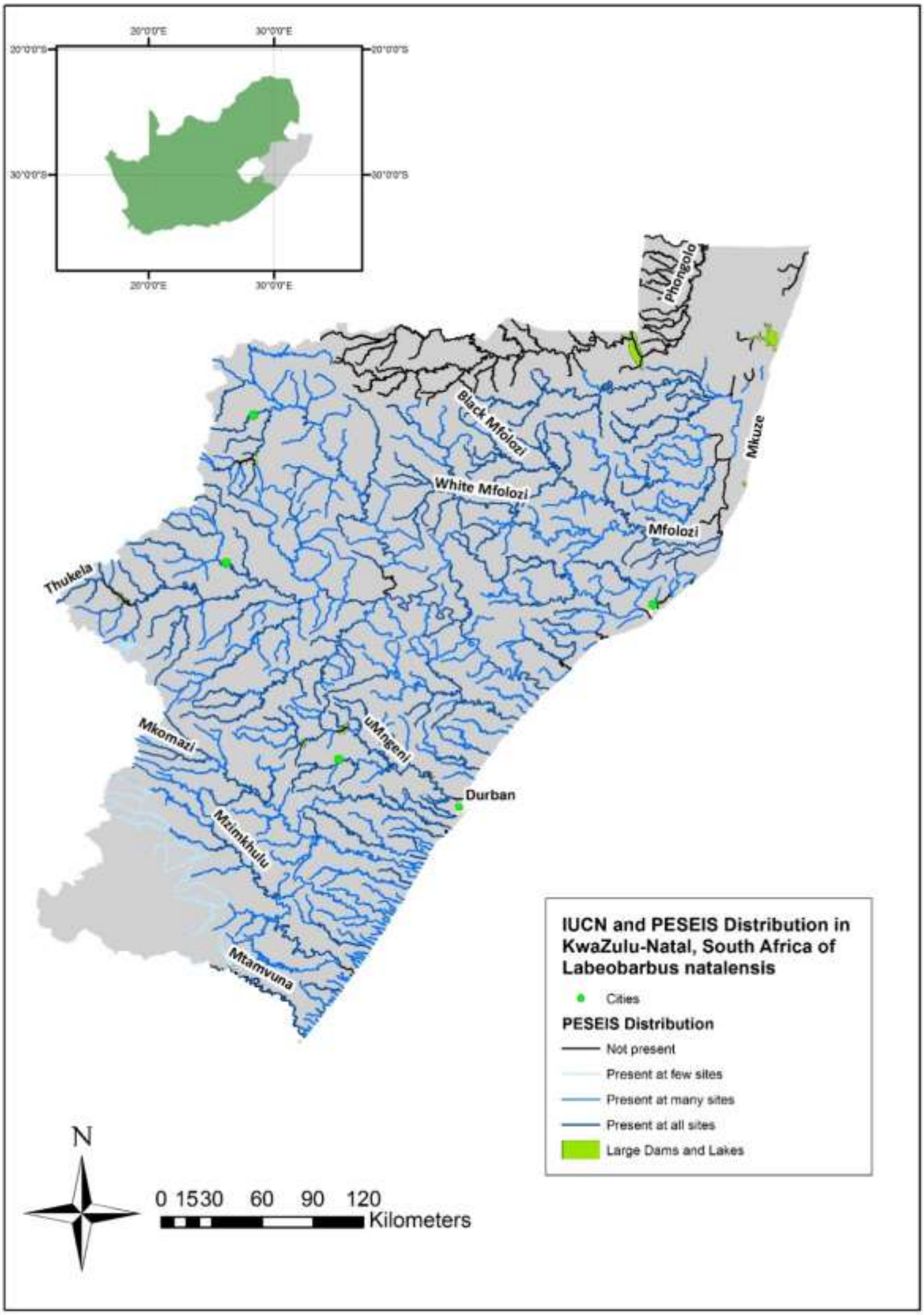

Fig. 3.1: PESEIS Distribution of *Labeobarbus natalensis* in KwaZulu-Natal, South Africa

3.4 Results

The expected distribution of *L. natalensis* extends throughout KZN south of the Pongola River system, where they do not occur. In 2015 and 2016 *L. natalensis* were collected in all major river systems of KZN with the exception of the Lovu and the Mlazi River systems. The sites selected for this study were all River Health Programme study sites within the distribution range of *L. natalensis*, generated from the PESEIS (Present Ecological State, Ecological Importance & Ecological Sensitivity) database, which was produced by the Department of Water and Sanitation, South Africa (DWA 2013).

Of the 33 study sites where KZN yellowfish were expected, they were recorded at 22 sites during the study period. Abundant populations of *L. natalensis* (both adult and sub-adult) were observed in the uMngeni, Thukela and Mfolozi River systems in particular. KZN yellowfish were also common in the Matikulu and Mkuze Rivers where few individuals greater than 100 mm were recorded (Fig. 3.2). 160 sub-adult KZN yellowfish (< 100 mm) were recorded on the study site on the Bushman's River (V7BUSH-MOORP). The drought resulted in the Mkuze River system becoming completely dry in some parts during the low flow survey June 2015.

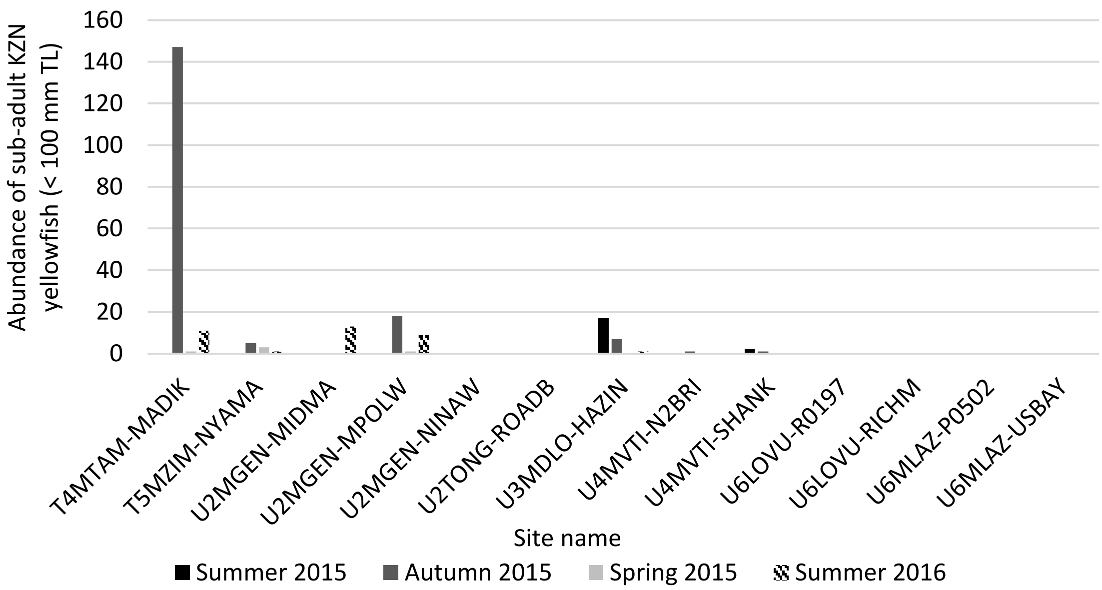

Fig 3.2: Abundance of sub-adult KZN yellowfish (< 100 mm TL) at River Health Programme study sites in the U and T catchments in KwaZulu-Natal, South Africa

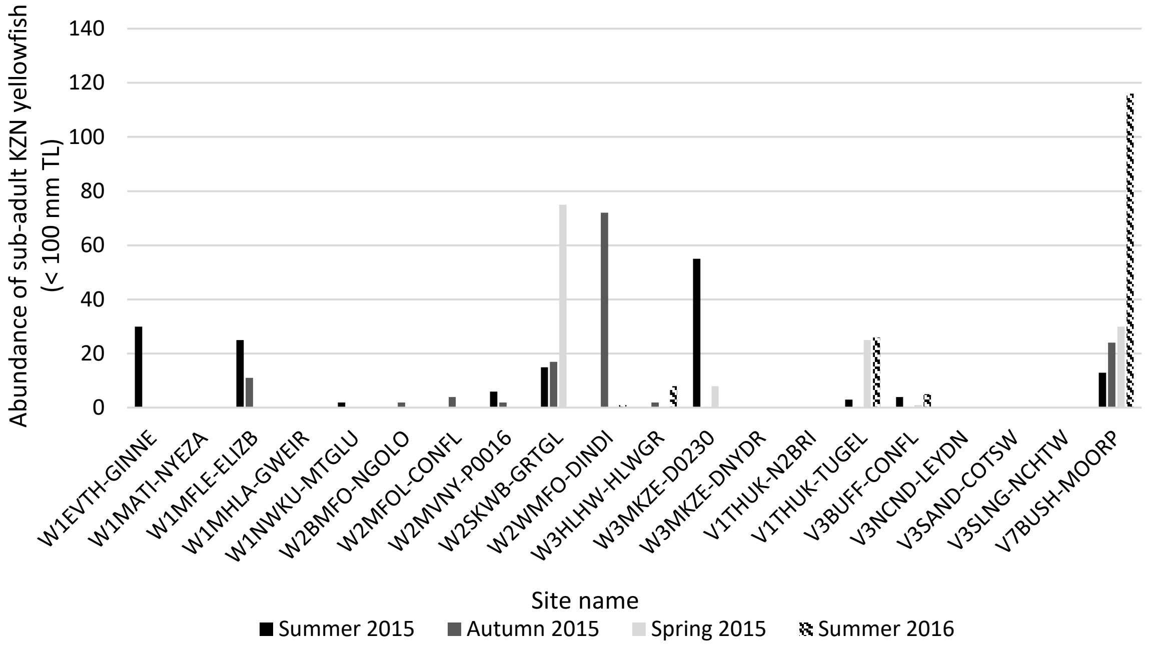

Fig 3.3: Abundance of sub-adult KZN yellowfish (< 100 mm TL) at River Health Programme study sites in the W and V catchments in KwaZulu-Natal, South Africa

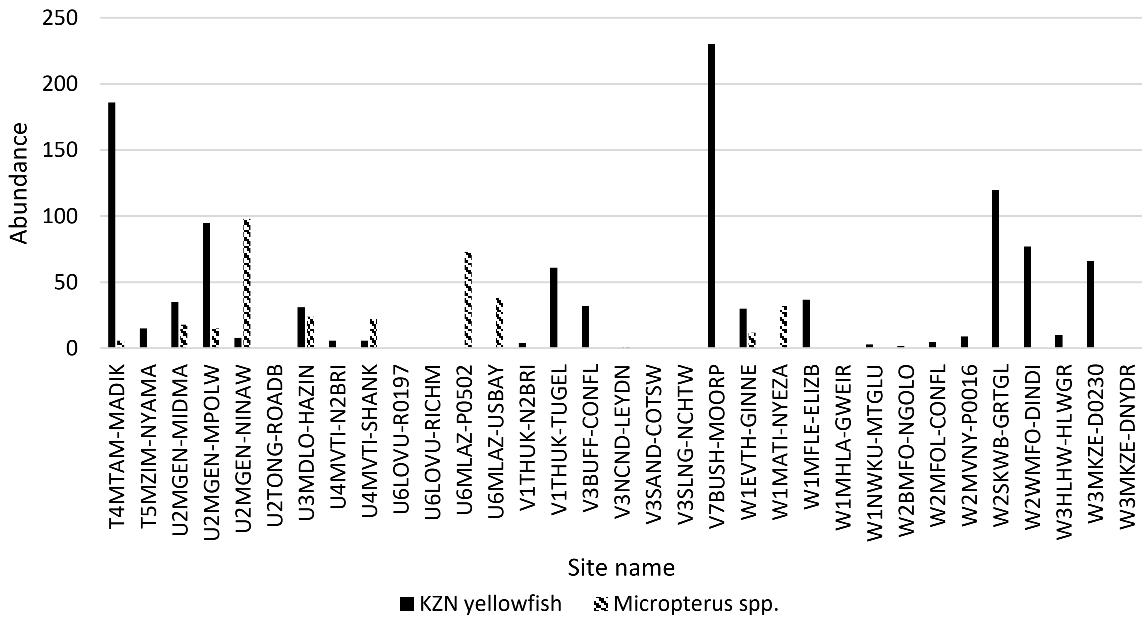

Fig 3.4: Abundance of KZN yellowfish and *Micropterus spp.* at River Health Programme study sites in KwaZulu-Natal, South Africa

One of the potential major threats to the wellbeing of *L. natalensis* populations in KZN is the encroachment of alien fish species, particularly *Micropterus spp*. *Micropterus spp.* were found at 11 sites within the KZN yellowfish range. KZN yellowfish and *Micropterus spp.* were found together at seven sites during the study period (Matikulu, Thukela, Mvoti, uMngeni, and Mzimkhhulu River catchments). No sub-adult KZN yellowfish were sampled at the lower uMgeni River site (U2MGEN-NINAW) during the study period. However, several adult KZN yellowfish (greater than 100 mm) were sampled at this study site, in addition to almost 100 *Micropterus spp*. individuals (Fig. 3.4). Within the expected range of the KZN yellowfish, *Micropterus spp*. were found at four study sites where KZN yellowfish were not recorded during the study period. At both of the sites on the Mlazi River system, large populations of *Micropterus spp*. were recorded while zero KZN yellowfish were recorded (Fig. 3.4).

The river systems in the northern parts of KZN were negatively impacted by drought during the study period, reducing the available habitat and flow for KZN yellowfish, especially larger specimens. During the survey in the first quarter of 2015, just one site had no flowing water. During the second quarter survey, one site had no flowing water while another site was completely dry. In the third quarter of the year, two sites were not flowing but in the final survey (summer 2016), six sites were not flowing while three were completely dry. All of dry sites were located in the northern parts of KZN, from the Mvoti River to the Phongolo River. The Mkuze River was amongst the most severly impacted by the drought. The site in the lower reaches was completely dry during two of the surveys while the site in the upper reaches was dry during just one survey.

3.3.1 Catch per unit effort

The average catch per unit efffort (CPUE, Fig. 3.4 and Fig. 3.5) during the study period for KZN yellowfish was 0.20. The summer 2015 sampling season recorded the highest CPUE for KZN yellowfish, with a CPUE of 0.26. The lowest CPUE for KZN yellowfish was recorded during the spring 2015 survey, with a CPUE of 0.16. The site with the highest mean CPUE for KZN yellowfish was on the Bushman’s river (V7BUSH-MOORP CPUE = 1.29) (Fig. 3.4). The average CPUE for KZN yellowfish for the study period at W3MKZE-D0230 was 0.97 despite recording KZN yellowfish at the site on just one of the surveys (Fig. 3.4). However, zero KZN yellowfish were recorded at this site in subsequent surveys.

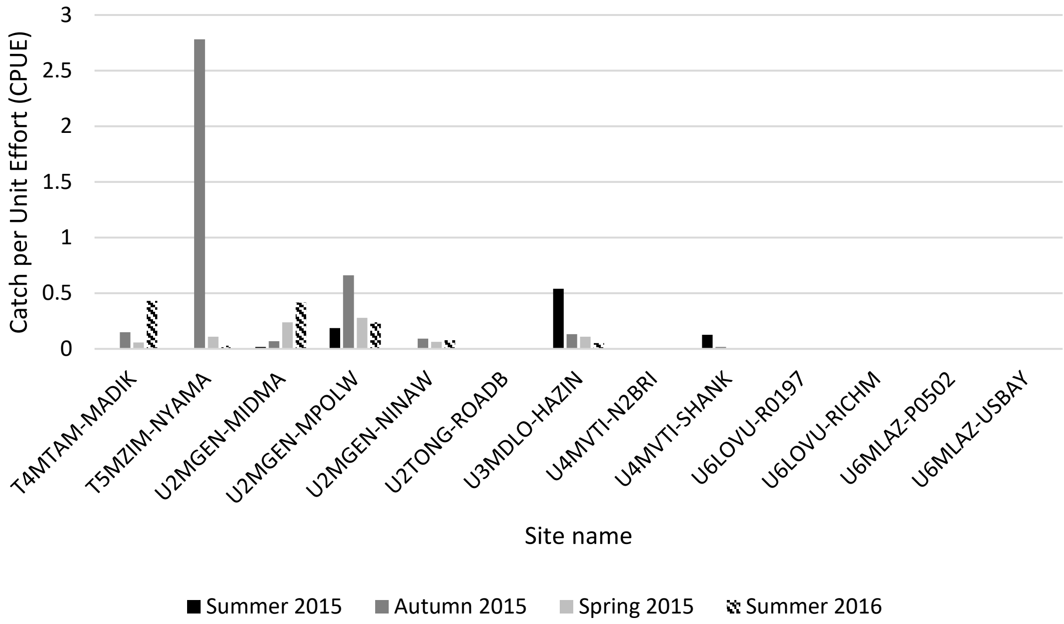

Fig. 3.5: Catch per unit effort for KZN yellowfish recorded during the study period in the U and T catchments in KwaZulu-Natal, South Africa

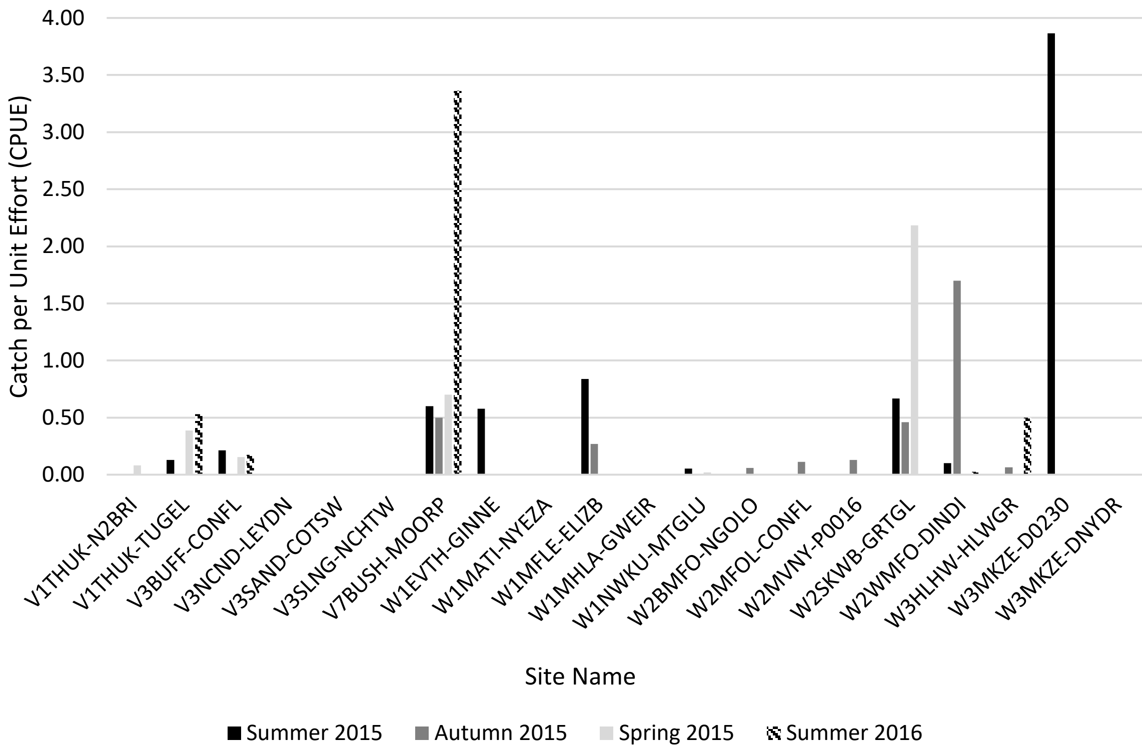

Fig. 3.6: Catch per unit effort for KZN yellowfish recorded during the study period in the V and W catchments in KwaZulu-Natal, South Africa

3.5 Discussion

The overall wellbeing of the KZN yellowfish populations, represented by distributions, abundances and catch per unit effort in KwaZulu-Natal continue to decline. Karssing (2008) suggested that a decline in the wellbeing of the KZN yellowfish populations has been observed from at least 2007. Karssing (2008) stated that the main causes of the decline in KZN yellowfish populations that were observed in 2007 were habitat change, pollution and water abstraction. They are able to survive and grow large in impoundments but still require migration for spawning (Wright and Coke 1975a). The combination of these posed a threat which was exacerbated by the severe drought. Annual rainfall was 30-40 % below the mean annual rainfall for KZN in 2014, 2015 and 2016 with a state of disaster being declared in many of the worst affected regions, mostly in the north of the province (Maharaj 2017). Several of the study sites in the KZN yellowfish distribution were completely dry during the study period. With populations already in a state of decline, their resilience to drought will be hindered. How well the KZN yellowfish will be able to recover after the drought is yet to be seen. Large KZN yellowfish are rarely found in water more shallow than 30 cm (Roux 2007). Extensive subsistence farming and forestry occur in the northern parts of KZN, both of which are known to cause sedimentation of rivers (Waters 1995). Consequently, this reduced favourable cover for *L. natalensis* while the extensive drought in KZN altered flows of these river systems (Crass 1969).

KZN yellowfish were not found at either of the study sites in the Mlazi River system and only found in low numbers in multiple other river systems in KZN. Zero mature adults were caught in the Mfolozi or Matikulu River systems, potentially due to a lack of suitable cover and depth. Extensive subsistence farming and forestry occur in this region, both of which are known to cause sedimentation of rivers (Waters 1995). Consequently, this reduced favorable cover for *L. natalensis* while the extensive drought in this region altered flows of these river systems (Crass 1969). Populations in the Mzimkulu and Mtamvuna River catchments showed signed of recruitment as well as populations of adult KZN yellowfish.

There are several major threats to *L. natalensis*, including poor farming practices, removal of riparian vegetation and trampling of the riparian zone by cattle. In the northern parts of KZN, the dominant land uses include forestry and subsistence farming, followed by cultivated land. There is scattered mining in the upper reaches of the Mkuze catchment, which consists mainly of coal mining. *Labeobarbus natalensis* showed a preference for water with high velocity, cobbles as a substrate and the substrate as a cover feature The loss of cobbles in rivers in KZN would result in a population shift away from *L. natalensis*, towards species which are more tolerant towards silt or sand as a substrate, such as the cichlids found in KZN.

KZN yellowfish populations can be divided into at least two groups based on differences in their mitochondrial DNA and should be conserved as separate populations (Bloomer 2007). While work is currently undergoing, preliminary results indicate that there is a clustering of alleles according to the river system (Bloomer 2007). The populations to the north and south of the Thukela River were found to be genetically different from the populations found in the Thukela River (Bloomer 2007).

The Mkuze, Mfolozi and Mhlathuze River catchments have historically been subjected to many types of agricultural activity, such as cotton, sugarcane and cattle (Crass 1969). As the intensity of the agricultural activity in this region increased, the amount of water being extracted increased (Crass 1969). The lower reaches of these catchments have been subjected to sedimentation which resulted in the loss of many pools, instead the river flows over shifting beds of sand (Crass 1969). According to Crass (1969), this has contributed significantly to the loss of many large specimens in the lowland reaches. Connectivity is a major issue in the Mkuze catchment, there are eight gauging weirs and one large waterfall on the Mkuze River, hindering migration for migratory fish (Anania 2015). In addition to this, Rivers-Moore et al. (2007) stated that there are at least 85 impoundments in the Mkuze catchment. Likewise, the Mfolozi River and its two main tributaries (Black and White Mfolozi Rivers) have eight gauging weirs and one large waterfall (Anania 2015). Historically, the Mkuze River has been relatively unsullied by pollutants, with only minor mineral contaminants from nearby coal mining (Crass 1969).

For decades, the Thukela River and its tributaries has been heavily polluted by man's activities. Oliff (1963) found that acid effluent from old mines was found to be entering several streams, leading to the Thukela River. Several of these streams had experienced fish kills, fortunately repopulation had occurred (Oliff 1963). The Thukela catchment is the second most impounded catchments in KZN, with over 672 dams, behind the Mzimkhulu catchment with over 1119 dams (Rivers-Moore et al. 2007). The Thukela-Vaal Transfer Scheme takes around 530 million m^3/year water to the Vaal River, and a number of smaller transfer schemes, collectively draw approximately an extra 250 million m^3/year water, posing a threat to the habitat of fish, especially during times of drought. The Thukela River catchment area is predominantly rural in character with forestry and agriculture as primary land uses. Newcastle is a major industrial centre and the only other significant industrial activity in the lower reaches where there are several mills. Sappi Thukela Mill is the largest user of water in the catchment, using approximately 24 million m^3/p.a. water (DWAF 2004b). Sappi extract water from the Thukela River and discharge into the eMandeni River which joins the Thukela shortly after the extraction point. In Venter (2013), the ecological wellbeing of fish below the Sappi Mill confluence on the eMandeni River to that of the fish above the confluence were compared. It was found that fish were in a fairly natural state above the confluence and in a largely modified to a severely modified state below the confluence (Venter 2013).

A recent study on the ecological state of the lower Mvoti River indicated that it is in a seriously modified state, which was predominantly due to surrounding land-uses such as agriculture and industry (Malherbe 2006). The habitat within the lower Mvoti River has been altered by sedimentation, which was caused by sugar cane agricultural activity (DWAF 2004a; Malherbe 2006). The agricultural activity altered the riparian zone in such a way that it increased erosion and turbidity levels in the river (Malherbe 2006). There are several mills on the Mvoti River which abstract water and release warm effluent back into the river; the abstraction compounds the problem, as it reduces the river's ability to carry the sediment into the ocean (Malherbe 2006). While the middle and upper reaches of the Mvoti catchment are not as riddled with industrial users, there is still substantial agricultural activity. Extensive forestry occurs upstream which contributes to the increasing problem of sedimentation downstream (DWAF 2004a; Malherbe 2006). Furthermore, the rural settlements in the upper reaches make use of the river for domestic purposes which results in increased microbial load (Malherbe 2006).

At least 12% of the uMngeni River catchment is urbanised, either formally or informally- a number which is expected to increase in years to come (WRC 2002). With an increase in the population relying upon the uMngeni River comes increased stress and pressure on an already highly utilised system. This increase in urbanisation leads to greater pressure on water supply leading to the construction of more impoundments in a catchment which already has four large impoundments (WRC 2002). In addition to these impoundments, there are ten weirs obstructing flow and preventing migration of fish (Anania 2015). Furthermore, urbanisation brings increased domestic, industrial and solid waste. WRC (2002) recorded samples from various points on the uMngeni River and tributaries having *Escherichia coli* counts in excess of 500000 counts per 100 ml sample regularly, with one sample containing over 1000000 counts per 100 ml (WRC 2002). Stretches of the uMngeni suffer from extensive alien plant invasion which results in the destabilisation and erosion of river banks (WRC 2002). Destabilisation of river banks leads to loss of undercut banks, a popular habitat type for fish, and an increase in sedimentation of the river. The most common land use practices in the uMngeni River catchment are commercial and residential, with sparse forestry and cultivated land in the upper reaches of the catchment. The systems located to the south to the Thukela River face more urbanisation than those to the north of the Thukela River; the two major economic regions of KZN are located in the uMngeni River catchment. The uMngeni River is under heavy pressure to provide drinking water for both of these regions and to aid this, four large impoundments and a further fifteen weirs exist along the length of the river, making it the most disconnected river in KZN (Anania 2015). Urbanisation around the uMngeni River has led to severely degraded water quality and habitat availability, resulting in increased contaminated run-off and faecal pollution (Karssing 2008; DWS 2016). The sites on the lowland reaches of the uMngeni River contained high faecal microbial content, potentially from untreated waste entering the river from nearby communities (DWS 2016). Karssing (2008) states that approximately 70% of the municipal wastewater treatment facilities in KZN are non-compliant, resulting in large quantities of untreated pollution and faecal matter entering rivers. *Labeobarbus natalensis* is known to have a moderate tolerance to pollution, however, when in polluted waters, it is known to develop deformities in the mouth parts and fins, as well as crooked backs (Coke 1999). The water quality in the upper reaches of catchments in KZN is relatively good but quickly declines as anthropogenic use intensifies towards the coast (Coke 1999).

KZN yellowfish were not found at either of the sites on the Mlazi River. Both of the sites were dominated by *Micropterus spp.* The predatory nature of *Micropterus spp.* poses a significant threat to the wellbeing of KZN yellowfish. The upper reaches of the Mlazi River catchment were not heavily polluted but were fragmented and heavily sedimented. Water quality deteriorated rapidly as the Mlazi River approaches the east coast of KZN. In the lower reaches, flows are heavily regulated by impoundments, large quantities of water are abstracted for irrigation and there is a significant nutrient input from upstream non-compliant waste water treatment works (WRC 2002). There is an increasing problem of encroaching alien vegetation in the Mlazi River, especially in the lower reaches, where the riparian zone is regularly overgrazed and trampled by cattle (WRC 2002).

The Mzimkhulu and Mtamvuna River catchments both had populations of KZN yellowfish with sub-adults and adults all being represented. The Mtamvuna River showed particularly good recruitment with large numbers of juveniles being seen in gravel beds and larger fish being recorded in fast flowing rapids. Despite the presence of *Micropterus spp.* at the site on the Mtamvuna River, the KZN yellowfish population was still intact. The KZN yellowfish population at the study site on the Mzimkhulu River was stable, with some juveniles and sub-adults but were not found in abundance. In the Mzimkhulu River catchment, approximately 39% of the land is used for commercial forestry and agriculture (predominantly livestock), while over 40% of the water use in the catchment goes towards commercial forestry (DWA 2011). There is a growing water shortage in the Mzimkhulu River catchment; the local municipality proposed a large instream impoundment in an attempt to mitigate this shortage (DWA 2011). The KZN yellowfish population is precariously positioned and the introduction of a large instream impoundment would restrict migration and increase sediment deposition on the river bed, thereby reducing the abundance of spawning beds.

The major sources of sediment are agriculture, forestry, urban development, and road construction (Waters 1995). It was found by Dudgeon (2000) that the removal of a forest near a river has the potential to increase turbidity and sedimentation which results in decreased fish abundance and biodiversity. Walser and Bart (1999) found that agricultural activity has a negative impact on the freshwater fish diversity of a river, predominantly due to increased sediment load. Sand, gravel, cobbles and boulders all have the potential to serve as cover from predators as well as spawning and feeding grounds for fish. Poor land management poses a serious threat to the wellbeing of *L. natalensis*. Poor agricultural practices lead to erosion which in turn result in the silting up of rivers (Karssing 2008). This silt would ordinarily be washed away with a flood but the construction of instream dams and weirs at regular intervals in KZN have slowed floods down, therefore they no longer remove silt (Karssing 2008). Silt then remains in the system, burying the gravel beds which act as spawning grounds for *L. natalensis* (Karssing 2008). Dams cause significant concern for freshwater biodiversity as they reduce flow levels during dry periods and alter flow regimes (Mantel et al. 2010). The construction of large instream impoundments has several negative impacts on the flow regime, multiple sources have found that a loss in connectivity in rivers contributes towards a significant loss in fish and macro-invertebrate diversity (Bunn and Arthington 2002; Poff and Zimmerman 2010; Gitay et al. 2011; Januchowski-Hartley et al. 2013). Dams have the potential to alter many aspects of flow, which all, in turn, negatively impact on fish communities. Construction of impoundments have severe impacts on rheophilic species by altering the flow and the increase in the duration of low flows can result in loss of habitat for native species (Poff et al. 2010; Poff and Zimmerman 2010).

The Mlazi River catchment, located between the Thukela and uMngeni River catchments, is dominated by agriculture and forestry, followed by sparse subsistence farming. Poor farming practice and the extensive removal of the riparian zone has left this catchment heavily laden with silt. The residential areas of Hammarsdale and Mpumalanga have contributed large amounts of nutrients into the Mlazi River (WRC 2002). On several occasions the Shongweni Dam has become toxic due to blue-green algal bloom and rendered the dam unsafe for domestic supply (WRC 2002). During the four surveys no KZN yellowfish were caught at either of the sites on the Mlazi River, this was predominantly due to a lack of suitable flow and habitat and poor water quality. The Mlazi system is dominated by alien fish and cichlids, which have a preference for slow flowing water and sand as a substrate type. In contrasting with the Mlazi River catchment, the Mzimkhulu and Mtamvuna River catchments had relatively large populations of KZN yellowfish, where both sub-adults and adults were recorded. The main land use in these catchments is forestry but with limited impact on the wellbeing of the rivers. Sparse trampling by livestock in the riparian zone resulted in erosion in sections of both catchments, leading to sedimentation of the river bed. Despite the negative impacts on the rivers, *L. natalensis* populations continue to show recruitment.

3.6 Conclusions and recommendations

Impoundments, while attracting some limnophilic species, have many negative impacts on ecological wellbeing and diversity. The removal of impoundments has been widely documented to result in multiple positive outcomes for the wellbeing of the river, including the return of some native species, improvement of fish passage, sediment movement, water quality, and spawning habitat (Winter 1990; Pawloski and Cook 1993; Hill et al. 1994; Dadswell 1996). It is recommended that sites where dams and weirs are no longer serving their purpose are identified, followed by studies looking at the potential removal of these. There is a need for further research into the different populations of *L. natalensis* as considerable morphological variation can be seen across the province. A morphometric analysis is required for the genetically unique Thukela River system population of *L. natalensis*, thereafter it is to be renamed as a new species and given a conservation status. The expansion of alien fish should be halted and reduced, especially in the Mlazi River system where no KZN yellowfish were found during the study period.

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3.8 Appendix 3.1

Table A 1: List of previous synonyms for *Labeobarbus natalensis*

Labeobarbus aureus, Cope 1867

Barbus bowkeri, Boulenger 1902

Barbus dendrotrachelus, Fowler 1934

Barbus grouti, Fowler 1934

Barbus lobochilus, Boulenger 1911

Barbus marleyi, Fowler 1934

Barbus mfongosi, Gilchrist & Thompson 1913

Barbus natalensis, Castelnau 1861

Barbus robinsoni, Gilchrist & Thompson 1913

Barbus stigmaticus, Fowler 1934

Barbus tugelensis, Fowler 1934

Barbus zuluensis, Gilchrist & Thompson 1913

Table A 2: River Health Programme Site Number, Name and Catchment in KZN

Site Number	RHP Name	River catchment
5	W3MKZE-D0230	Mkuze
7	W3HLHW-HLWGR	Hluhluwe, Mfolozi
6	W3MKZE-DNYDR	Mkuze
8	W2SKWB-GRTGL	Sikwebezi, Black Mfolozi, Mfolozi
9	W2BMFO-NGOLO	Black Mfolozi, Mfolozi
10	W2MVNY-P0016	Mvunyana, White Mfolozi, Mfolozi
11	W2WMFO-DINDI	White Mfolozi, Mfolozi
12	W2MFOL-CONFL	Mfolozi
13	W1MFLE-ELIZB	Mfule, Mhlathuze
14	W1MHLA-GWEIR	Mhlathuze
15	W1NWKU-MTGLU	Nwaku, Matikulu
16	W1EVTH-GINNE	Vutha/Matikulu, Matikulu
17	W1MATI-NYEZA	Matikulu
18	V3SLNG NCHTW	Slang, Buffalo, Thukela
19	V3NCND-LEYDN	Ncandu, Buffalo, Thukela
20	V3BUFF-CONFL	Buffalo, Thukela
21	V3SAND-COTSW	Mzinyashana, Buffalo, Thukela
22	V1THUK-TUGEL	Thukela
23	V7BUSH-MOORP	Bushmans, Thukela
24	V2UNSP-KMBRG	Mooi/Mfulankomo, Mooi, Thukela
25	V1THUK-RAILB	Thukela
26	U4MVOT-SHANK	Mvoti
27	U4MVOT-N2BRI	Mvoti
28	U2TONG-ROADB	Tongati, Tongati
29	U3MDLO-HAZIN	Mdloti
30	U2MGNI-DRGLE	uMngeni
31	U2MGEN-MIDMA	uMngeni
32	U2MGEN-MPOLW	uMngeni
33	U2MGEN-NINAW	uMngeni
35	U6MLAZ-USBAY	Mlazi
36	U6MLAZ-P0502	Mlazi
38	U6LOVU-RICHM	Lovu
41	U6LOVU-R0197	Lovu
42	U1MKMZ-SANIP	Mkhomazana, Mkomazi
43	T5MZIM-NYAMA	uMzimkhulu
44	T4MTAM-MADIK	Mtamvuna, Mtamvuna

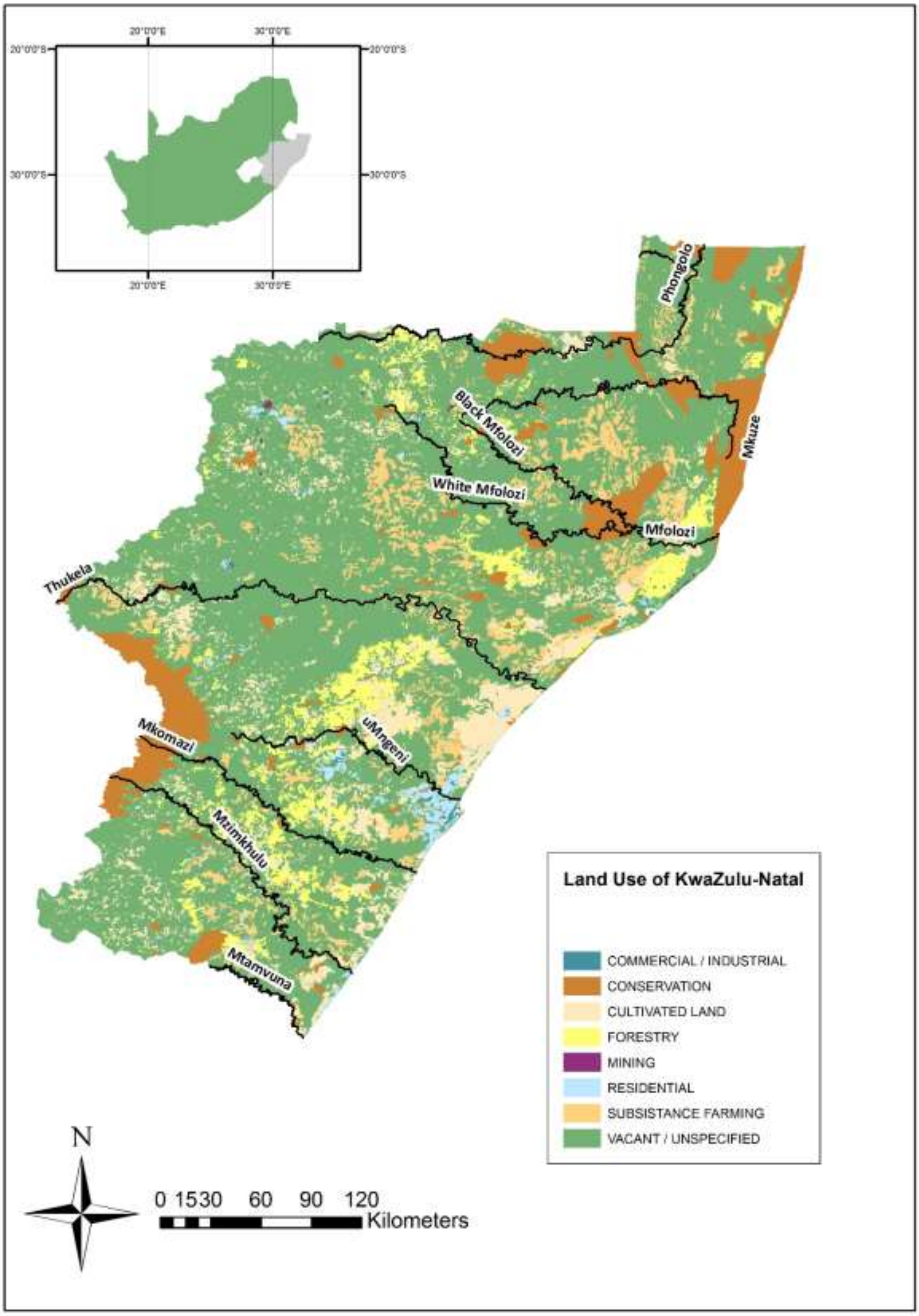

Fig A 1: Land use map of KwaZulu-Natal, South Africa

CHAPTER 4:

CONCLUSIONS

4.1 Introduction

This chapter summarises and discusses the main findings of the research in relation to the aim and objectives of the study. Based on the outcomes of the study, management and conservation recommendations are presented.

Freshwater ecosystems are amongst the most threatened, yet under protected on the planet (Sala et al. 2000). Freshwater makes up less than 1% of surface water on Earth but is home to around one third of all vertebrate species (Gleick 1996; Dudgeon et al. 2006). Each provides several vital services to people and animals alike, including food and water, and serves as biodiversity hotspots (Vorosmarty et al. 2010). These services, however, are increasingly threatened by ever-growing human populations and demands (Rodriguez et al. 2006). Allan et al. (1997) recognised that the increase in demands on river systems directly threatens its ecological integrity and result in a restructuring of fish communities. River systems in poor health show a decline in sensitive fish species, making way for more resilient (often alien) species of fish to dominate, thereby reducing the diversity of the system (Onorato et al. 2000; Scott and Helfman 2001). River systems have fallen victim to the growing economy in South Africa. In the province of KwaZulu-Natal (KZN), alien species have spread extensively and many native, ecologically sensitive species of fish have declined.

Fish have long been used as indicators of river wellbeing as they are sensitive to and respond differently to various environmental stressors (Rapport 1989). They reflect the long term health of a system and the wellbeing of entire reaches of rivers as they are relatively long lived and mobile (Rapport 1989). Furthermore, fish have a high social, ecological and economic value and are well known by local communities which make fish a valuable tool in the assessment of ecological states of systems (Rapport 1989).

Around 62-70 species of freshwater fishes are found in KZN. According to the Department of Water and Sanitation's records, KZN is home to around 62 species of freshwater species of fish but according to Ezemvelo KZN Wildlife (governmental organisation responsible for maintaining wildlife conservation areas and biodiversity in KZN, including freshwater fishes), there are around 70 species of freshwater fish in the province. Past research of many of these species is sparse, outdated and in need of update. The study area consisted of 40 sites, located on 15 river systems, all located in KZN. The sites ranged from the upper reaches of rivers right down to the lowland reaches, near the estuaries. Large areas of KZN are utilised by agricultural activities while areas surrounding some rivers, such as the uMngeni River, are heavily populated and have relatively high anthropogenic effects.

4.2 Research findings

The following objectives were established to assess the current state of freshwater fish populations and river wellbeing in selected rivers in KZN:

The first objective was to assess the fish community of selected KZN rivers using various accredited techniques (Chapter 2). River Health Programme protocols (Roux 2001) and the Fish Response Assessment Index (Kleynhans 2007) were used as a rapid approach to assess the wellbeing of the fish communities in KZN. This was done in conjunction with a redundancy analysis using Canoco version 4.53 software (ter Braak and Šmilauer 2002). The state of the selected river systems in KZN were found to be in a diminished state during the study period, predominantly due to the drought in large parts of the study area. Five study sites were found to be in an unacceptable, 'Seriously Modified' state (Ecological Category = E) during the study period. These sites were situated in the lower reaches of their respective rivers and in areas of high anthropogenic use. It was found that three of the four sites on the economically important uMngeni River were in a 'Moderately modified' state (EC = C). The fourth study site on the uMngeni River, found to be in a 'Largely modified' state (EC = D), was located in the lower reaches of the river, near large urban settlements. Furthermore, the study site was dominated by alien species of fish (Chapter 2).

The second objective was to assess the wellbeing of KZN yellowfish *Labeobarbus natalensis* in KZN (Chapter 3). It is an endemic species which has considerable phenotypic diversity, with at least two visibly distinguishable populations (Karssing 2008). The populations in the upper reaches of river systems in KZN being elongated and the populations in the lower reaches having a deeper body (Karssing 2008). The genotypic differences between the populations of the KZN yellowfish are yet to be fully studied but preliminary results suggest that there are at least two genetically unique populations (Bloomer 2007). Bloomer (2007) found that the populations north and south of the Thukela River were found to be genetically different from the populations found in the Thukela River.

Of particular concern were the sites where no KZN yellowfish were found but they were expected based on distribution maps and historical data (Chapter 3). Based on this, it can be said that the state of the KZN yellowfish during the study period is diminished at selected study sites. KZN yellowfish can be shown to have a preference for cobbles as a substrate and water with a high velocity (Chapter 3). The KZN yellowfish was recorded in low abundances in several river systems, including the Mvoti and Mfolozi River systems. In these river systems the major drivers of change were sedimentation and a low quantity of water, therefore heavily impacting upon the KZN yellowfish.

At the two study sites on the Mlazi River system, no KZN yellowfish were found during the study period (Chapter 3). The study sites on the Mlazi River system were dominated by alien species of fish, had diminished water quality, and poor habitat availability. The accumulative effects of these, along with the drought during the study period, resulted in the native KZN yellowfish populations being in a poor state at the study sites (Chapter 3).

4.3 Recommendations

This results of this thesis explain the response of freshwater fish species to major environmental drivers in selected river systems in KZN. Using the Fish Response Assessment Index (FRAI) and a redundancy analysis, it was shown that many river systems in KZN were in an undesirable state. Five study sites in particular were found to be in ‘Seriously Modified’ state (Ecological Category = E) during the study period. It is recommended that immediate attention is paid to the driving factor behind the diminished state of these sites. These sites are characterised by alien fish, alien riparian vegetation and poor water quality. An improvement in these impairments would likely see an improvement in the fish populations at the sites. Furthermore, the removal of unnecessary weirs and other in-stream barriers would aid the recovery of freshwater fish populations. Enforcing already passed guidelines around the utilisation of the riparian zone in agricultural activities is likely to reduce the amount of sediment deposited onto the riverbed and help preserve vital habitat and substrate for freshwater fish species such as *L. natalensis*.

To reduce uncertainty in the future studies in KZN, the following future activities are proposed:

1. An increase in the intensity of surveys will provide a more thorough overview of the state of freshwater fish in KZN.
2. An update on the spread of alien fish species in KZN river systems will aid the effort to prevent them from spreading further. Furthermore, a study on the impact that the major alien species have on native fish species would be valuable.

3. A detailed study on the water quality of KZN river systems would aid and direct mitigation efforts around the improvement of water quality.
4. Further work is necessary on the KZN yellowfish to better direct conservation efforts. A more in-depth study on its genotype and phenotype would likely result in at least one new species of yellowfish being defined. This could potentially result in one or both being listed on the IUCN red list as threatened.

4.4 References

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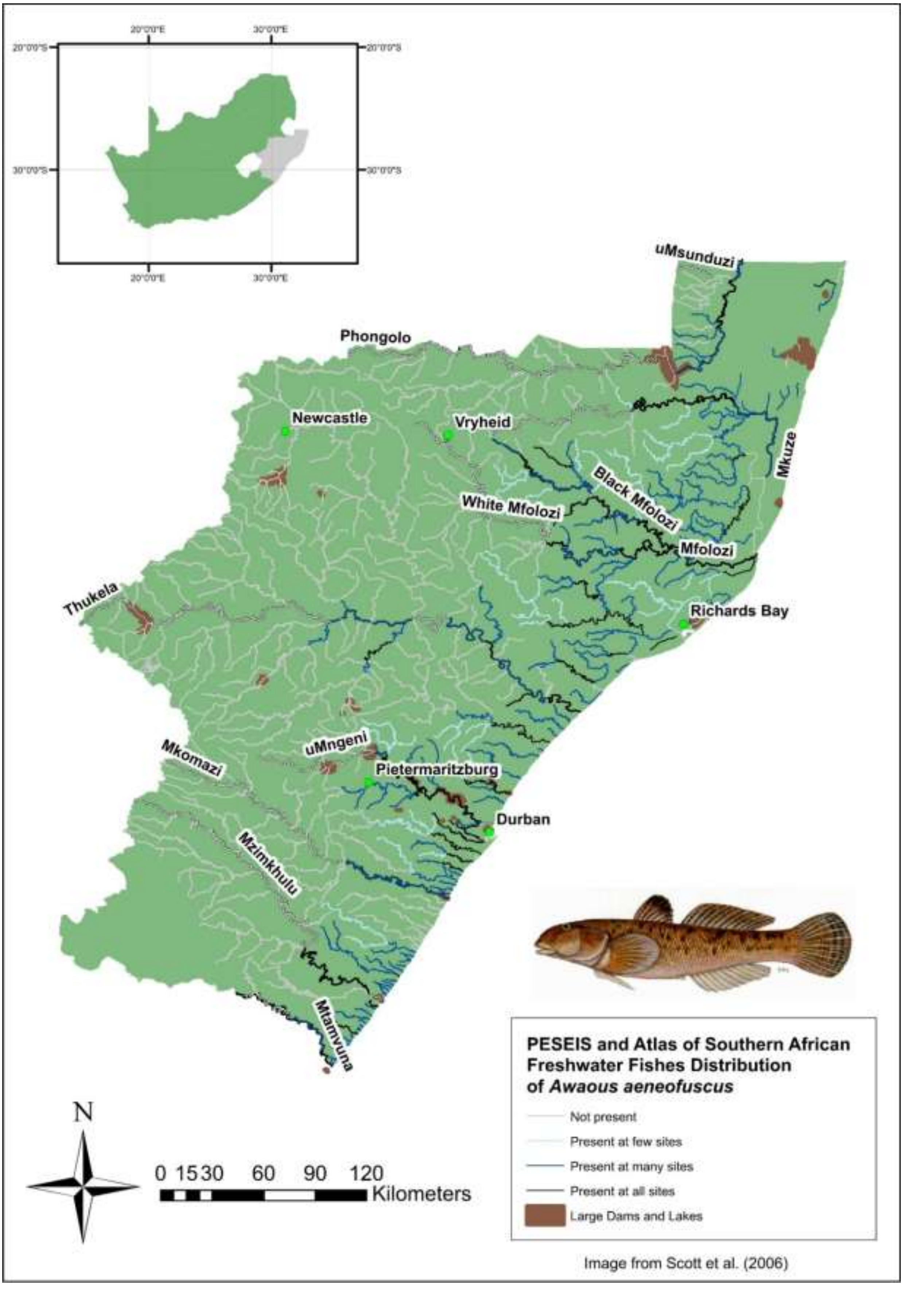
Appendix 4.1 Supplementary Fig. 4. 1: PESEIS freshwater fish distribution and Atlas of Southern African Freshwater Fishes Distribution in KwaZulu-Natal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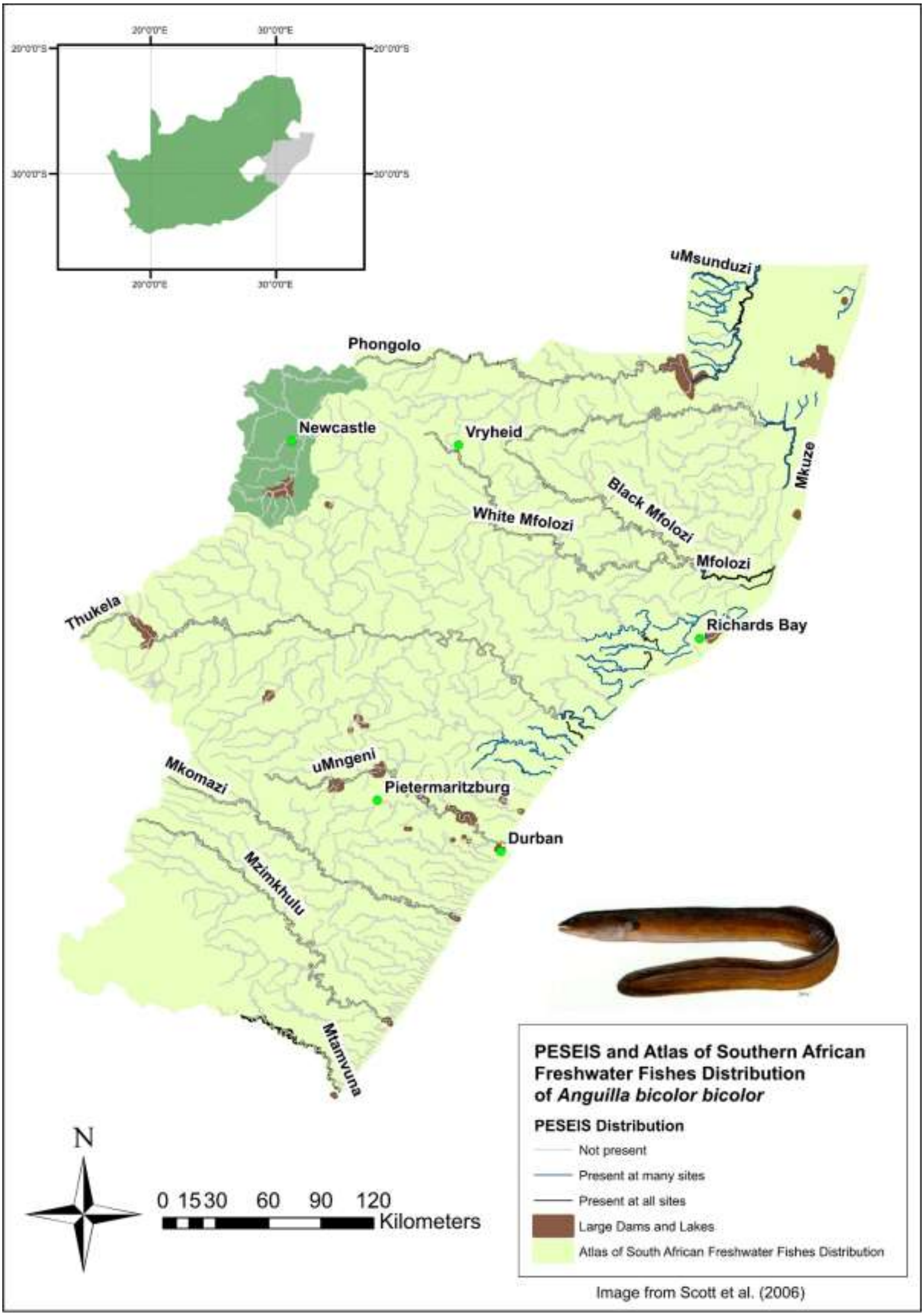

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PESEIS and Atlas of Southern African Freshwater Fishes Distribution of *Anguilla bicolor bicolor*
PESEIS Distribution
Not present
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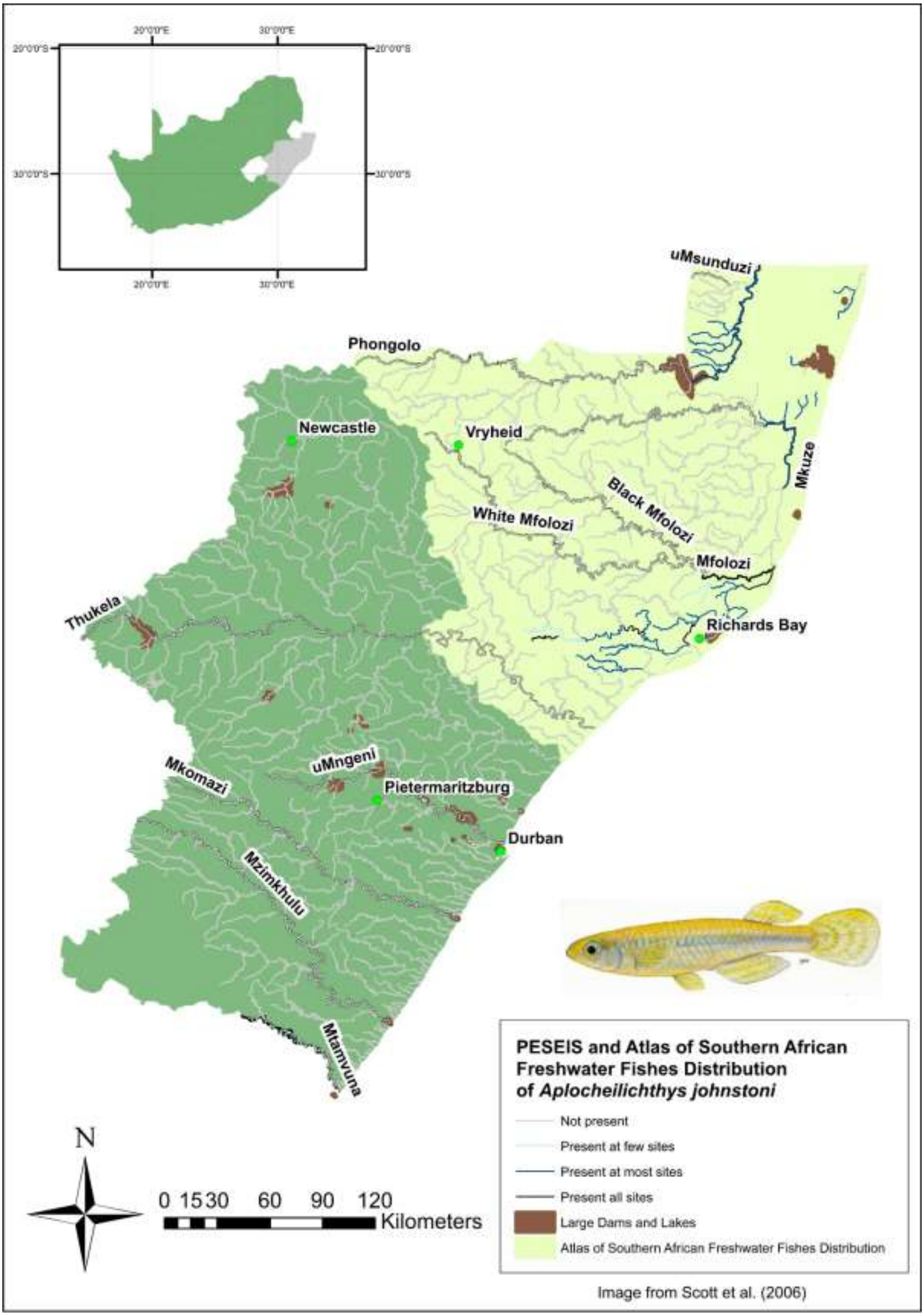
Large Dams and Lakes
Atlas of South African Freshwater Fishes Distribution
Image from Scott et al. (2006)



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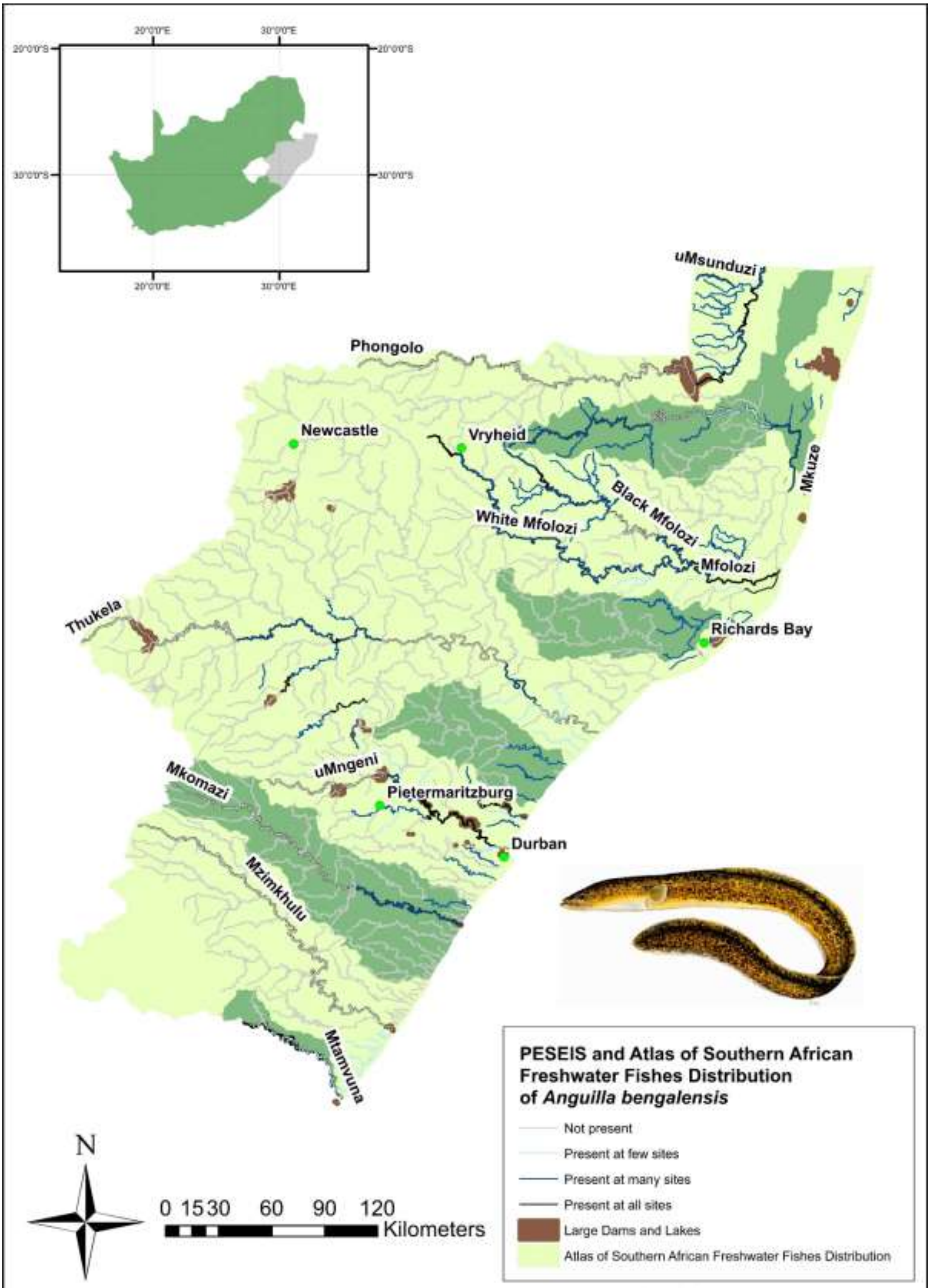

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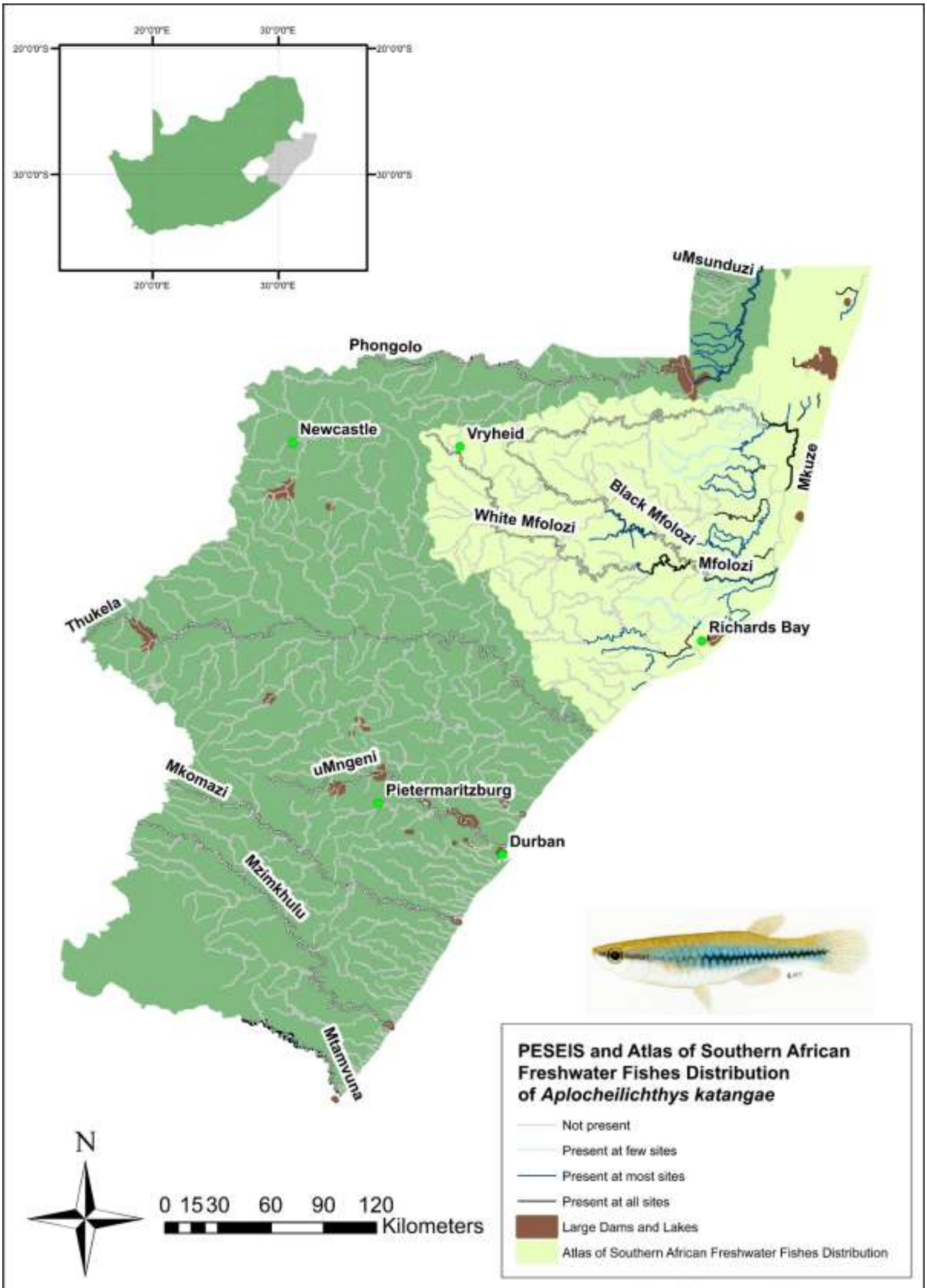

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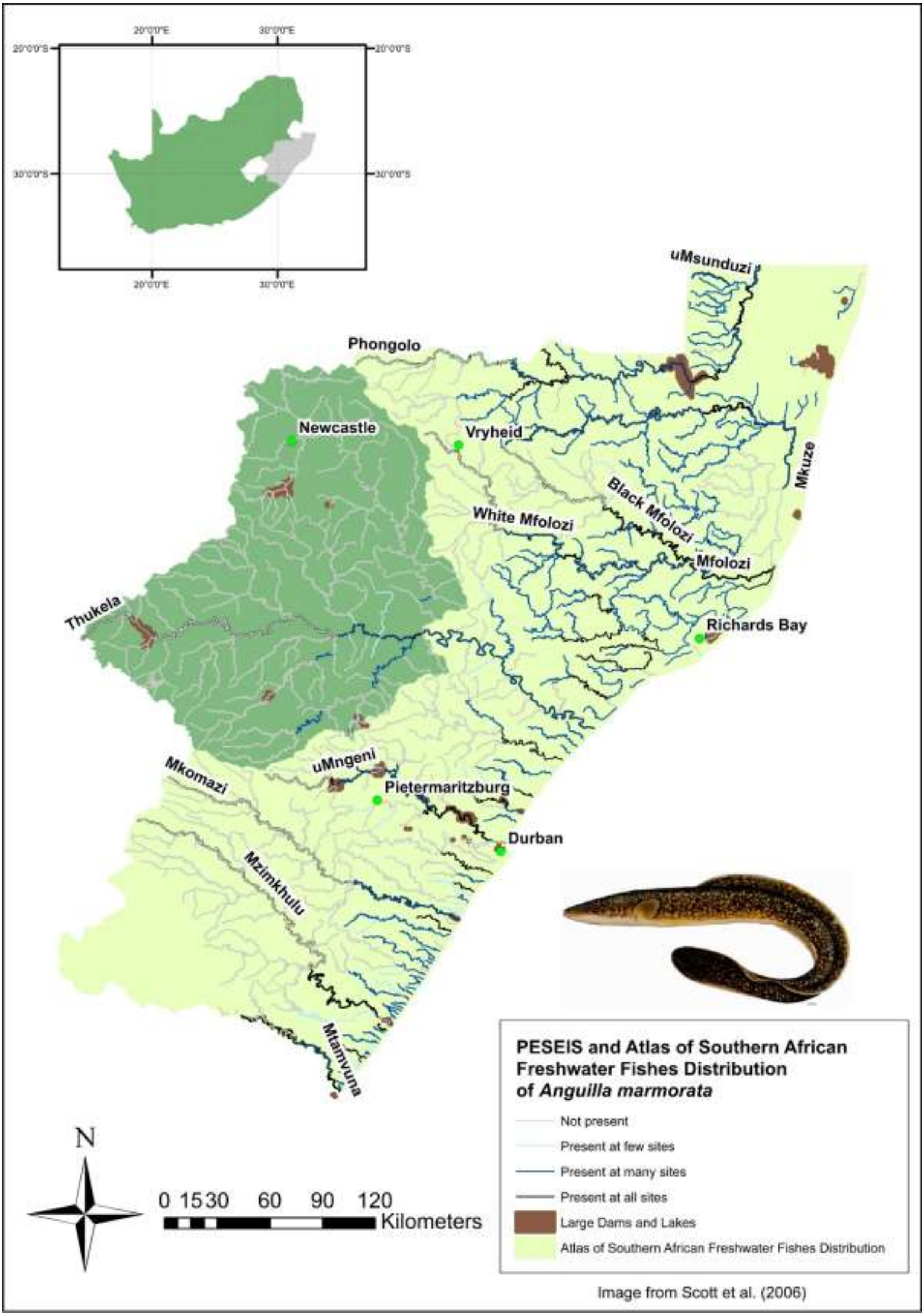

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PESEIS and Atlas of Southern African Freshwater Fishes Distribution of *Anguilla marmorata*
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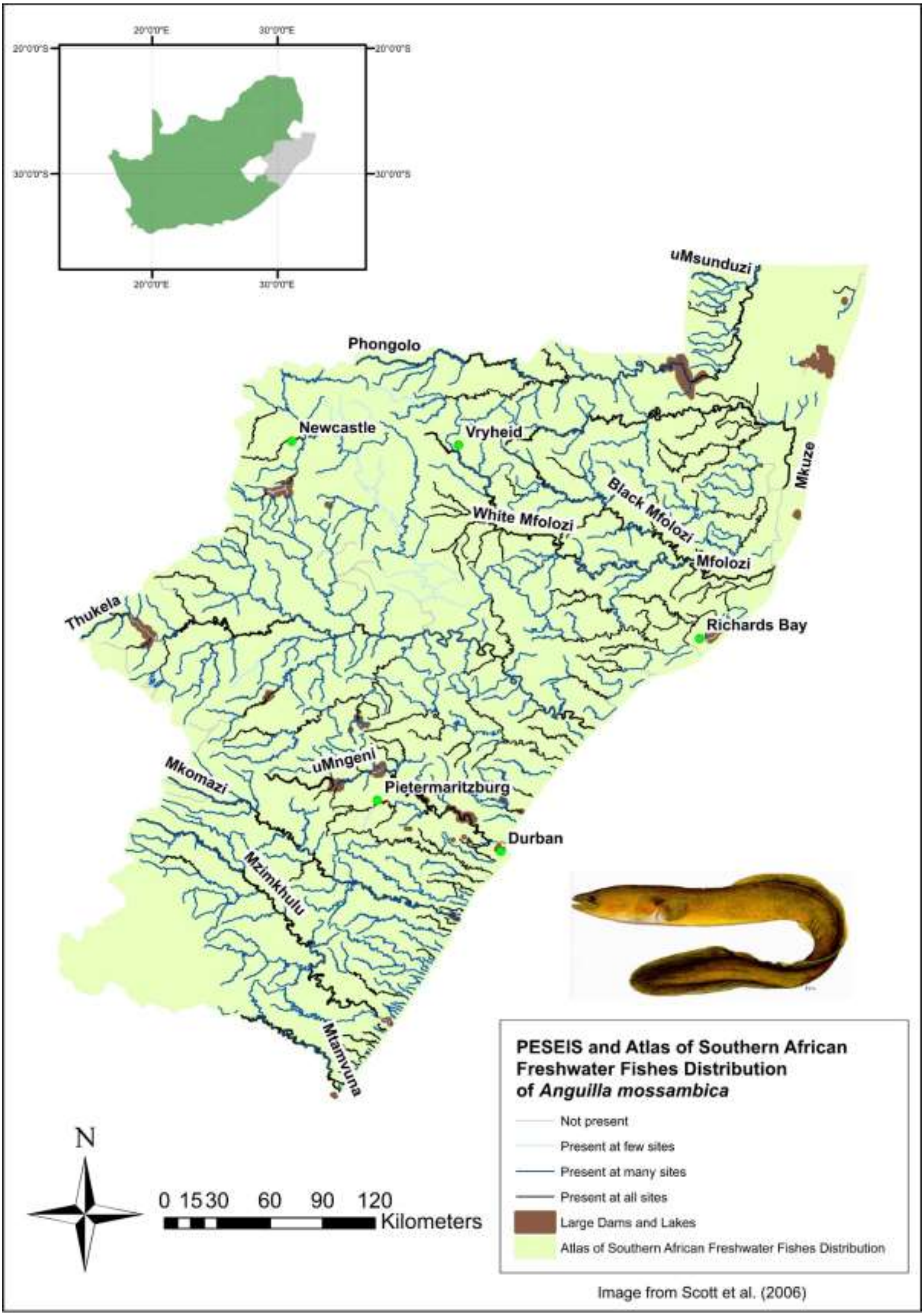

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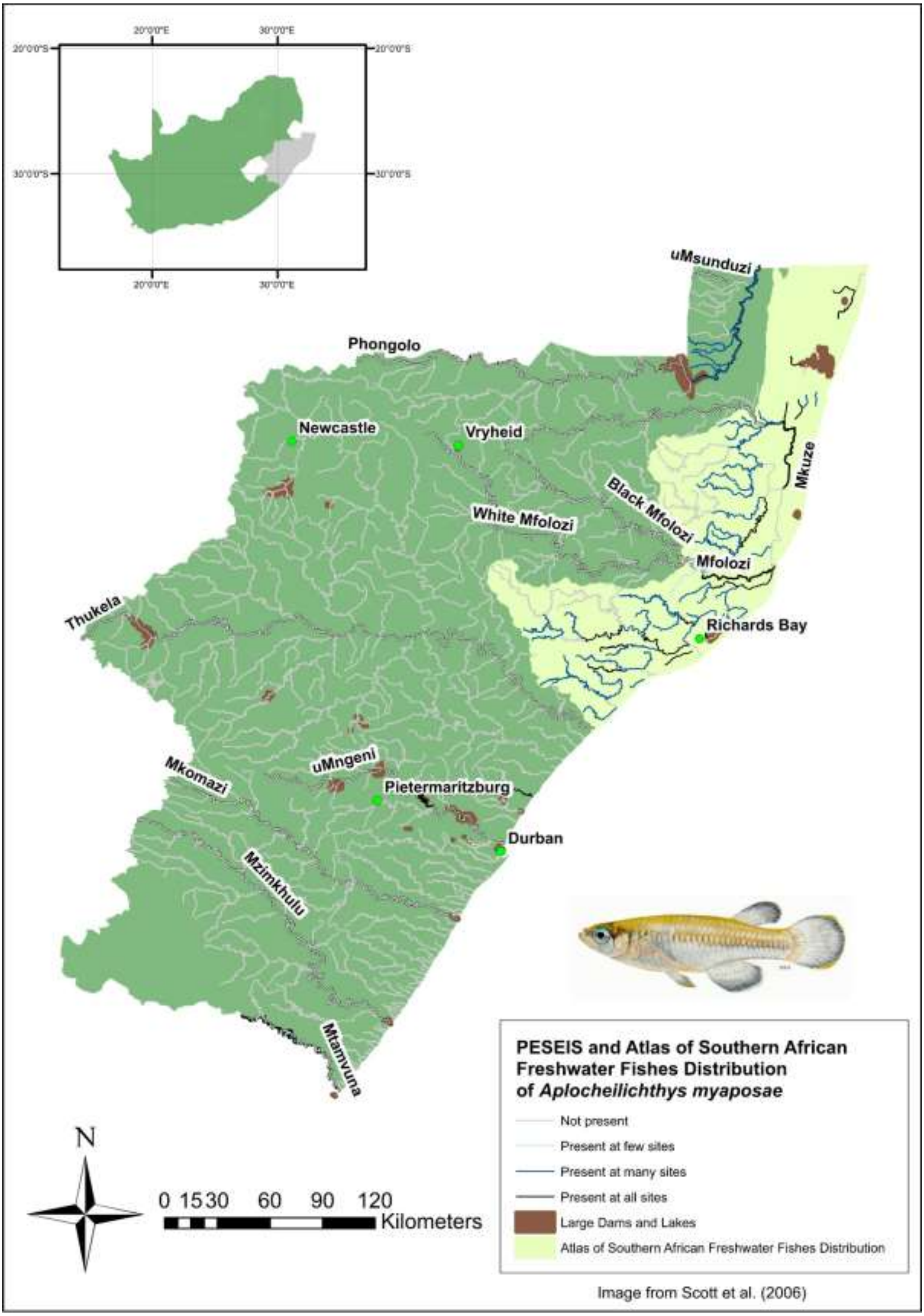
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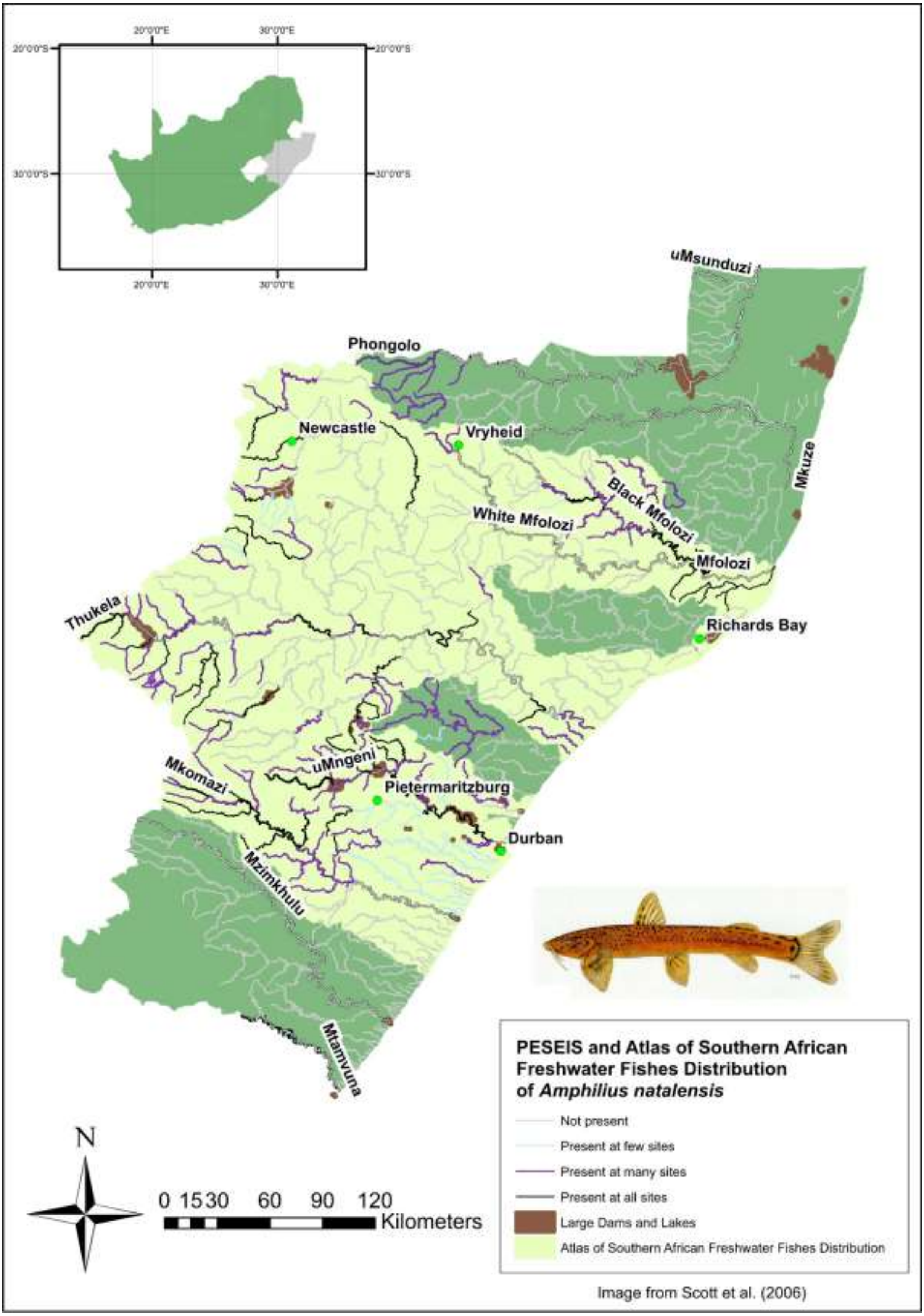

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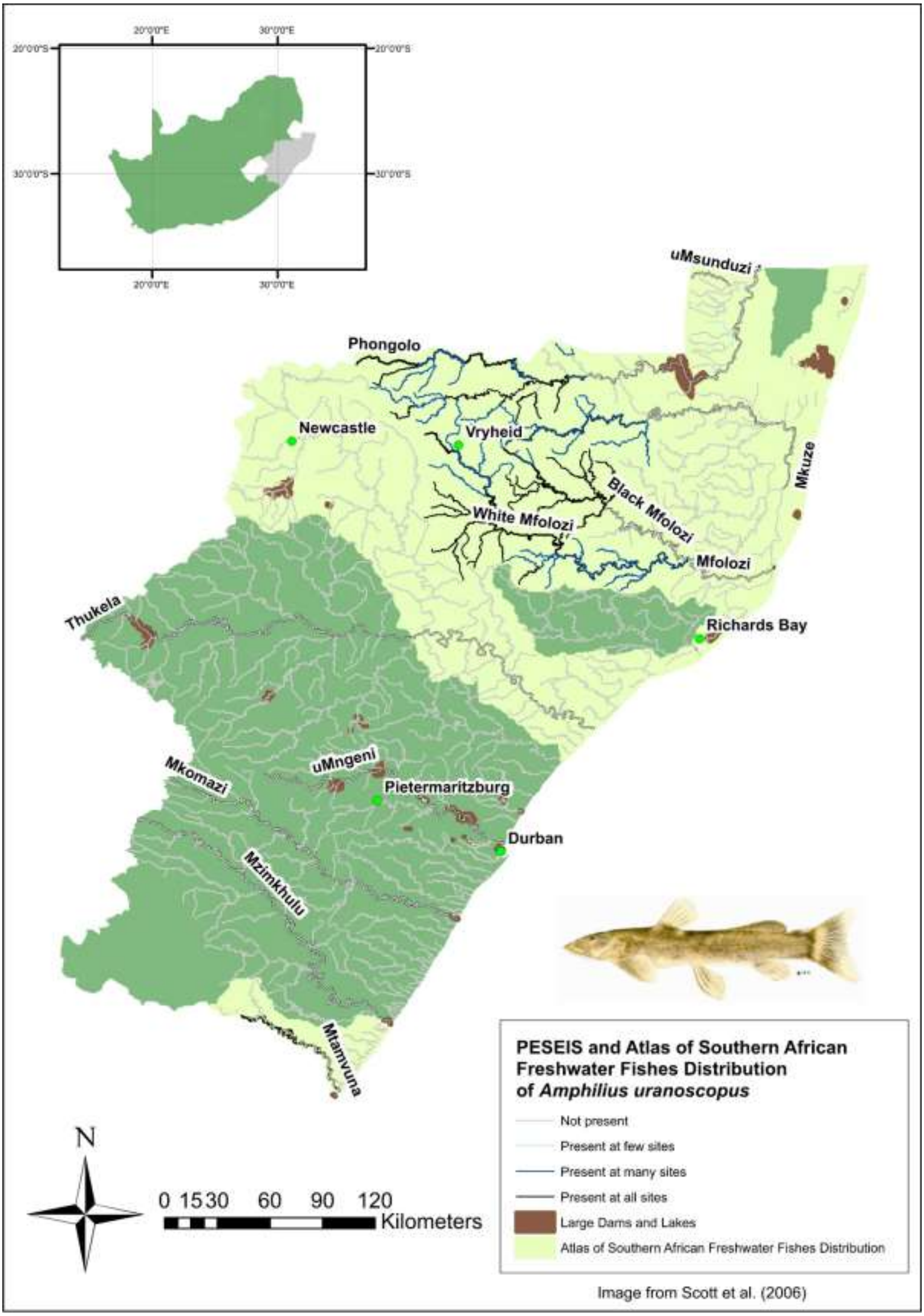

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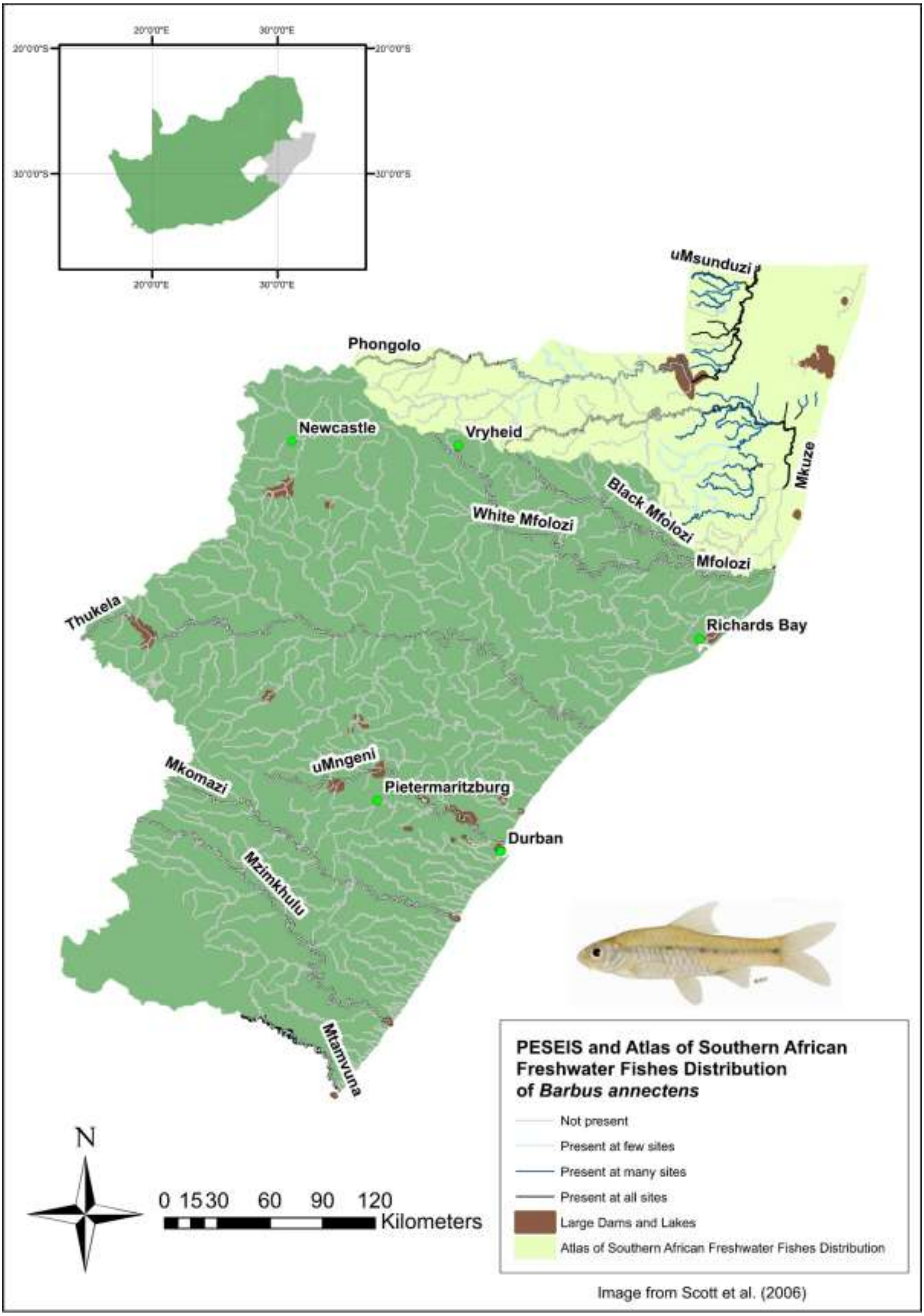

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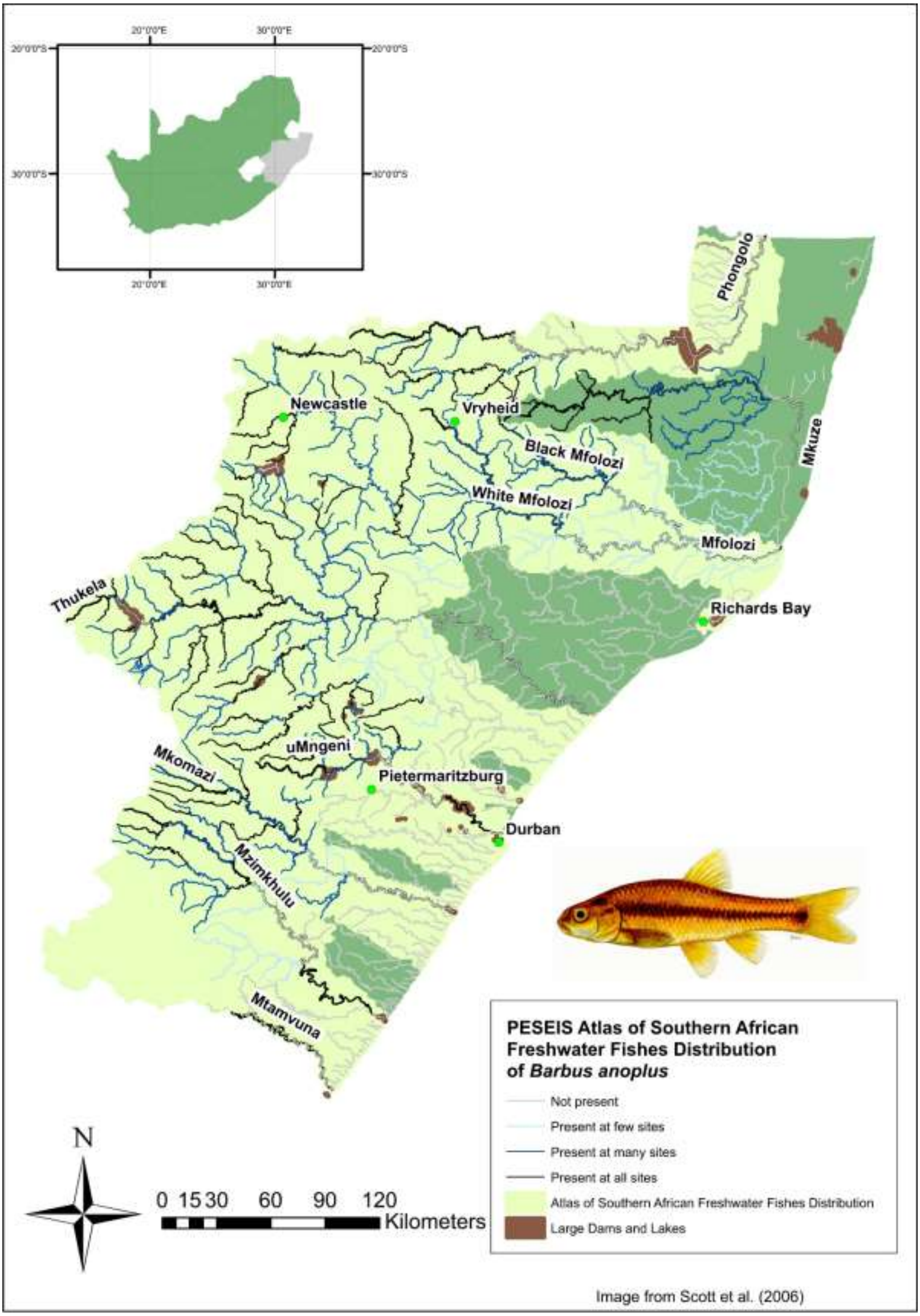
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PESEIS Atlas of Southern African Freshwater Fishes Distribution of *Barbus anoplus*
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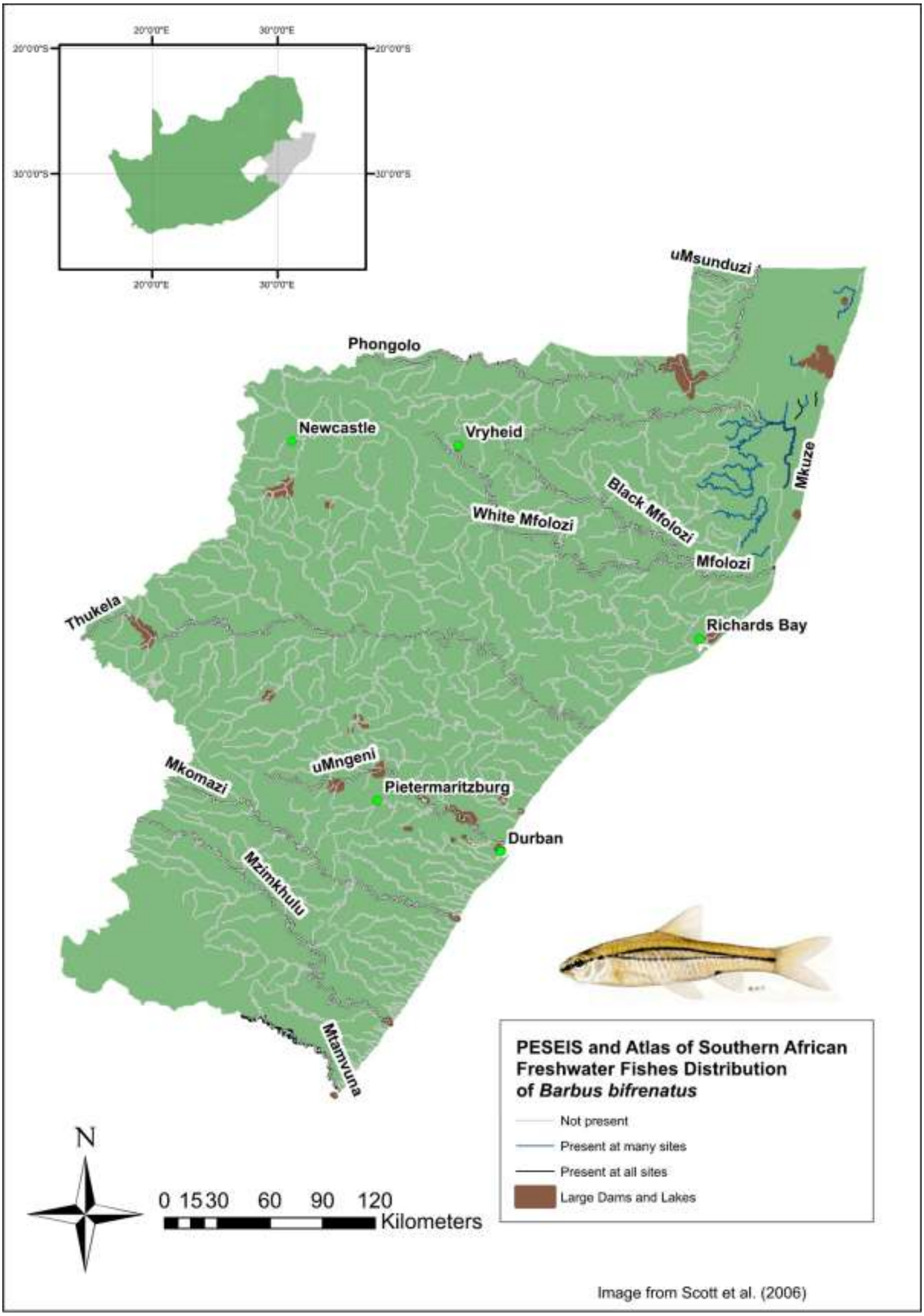

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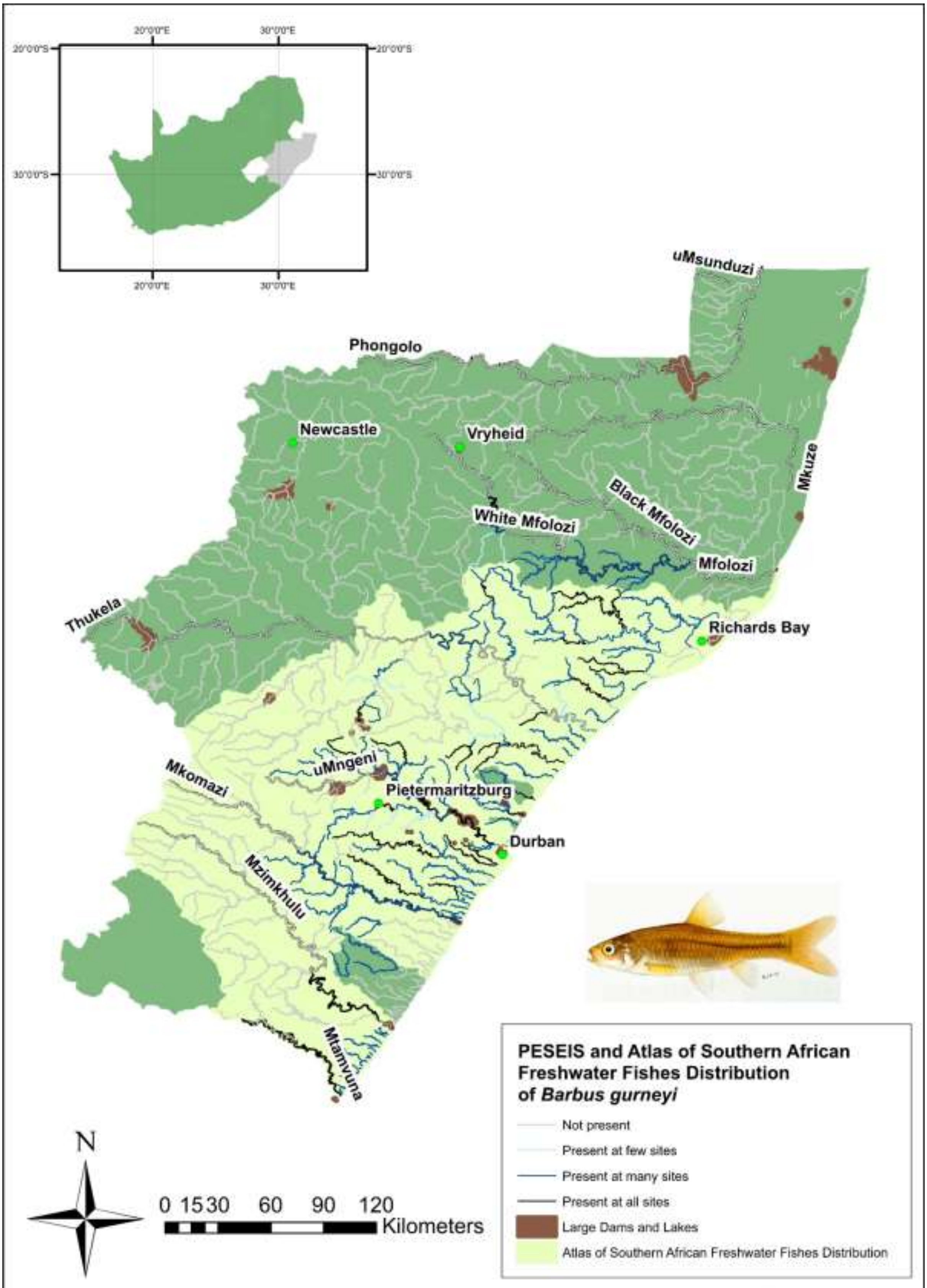

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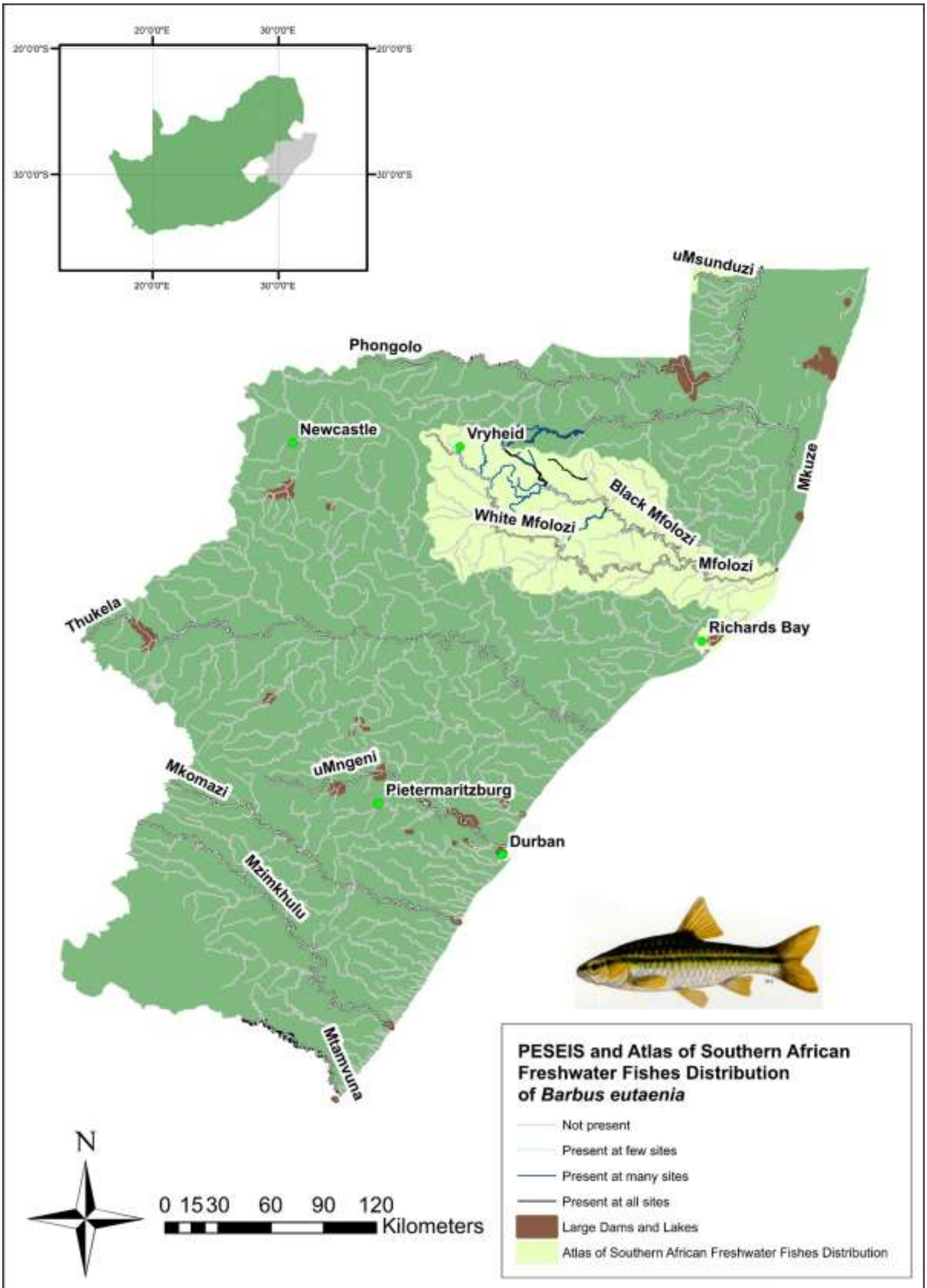

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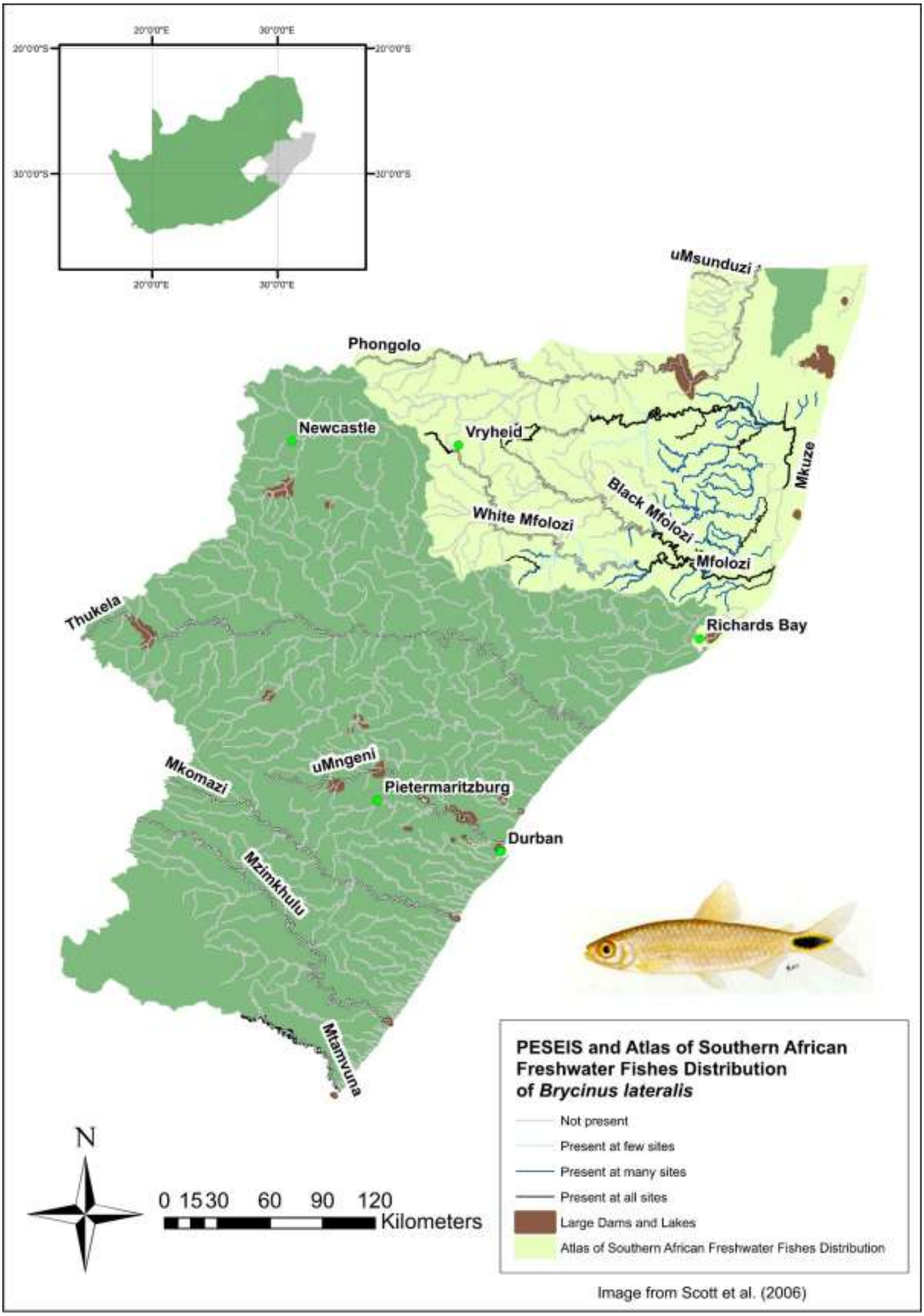

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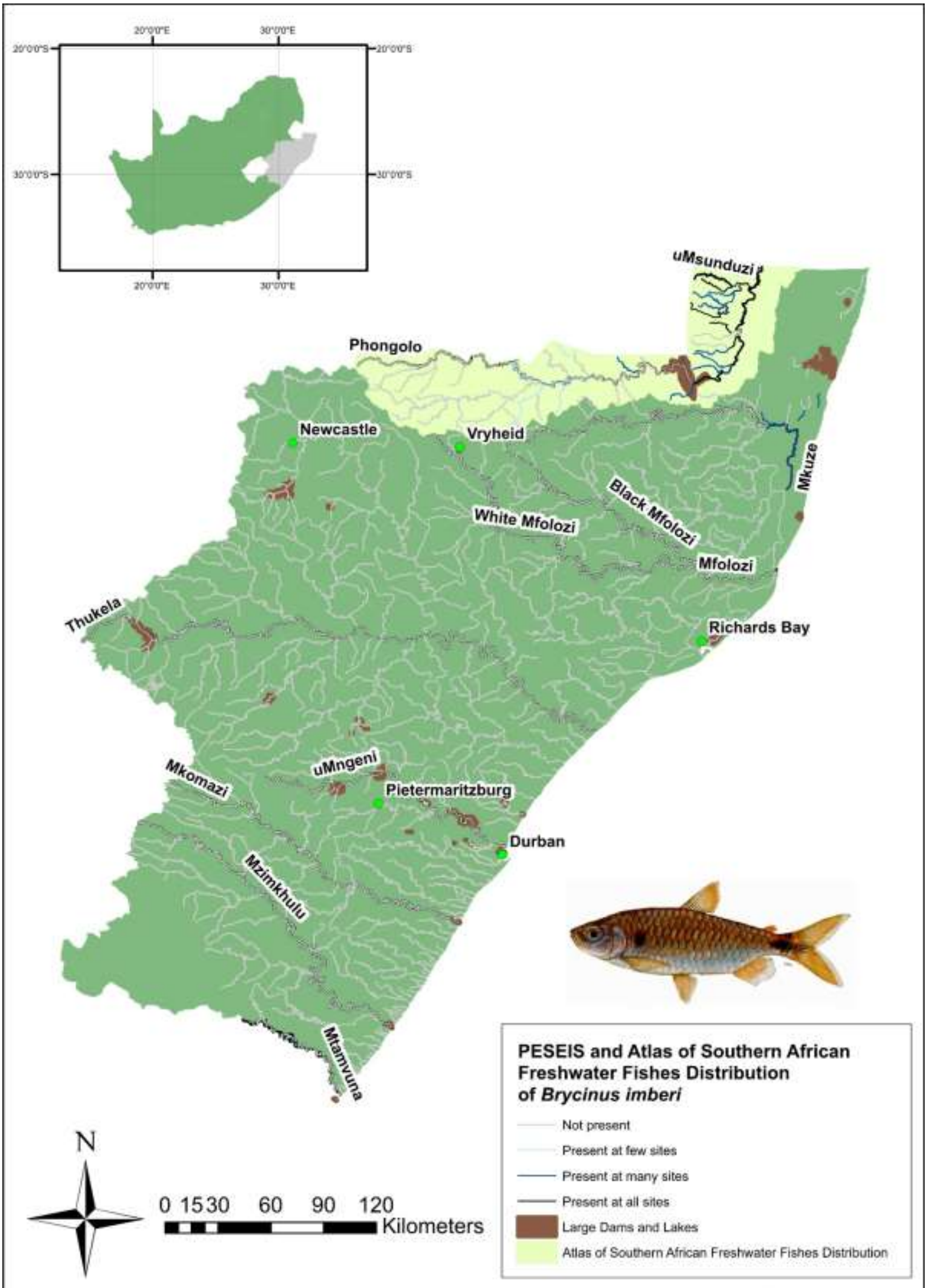

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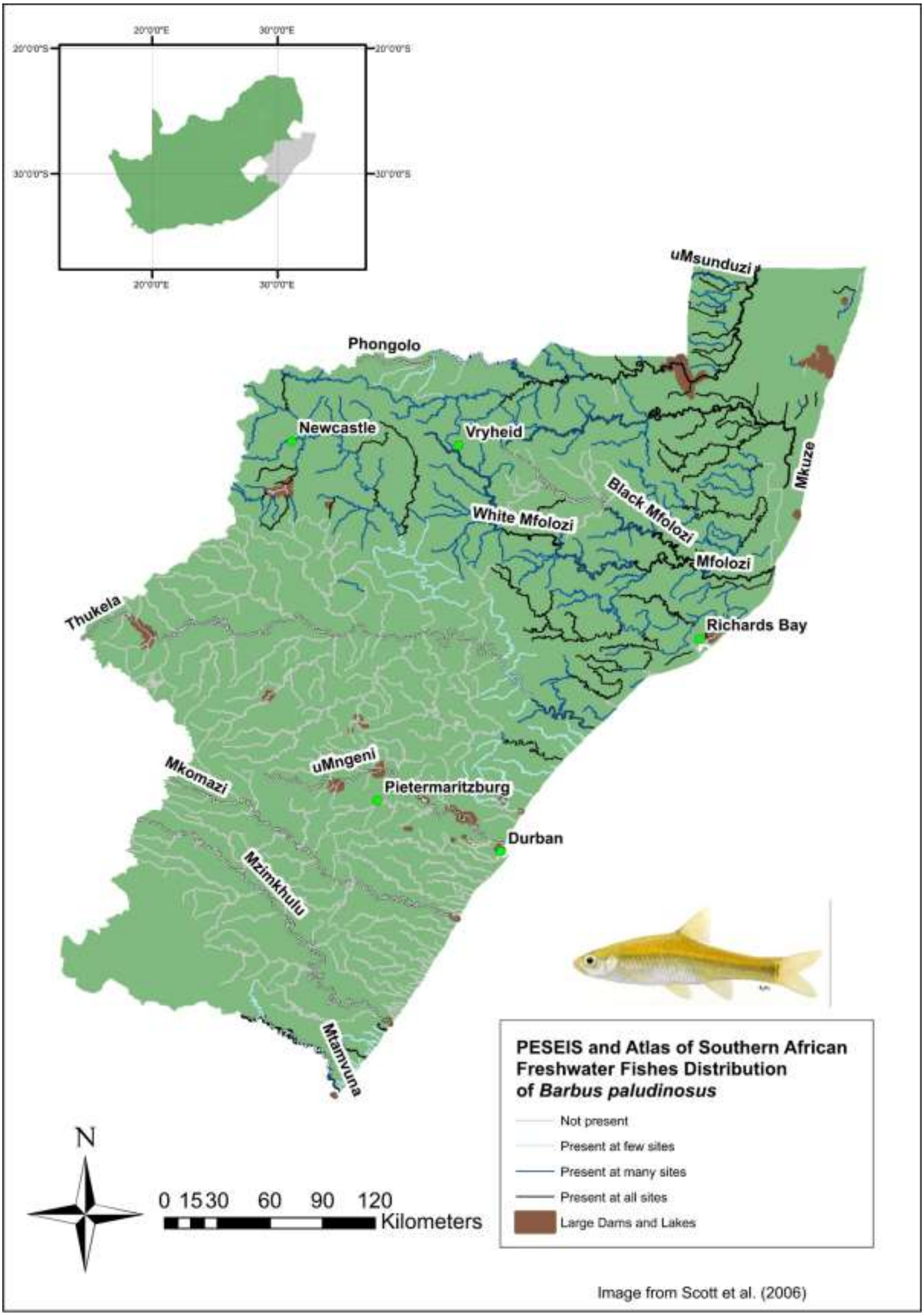

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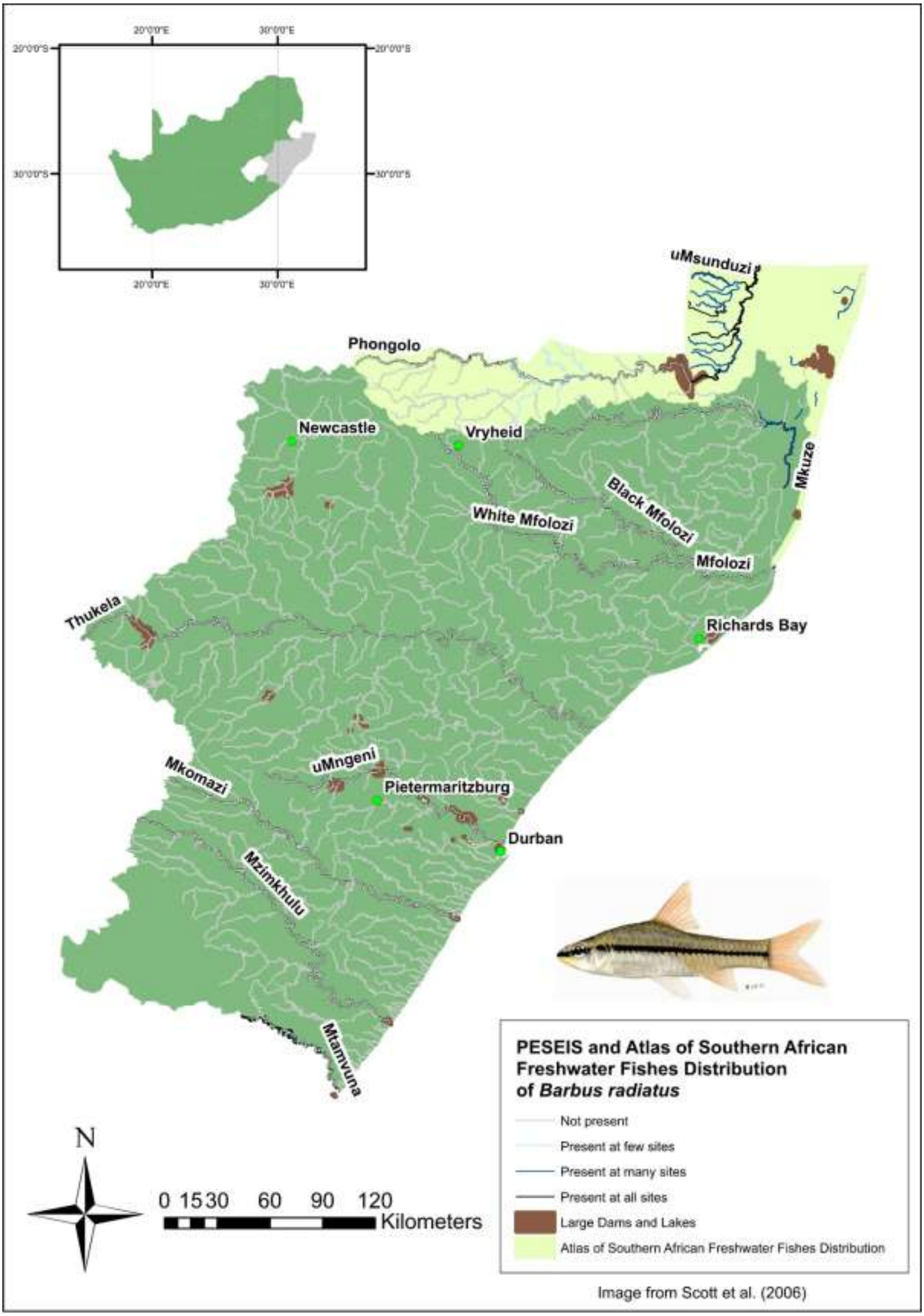

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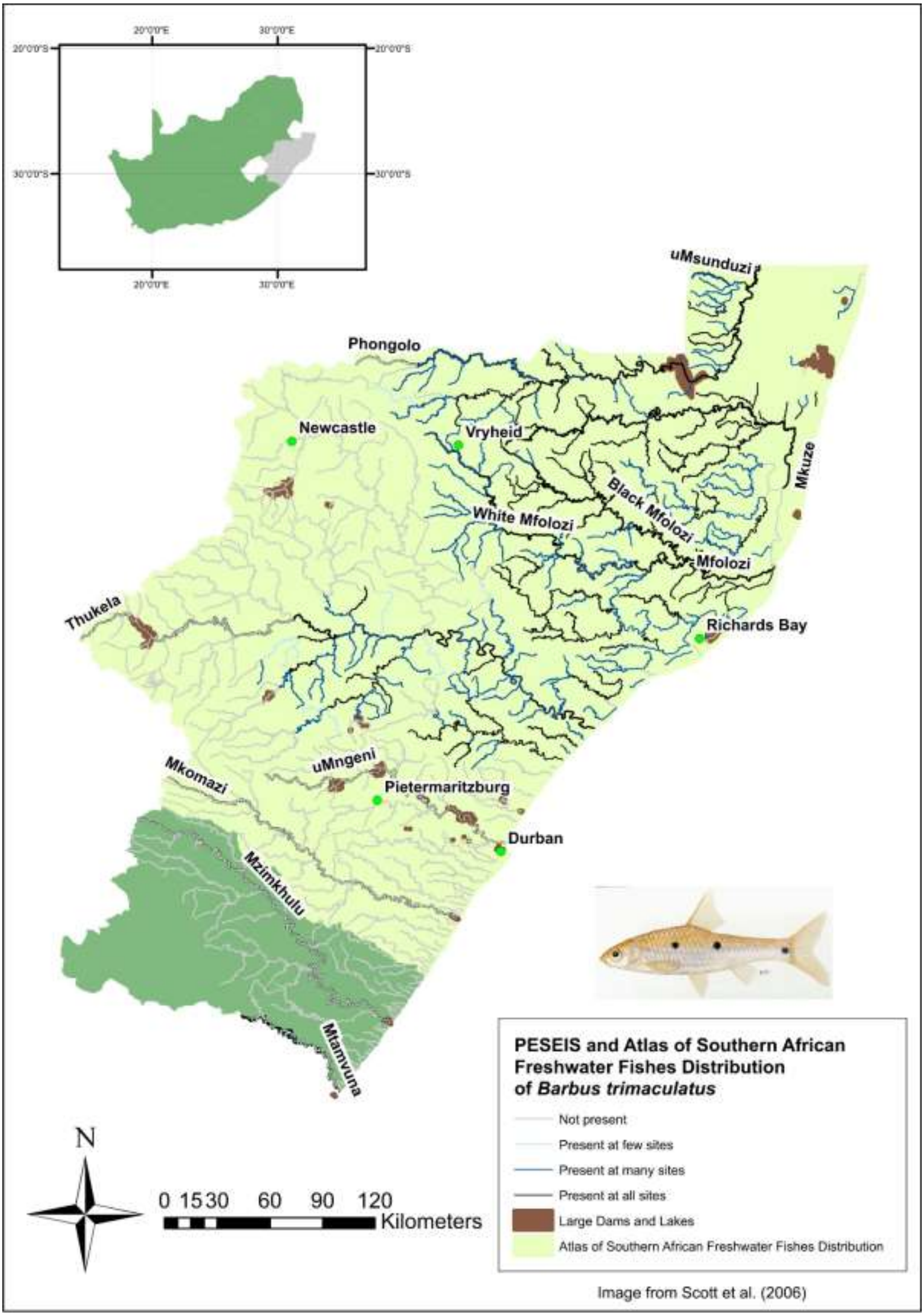
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PESEIS and Atlas of Southern African Freshwater Fishes Distribution of *Barbus trimaculatus*
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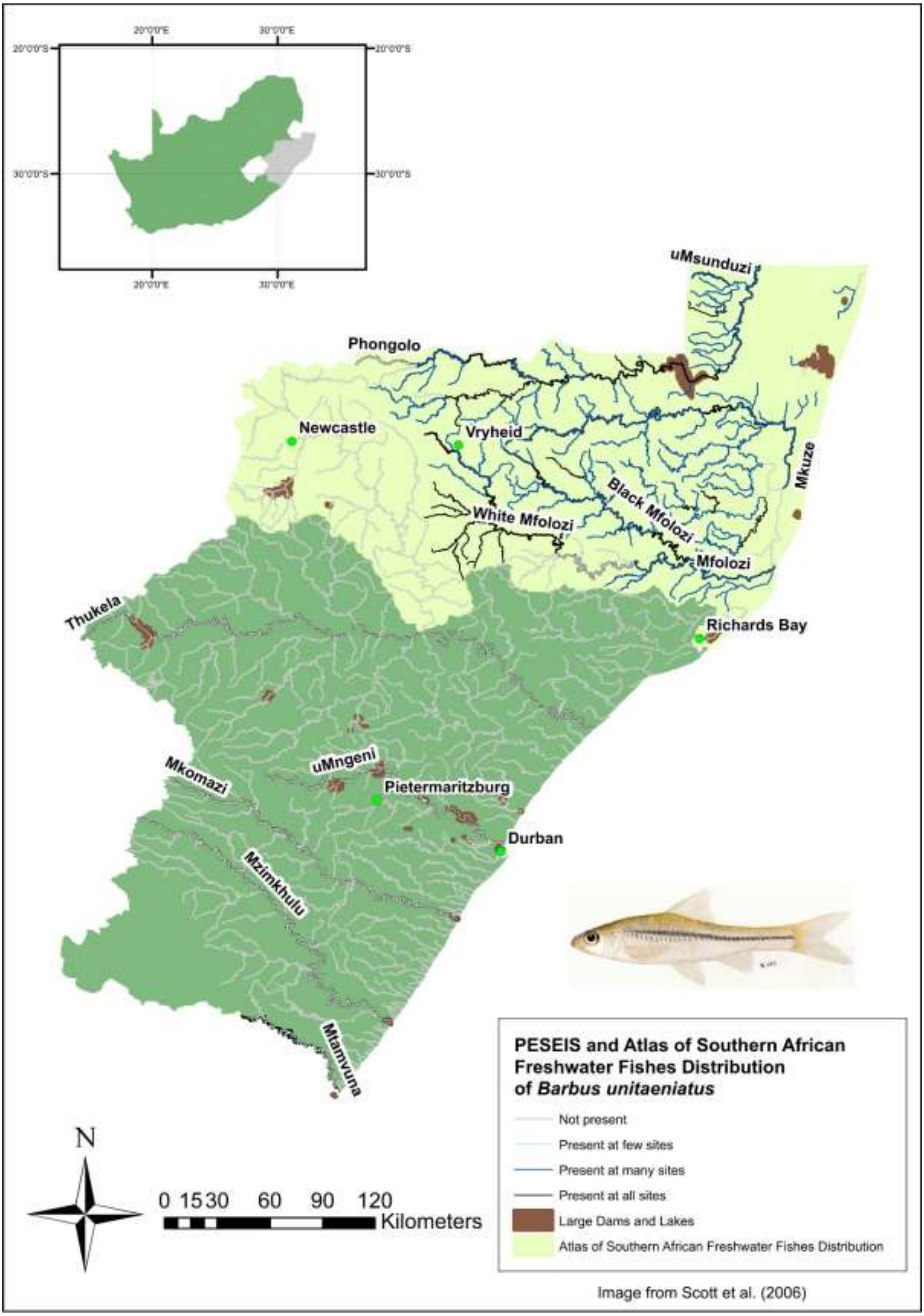
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PESEIS and Atlas of Southern African Freshwater Fishes Distribution of *Barbus unitaeniatus*
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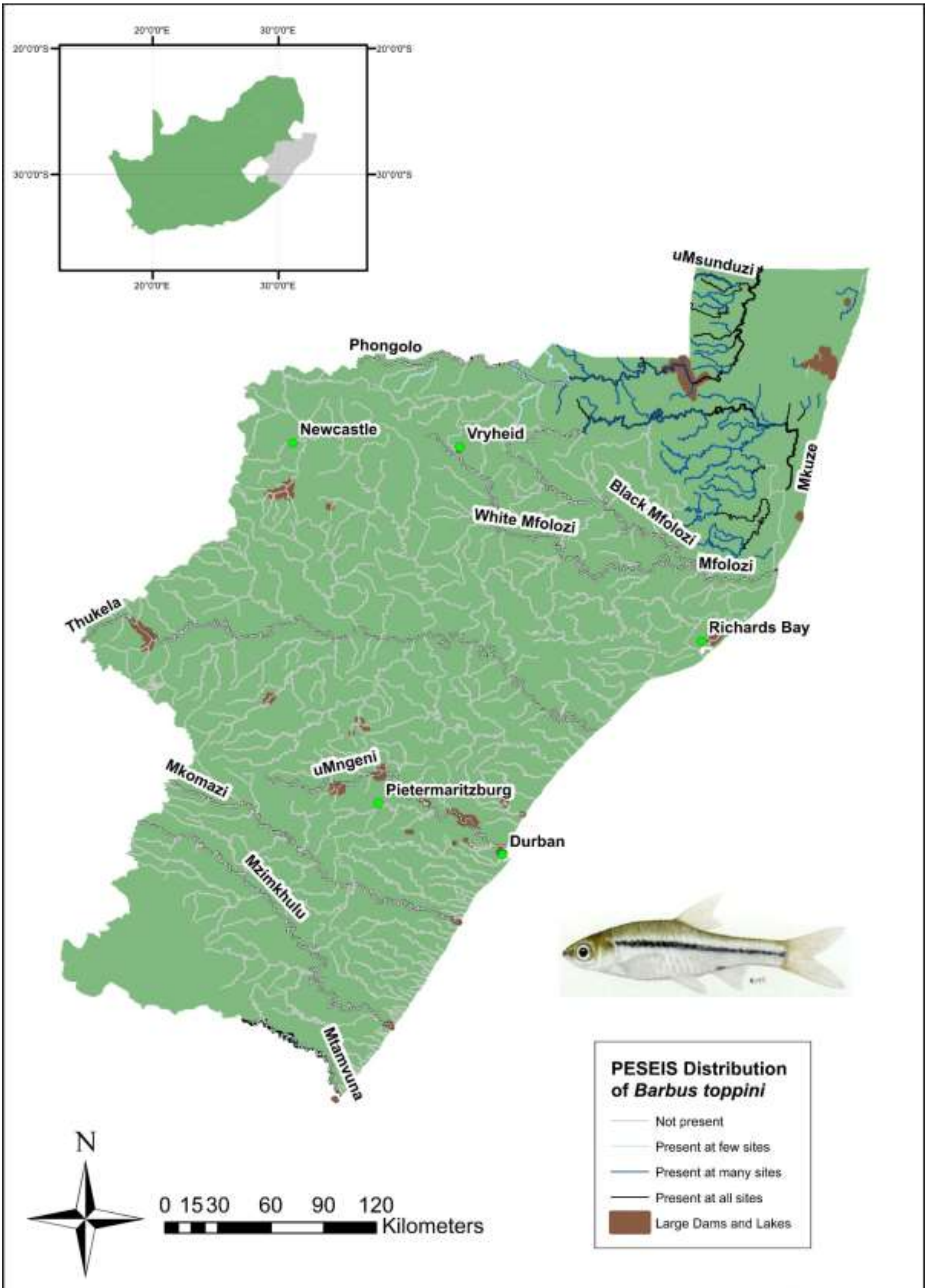

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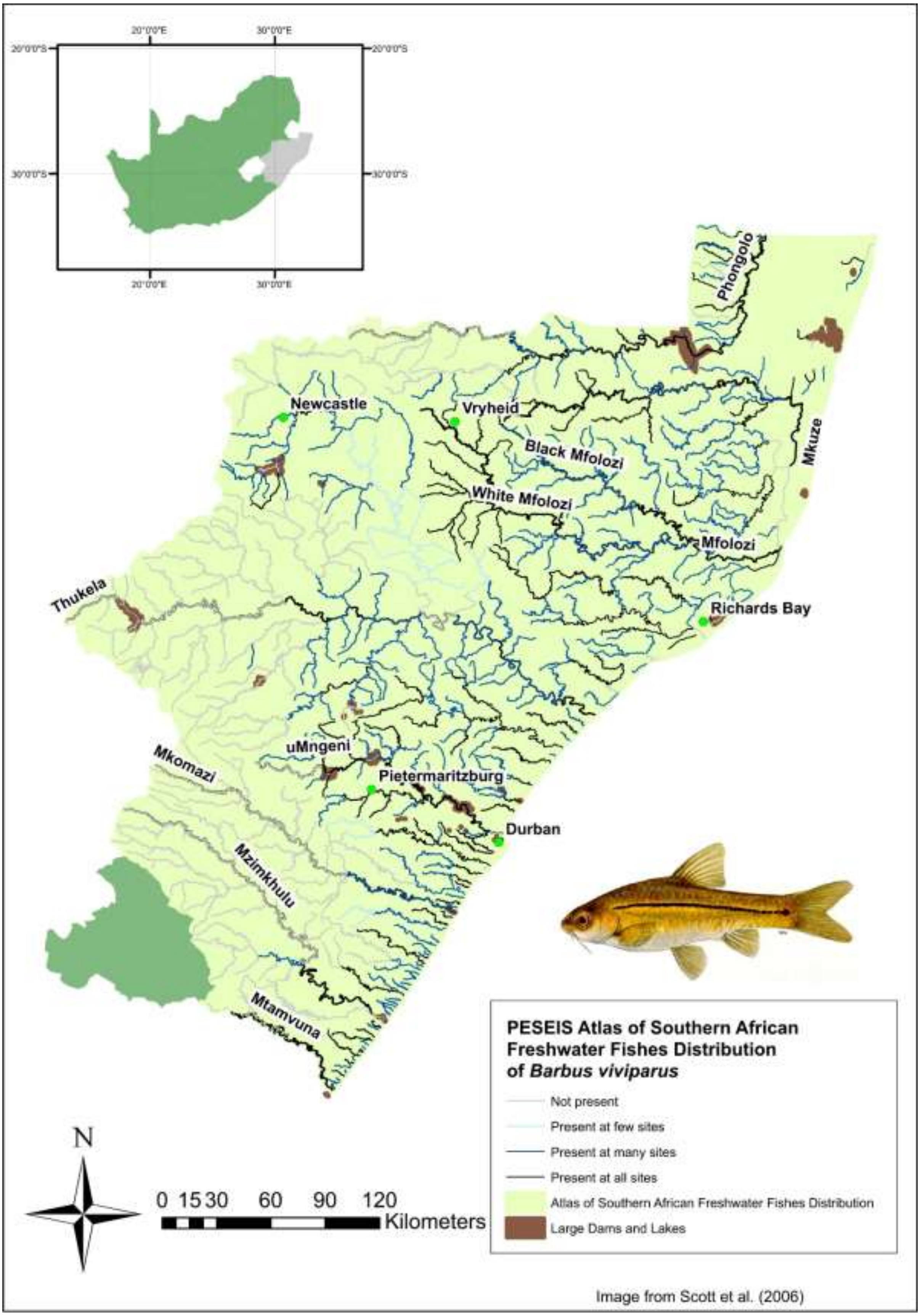

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PESEIS Atlas of Southern African Freshwater Fishes Distribution of Barbus viviparus
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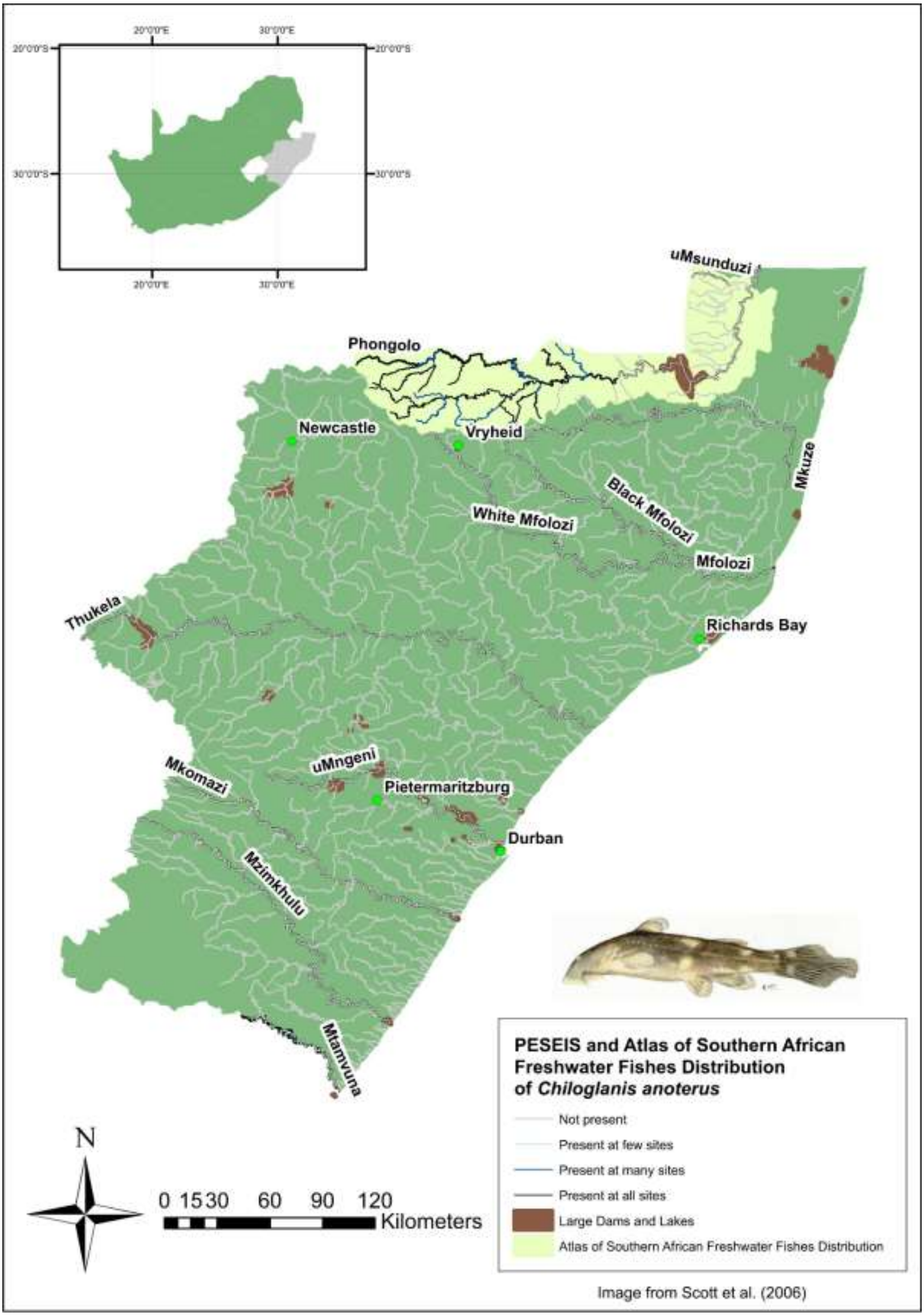

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PESEIS and Atlas of Southern African Freshwater Fishes Distribution of *Chiloglanis anoterus*
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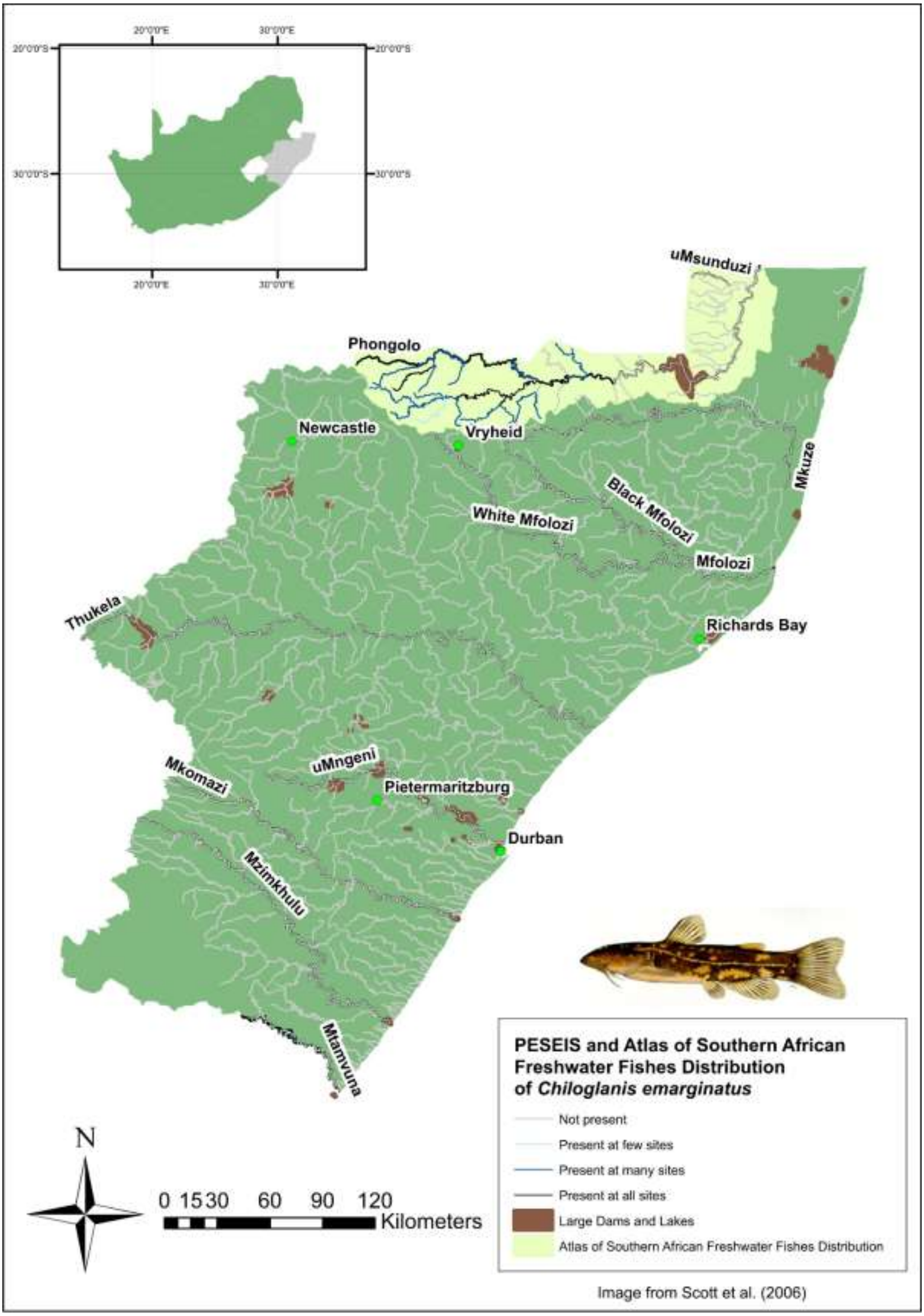
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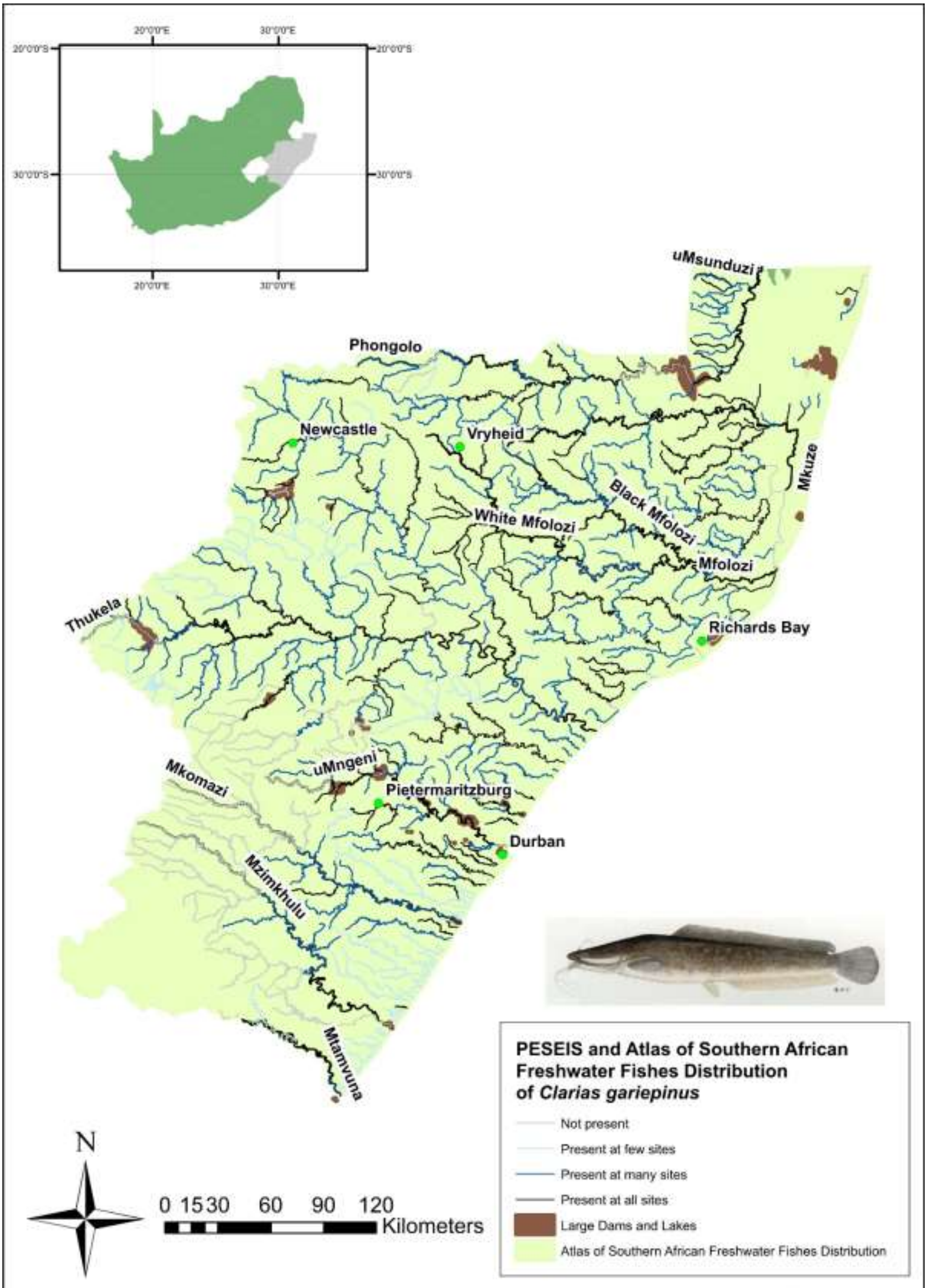
Kilometers
PESEIS and Atlas of Southern African Freshwater Fishes Distribution of *Chiloglanis emarginatus*
Not present
Present at few sites
Present at many sites
Present at all sites
Large Dams and Lakes
Atlas of Southern African Freshwater Fishes Distribution
Image from Scott et al. (2006)



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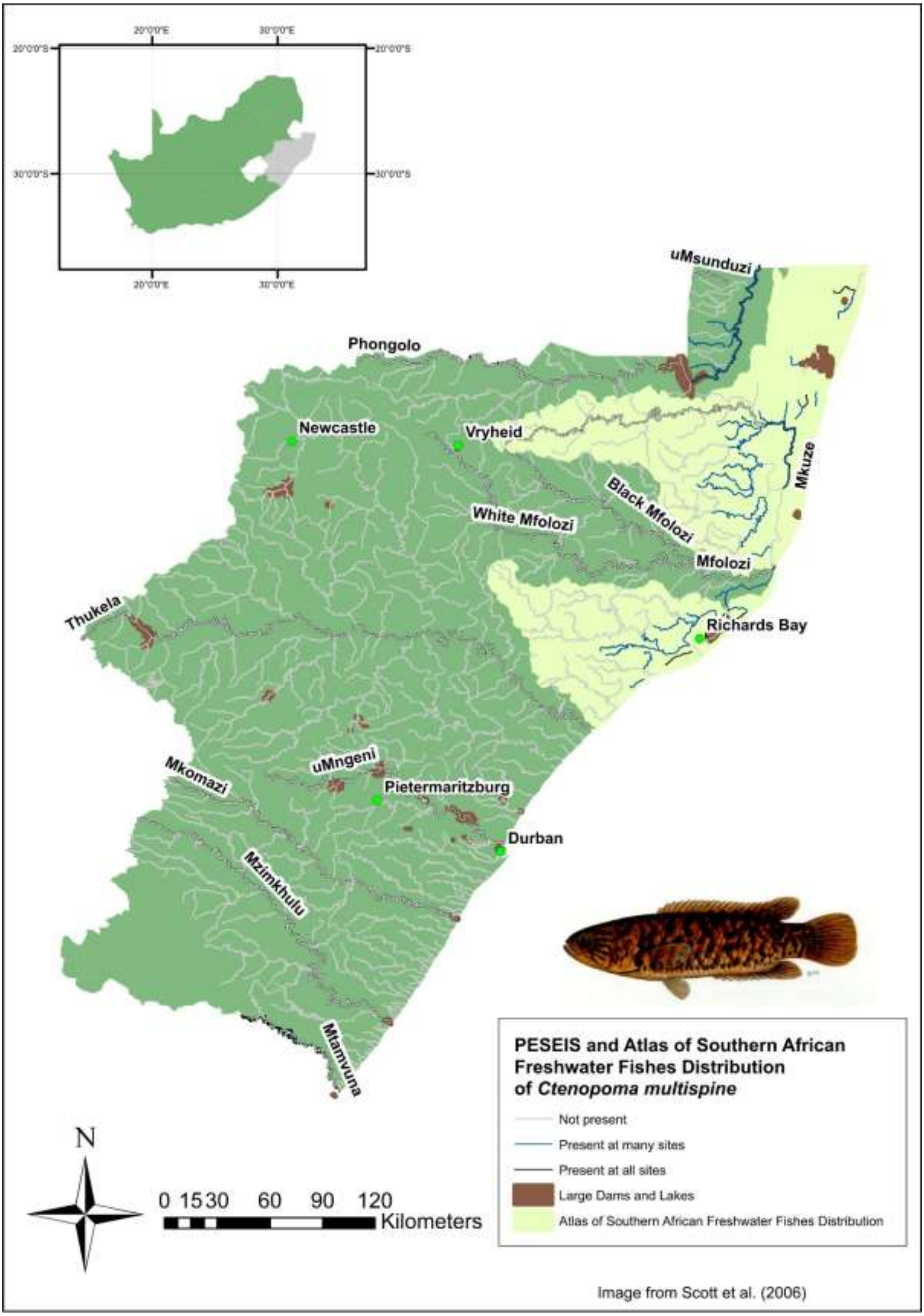
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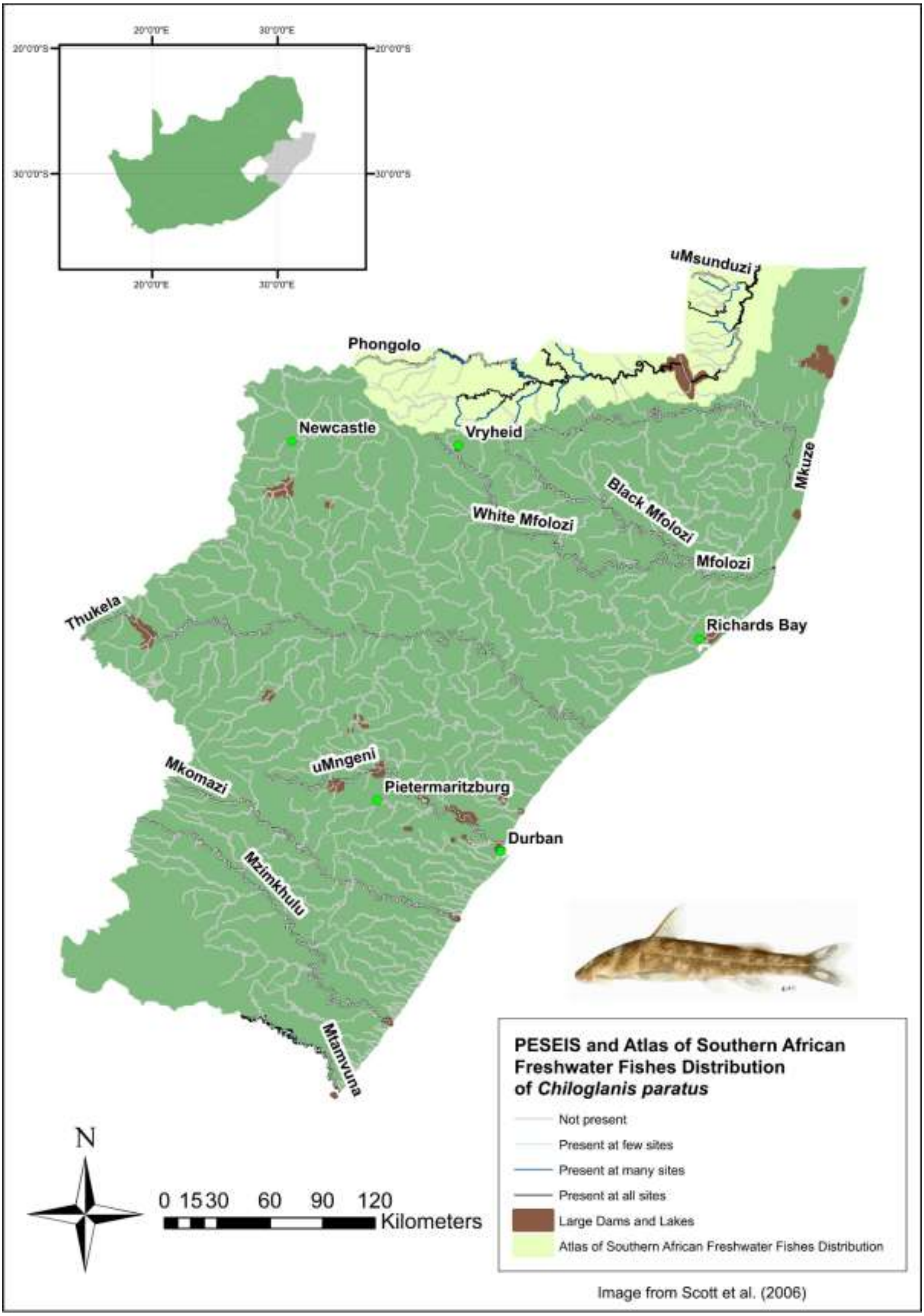
PESEIS and Atlas of Southern African Freshwater Fishes Distribution of *Ctenopoma multispine*
Not present
Present at many sites
Present at all sites
Large Dams and Lakes
Atlas of Southern African Freshwater Fishes Distribution
N
0 15 30 60 90 120
Kilometers
Image from Scott et al. (2006)



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N
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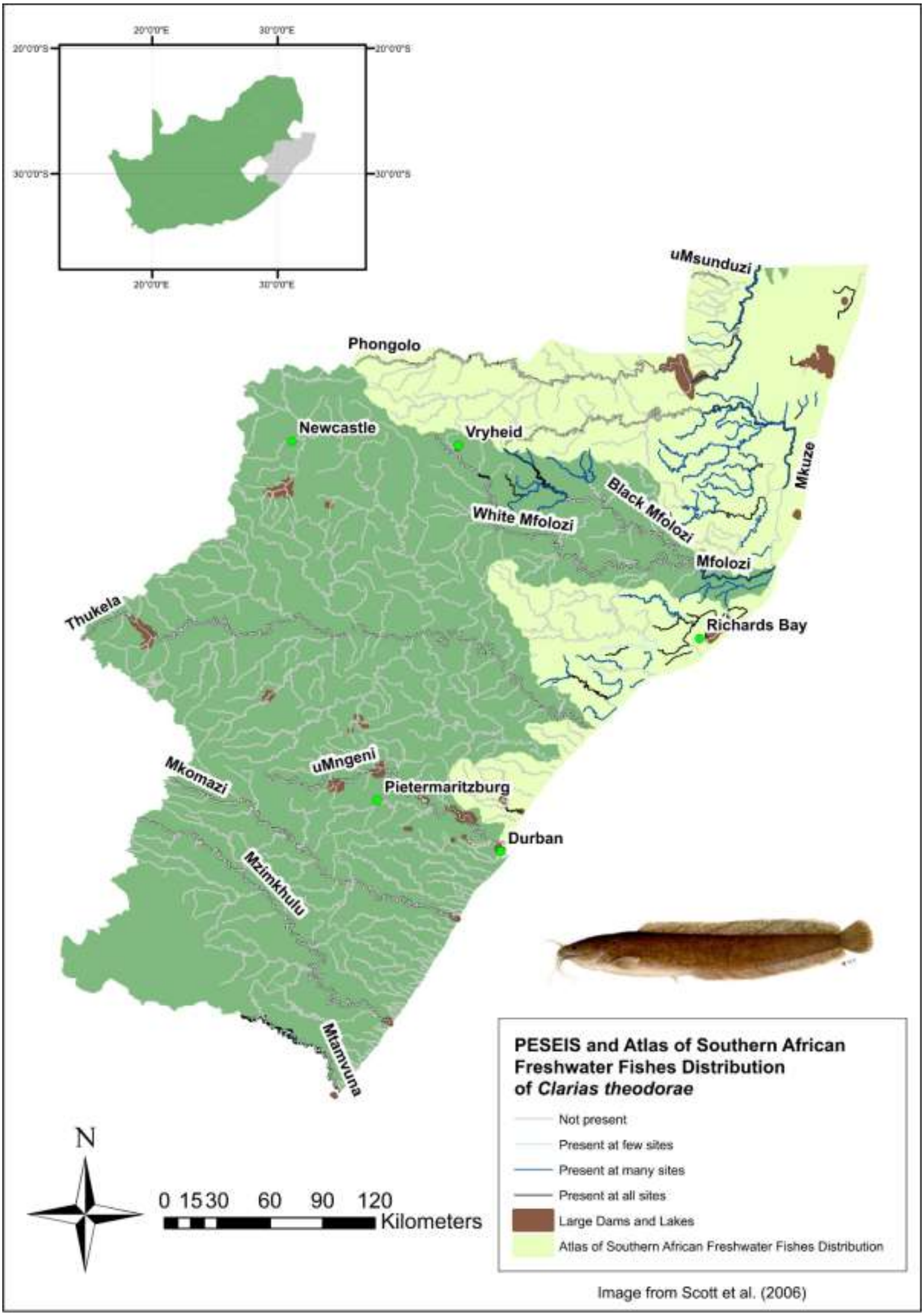
Kilometers
PESEIS and Atlas of Southern African Freshwater Fishes Distribution of *Chiloglanis paratus*
Not present
Present at few sites
Present at many sites
Present at all sites
Large Dams and Lakes
Atlas of Southern African Freshwater Fishes Distribution
Image from Scott et al. (2006)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PESEIS and Atlas of Southern African Freshwater Fishes Distribution of *Clarias theodorae*
Not present
Present at few sites
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Large Dams and Lakes
Atlas of Southern African Freshwater Fishes Distribution
N
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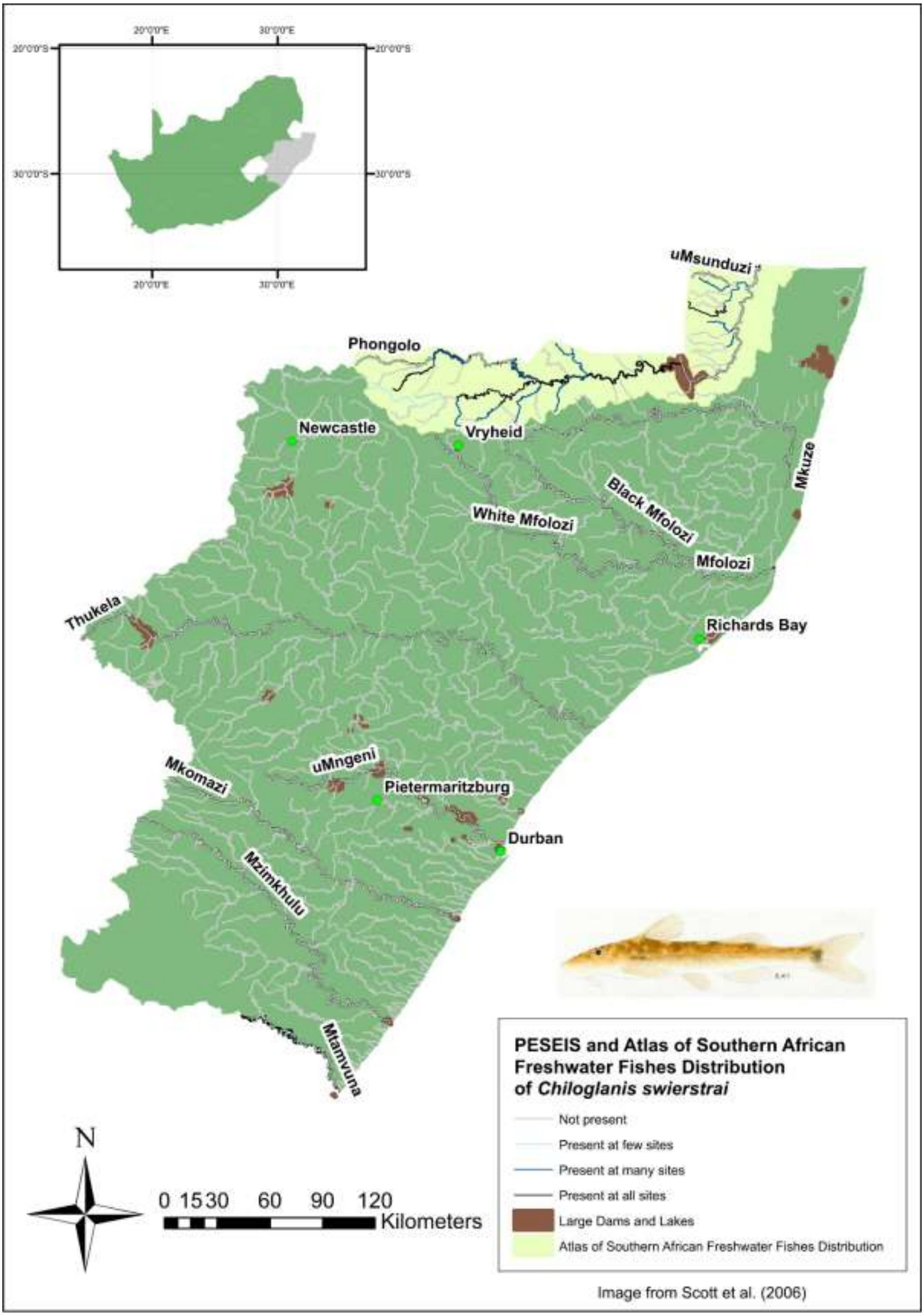
Kilometers
Image from Scott et al. (2006)



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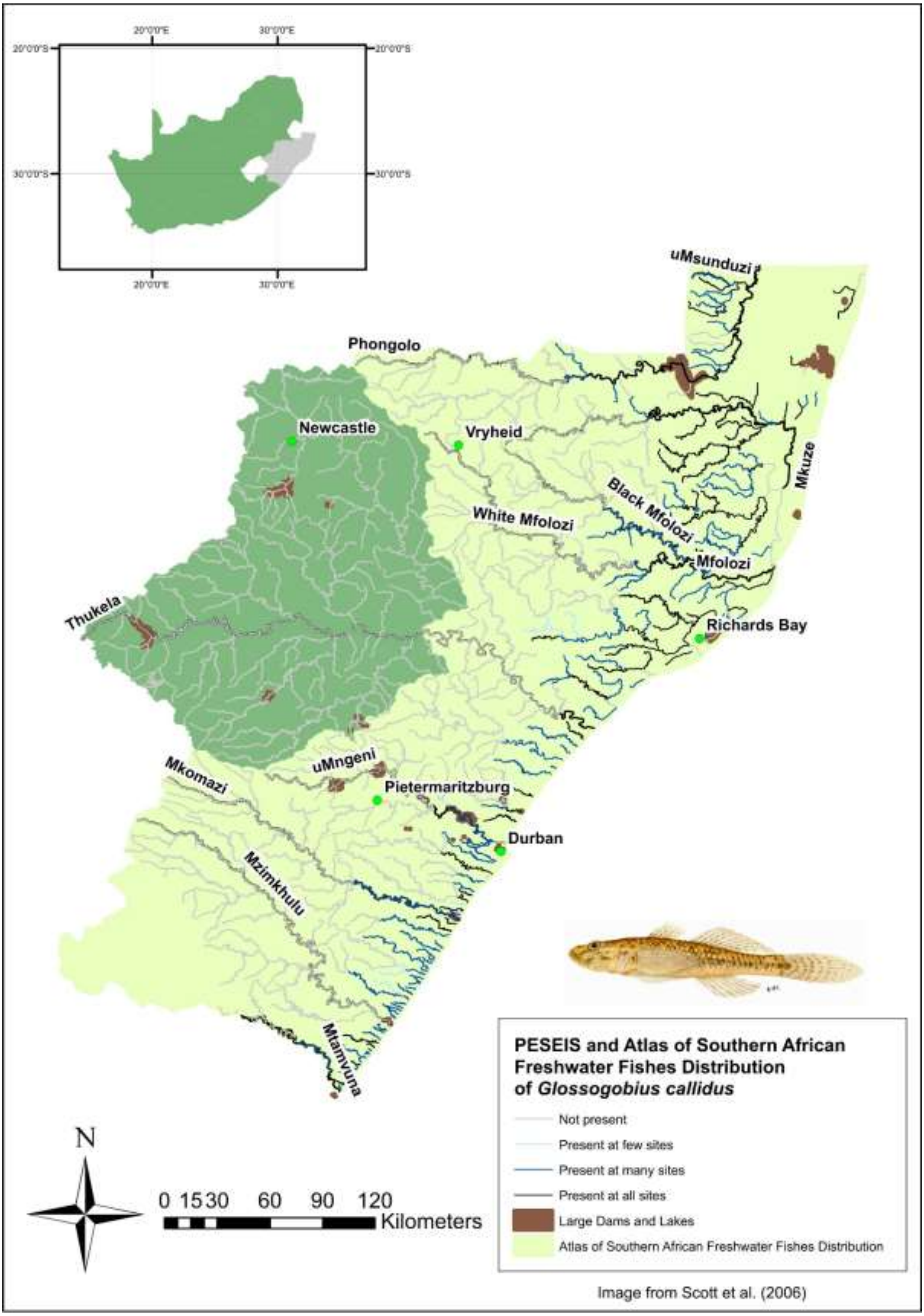
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PESEIS and Atlas of Southern African Freshwater Fishes Distribution of Glossogobius callidus
Not present
Present at few sites
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Present at all sites
Large Dams and Lakes
Atlas of Southern African Freshwater Fishes Distribution
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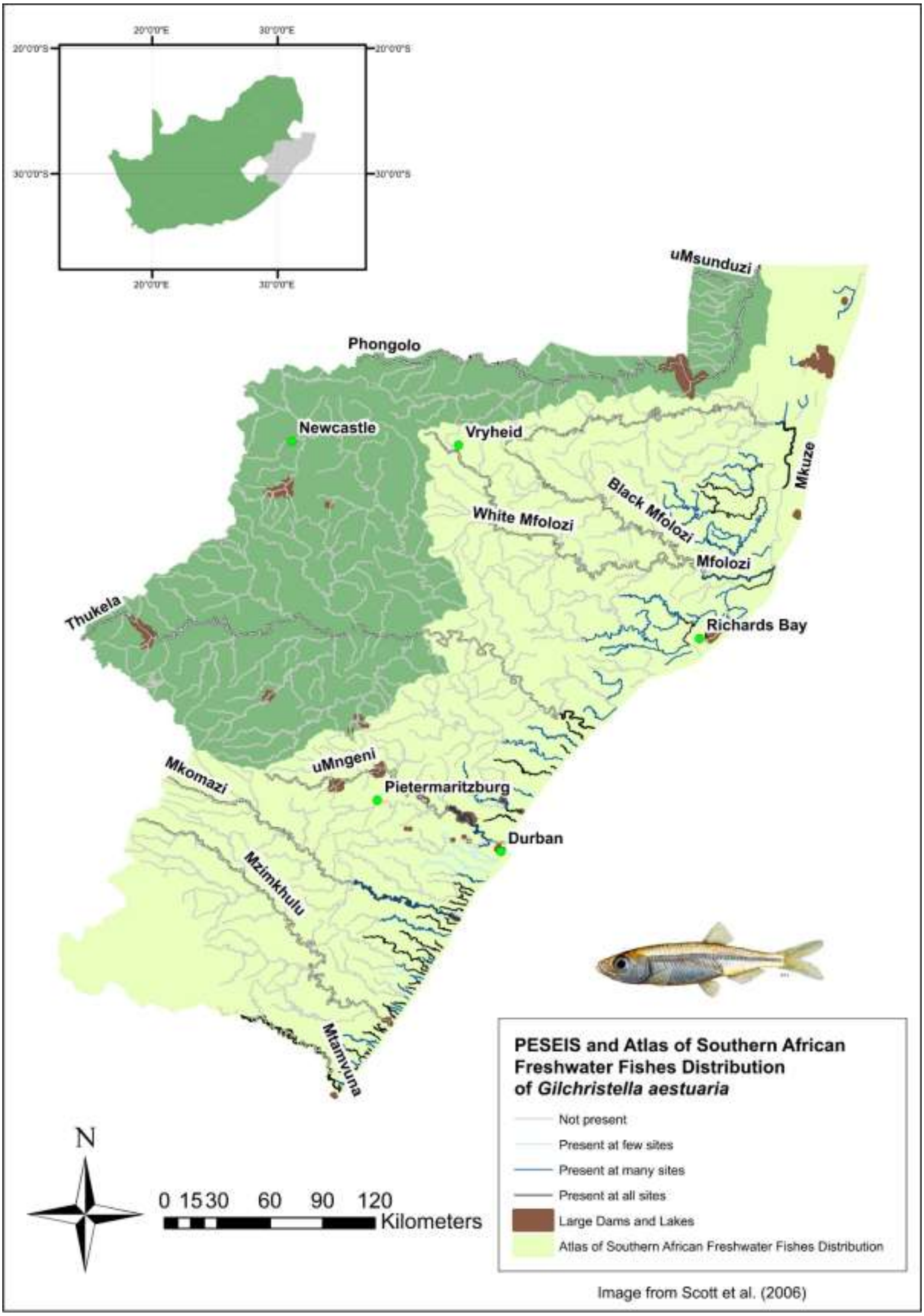
Kilometers
Image from Scott et al. (2006)



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PESEIS and Atlas of Southern African Freshwater Fishes Distribution of *Gilchristella aestuaria*
Not present
Present at few sites
Present at many sites
Present at all sites
Large Dams and Lakes
Atlas of Southern African Freshwater Fishes Distribution
N
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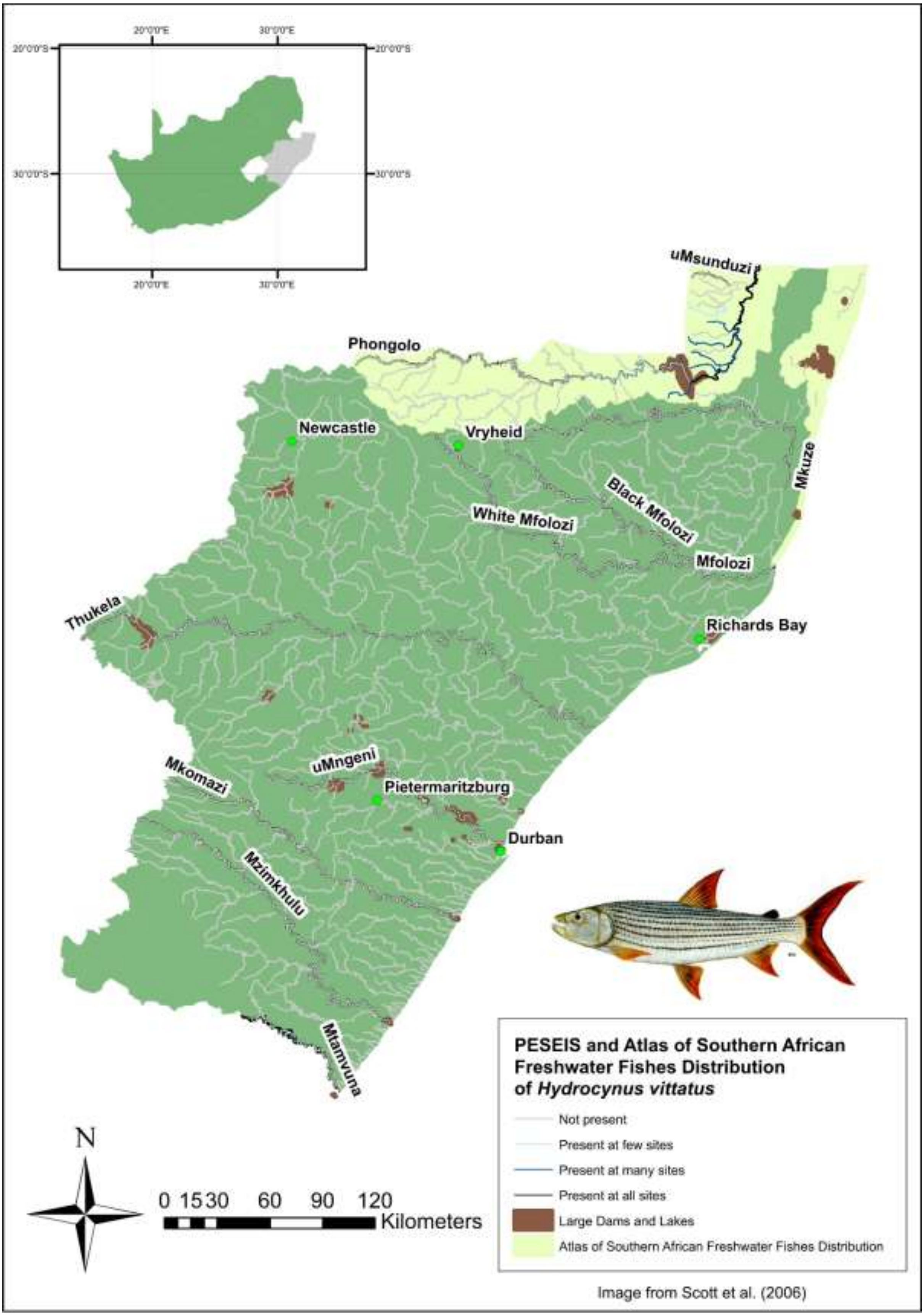
Kilometers
Image from Scott et al. (2006)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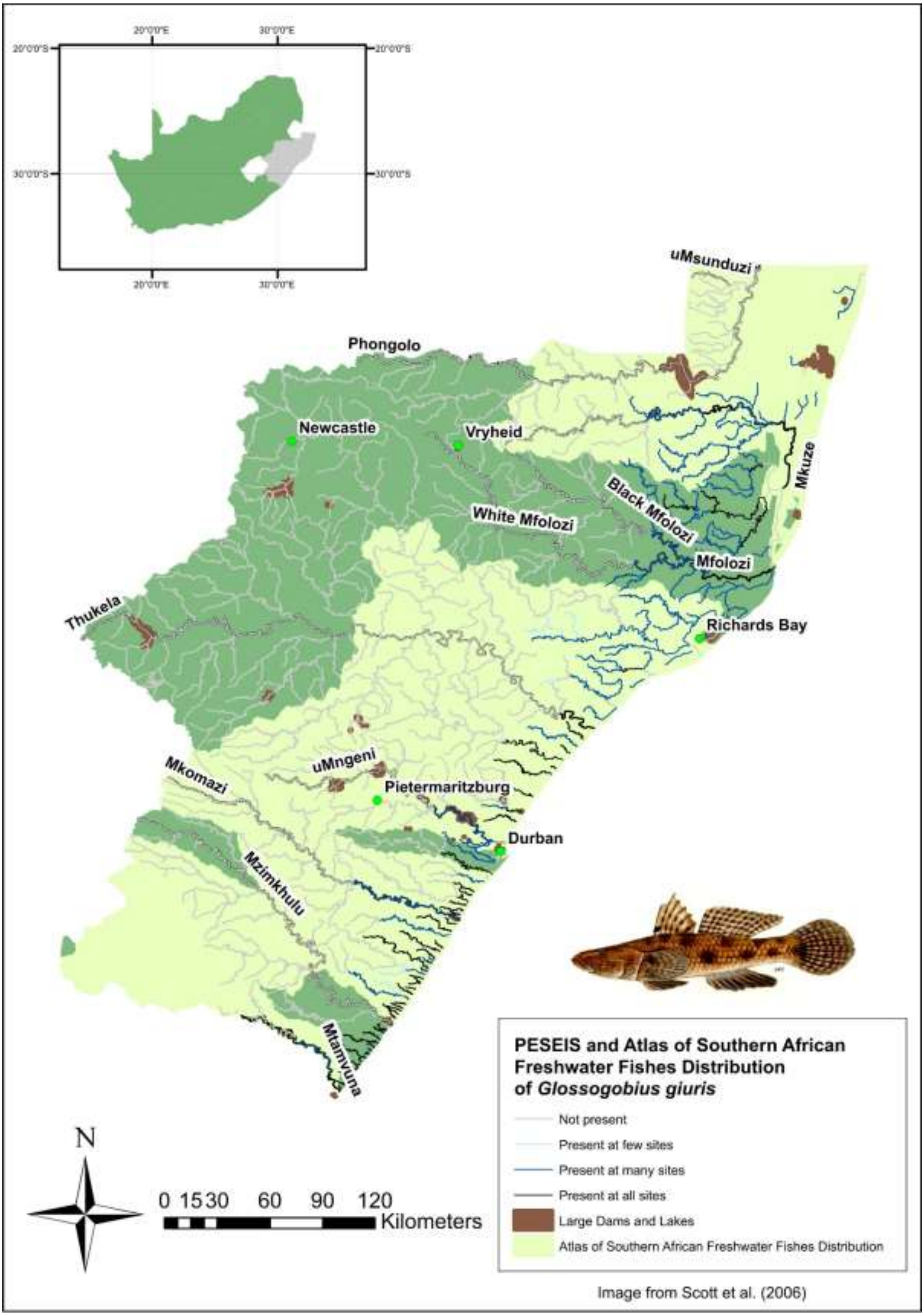
N
0 15 30 60 90 120
Kilometers
PESEIS and Atlas of Southern African Freshwater Fishes Distribution of *Hydrocynus vittatus*
Not present
Present at few sites
Present at many sites
Present at all sites
Large Dams and Lakes
Atlas of Southern African Freshwater Fishes Distribution
Image from Scott et al. (2006)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Mtamvuna
PESEIS and Atlas of Southern African Freshwater Fishes Distribution of *Glossogobius giuris*
Not present
Present at few sites
Present at many sites
Present at all sites
Large Dams and Lakes
Atlas of Southern African Freshwater Fishes Distribution
N
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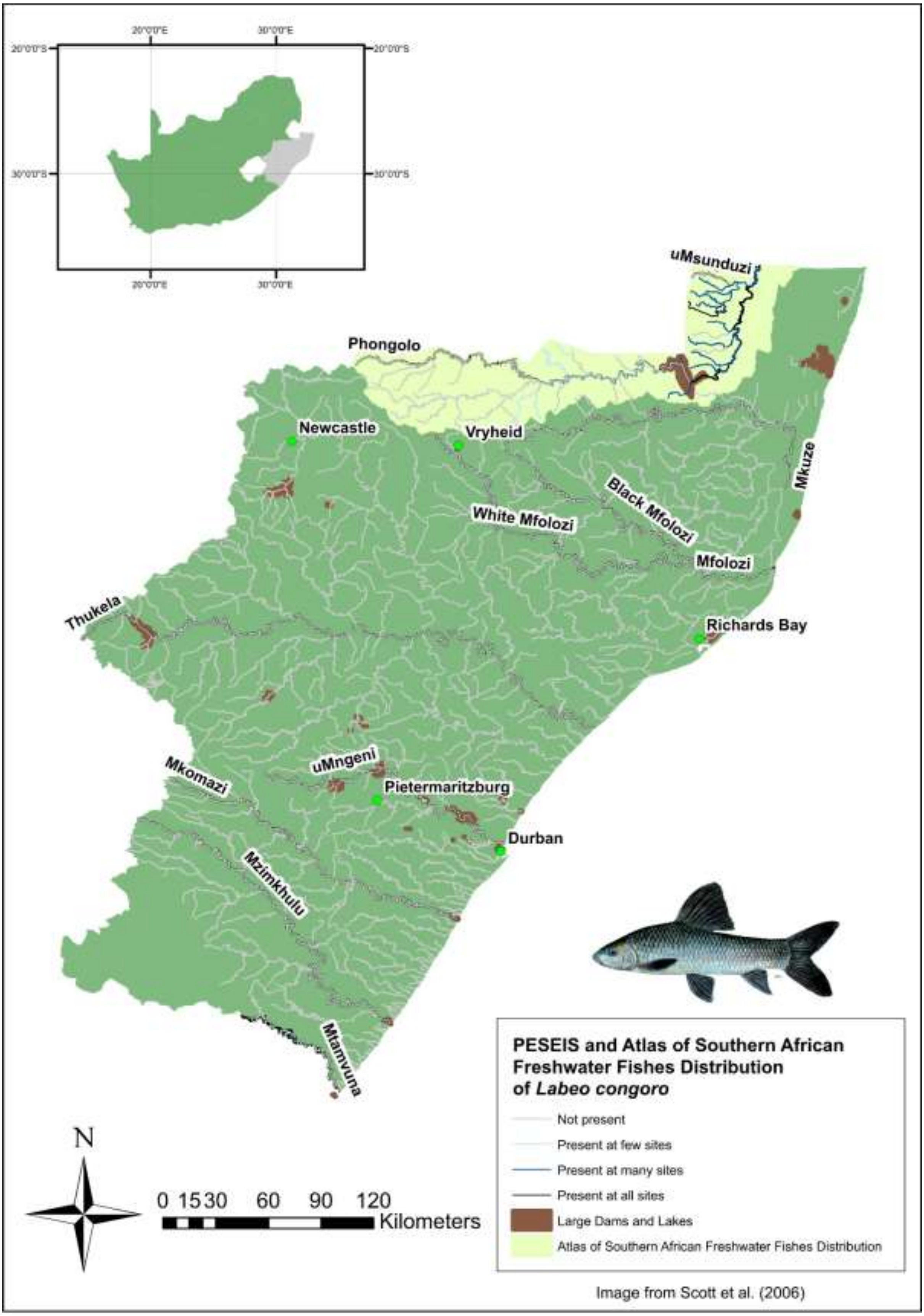
Kilometers
Image from Scott et al. (2006)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PESEIS and Atlas of Southern African Freshwater Fishes Distribution of *Labeo congoro*
Not present
Present at few sites
Present at many sites
Present at all sites
Large Dams and Lakes
Atlas of Southern African Freshwater Fishes Distribution
N
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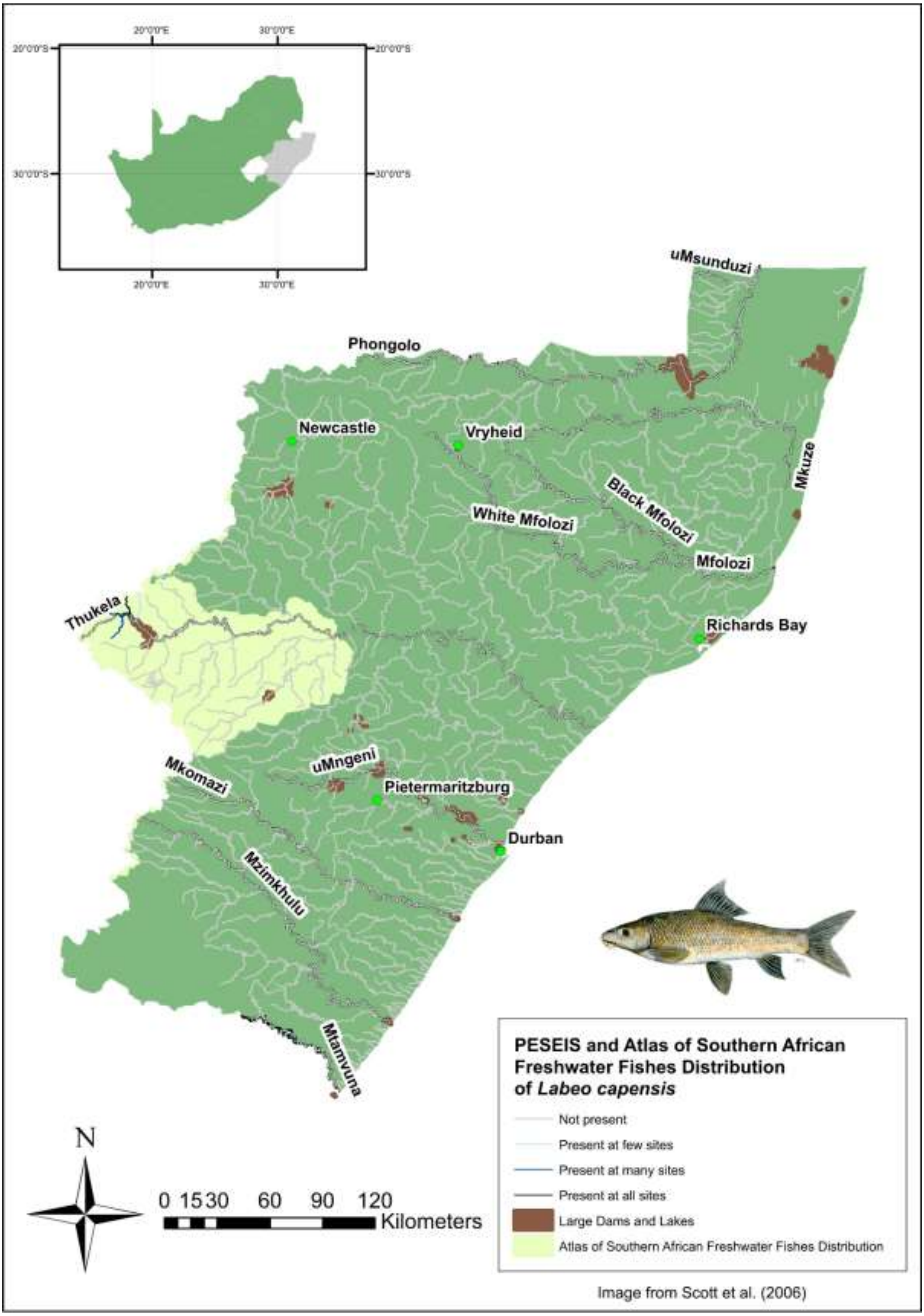
Kilometers
Image from Scott et al. (2006)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PESEIS and Atlas of Southern African Freshwater Fishes Distribution of *Labeo capensis*
Not present
Present at few sites
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Present at all sites
Large Dams and Lakes
Atlas of Southern African Freshwater Fishes Distribution
N
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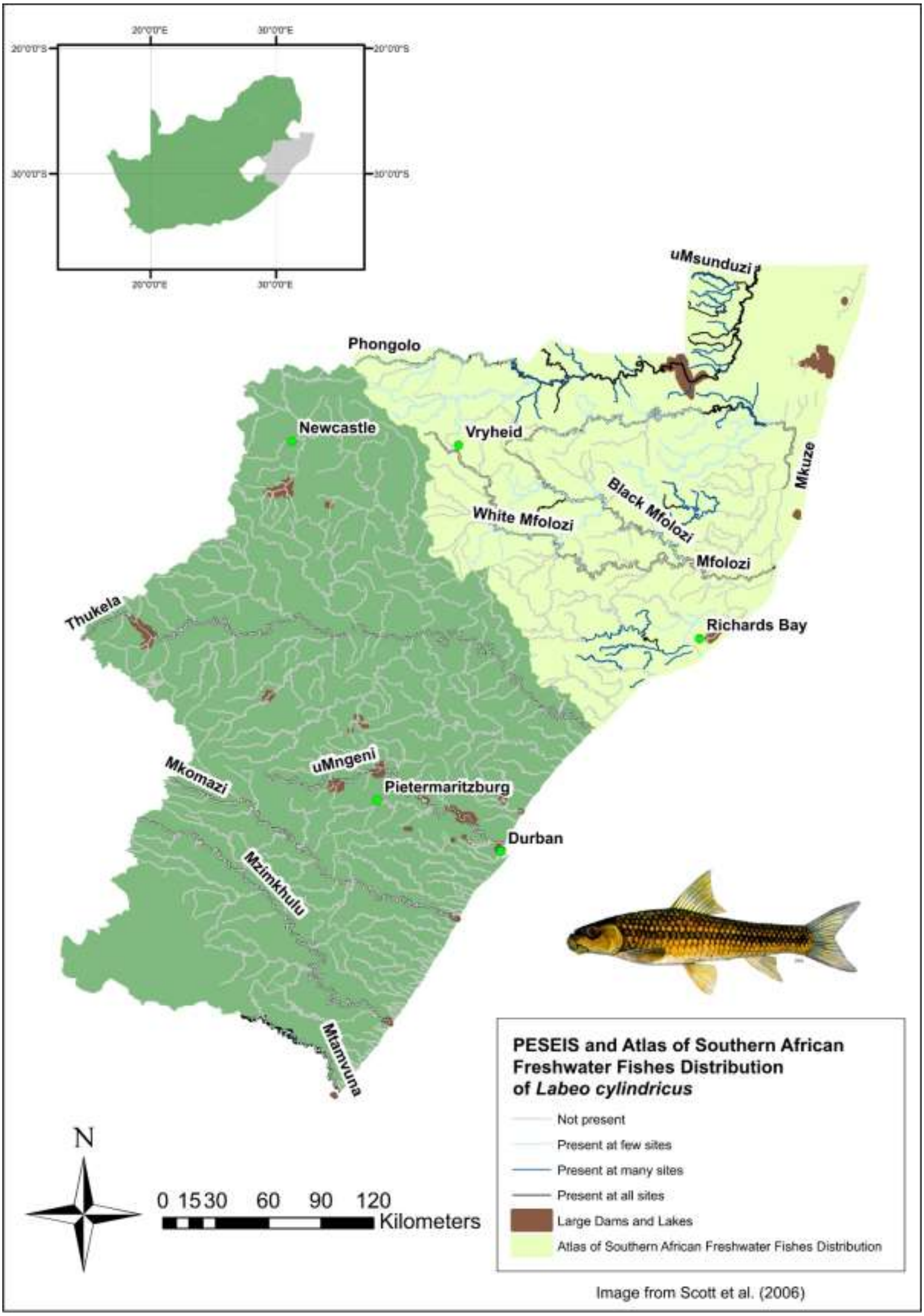
Kilometers
Image from Scott et al. (2006)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PESEIS and Atlas of Southern African Freshwater Fishes Distribution of *Labeo cylindricus*
Not present
Present at few sites
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Large Dams and Lakes
Atlas of Southern African Freshwater Fishes Distribution
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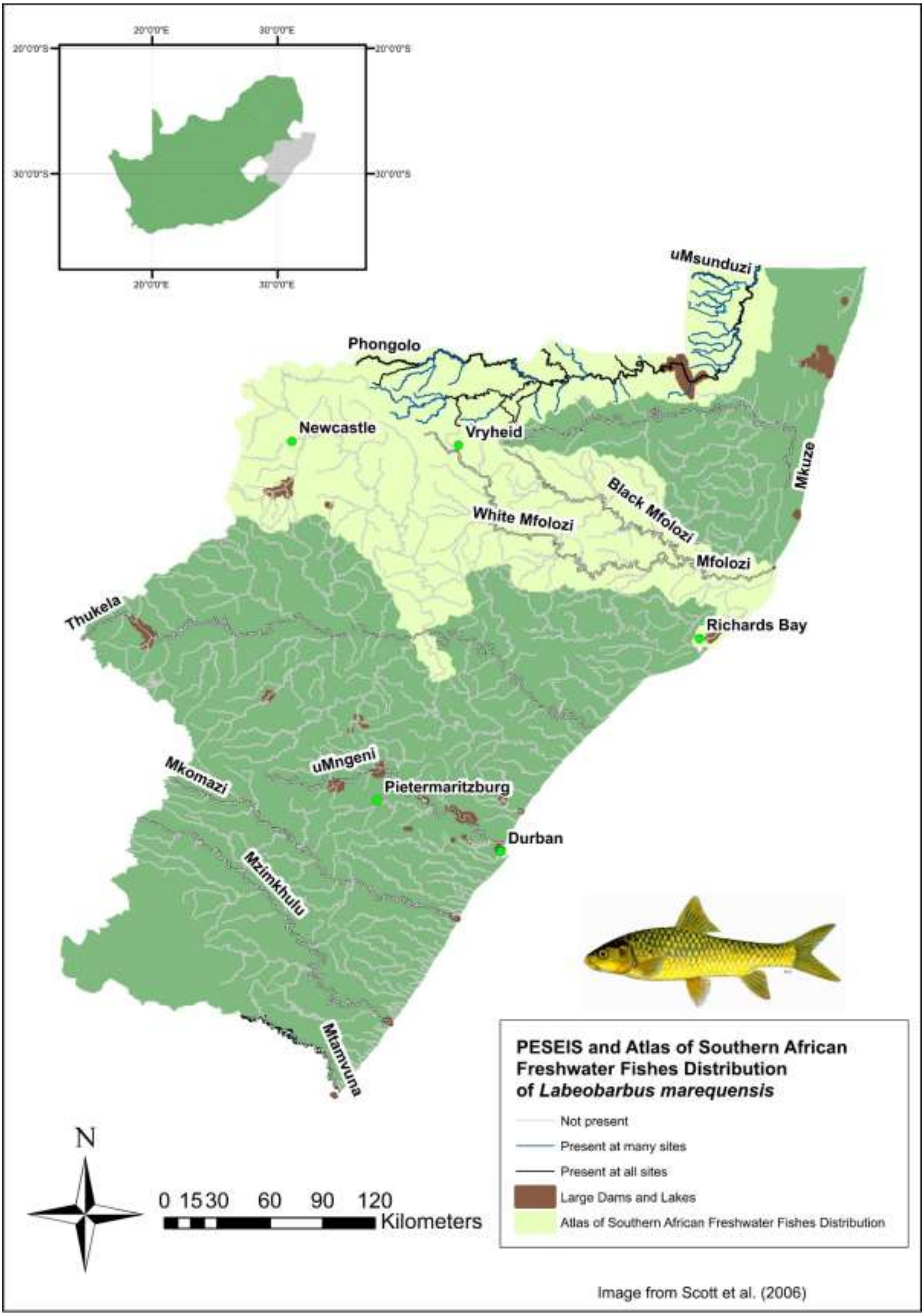
Kilometers
Image from Scott et al. (2006)



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PESEIS and Atlas of Southern African Freshwater Fishes Distribution of *Labeobarbus marequensis*
Not present
Present at many sites
Present at all sites
Large Dams and Lakes
Atlas of Southern African Freshwater Fishes Distribution
N
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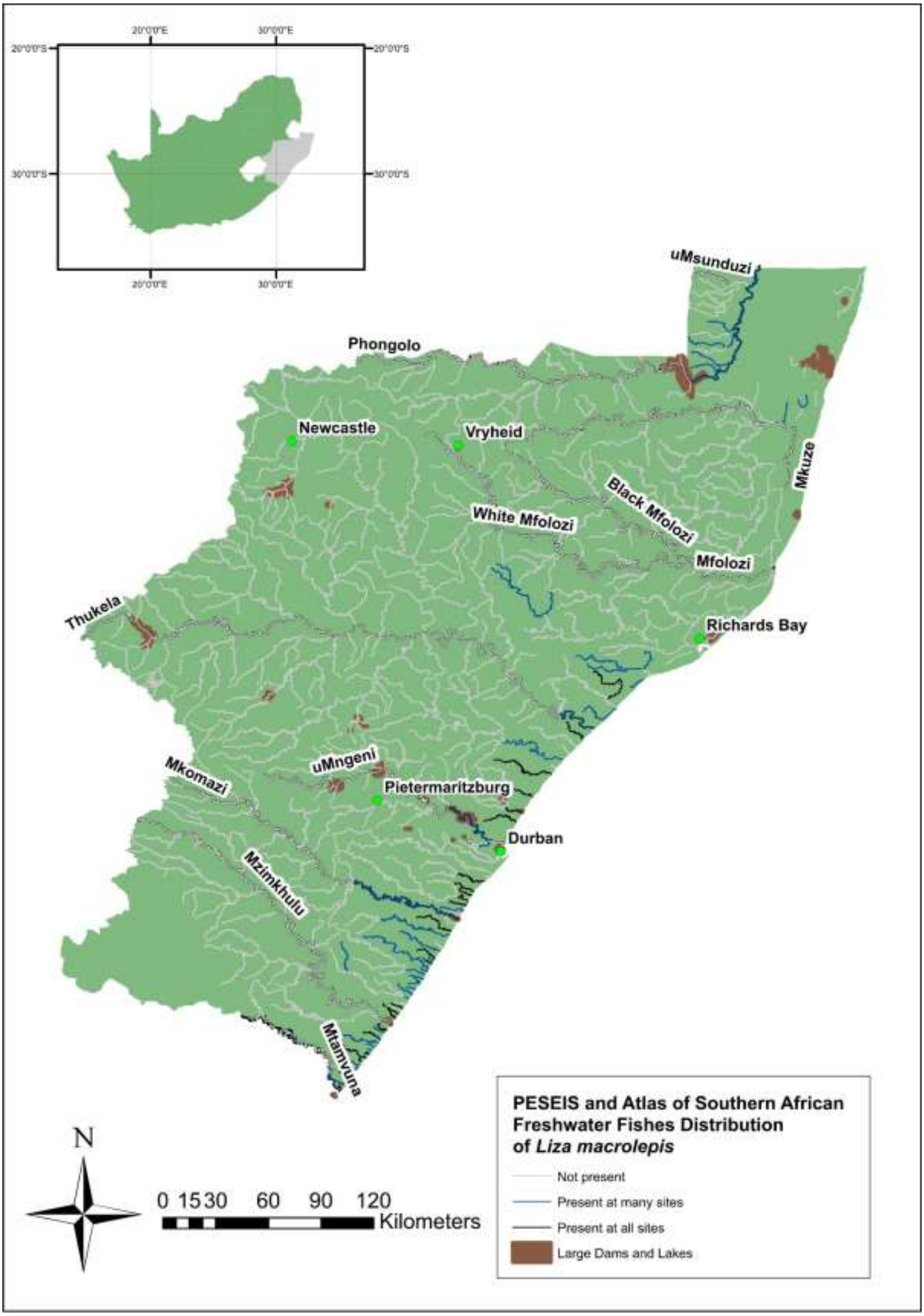
Kilometers
Image from Scott et al. (2006)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PESEIS and Atlas of Southern African Freshwater Fishes Distribution of Liza macrolepis
Not present
Present at many sites
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Large Dams and Lakes
N
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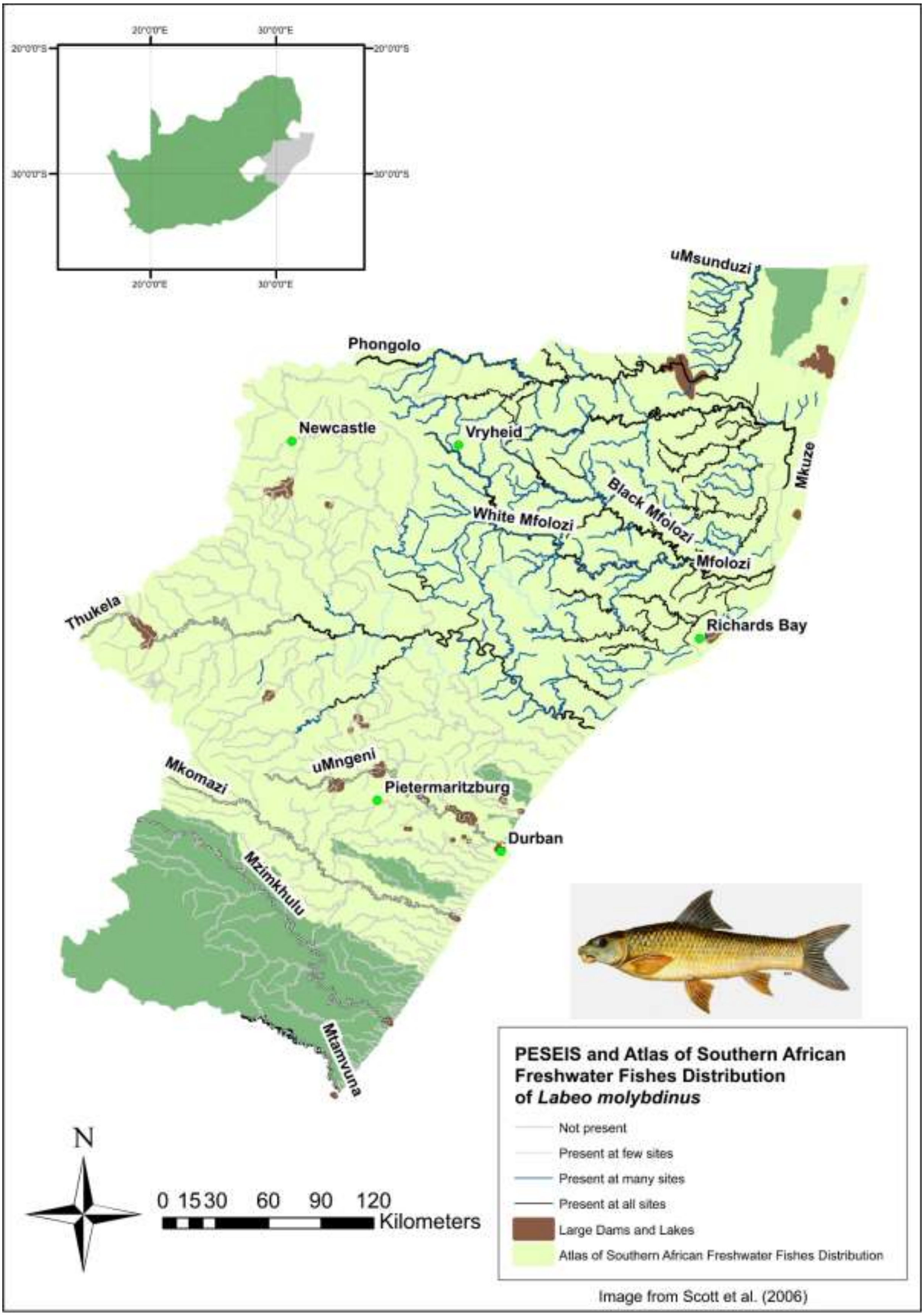
Kilometers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PESEIS and Atlas of Southern African Freshwater Fishes Distribution of *Labeo molybdinus*
Not present
Present at few sites
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Large Dams and Lakes
Atlas of Southern African Freshwater Fishes Distribution
N
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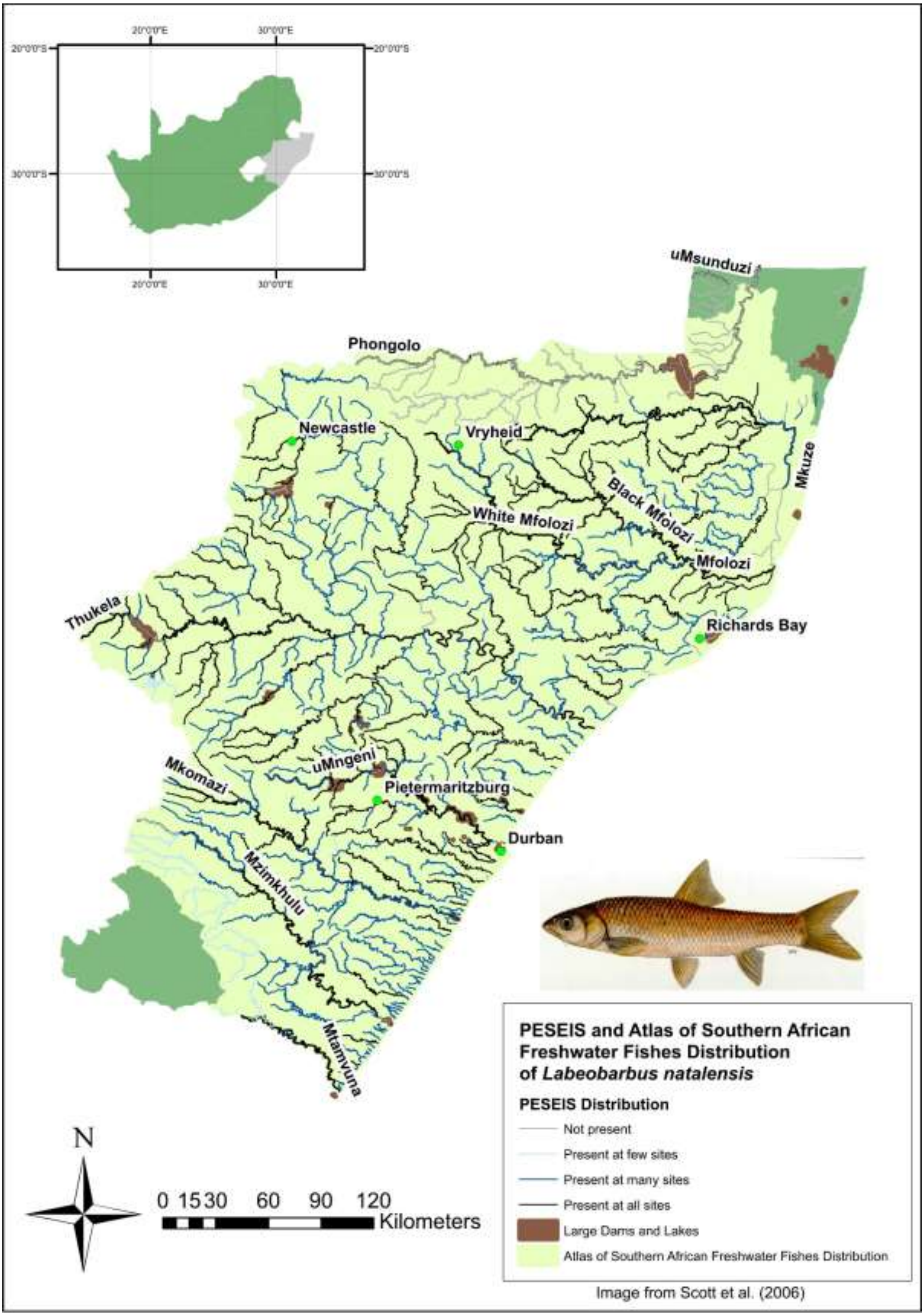
Kilometers
Image from Scott et al. (2006)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Mtamvuna
N
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Kilometers
PESEIS and Atlas of Southern African Freshwater Fishes Distribution of *Labeobarbus natalensis*
PESEIS Distribution
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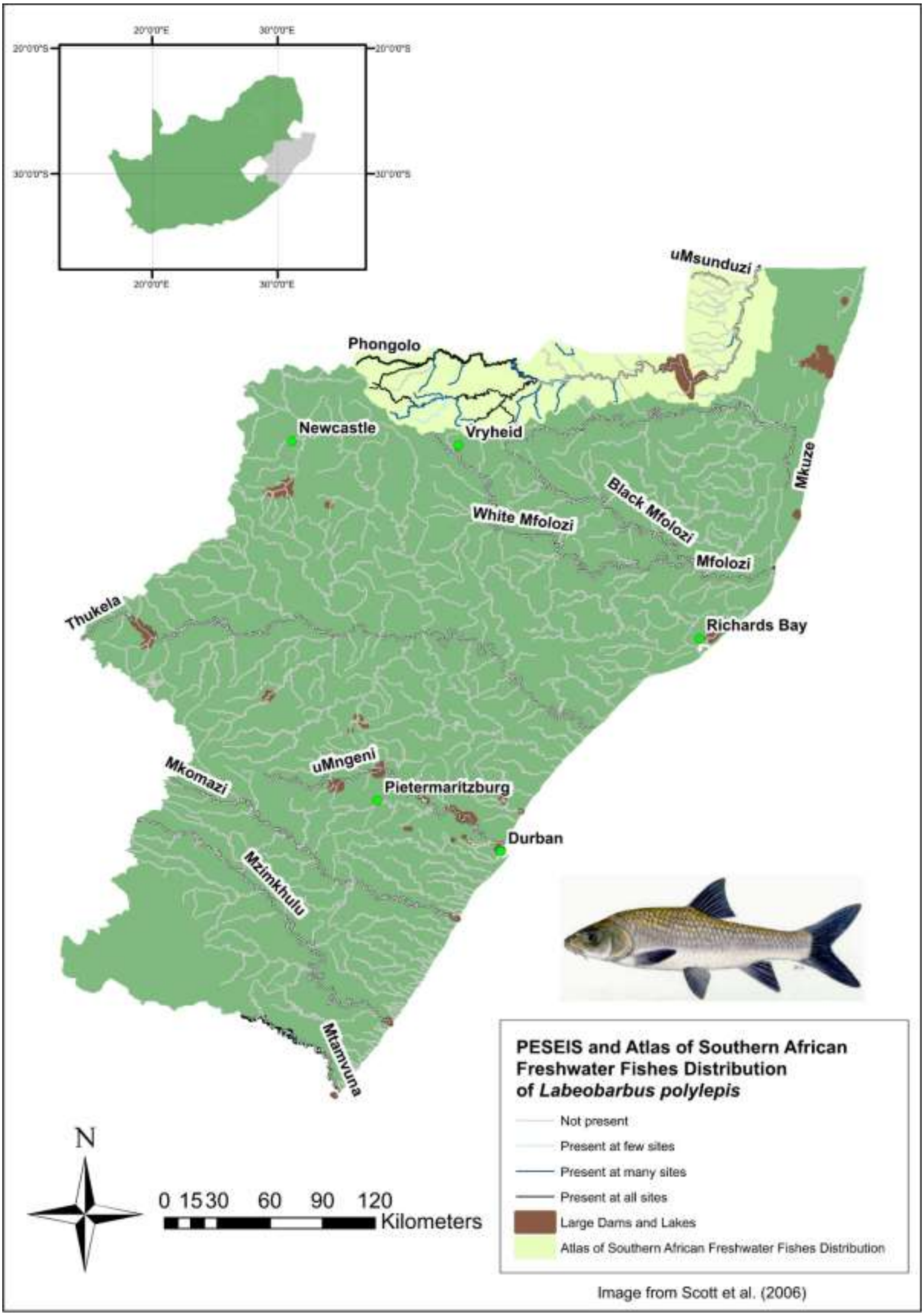
Present at many sites
Present at all sites
Large Dams and Lakes
Atlas of Southern African Freshwater Fishes Distribution
Image from Scott et al. (2006)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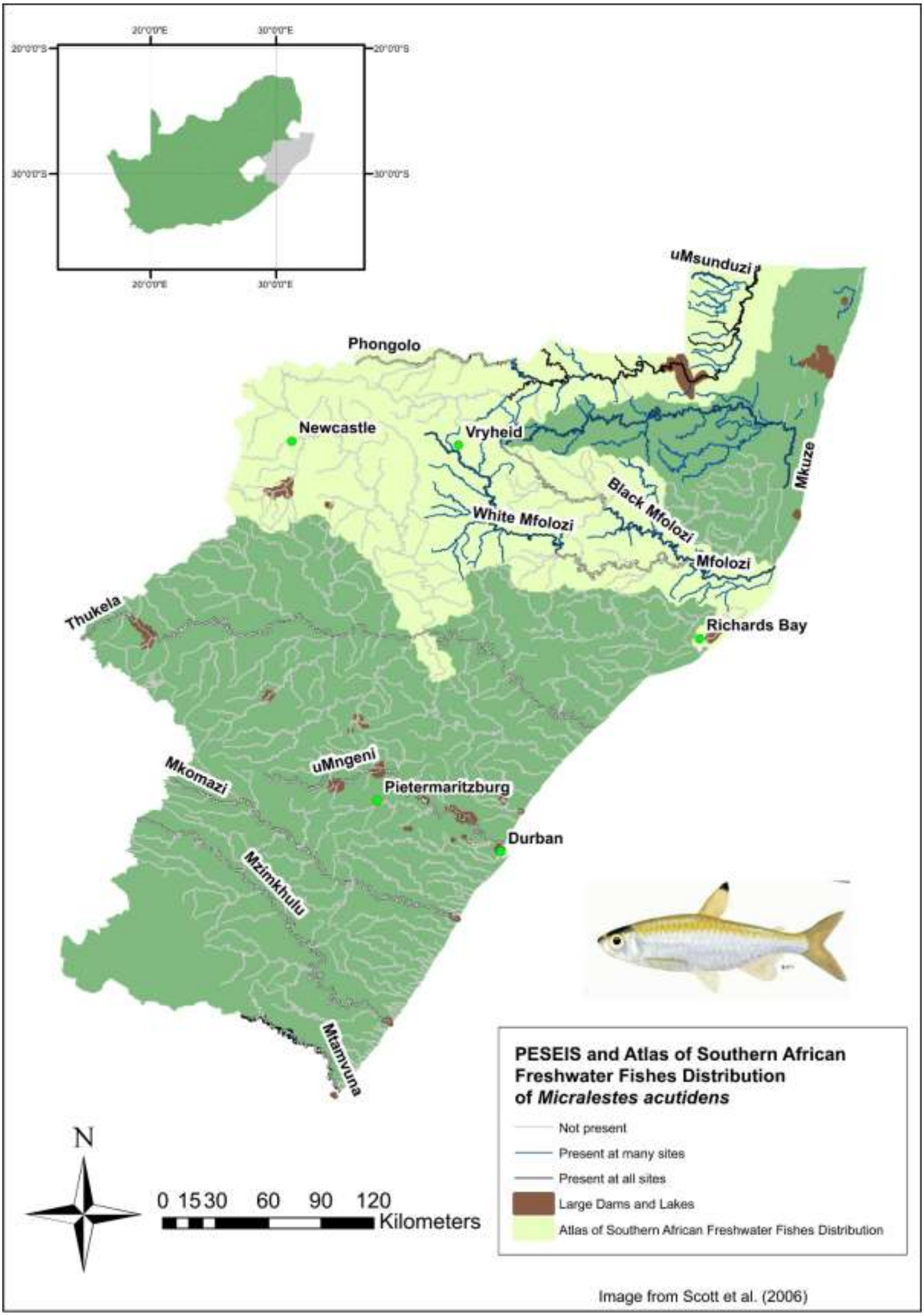
Mtamvuna
N
0 15 30 60 90 120
Kilometers
PESEIS and Atlas of Southern African Freshwater Fishes Distribution of *Labeobarbus polylepis*
Not present
Present at few sites
Present at many sites
Present at all sites
Large Dams and Lakes
Atlas of Southern African Freshwater Fishes Distribution
Image from Scott et al. (2006)



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PESEIS and Atlas of Southern African Freshwater Fishes Distribution of *Micralestes acutidens*
Not present
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Large Dams and Lakes
Atlas of Southern African Freshwater Fishes Distribution
N
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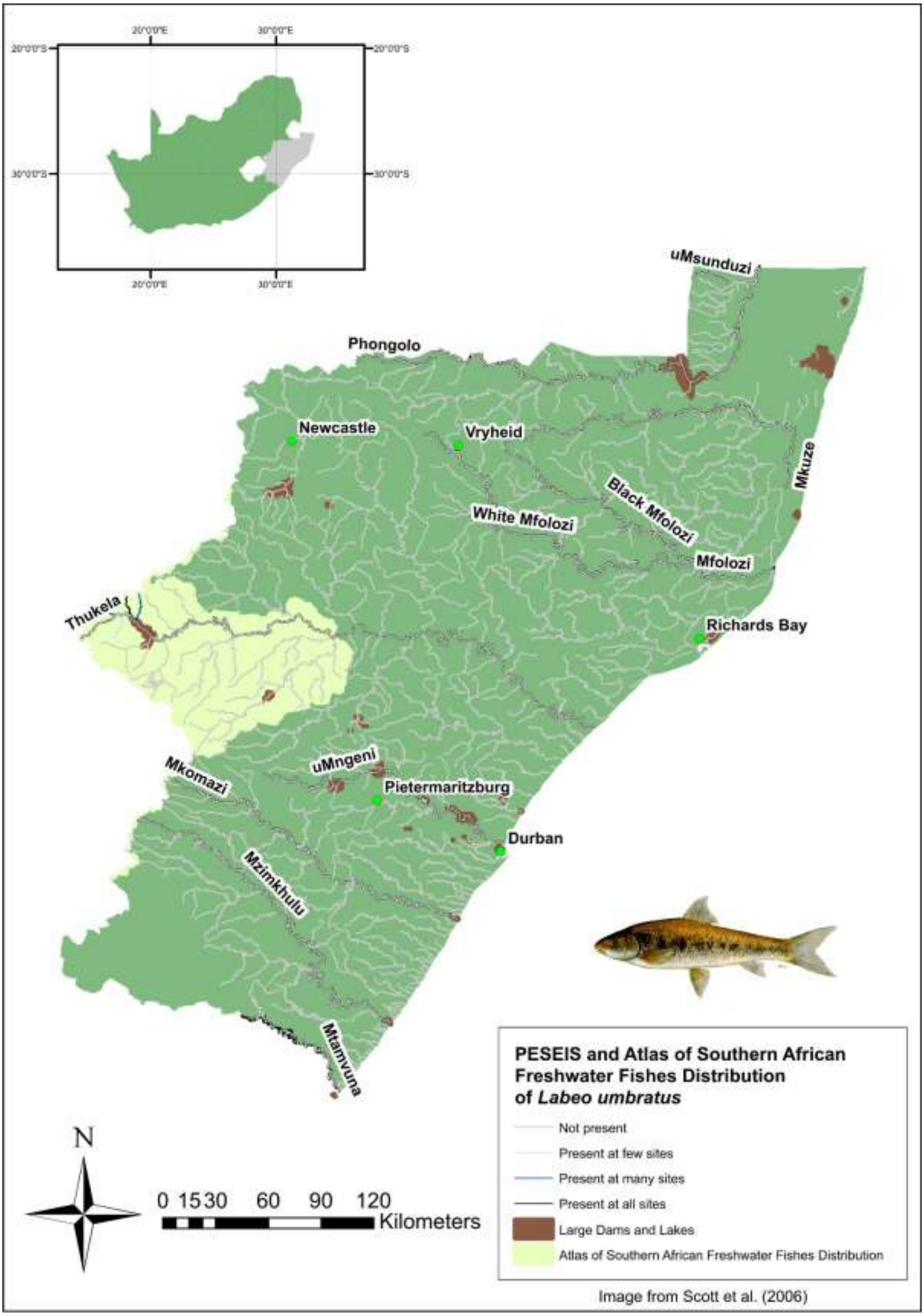
Kilometers
Image from Scott et al. (2006)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PESEIS and Atlas of Southern African Freshwater Fishes Distribution of *Labeo umbratus*
Not present
Present at few sites
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Large Dams and Lakes
Atlas of Southern African Freshwater Fishes Distribution
N
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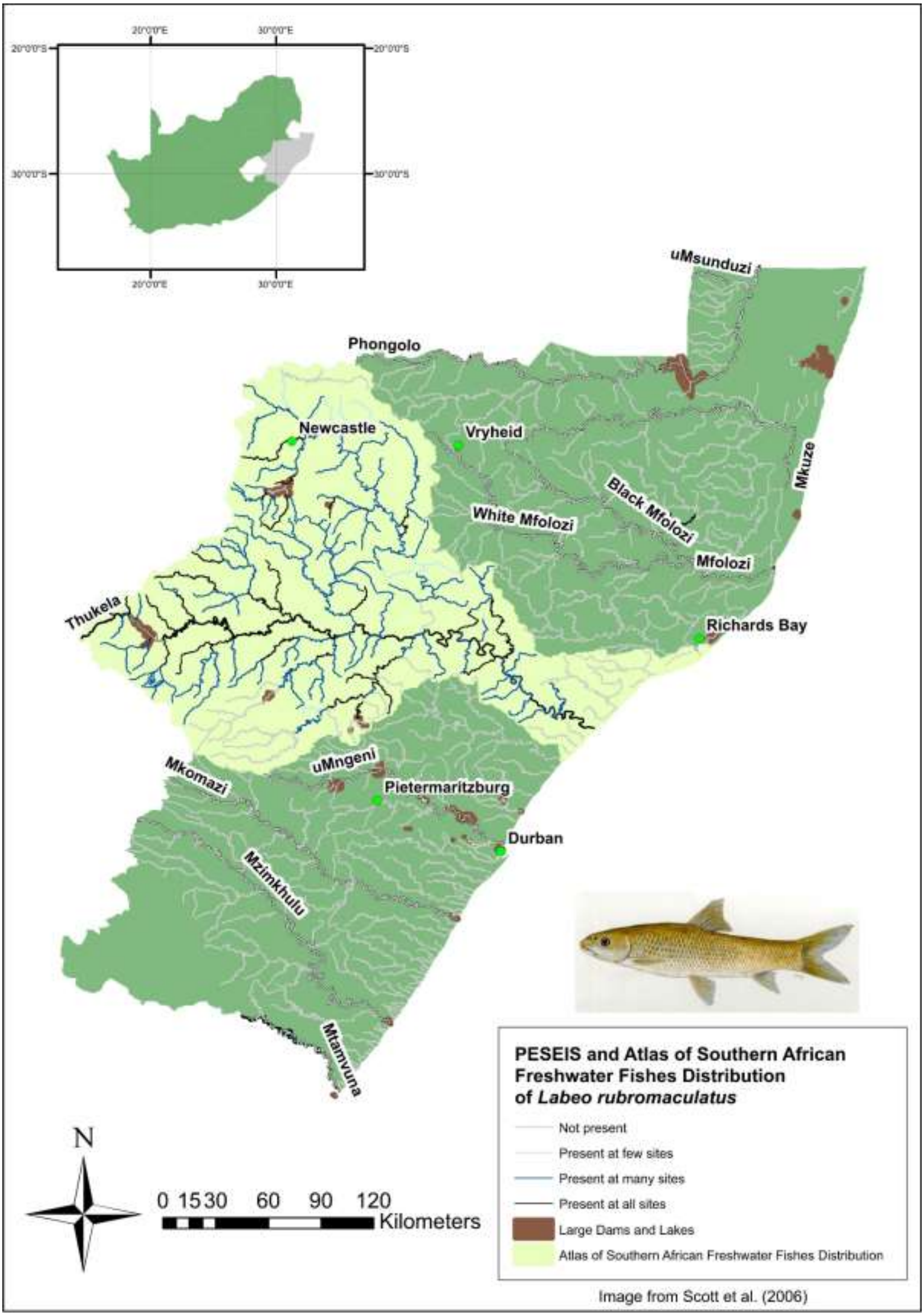
Kilometers
Image from Scott et al. (2006)



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PESEIS and Atlas of Southern African Freshwater Fishes Distribution of *Labeo rubromaculatus*
Not present
Present at few sites
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Present at all sites
Large Dams and Lakes
Atlas of Southern African Freshwater Fishes Distribution
N
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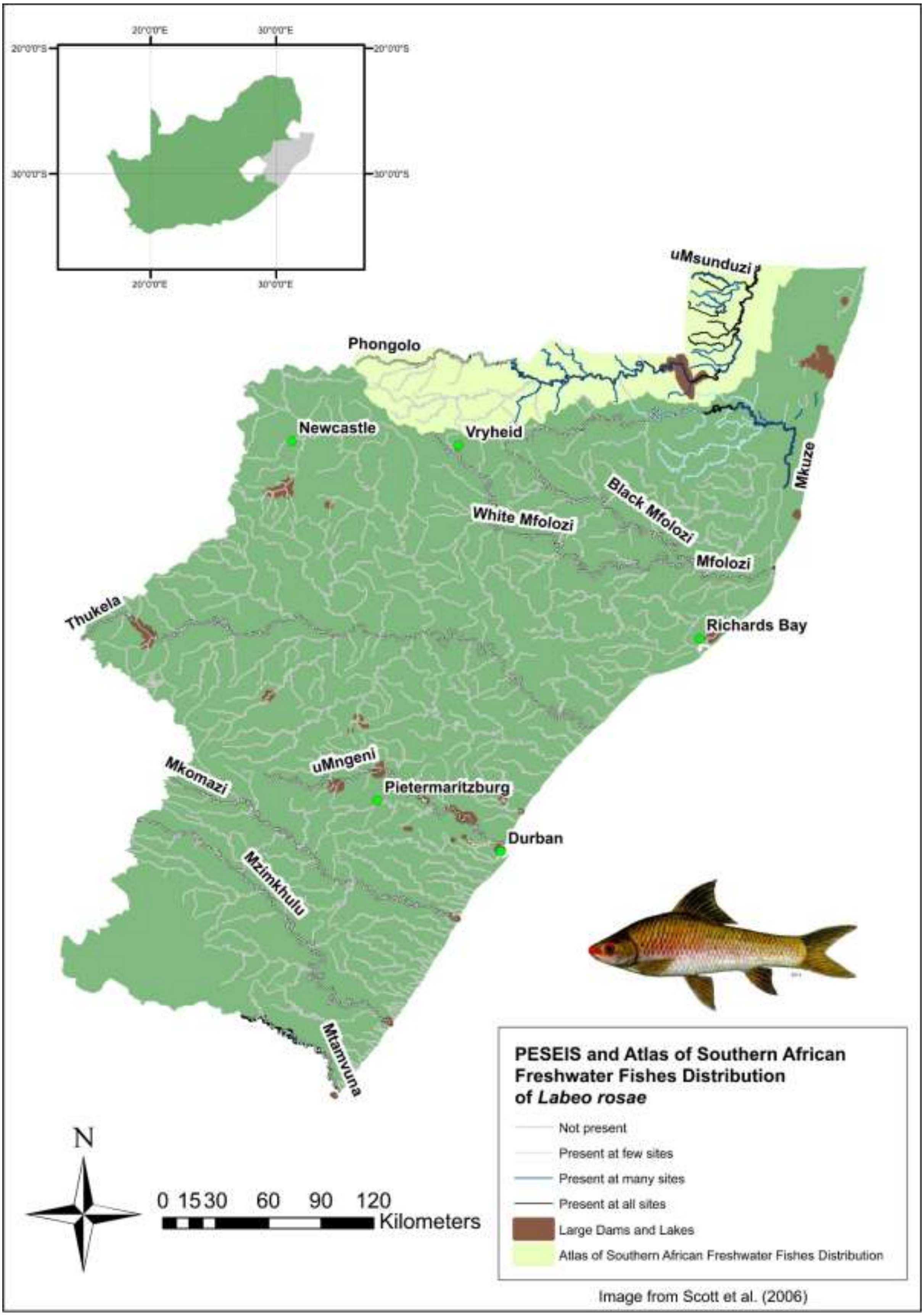
Kilometers
Image from Scott et al. (2006)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PESEIS and Atlas of Southern African Freshwater Fishes Distribution of *Labeo rosae*
Not present
Present at few sites
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Large Dams and Lakes
Atlas of Southern African Freshwater Fishes Distribution
N
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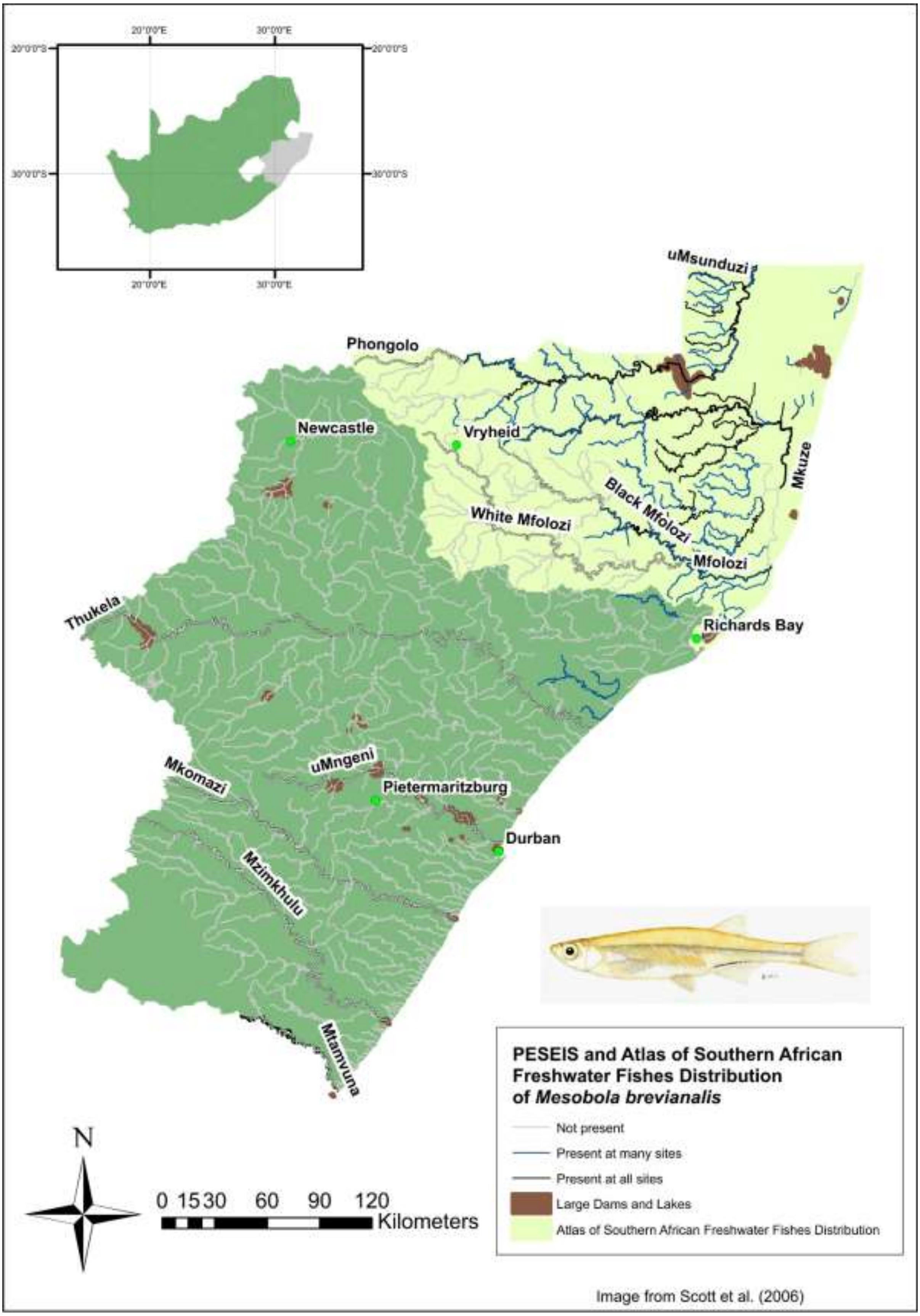
Kilometers
Image from Scott et al. (2006)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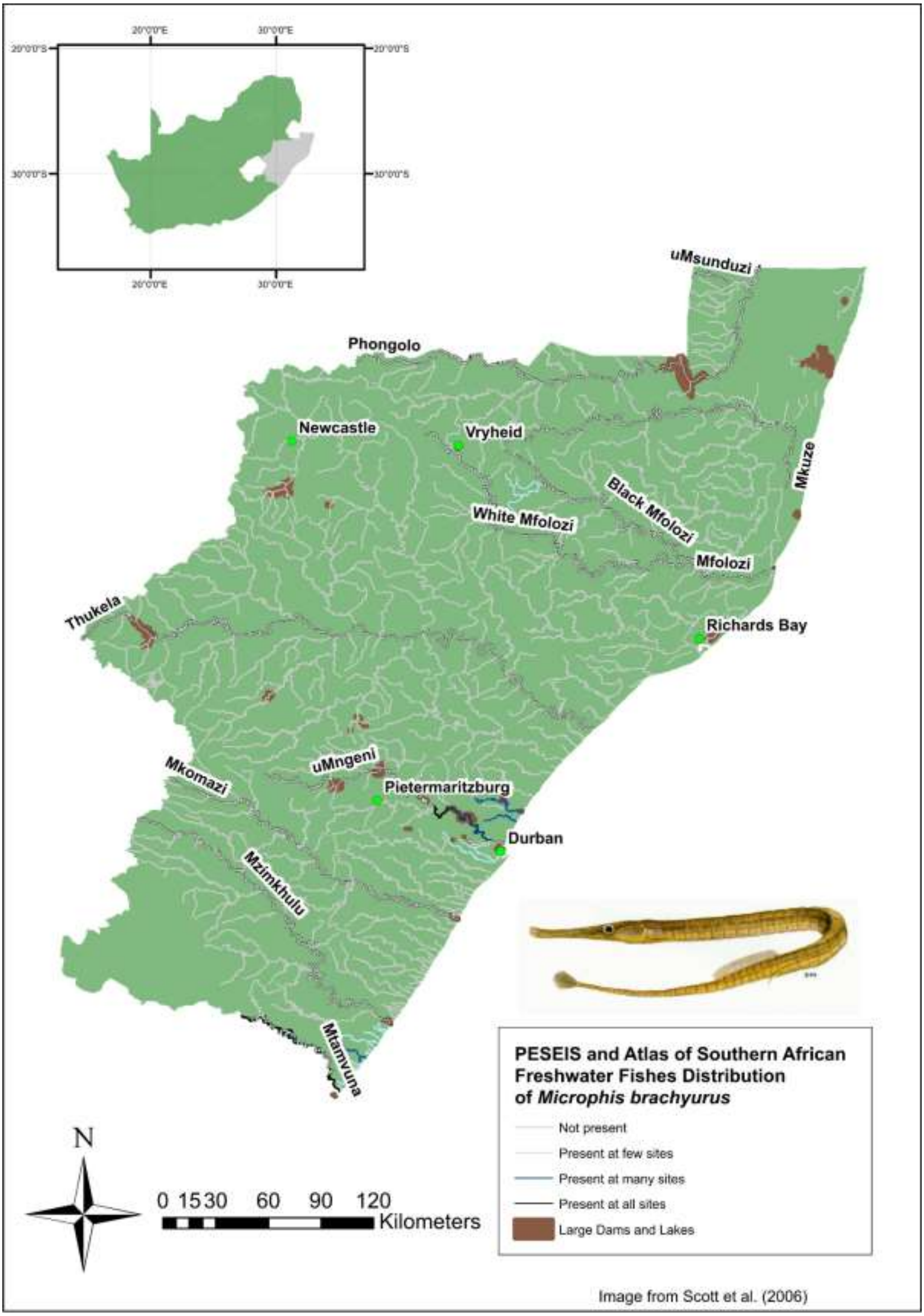
Mtamvuna
PESEIS and Atlas of Southern African Freshwater Fishes Distribution of *Mesobola brevianalis*
Not present
Present at many sites
Present at all sites
Large Dams and Lakes
Atlas of Southern African Freshwater Fishes Distribution
N
0 15 30 60 90 120
Kilometers
Image from Scott et al. (2006)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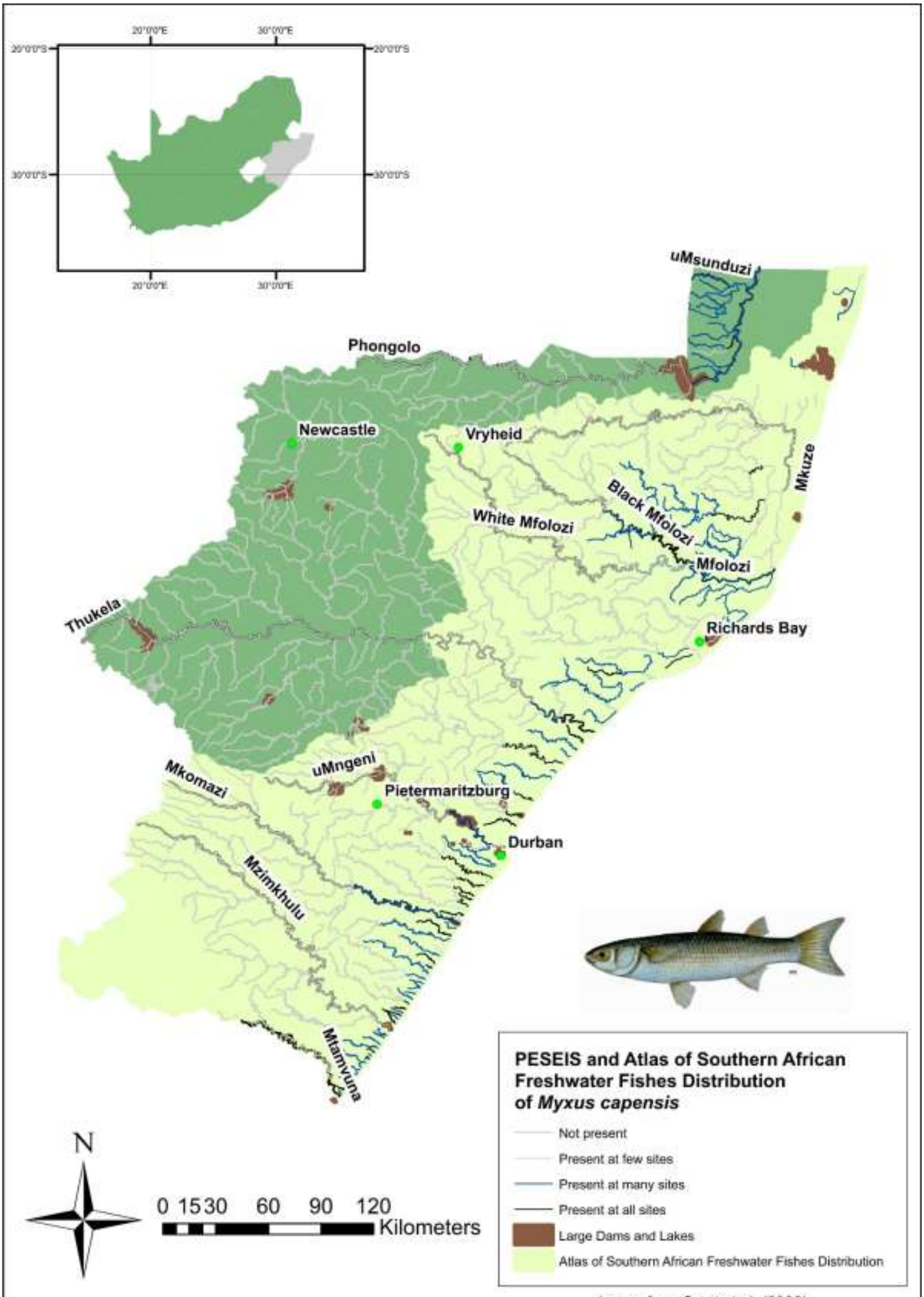
PESEIS and Atlas of Southern African Freshwater Fishes Distribution of *Microphis brachyurus*
Not present
Present at few sites
Present at many sites
Present at all sites
Large Dams and Lakes
N
0 15 30 60 90 120
Kilometers
Image from Scott et al. (2006)



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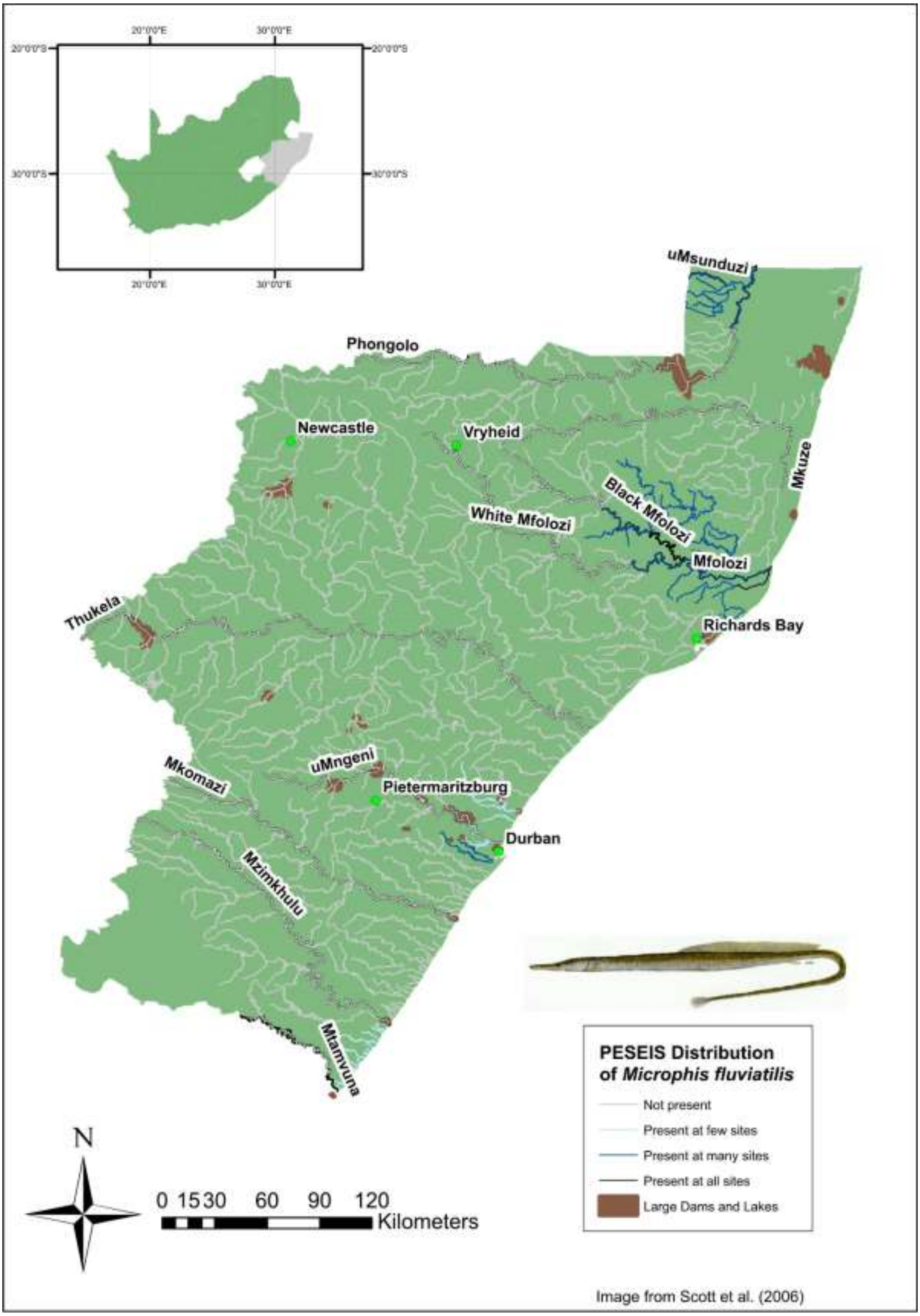

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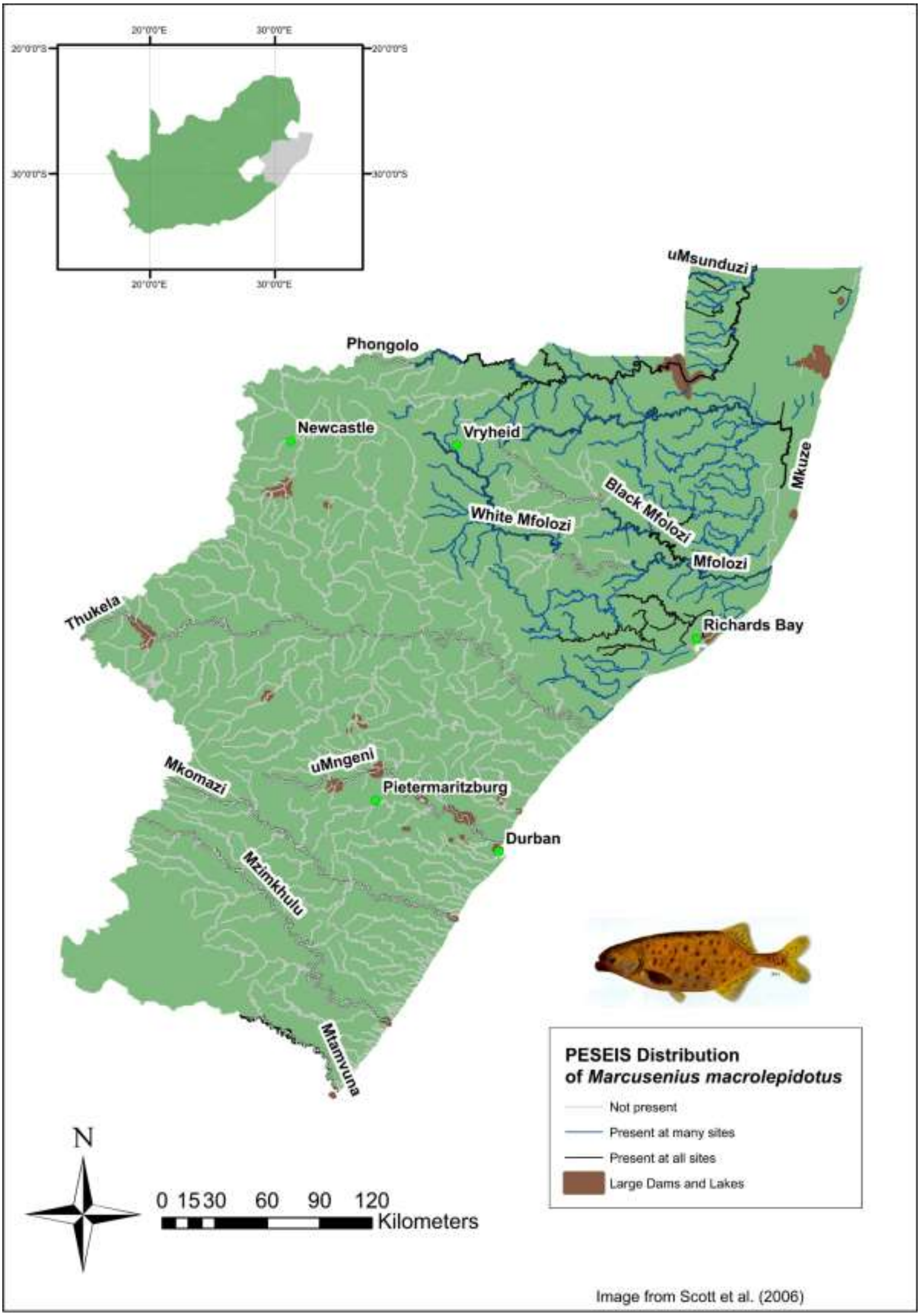
PESEIS Distribution
of *Microphis fluviatilis*
Not present
Present at few sites
Present at many sites
Present at all sites
Large Dams and Lakes
N
0 15 30 60 90 120
Kilometers
Image from Scott et al. (2006)



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Mtamvuna
PESEIS Distribution
of Marcusenius macrolepidotus
Not present
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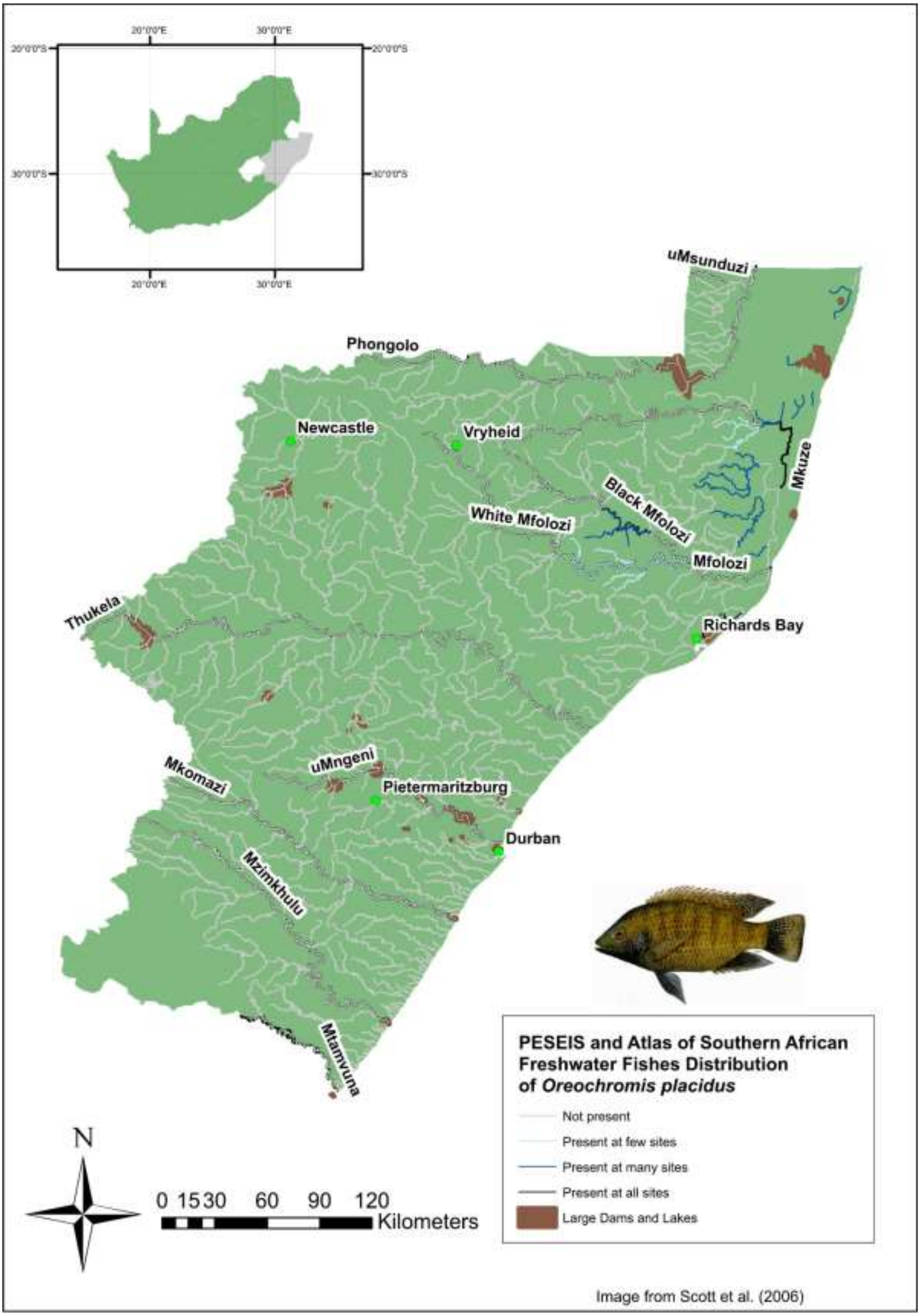
Present at all sites
Large Dams and Lakes
N
0 15 30 60 90 120
Kilometers
Image from Scott et al. (2006)



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PESEIS and Atlas of Southern African Freshwater Fishes Distribution of *Oreochromis placidus*
Not present
Present at few sites
Present at many sites
Present at all sites
Large Dams and Lakes
N
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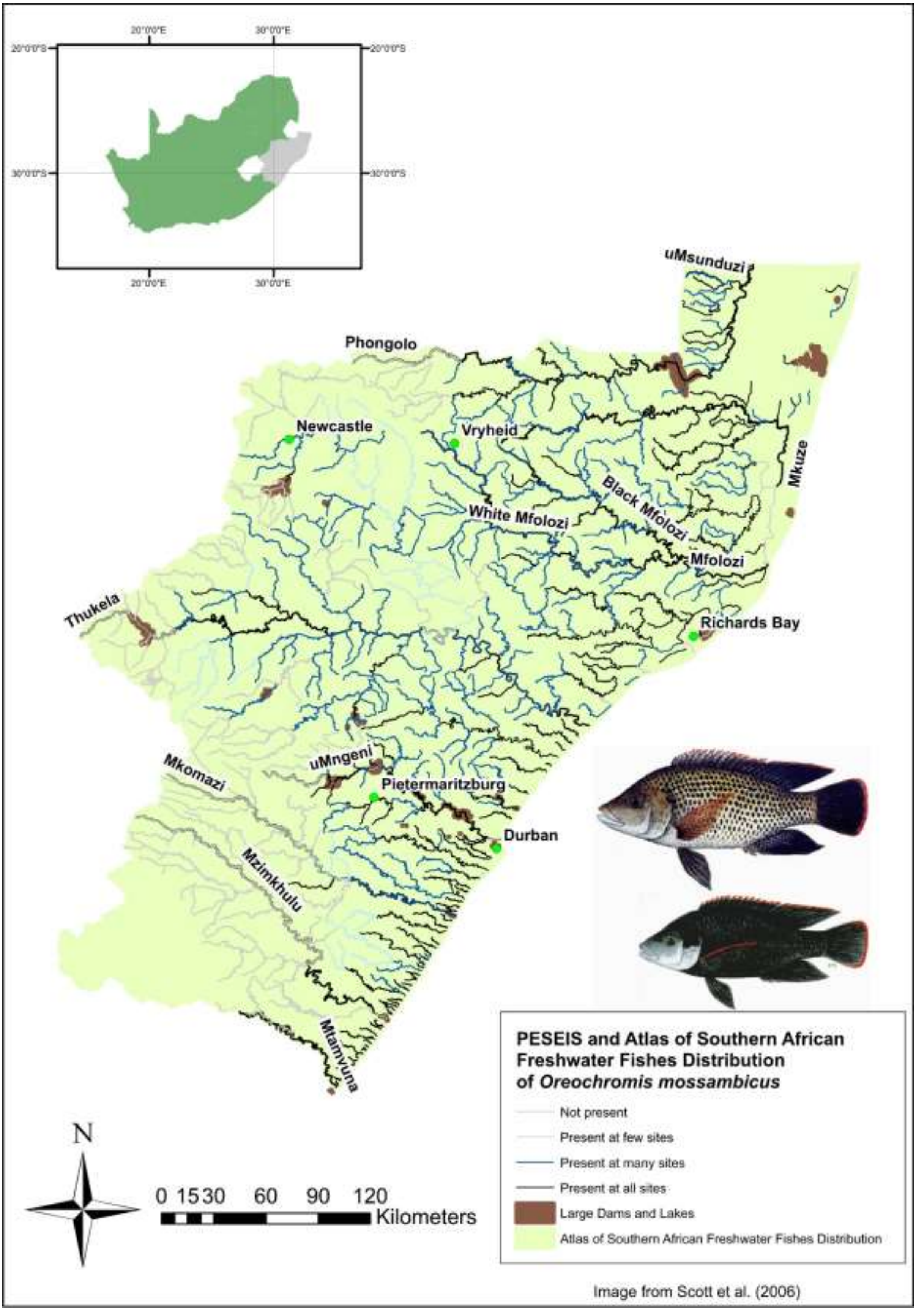
Kilometers
Image from Scott et al. (2006)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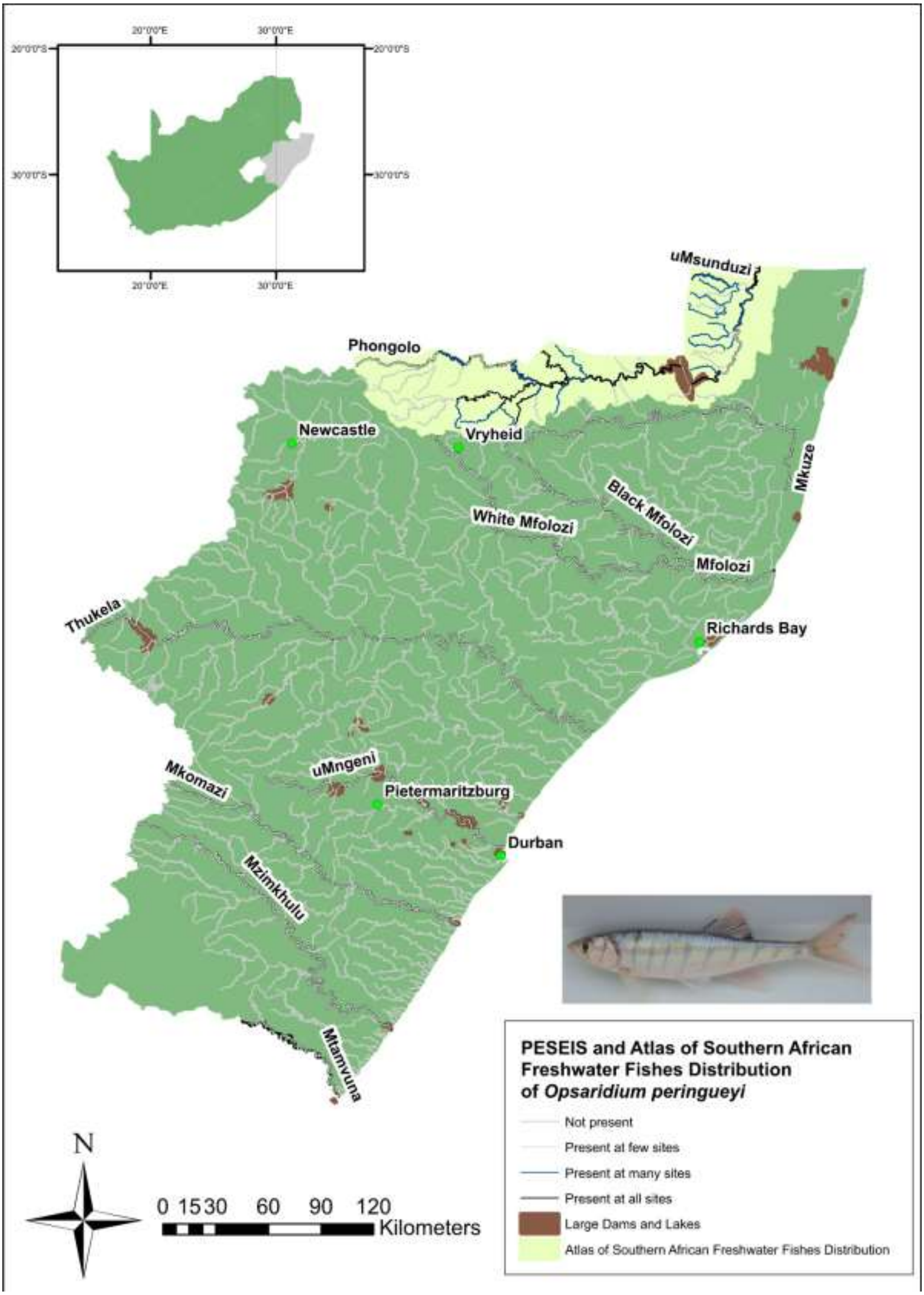
PESEIS and Atlas of Southern African
Freshwater Fishes Distribution
of Oreochromis mossambicus
Not present
Present at few sites
Present at many sites
Present at all sites
Large Dams and Lakes
Atlas of Southern African Freshwater Fishes Distribution
N
0 15 30 60 90 120
Kilometers
Image from Scott et al. (2006)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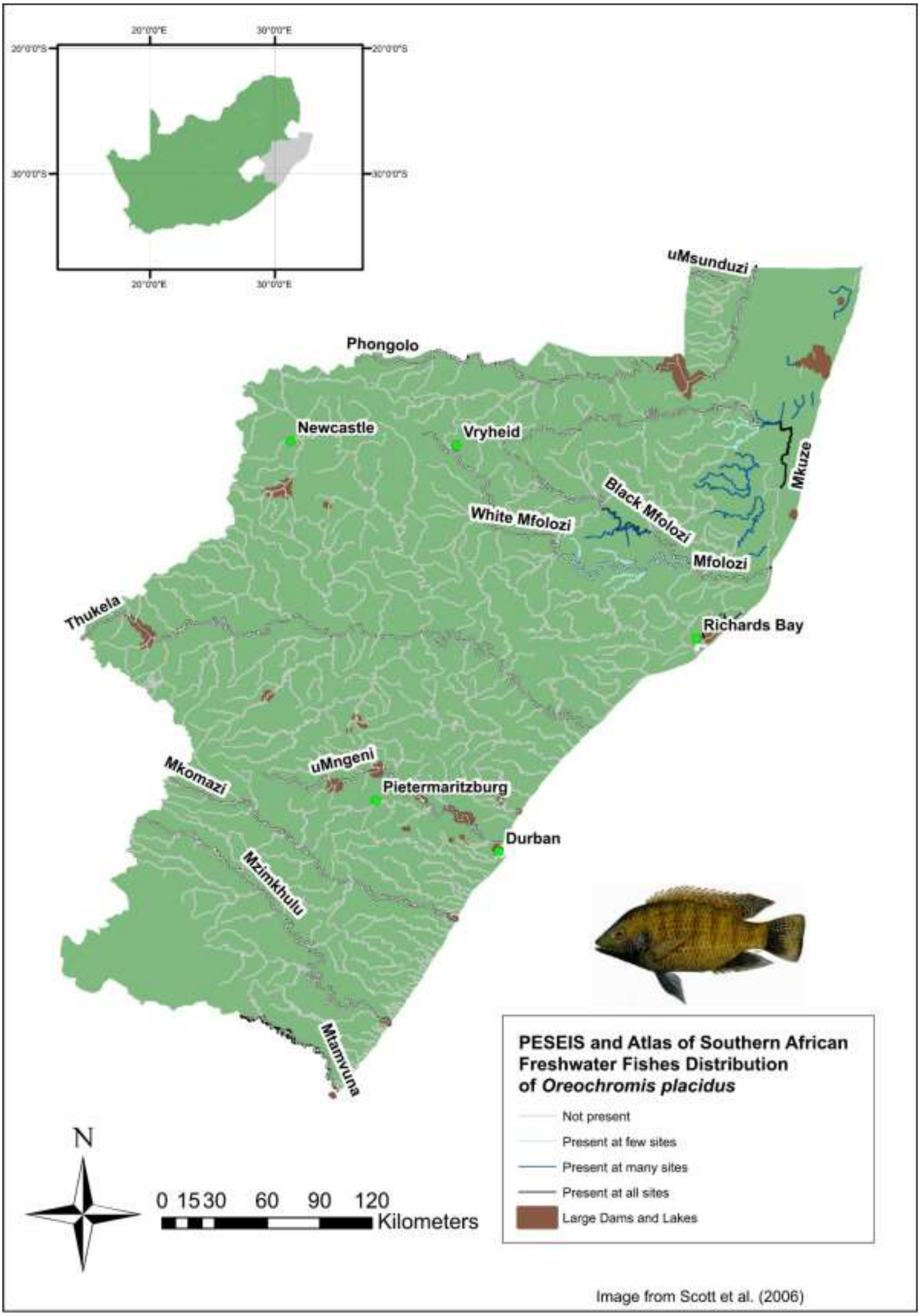
Black Mfolozi
White Mfolozi
Mfolozi
Thukela
Richards Bay
uMngeni
Mkomazi
Pietermaritzburg
Durban
Mzimkhulu
Mtamvuna
PESEIS and Atlas of Southern African
Freshwater Fishes Distribution
of *Opsaridium peringueyi*
Not present
Present at few sites
Present at many sites
Present at all sites
Large Dams and Lakes
Atlas of Southern African Freshwater Fishes Distribution
N
0 15 30 60 90 120
Kilometers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Pietermaritzburg
Durban
Mzimkhulu
Mtamvuna
PESEIS and Atlas of Southern African Freshwater Fishes Distribution of *Oreochromis placidus*
Not present
Present at few sites
Present at many sites
Present at all sites
Large Dams and Lakes
N
0 15 30 60 90 120
Kilometers
Image from Scott et al. (2006)

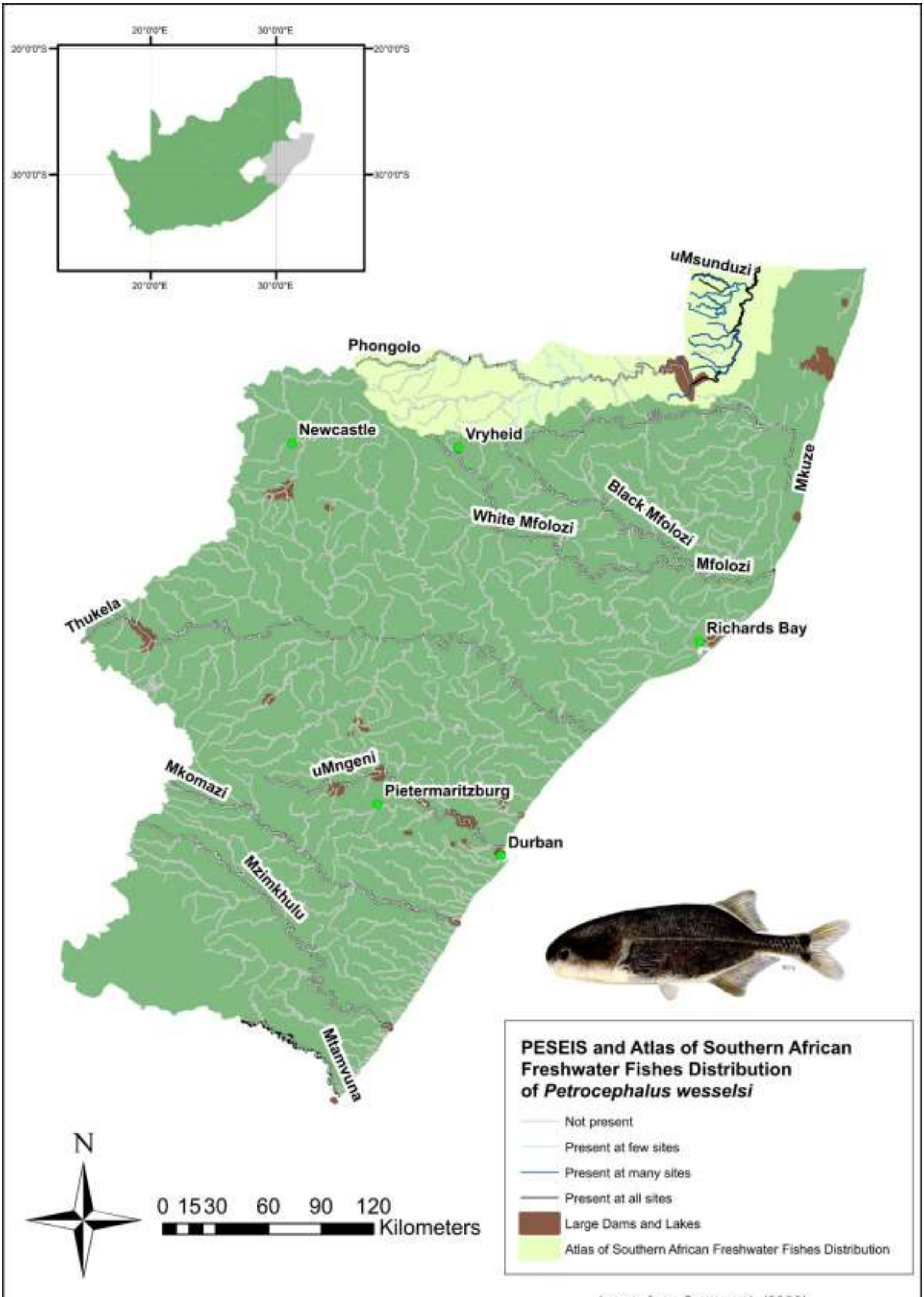
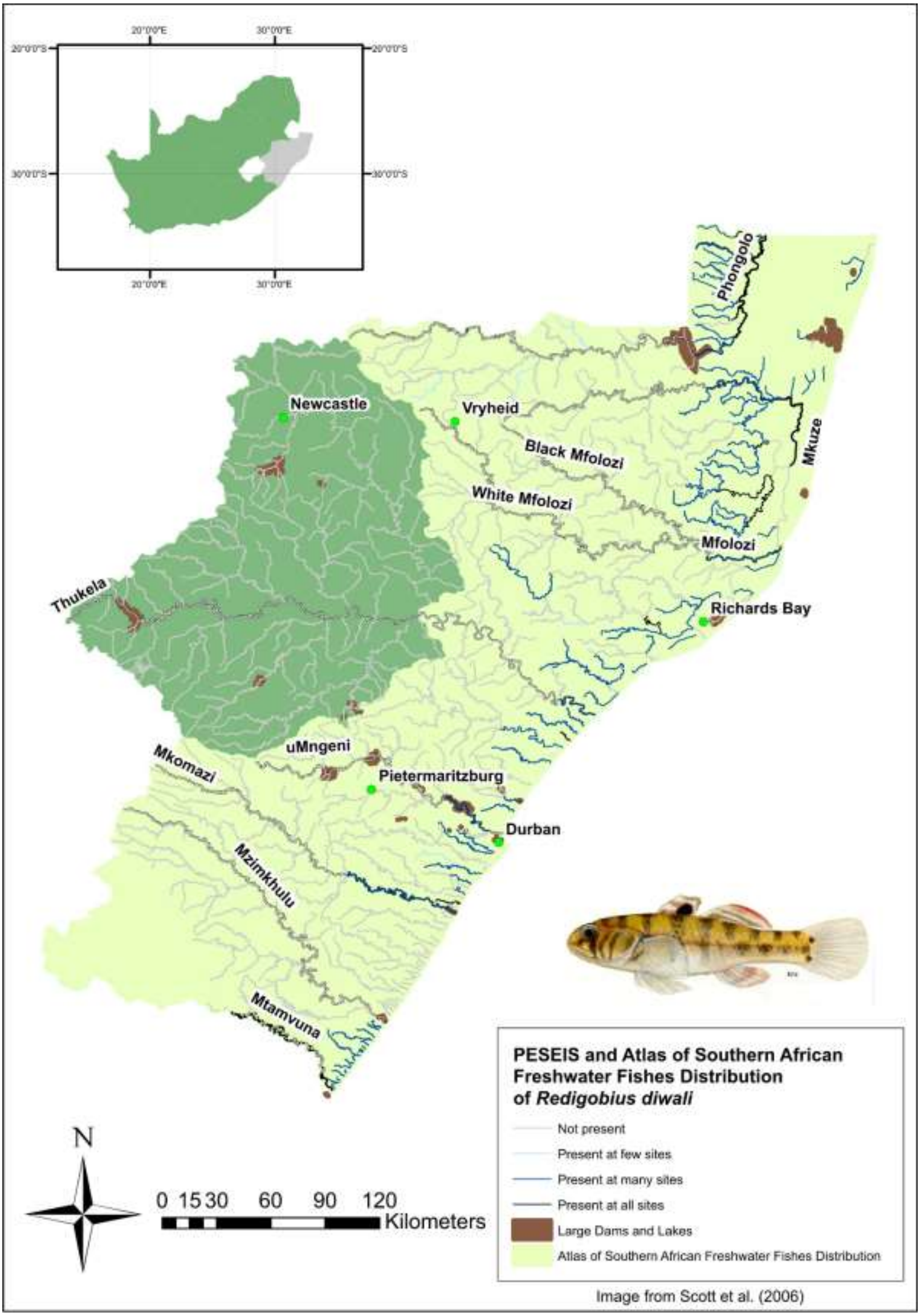


Image from Scott et al. (2006)



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Durban
Mzimkhulu
Mtamvuna
PESEIS and Atlas of Southern African Freshwater Fishes Distribution of Redigobius diwali
Not present
Present at few sites
Present at many sites
Present at all sites
Large Dams and Lakes
Atlas of Southern African Freshwater Fishes Distribution
N
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Kilometers
Image from Scott et al. (2006)

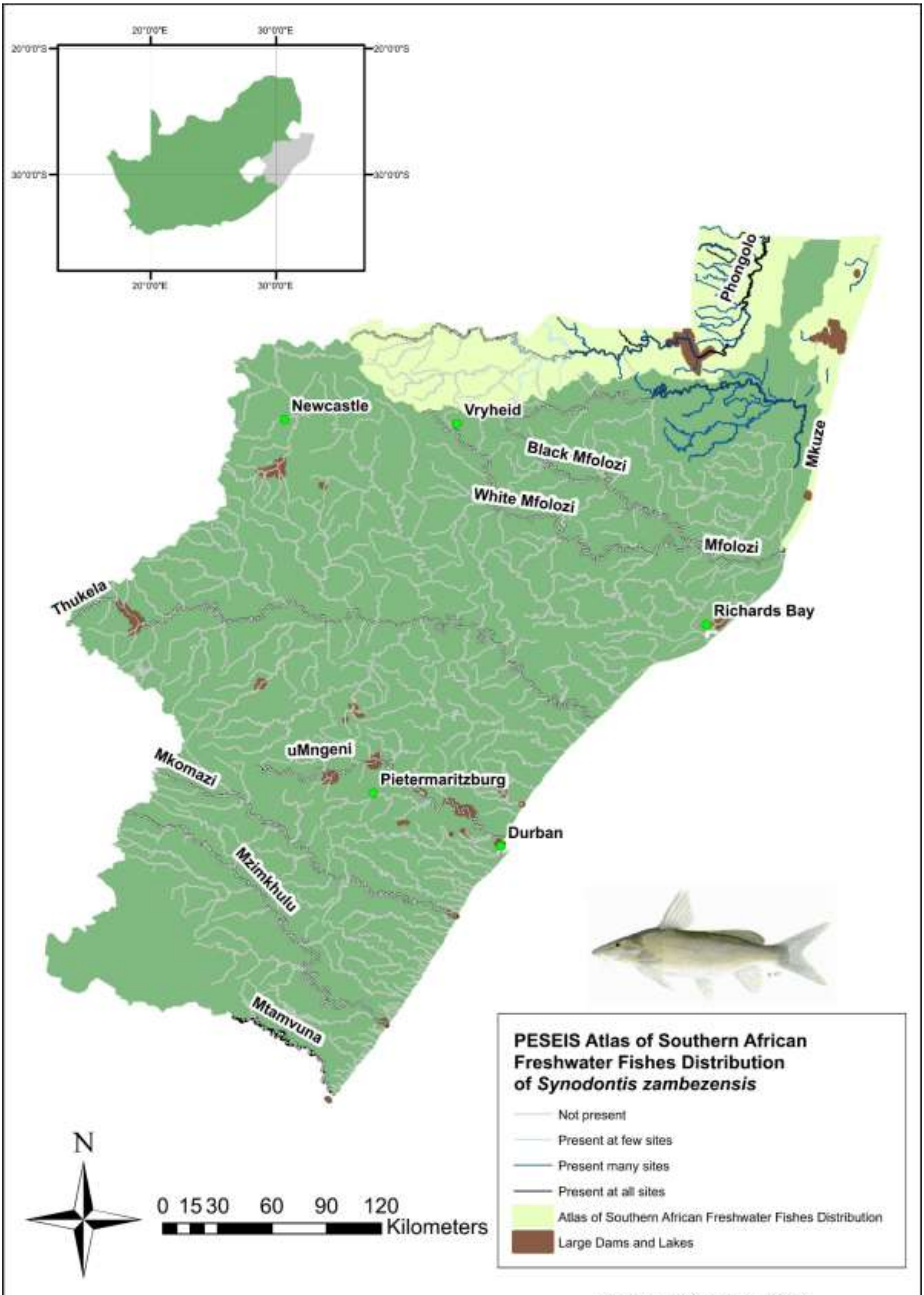
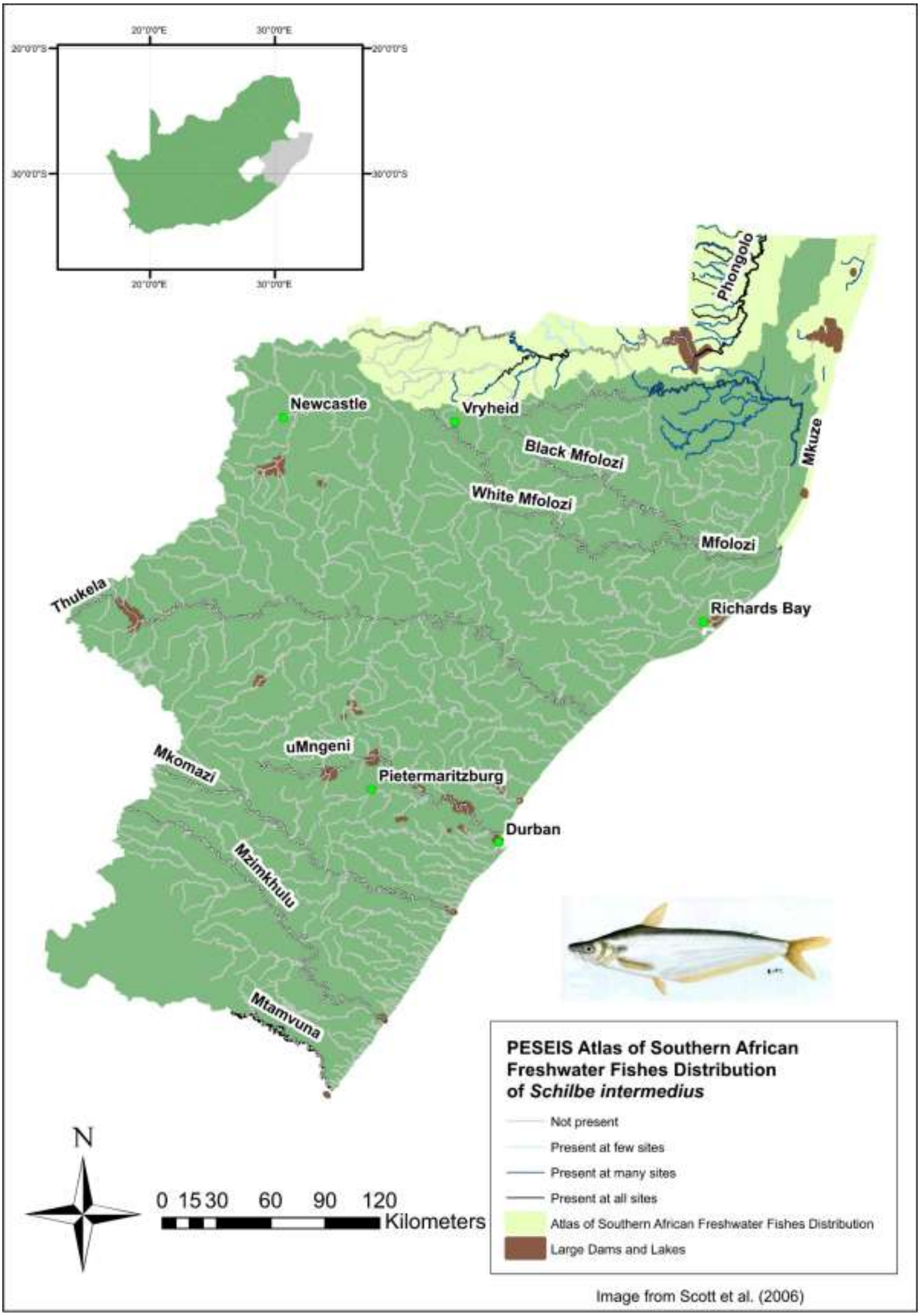


Image from Scott et al. (2006)



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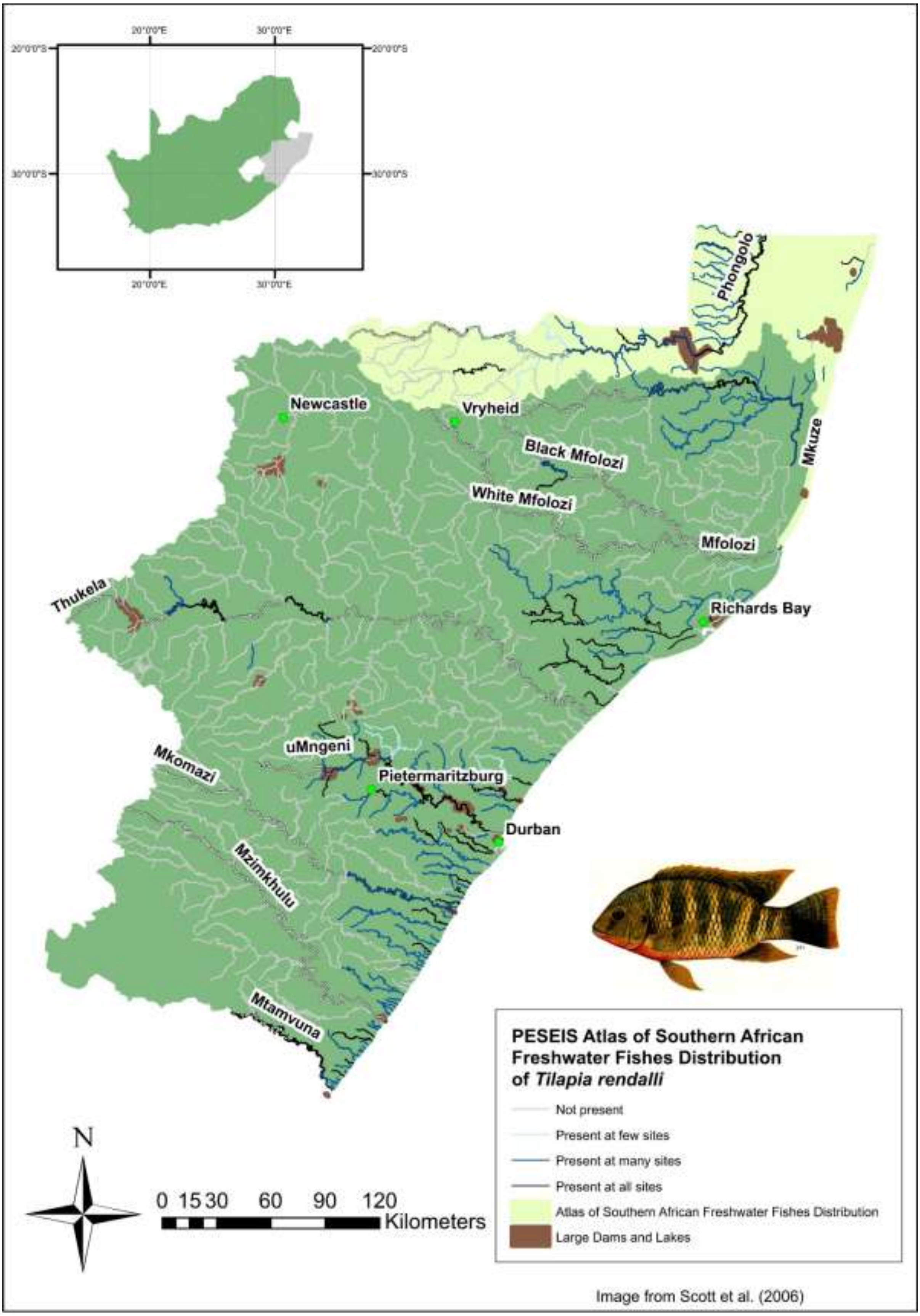
Mkomazi
Pietermaritzburg
Durban
Mzimkhulu
Mtamvuna
PESEIS Atlas of Southern African Freshwater Fishes Distribution of *Schilbe intermedius*
Not present
Present at few sites
Present at many sites
Present at all sites
Atlas of Southern African Freshwater Fishes Distribution
Large Dams and Lakes
N
0 15 30 60 90 120
Kilometers
Image from Scott et al. (2006)



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Mfolozi
Thukela
Richards Bay
uMngeni
Mkomazi
Pietermaritzburg
Durban
Mzimkhulu
Mtamvuna
PESEIS Atlas of Southern African Freshwater Fishes Distribution of Tilapia rendalli
Not present
Present at few sites
Present at many sites
Present at all sites
Atlas of Southern African Freshwater Fishes Distribution
Large Dams and Lakes
N
0 15 30 60 90 120
Kilometers
Image from Scott et al. (2006)

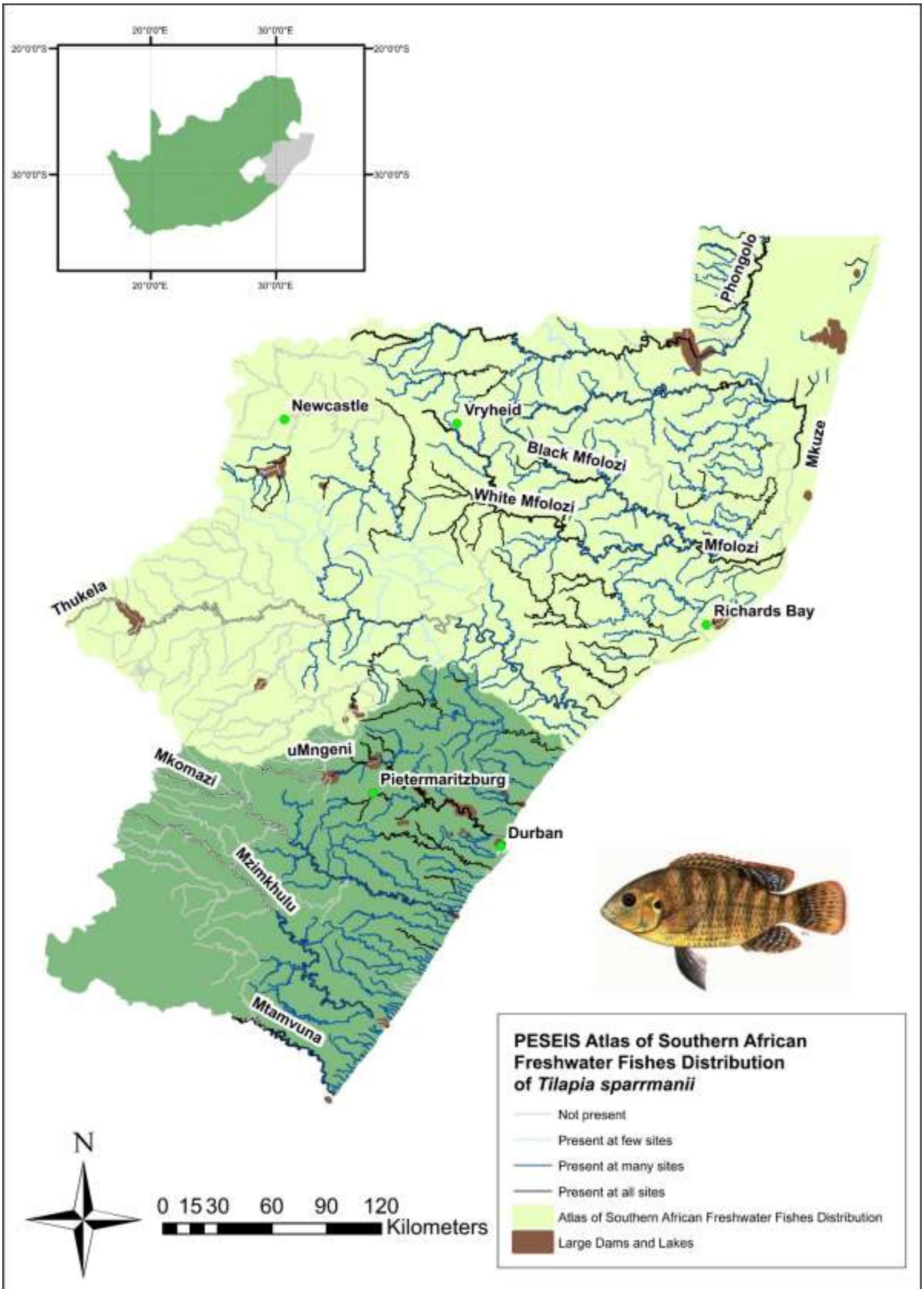
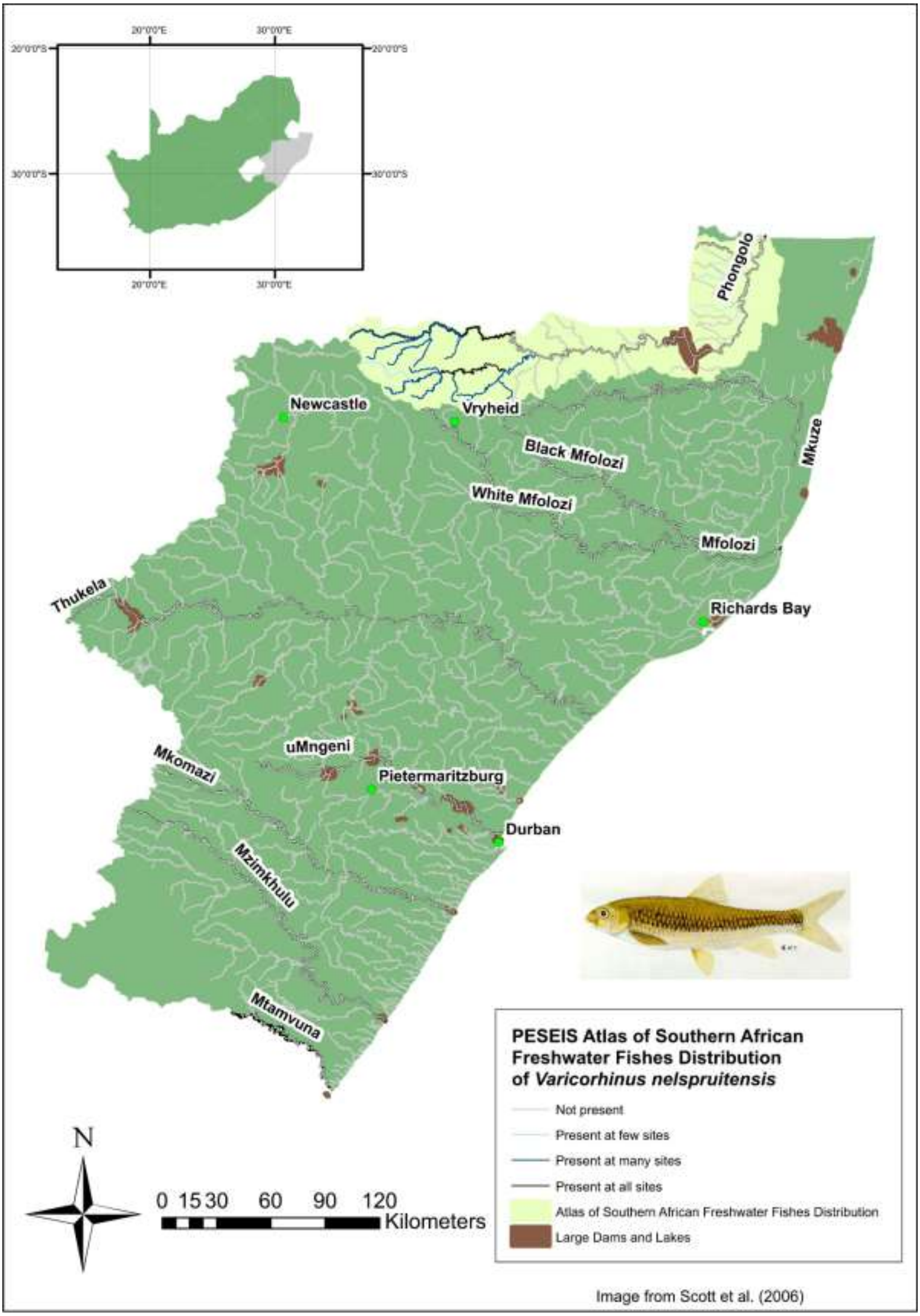


Image from Scott et al. (2006)



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White Mfolozi
Mfolozi
Thukela
Richards Bay
uMngeni
Mkomazi
Pietermaritzburg
Durban
Mzimkhulu
Mtamvuna
PESEIS Atlas of Southern African Freshwater Fishes Distribution of *Varicorhinus nelspruitensis*
Not present
Present at few sites
Present at many sites
Present at all sites
Atlas of Southern African Freshwater Fishes Distribution
Large Dams and Lakes
N
0 15 30 60 90 120
Kilometers
Image from Scott et al. (2006)

Appendix 4.2 Raw FRAI data for all 40 River Health Programme sites for four surveys during the study period in KwaZulu-Natal, South Africa

Site Name	T4MTAM-MADIK-RHP 41	**Assessor**	W Evans
River	Mtamvuna	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC			
				Su15	Au15	Sp15	Su16
AAEN	AWAOUS AENEOFUSCUS (PETERS 1852)		4.93	-	-	-	-
ABER	ACANTHOPAGRUS BERDA (FORSSKÅL, 1775)		3.64	-	-	-	-
ALAB	ANGUILLA BENGALENSIS LABIATA PETERS, 1852		3.64	-	-	-	-
AMAR	ANGUILLA MARMORATA QUOY & GAIMARD 1824		3.64	-	-	-	-
AMOS	ANGUILLA MOSSAMBICA PETERS 1852		5.00	-	-	-	-
BGUR	BARBUS GURNEYI GÜNTHER, 1868		4.93	-	-	-	-
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861		5.00	-	5	3	5
BPAL	BARBUS PALLIDUS SMITH, 1841		1.36	-	-	-	-
BPAU	BARBUS PALUDINOSUS PETERS, 1852		5.00	-	-	-	-
BVIV	BARBUS VIVIPARUS WEBER, 1897		4.93	-	-	5	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)		5.00	-	1	-	-
GCAL	GLOSSOGOBIUS CALLIDUS SMITH, 1937		3.64	-	-	-	-
GGIU	GLOSSOGOBIUS GIURIS (HAMILTON-BUCHANAN, 1822)		3.64	-	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)		5.00	-	1	-	-

PPHI	PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)	5.00	-	-	-	-
TREN	TILAPIA RENDALLI (BOULENGER, 1896)	5.00	-	-	-	-
TSPA	TILAPIA SPARRMANII SMITH, 1840	5.00	-	-	-	-
BANO	BARBUS ANOPLUS WEBER, 1897	5.00	-	1	-	3

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	-	1	3	1
	Fast-Shallow	-	1	1	1
	Slow-Deep	-	1	2	1
	Slow-Shallow	-	1	1	1
Cover features	Overhanging veg	-	2	2	2
	Undercut banks	-	2	2	2
	Substrate	-	1	1	1
	Instream veg	-	2	2	2
	Water column	-	0	0	0

	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	-	2	3	2
	Moderately intolerant to no flow	-	1	2	1
	Moderately tolerant to no flow	-	1	1	1
	Tolerant to no flow	-	1	1	1

	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	-	3	3	3
	Moderately intolerant to modified physico-chemical conditions	-	2	3	2
	Moderately tolerant to modified physico-chemical conditions	-	1	1	1
	Tolerant modified to physico-chemical conditions	-	1	1	1

	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	-	1	1	1
	Movement between reaches	-	1	1	1
	Movement within a reach	-	1	1	1
	Extent of the following in the reach	**Su15**	**Au15**	**Sp15**	**Su16**
Changes in connectivity	Weirs and causeways	-	2	2	2
	Impoundments	-	0	0	0
	Physico-chemical barriers	-	1	1	1
	Flow modifications	-	1	1	1
	Introduced/alien species	**Su15**	**Au15**	**Sp15**	**Su16**
Introduced/alien species	Introduced/alien predacious species 1	-	-	MSAL	MSAL
	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	-	-	-	-
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	-	-	2	2
	FROC of introduced competing spp?	-	-	1	1
	The impact of introduced habitat modifying spp?	-	-	0	0
	FROC of habitat modifying spp?	-	-	0	0
	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		-	39.3	30.4	36.1
EC: FRAI		-	D/E	E	E
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		-	74.4	67	73
EC: FRAI		-	C	C	C

Site Name	T5MZIM-NYAMA-RHP 42	**Assessor**	W Evans
River	Mzimkhulu	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC			
				Su15	Au15	Sp15	Su16
AAEN	AWAOUS AENEOFUSCUS (PETERS 1852)		5.00	-	-	-	-
AMAR	ANGUILLA MARMORATA QUOY & GAIMARD 1824		3.99	-	-	-	-
AMOS	ANGUILLA MOSSAMBICA PETERS 1852		5.00	-	-	-	-
BANO	BARBUS ANOPLUS WEBER, 1897		5.00	-	-	-	-
BGUR	BARBUS GURNEYI GÜNTHER, 1868		5.00	-	-	-	-
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861		5.00	-	5	3	3
BPAL	BARBUS PALLIDUS SMITH, 1841		1.01	-	-	-	-
BVIV	BARBUS VIVIPARUS WEBER, 1897		5.00	-	-	-	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)		5.00	-	-	2	1
MCEP	MUGIL CEPHALUS LINNAEUS, 1758		3.99	-	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)		5.00	-	1	1	3
TSPA	TILAPIA SPARRMANII SMITH, 1840		5.00	-	-	-	-
BTRI	BARBUS TRIMACULATUS PETERS, 1852		5.00	-	1	-	-
MCAP	MYXUS CAPENSIS (VALENCIENNES, 1836)		3.00	-	-	1	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	-	2	3	3
	Fast-Shallow	-	2	2	3
	Slow-Deep	-	1	2	2

Cover features	Slow-Shallow	-	1	1	1
	Overhanging veg	-	3	3	3
	Undercut banks	-	3	3	3
	Substrate	-	1	1	1
	Instream veg	-	3	3	3
	Water column	-	1	1	1

	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	-	1	1	1
	Moderately intolerant to no flow	-	1	1	1
	Moderately tolerant to no flow	-	1	1	1
	Tolerant to no flow	-	1	1	1

	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	-	3	2	2
	Moderately intolerant to modified physico-chemical conditions	-	1	1	1
	Moderately tolerant to modified physico-chemical conditions	-	1	1	1
	Tolerant modified to physico-chemical conditions	-	1	1	1

	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	-	3	3	3
	Movement between reaches	-	1	1	1
	Movement within a reach	-	1	1	1

	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	-	1	1	1
	Impoundments	-	0	0	0
	Physico-chemical barriers	-	1	1	1
	Flow modifications	-	1	1	1

	Introduced/alien species	Su15	Au15	Sp15	Su16

Introduced/alien species	Introduced/alien predacious species 1	-	-	-	-
	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	-	-	-	-
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	-	-	-	-
	FROC of introduced competing spp?	-	-	-	-
	The impact of introduced habitat modifying spp?	-	-	-	-
	FROC of habitat modifying spp?	-	-	-	-
	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		-	36.9	27.3	30
EC: FRAI		-	E	E	E
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		-	68.5	67.4	66.5
EC: FRAI		-	C	C	C

Site Name	U1MKMZ-SANIP-RHP 9	**Assessor**	W Evans
River	Mkhomazana	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC			
				Su15	Au15	Sp15	Su16
AMOS	ANGUILLA MOSSAMBICA PETERS 1852		4.79	-	-	-	-
ANAT	AMPHILIUS NATALENSIS BOULENGER, 1917		4.55	-	-	-	-
BANO	BARBUS ANOPLUS WEBER, 1897		4.55	-	-	-	-

BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861	3.91	-	-	-	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	-	1	1	1
	Fast-Shallow	-	1	1	0
	Slow-Deep	-	1	1	1
	Slow-Shallow	-	1	1	1
Cover features	Overhanging veg	-	1	1	0
	Undercut banks	-	2	2	1
	Substrate	-	1	1	0
	Instream veg	-	1	1	1
	Water column	-	1	1	1

	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	-	1	2	1
	Moderately intolerant to no flow	-	1	2	1
	Moderately tolerant to no flow	-	1	1	1
	Tolerant to no flow	-	1	1	1

	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	-	1	1	1
	Moderately intolerant to modified physico-chemical conditions	-	1	1	1
	Moderately tolerant to modified physico-chemical conditions	-	1	1	1
	Tolerant modified to physico-chemical conditions	-	1	1	1

	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	-	5	4	5
	Movement between reaches	-	2	2	2
	Movement within a reach	-	1	1	1

	Extent of the following in the reach	Su15	Au15	Sp15	Su16

	Weirs and causeways	-	2	2	2
Changes in connectivity	Impoundments	-	0	0	0
	Physico-chemical barriers	-	0	0	0
	Flow modifications	-	0	0	0
	Introduced/alien species	Su15	Au15	Sp15	Su16
Introduced/alien species	Introduced/alien predacious species 1	-	OMYK	OMYK	OMYK
	Introduced/alien predacious species 2	-	STRU	STRU	STRU
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	-	-	-	-
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	-	3	4	3
	FROC of introduced competing spp?	-	1	3	1
	The impact of introduced habitat modifying spp?	-	0	0	0
	FROC of habitat modifying spp?	-	0	0	0
	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		-	7.52	7.48	7.52
EC: FRAI		-	F	F	F
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		-	70.7	68.7	74.1
EC: FRAI		-	C	C	C

Site Name	U2MGEN-MIDMA-RHP 12	**Assessor**	W Evans
River	Mgeni	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC			
				Su15	Au15	Sp15	Su16

AMAR	ANGUILLA MARMORATA QUOY & GAIMARD 1824	5.00	-	-	-	-
AMOS	ANGUILLA MOSSAMBICA PETERS 1852	5.00	-	-	-	-
ANAT	AMPHILIUS NATALENSIS BOULENGER, 1917	4.95	-	-	-	-
BANO	BARBUS ANOPLUS WEBER, 1897	4.95	-	-	-	-
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861	5.00	3	3	3	5
BVIV	BARBUS VIVIPARUS WEBER, 1897	4.95	-	-	-	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)	5.00	-	1	3	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)	5.00	-	-	-	-
TREN	TILAPIA RENDALLI (BOULENGER, 1896)	4.95	-	-	-	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	2	2	3	1
	Fast-Shallow	2	2	2	1
	Slow-Deep	1	1	2	0
	Slow-Shallow	1	1	1	0
Cover features	Overhanging veg	1	1	2	1
	Undercut banks	1	1	3	1
	Substrate	2	2	2	2
	Instream veg	1	1	2	1
	Water column	2	2	3	2

	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	4	3	3	3
	Moderately intolerant to no flow	3	3	3	3
	Moderately tolerant to no flow	1	1	1	1
	Tolerant to no flow	1	1	1	1

	Response of species that are	Su15	Au15	Sp15	Su16

	Intolerant to modified physico-chemical conditions	3	2	2	2
	Moderately intolerant to modified physico-chemical conditions	2	3	2	3
Physico-chemical conditions	Moderately tolerant to modified physico-chemical conditions	1	1	1	1
	Tolerant modified to physico-chemical conditions	1	1	1	1

	Response of which require	Su15	Au15	Sp15	Su16
	Catchment scale movement	5	5	5	5
Migration	Movement between reaches	2	2	2	2
	Movement within a reach	1	1	1	1

	Extent of the following in the reach	Su15	Au15	Sp15	Su16
	Weirs and causeways	3	3	3	3
Changes in connectivity	Impoundments	3	3	3	3
	Physico-chemical barriers	1	1	1	1
	Flow modifications	1	1	1	1

	Introduced/alien species	Su15	Au15	Sp15	Su16
	Introduced/alien predacious species 1	MSAL	MSAL	MSAL	MSAL
	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
Introduced/alien species	Introduced/alien habitat modifying species 1	CCAR	CCAR	CCAR	CCAR
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	3	3	3	3
	FROC of introduced competing spp?	2	2	3	2
	The impact of introduced habitat modifying spp?	1	1	1	1

	FROC of habitat modifying spp?	2	2	2	1
	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		14.8	16.3	16.9	19.8
EC: FRAI		F	F	F	E/F
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		58.1	59.1	53.6	63.6
EC: FRAI		C/D	C/D	D	C

Site Name	U2MGEN-MPOLW-RHP 14	**Assessor**	W Evans
River	Mgeni	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC			
				Su15	Au15	Sp15	Su16
AAEN	AWAOUS AENEOFUSCUS (PETERS 1852)		5.00	-	-	-	-
ALAB	ANGUILLA BENGALENSIS LABIATA PETERS, 1852		4.45	-	-	-	-
AMAR	ANGUILLA MARMORATA QUOY & GAIMARD 1824		4.45	-	-	-	-
AMOS	ANGUILLA MOSSAMBICA PETERS 1852		5.00	-	-	-	-
ANAT	AMPHILIUS NATALENSIS BOULENGER, 1917		5.00	-	-	-	1
BGUR	BARBUS GURNEYI GÜNTHER, 1868		5.00	-	-	-	-
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861		5.00	5	5	5	5
BPAL	BARBUS PALLIDUS SMITH, 1841		0.55	-	-	-	-
BVIV	BARBUS VIVIPARUS WEBER, 1897		5.00	-	-	-	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)		5.00	-	-	-	3
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)		5.00	-	-	3	1
PPHI	PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)		5.00	-	-	-	1

TREN	TILAPIA RENDALLI (BOULENGER, 1896)	5.00	1	1	-	3
TSPA	TILAPIA SPARRMANII SMITH, 1840	5.00	3	3	-	3

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	3	3	3	2
	Fast-Shallow	3	3	2	2
	Slow-Deep	2	2	1	1
	Slow-Shallow	2	2	1	1
Cover features	Overhanging veg	2	1	2	2
	Undercut banks	1	1	1	1
	Substrate	0	0	1	0
	Instream veg	2	1	1	2
	Water column	2	0	2	2

	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	2	3	3	3
	Moderately intolerant to no flow	2	2	3	3
	Moderately tolerant to no flow	1	1	2	2
	Tolerant to no flow	0	1	1	1

	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	2	2	2	2
	Moderately intolerant to modified physico-chemical conditions	1	2	2	2
	Moderately tolerant to modified physico-chemical conditions	1	1	1	1
	Tolerant modified to physico-chemical conditions	0	0	1	1

	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	5	5	5	5
	Movement between reaches	1	1	1	1
	Movement within a reach	0	0	0	0

	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	2	2	2	2
	Impoundments	5	5	5	5
	Physico-chemical barriers	3	3	3	3
	Flow modifications	2	2	2	2

	Introduced/alien species	Su15	Au15	Sp15	Su16
Introduced/alien species	Introduced/alien predacious species 1	MSAL	MSAL	MSAL	MSAL
	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	CCAR	CCAR	CCAR	CCAR
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	3	3	3	3
	FROC of introduced competing spp?	1	1	2	1
	The impact of introduced habitat modifying spp?	1	1	1	1
	FROC of habitat modifying spp?	1	1	1	1

	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		27.2	26.7	25.3	36
EC: FRAI		E	E	E	E

	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		66	69.9	61.2	62.7
EC: FRAI		C	C	C/D	C

Site Name	U2MGEN-NINAW-RHP 8	**Assessor**	W Evans
River	Mgeni	**Reviewed**	G O'Brien

ABR	SPECIES			OBSERVED FROC

			REFERENCE FROC	Su15	Au15	Sp15	Su16
AAEN	AWAOUS AENEOFUSCUS (PETERS 1852)		5.00	3	3	1	3
ABER	ACANTHOPAGRUS BERDA (FORSSKÅL, 1775)		3.74	-	-	-	-
ALAB	ANGUILLA BENGALENSIS LABIATA PETERS, 1852		3.74	-	-	-	-
AMAR	ANGUILLA MARMORATA QUOY & GAIMARD 1824		3.74	-	1	-	-
AMOS	ANGUILLA MOSSAMBICA PETERS 1852		5.00	-	-	3	-
ANAT	AMPHILIUS NATALENSIS BOULENGER, 1917		5.00	-	-	-	-
BANO	BARBUS ANOPLUS WEBER, 1897		5.00	-	-	-	-
BGUR	BARBUS GURNEYI GÜNTHER, 1868		5.00	-	-	-	-
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861		5.00	1	-	3	3
BPAL	BARBUS PALLIDUS SMITH, 1841		1.26	-	-	-	-
BVIV	BARBUS VIVIPARUS WEBER, 1897		5.00	-	-	-	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)		5.00	-	-	-	-
GAES	GILCHRISTELLA AESTUARIA (GILCHRIST, 1913)		3.74	-	-	-	-
GCAL	GLOSSOGOBIUS CALLIDUS SMITH, 1937		3.74	-	-	-	-
GGIU	GLOSSOGOBIUS GIURIS (HAMILTON-BUCHANAN, 1822)		3.74	-	-	-	-
LMCR	LIZA MACROLEPIS (SMITH, 1846)		3.74	-	-	-	-
MARG	MONODACTYLUS ARGENTEUS (LINNAEUS, 1758)		3.74	-	-	-	-
MBRA	MICROPHIS BRACHYURUS BLEEKER, 1853		3.74	-	-	-	-

MCAP	MYXUS CAPENSIS (VALENCIENNES, 1836)	3.74	-	-	-	-
MCEP	MUGIL CEPHALUS LINNAEUS, 1758	3.74	-	-	-	-
MFLU	MICROPHIS FLUVIATILIS (PETERS, 1852)	3.74	-	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)	5.00	-	-	-	-
PPHI	PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)	5.00	1	1	1	-
RDEW	REDIGOBIUS DEWAALI (WEBER, 1897)	3.74	-	-	-	-
TREN	TILAPIA RENDALLI (BOULENGER, 1896)	5.00	-	-	-	-
TSPA	TILAPIA SPARRMANII SMITH, 1840	5.00	-	-	1	1

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	3	3	3	2
	Fast-Shallow	2	3	3	2
	Slow-Deep	2	2	2	1
	Slow-Shallow	1	2	2	1
Cover features	Overhanging veg	2	2	2	2
	Undercut banks	2	2	2	2
	Substrate	1	1	1	1
	Instream veg	2	2	2	2
	Water column	1	3	3	3

	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	3	3	3	3
	Moderately intolerant to no flow	2	2	2	3
	Moderately tolerant to no flow	2	2	2	3
	Tolerant to no flow	0	0	1	2

	Response of species that are	Su15	Au15	Sp15	Su16
	Intolerant to modified physico-chemical conditions	2	2	2	2

	Moderately intolerant to modified physico-chemical conditions	1	1	2	1
Physico-chemical conditions	Moderately tolerant to modified physico-chemical conditions	1	1	1	1
	Tolerant modified to physico-chemical conditions	0	0	1	0
	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	5	5	5	5
	Movement between reaches	3	3	3	3
	Movement within a reach	2	2	2	2
	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	3	3	3	3
	Impoundments	5	5	5	5
	Physico-chemical barriers	1	1	1	1
	Flow modifications	3	3	3	3
	Introduced/alien species	Su15	Au15	Sp15	Su16
Introduced/alien species	Introduced/alien predacious species 1	LMAC	LMAC	LMAC	LMAC
	Introduced/alien predacious species 2	MSAL	MSAL	MSAL	MSAL
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	-	-	-	-
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	3	3	4	4
	FROC of introduced competing spp?	1	1	2	3
	The impact of introduced habitat modifying spp?	0	0	0	0
	FROC of habitat modifying spp?	0	0	0	0
	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				

		Su15	Au15	Sp15	Su16
FRAI (%)		10.8	11.3	16.1	11.6
EC: FRAI		F	F	F	F
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		59.4	58.5	51.9	50.5
EC: FRAI		C/D	C/D	D	D

Site Name	U2MGNI-DRGLE-RHP 13	**Assessor**	W Evans
River	Mgeni	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC Su15	Au15	Sp15	Su16
AMOS	ANGUILLA MOSSAMBICA PETERS 1852		5.00	-	-	-	-
ANAT	AMPHILIUS NATALENSIS BOULENGER, 1917		5.00	-	-	-	-
BANO	BARBUS ANOPLUS WEBER, 1897		4.95	-	-	-	-
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861		4.95	-	-	-	-
AMAR	ANGUILLA MARMORATA QUOY & GAIMARD 1824		5.00	-	-	-	-
BVIV	BARBUS VIVIPARUS WEBER, 1897		4.95	-	1	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)		5.00	-	-	-	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)		5.00	-	-	-	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	-	1	1	2
	Fast-Shallow	-	1	1	2
	Slow-Deep	-	1	1	1
	Slow-Shallow	-	0	0	0
Cover features	Overhanging veg	-	1	1	2
	Undercut banks	-	1	1	1
	Substrate	-	0	0	0

	Instream veg	-	1	1	1
	Water column	-	1	1	2
	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	-	2	2	2
	Moderately intolerant to no flow	-	2	1	2
	Moderately tolerant to no flow	-	1	1	1
	Tolerant to no flow	-	1	1	1
	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	-	1	1	1
	Moderately intolerant to modified physico-chemical conditions	-	0	1	0
	Moderately tolerant to modified physico-chemical conditions	-	0	0	0
	Tolerant modified to physico-chemical conditions	-	0	0	0
	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	-	4	4	4
	Movement between reaches	-	3	3	3
	Movement within a reach	-	1	1	1
	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	-	3	3	3
	Impoundments	-	2	2	2
	Physico-chemical barriers	-	1	1	1
	Flow modifications	-	1	1	1
	Introduced/alien species	Su15	Au15	Sp15	Su16
Introduced/alien species	Introduced/alien predacious species 1	-	OMYK	OMYK	OMYK
	Introduced/alien predacious species 2	-	STRU	STRU	STRU

Introduced/alien predacious species 3		-	-	-	-
Introduced/alien habitat modifying species 1		-	-	-	-
Introduced/alien habitat modifying species 2		-	-	-	-
The impact of introduced competing spp?		-	2	3	3
FROC of introduced competing spp?		-	1	1	2
The impact of introduced habitat modifying spp?		-	0	0	0
FROC of habitat modifying spp?		-	0	0	0

	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		-	10.7	7.5	7.1
EC: FRAI		-	F	F	F

	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		-	74.8	74.3	70.3
EC: FRAI		-	C	C	C

Site Name	U2TONG-ROADB-RHP 11	**Assessor**	W Evans
River	Tongati	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC			
				Su15	Au15	Sp15	Su16
AAEN	AWAOUS AENEOFUSCUS (PETERS 1852)		5.00	-	-	3	3
ABER	ACANTHOPAGRUS BERDA (FORSSKÅL, 1775)		3.67	-	-	-	-
ALAB	ANGUILLA BENGALENSIS LABIATA PETERS, 1852		3.67	-	-	-	-
AMAR	ANGUILLA MARMORATA QUOY & GAIMARD 1824		3.67	-	-	-	-
AMOS	ANGUILLA MOSSAMBICA PETERS 1852		5.00	-	-	-	-

AMYA	APLOCHEILICHTHYS MYAPOSAE (BOULENGER, 1908)	3.67	-	-	-	-
BGUR	BARBUS GURNEYI GÜNTHER, 1868	5.00	-	-	-	-
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861	5.00	-	-	-	-
BPAL	BARBUS PALLIDUS SMITH, 1841	1.33	-	-	-	-
BPAU	BARBUS PALUDINOSUS PETERS, 1852	5.00	-	-	5	3
BVIV	BARBUS VIVIPARUS WEBER, 1897	5.00	-	-	1	3
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)	5.00	-	-	1	-
GAES	GILCHRISTELLA AESTUARIA (GILCHRIST, 1913)	3.67	-	-	-	-
GCAL	GLOSSOGOBIUS CALLIDUS SMITH, 1937	3.67	-	-	-	-
GGIU	GLOSSOGOBIUS GIURIS (HAMILTON-BUCHANAN, 1822)	3.67	-	-	-	-
LMCR	LIZA MACROLEPIS (SMITH, 1846)	3.67	-	-	-	-
LRIC	LIZA RICHARDSONII (SMITH, 1846)	3.67	-	-	-	-
MARG	MONODACTYLUS ARGENTEUS (LINNAEUS, 1758)	3.67	-	-	-	-
MCAP	MYXUS CAPENSIS (VALENCIENNES, 1836)	3.67	-	-	2	-
MCEP	MUGIL CEPHALUS LINNAEUS, 1758	3.67	-	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)	5.00	3	3	-	-
PPHI	PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)	5.00	-	1	-	-
TREN	TILAPIA RENDALLI (BOULENGER, 1896)	5.00	-	-	-	-
TSPA	TILAPIA SPARRMANII SMITH, 1840	5.00	-	-	-	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	3	4	4	4
	Fast-Shallow	3	4	4	4
	Slow-Deep	3	3	2	3
	Slow-Shallow	1	1	1	1
Cover features	Overhanging veg	2	3	2	2
	Undercut banks	4	4	4	4
	Substrate	4	4	4	4
	Instream veg	2	2	1	2
	Water column	4	4	4	4
	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	4	4	4	4
	Moderately intolerant to no flow	4	4	4	4
	Moderately tolerant to no flow	3	3	3	3
	Tolerant to no flow	1	2	1	1
	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	4	4	4	4
	Moderately intolerant to modified physico-chemical conditions	4	4	4	4
	Moderately tolerant to modified physico-chemical conditions	2	2	2	3
	Tolerant modified to physico-chemical conditions	2	2	2	2
	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	3	3	3	3
	Movement between reaches	3	3	3	3
	Movement within a reach	2	2	2	2
	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	3	3	3	3
	Impoundments	4	4	4	4

	Physico-chemical barriers	3	3	3	3
	Flow modifications	4	4	4	4
	Introduced/alien species	Su15	Au15	Sp15	Su16
Introduced/alien species	Introduced/alien predacious species 1	PRET	PRET	PRET	PRET
	Introduced/alien predacious species 2	MSAL	MSAL	MSAL	MSAL
	Introduced/alien predacious species 3	ONIL	ONIL	ONIL	ONIL
	Introduced/alien habitat modifying species 1	PRET	PRET	PRET	PRET
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	4	3	4	2
	FROC of introduced competing spp?	4	3	4	3
	The impact of introduced habitat modifying spp?	1	1	1	1
	FROC of habitat modifying spp?	1	1	1	1
	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		7.9	9.6	13	15.2
EC: FRAI		F	F	F	F
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		38.9	36	33.8	36.4
EC: FRAI		D/E	E	E	E

Site Name	U3MDLO-HAZIN-RHP 10	**Assessor**	W Evans
River	Mdloti	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC			
				Su15	Au15	Sp15	Su16
AAEN	AWAOUS AENEOFUSCUS (PETERS 1852)		5.00	-	-	-	-

ALAB	ANGUILLA BENGALENSIS LABIATA PETERS, 1852	2.15	-	-	-	-
AMAR	ANGUILLA MARMORATA QUOY & GAIMARD 1824	2.15	-	-	-	-
AMOS	ANGUILLA MOSSAMBICA PETERS 1852	5.00	-	-	1	-
ANAT	AMPHILIUS NATALENSIS BOULENGER, 1917	5.00	-	-	-	-
BGUR	BARBUS GURNEYI GÜNTHER, 1868	5.00	-	-	-	-
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861	5.00	3	3	3	3
BPAL	BARBUS PALLIDUS SMITH, 1841	2.85	-	-	-	-
BPAU	BARBUS PALUDINOSUS PETERS, 1852	5.00	-	-	-	-
BVIV	BARBUS VIVIPARUS WEBER, 1897	5.00	-	-	-	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)	5.00	-	-	-	3
GAES	GILCHRISTELLA AESTUARIA (GILCHRIST, 1913)	2.15	-	-	-	-
MBRA	MICROPHIS BRACHYURUS BLEEKER, 1853	2.15	-	-	-	-
MFLU	MICROPHIS FLUVIATILIS (PETERS, 1852)	2.15	-	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)	5.00	1	1	4	3
PPHI	PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)	5.00	-	-	-	-
TREN	TILAPIA RENDALLI (BOULENGER, 1896)	5.00	-	-	-	-
TSPA	TILAPIA SPARRMANII SMITH, 1840	5.00	-	-	-	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	2	3	3	3
	Fast-Shallow	1	2	2	2
	Slow-Deep	2	2	2	2

Cover features	Slow-Shallow	1	1	1	1
	Overhanging veg	2	3	3	2
	Undercut banks	3	3	3	3
	Substrate	3	3	3	3
	Instream veg	2	2	2	2
	Water column	2	2	3	3
	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	3	4	4	4
	Moderately intolerant to no flow	3	3	3	3
	Moderately tolerant to no flow	2	3	3	3
	Tolerant to no flow	2	3	3	3
	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	3	3	4	4
	Moderately intolerant to modified physico-chemical conditions	2	3	3	3
	Moderately tolerant to modified physico-chemical conditions	2	2	3	3
	Tolerant modified to physico-chemical conditions	1	1	1	1
	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	3	3	3	3
	Movement between reaches	2	2	2	2
	Movement within a reach	2	2	2	2
	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	3	3	3	3
	Impoundments	3	3	3	3
	Physico-chemical barriers	2	2	3	3
	Flow modifications	2	2	2	2
	Introduced/alien species	Su15	Au15	Sp15	Su16

	Introduced/alien predacious species 1	MSAL	MSAL	MSAL	MSAL
	Introduced/alien predacious species 2	PRET	PRET	PRET	PRET
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	PRET	PRET	PRET	PRET
Introduced/alien species	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	3	3	3	3
	FROC of introduced competing spp?	2	2	2	3
	The impact of introduced habitat modifying spp?	1	1	1	2
	FROC of habitat modifying spp?	1	1	1	2
	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		16.7	16.7	18.9	11.7
EC: FRAI		F	F	E/F	F
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		52.9	47.1	43	38.4
EC: FRAI		D	D	D	D/E

Site Name	U4MVOT-N2BRI-RHP 38	**Assessor**	W Evans
River	Umvoti	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC			
				Su15	Au15	Sp15	Su16
AAEN	AWAOUS AENEOFUSCUS (PETERS 1852)		5.00	-	-	1	1
ABER	ACANTHOPAGRUS BERDA (FORSSKÅL, 1775)		5.00	-	-	-	-
ALAB	ANGUILLA BENGALENSIS LABIATA PETERS, 1852		5.00	-	-	-	-

AMAR	ANGUILLA MARMORATA QUOY & GAIMARD 1824	5.00	-	-	-	-
AMOS	ANGUILLA MOSSAMBICA PETERS 1852	5.00	-	-	-	-
BGUR	BARBUS GURNEYI GÜNTHER, 1868	5.00	-	-	-	-
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861	5.00	3	3	-	-
BPAU	BARBUS PALUDINOSUS PETERS, 1852	5.00	-	-	-	-
BTRI	BARBUS TRIMACULATUS PETERS, 1852	5.00	3	1	3	3
BVIV	BARBUS VIVIPARUS WEBER, 1897	5.00	-	-	-	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)	5.00	1	1	3	3
GAES	GILCHRISTELLA AESTUARIA (GILCHRIST, 1913)	5.00	-	-	-	-
GCAL	GLOSSOGOBIUS CALLIDUS SMITH, 1937	5.00	-	-	-	-
GGIU	GLOSSOGOBIUS GIURIS (HAMILTON-BUCHANAN, 1822)	5.00	-	-	-	-
LMCR	LIZA MACROLEPIS (SMITH, 1846)	5.00	-	-	-	-
LRIC	LIZA RICHARDSONII (SMITH, 1846)	5.00	-	-	-	-
MCAP	MYXUS CAPENSIS (VALENCIENNES, 1836)	5.00	-	-	-	-
MCEP	MUGIL CEPHALUS LINNAEUS, 1758	5.00	-	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)	5.00	3	3	5	3
PPHI	PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)	5.00	-	-	-	-
RDEW	REDIGOBIUS DEWAALI (WEBER, 1897)	5.00	-	-	-	-
TSPA	TILAPIA SPARRMANII SMITH, 1840	5.00	1	-	-	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	3	4	4	4
	Fast-Shallow	3	3	3	4
	Slow-Deep	3	4	4	4
	Slow-Shallow	2	2	2	2
Cover features	Overhanging veg	3	3	3	3
	Undercut banks	4	4	4	4
	Substrate	5	5	5	5
	Instream veg	3	3	3	3
	Water column	4	4	3	4

	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	4	4	3	4
	Moderately intolerant to no flow	3	3	3	4
	Moderately tolerant to no flow	3	3	3	3
	Tolerant to no flow	2	2	1	2

	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	5	5	5	5
	Moderately intolerant to modified physico-chemical conditions	5	5	5	5
	Moderately tolerant to modified physico-chemical conditions	3	3	3	3
	Tolerant modified to physico-chemical conditions	3	3	3	3

	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	3	3	3	3
	Movement between reaches	4	4	4	4
	Movement within a reach	3	3	3	3

	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	3	3	3	3
	Impoundments	0	0	0	0

		Su15	Au15	Sp15	Su16
	Physico-chemical barriers	5	5	5	5
	Flow modifications	4	4	4	4
	Introduced/alien species	Su15	Au15	Sp15	Su16
Introduced/alien species	Introduced/alien predacious species 1	PRET	PRET	PRET	PRET
	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	PRET	PRET	PRET	PRET
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	1	1	1	1
	FROC of introduced competing spp?	1	1	1	1
	The impact of introduced habitat modifying spp?	1	1	1	1
	FROC of habitat modifying spp?	1	1	1	1
	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		18.1	16.8	16.3	15.9
EC: FRAI		E/F	F	F	F
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		31	29	35.4	30.6
EC: FRAI		E	E	E	E

Site Name	U4MVOT-SHANK-RHP 16	**Assessor**	W Evans
River	Mvoti	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC Su15	Au15	Sp15	Su16
AMOS	ANGUILLA MOSSAMBICA PETERS 1852		4.96	-	-	-	-

ANAT	AMPHILIUS NATALENSIS BOULENGER, 1917	4.72	-	-	-	-
BANO	BARBUS ANOPLUS WEBER, 1897	4.72	-	-	-	-
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861	4.26	3	1	-	-
BVIV	BARBUS VIVIPARUS WEBER, 1897	4.26	1	5	-	1
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)	4.72	-	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)	4.72	-	-	-	-
TSPA	TILAPIA SPARRMANII SMITH, 1840	4.72	3	3	-	3
AURA	AMPHILIUS URANOSCOPUS (PFEFFER, 1889)	4.72	-	1	-	-
	Response of species with a preference/tolerance to		Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep		3	2	-	4
	Fast-Shallow		2	2	-	3
	Slow-Deep		3	3	-	2
	Slow-Shallow		1	1	-	1
Cover features	Overhanging veg		3	2	-	4
	Undercut banks		2	2	-	2
	Substrate		2	2	-	2
	Instream veg		2	2	-	2
	Water column		2	2	-	3
	Response of species that are		Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow		2	2	-	3
	Moderately intolerant to no flow		3	2	-	3
	Moderately tolerant to no flow		3	2	-	2
	Tolerant to no flow		2	1	-	2
	Response of species that are		Su15	Au15	Sp15	Su16
	Intolerant to modified physico-chemical conditions		2	1	-	1

Physico-chemical conditions	Moderately intolerant to modified physico-chemical conditions	1	1	-	1
	Moderately tolerant to modified physico-chemical conditions	1	1	-	1
	Tolerant modified to physico-chemical conditions	1	1	-	1
	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	2	2	-	2
	Movement between reaches	2	2	-	2
	Movement within a reach	1	1	-	1
	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	3	3	-	3
	Impoundments	0	0	-	0
	Physico-chemical barriers	1	1	-	1
	Flow modifications	2	2	-	2
	Introduced/alien species	Su15	Au15	Sp15	Su16
Introduced/alien species	Introduced/alien predacious species 1	MSAL	MSAL	-	MSAL
	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	-	-	-	-
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	3	3	-	3
	FROC of introduced competing spp?	1	1	-	3
	The impact of introduced habitat modifying spp?	0	0	-	0
	FROC of habitat modifying spp?	0	0	-	0
	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				

FRAI (%)				25.5	28.4	-	13.4
EC: FRAI				E	E	-	F
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE						
FRAI (%)				56.9	63.1	-	53.9
EC: FRAI				D	C	-	D

Site Name	U6LOVU-R0197-RHP 1	**Assessor**	W Evans
River	Lovu	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC			
				Su15	Au15	Sp15	Su16
AAEN	AWAOUS AENEOFUSCUS (PETERS 1852)		5.00	-	-	-	-
ABER	ACANTHOPAGRUS BERDA (FORSSKÅL, 1775)		2.02	-	-	-	-
ALAB	ANGUILLA BENGALENSIS LABIATA PETERS, 1852		2.02	-	-	-	-
AMAR	ANGUILLA MARMORATA QUOY & GAIMARD 1824		5.00	-	-	-	-
AMOS	ANGUILLA MOSSAMBICA PETERS 1852		5.00	-	-	-	-
ANAT	AMPHILIUS NATALENSIS BOULENGER, 1917		2.02	-	-	-	-
BGUR	BARBUS GURNEYI GÜNTHER, 1868		2.02	-	-	-	-
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861		5.00	-	-	-	-
BVIV	BARBUS VIVIPARUS WEBER, 1897		2.02	-	-	-	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)		5.00	-	-	-	-
GAES	GILCHRISTELLA AESTUARIA (GILCHRIST, 1913)		5.00	-	-	-	-
GCAL	GLOSSOGOBIUS CALLIDUS SMITH, 1937		2.02	-	-	-	-

GGIU	GLOSSOGOBIUS GIURIS (HAMILTON-BUCHANAN, 1822)	2.02	-	-	-	-
LMCR	LIZA MACROLEPIS (SMITH, 1846)	5.00	-	-	-	-
LRIC	LIZA RICHARDSONII (SMITH, 1846)	5.00	-	-	-	-
MARG	MONODACTYLUS ARGENTEUS (LINNAEUS, 1758)	5.00	-	-	-	-
MCAP	MYXUS CAPENSIS (VALENCIENNES, 1836)	5.00	-	-	-	-
MCEP	MUGIL CEPHALUS LINNAEUS, 1758	5.00	-	-	-	-
MFAL	MONODACTYLUS FALCIFORMIS LACEPÈDE, 1801	5.00	-	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)	5.00	-	-	1	1
PPHI	PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)	5.00	-	-	-	-
RDEW	REDIGOBIUS DEWAALI (WEBER, 1897)	5.00	-	-	-	-
TREN	TILAPIA RENDALLI (BOULENGER, 1896)	2.02	-	-	-	-
TSPA	TILAPIA SPARRMANII SMITH, 1840	5.00	-	-	-	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	4	4	4	4
	Fast-Shallow	4	4	4	4
	Slow-Deep	0	0	0	0
	Slow-Shallow	3	2	2	2
Cover features	Overhanging veg	3	3	3	3
	Undercut banks	4	4	4	4
	Substrate	4	5	5	5
	Instream veg	4	5	5	5
	Water column	2	3	4	3

	Response of species that are	Su15	Au15	Sp15	Su16
	Intolerant to no flow	5	5	5	5

Flow dependence	Moderately intolerant to no flow	5	5	4	4
	Moderately tolerant to no flow	3	3	3	3
	Tolerant to no flow	3	3	3	3
	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	5	5	5	4
	Moderately intolerant to modified physico-chemical conditions	5	5	4	4
	Moderately tolerant to modified physico-chemical conditions	3	3	3	3
	Tolerant modified to physico-chemical conditions	1	1	1	1
	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	3	3	3	3
	Movement between reaches	2	2	2	2
	Movement within a reach	1	1	1	1
	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	3	3	3	3
	Impoundments	1	1	1	1
	Physico-chemical barriers	4	4	4	4
	Flow modifications	3	3	3	3
	Introduced/alien species	Su15	Au15	Sp15	Su16
Introduced/alien species	Introduced/alien predacious species 1	-	-	-	-
	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	-	-	-	-
	Introduced/alien habitat modifying species 2	-	-	-	-

	The impact of introduced competing spp?	-	-	-	-
	FROC of introduced competing spp?	-	-	-	-
	The impact of introduced habitat modifying spp?	-	-	-	-
	FROC of habitat modifying spp?	-	-	-	-

	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		12	12	14	14
EC: FRAI		F	F	F	F
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		37.4	36	37.2	39.2
EC: FRAI		E	E	E	D/E

Site Name	U6LOVU-RICHM-RHP 4	**Assessor**	W Evans
River	Lovu	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC Su15	Au15	Sp15	Su16
AMOS	ANGUILLA MOSSAMBICA PETERS 1852		5.00	-	-	-	-
ANAT	AMPHILIUS NATALENSIS BOULENGER, 1917		5.00	-	-	-	-
BGUR	BARBUS GURNEYI GÜNTHER, 1868		4.88	-	-	-	-
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861		4.88	-	-	-	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)		5.00	1	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)		5.00	-	1	-	-
TSPA	TILAPIA SPARRMANII SMITH, 1840		5.00	1	-	-	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
	Fast-Deep	3	3	3	4

Velocity Depth Metric	Fast-Shallow	3	3	3	3
	Slow-Deep	2	2	2	2
	Slow-Shallow	1	1	1	2
Cover features	Overhanging veg	1	2	2	2
	Undercut banks	3	3	4	4
	Substrate	3	3	4	4
	Instream veg	3	3	3	3
	Water column	2	2	3	4
	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	4	3	4	4
	Moderately intolerant to no flow	4	3	4	3
	Moderately tolerant to no flow	3	3	3	3
	Tolerant to no flow	2	2	2	2
	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	3	2	3	3
	Moderately intolerant to modified physico-chemical conditions	2	2	2	2
	Moderately tolerant to modified physico-chemical conditions	2	1	2	1
	Tolerant modified to physico-chemical conditions	1	0	1	1
	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	3	3	3	3
	Movement between reaches	3	3	3	3
	Movement within a reach	3	3	3	3
	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	2	2	2	2
	Impoundments	0	0	0	0
	Physico-chemical barriers	3	3	3	3
	Flow modifications	3	4	4	4

	Introduced/alien species	Su15	Au15	Sp15	Su16
Introduced/alien species	Introduced/alien predacious species 1	-	-	-	-
	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	-	-	-	-
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	-	-	-	-
	FROC of introduced competing spp?	-	-	-	-
	The impact of introduced habitat modifying spp?	-	-	-	-
	FROC of habitat modifying spp?	-	-	-	-
	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		10.8	9.8	8	8
EC: FRAI		F	F	F	F
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		48.4	52.5	45.2	43.4
EC: FRAI		D	D	D	D

Site Name	U6MLAZ-P0502-RHP 5	**Assessor**	W Evans
River	Mlazi	**Reviewed**	G O'Brien

ABR	SPECIES	REFERENCE FROC	OBSERVED FROC Su15	Au15	Sp15	Su16
AAEN	AWAOUS AENEOFUSCUS (PETERS 1852)	4.96	-	-	-	-
AMOS	ANGUILLA MOSSAMBICA PETERS 1852	5.00	1	-	-	-

ANAT	AMPHILIUS NATALENSIS BOULENGER, 1917	5.00	-	-	-	-
BGUR	BARBUS GURNEYI GÜNTHER, 1868	4.96	-	-	-	-
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861	4.96	-	-	-	-
BPAL	BARBUS PALLIDUS SMITH, 1841	1.99	-	-	-	-
BVIV	BARBUS VIVIPARUS WEBER, 1897	4.96	-	-	-	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)	5.00	-	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)	5.00	-	-	-	1
PPHI	PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)	5.00	-	-	-	-
TREN	TILAPIA RENDALLI (BOULENGER, 1896)	5.00	-	-	-	-
TSPA	TILAPIA SPARRMANII SMITH, 1840	5.00	-	-	-	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	3	3	4	3
	Fast-Shallow	2	2	3	2
	Slow-Deep	3	3	3	3
	Slow-Shallow	1	1	1	1
Cover features	Overhanging veg	1	1	2	1
	Undercut banks	3	3	3	3
	Substrate	3	3	3	3
	Instream veg	2	2	2	2
	Water column	3	3	4	3

	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	2	2	3	2
	Moderately intolerant to no flow	2	2	2	2
	Moderately tolerant to no flow	2	2	2	2
	Tolerant to no flow	1	1	1	1

	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	3	2	2	3
	Moderately intolerant to modified physico-chemical conditions	2	2	2	3
	Moderately tolerant to modified physico-chemical conditions	1	1	1	2
	Tolerant modified to physico-chemical conditions	1	0	0	1

	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	4	4	4	4
	Movement between reaches	2	2	2	2
	Movement within a reach	1	1	1	1

	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	2	2	2	2
	Impoundments	4	4	4	4
	Physico-chemical barriers	2	2	2	2
	Flow modifications	2	2	2	2

	Introduced/alien species	Su15	Au15	Sp15	Su16
Introduced/alien species	Introduced/alien predacious species 1	MSAL	MSAL	MSAL	MSAL
	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	-	-	-	-
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	4	3	3	3
	FROC of introduced competing spp?	4	3	4	3

	The impact of introduced habitat modifying spp?	0	0	0	0
	FROC of habitat modifying spp?	0	0	0	0

	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		6.9	5.2	4.3	7
EC: FRAI		F	F	F	F
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		50.8	53.6	51.1	50.6
EC: FRAI		D	D	D	D

Site Name	U6MLAZ-USBAY-RHP 6	**Assessor**	W Evans
River	Mlazi	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC			
				Su15	Au15	Sp15	Su16
AMOS	ANGUILLA MOSSAMBICA PETERS 1852		4.93	-	-	-	-
ANAT	AMPHILIUS NATALENSIS BOULENGER, 1917		4.41	-	-	-	-
BGUR	BARBUS GURNEYI GÜNTHER, 1868		3.72	-	-	-	-
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861		3.72	-	-	-	-
BPAL	BARBUS PALLIDUS SMITH, 1841		2.85	-	-	-	-
BVIV	BARBUS VIVIPARUS WEBER, 1897		3.72	-	-	-	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)		4.41	-	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)		4.41	-	1	3	3
TSPA	TILAPIA SPARRMANII SMITH, 1840		4.41	-	-	-	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity	Fast-Deep	3	3	3	2
Depth Metric	Fast-Shallow	2	2	3	1

Cover features	Slow-Deep	3	3	3	2
	Slow-Shallow	1	1	1	1
	Overhanging veg	1	2	2	2
	Undercut banks	3	3	3	3
	Substrate	4	3	4	3
	Instream veg	2	2	2	2
	Water column	3	3	3	2
	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	3	3	3	2
	Moderately intolerant to no flow	2	2	2	2
	Moderately tolerant to no flow	2	1	2	2
	Tolerant to no flow	0	1	1	1
	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	3	2	2	2
	Moderately intolerant to modified physico-chemical conditions	2	2	2	2
	Moderately tolerant to modified physico-chemical conditions	2	1	1	1
	Tolerant modified to physico-chemical conditions	2	1	1	1
	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	3	3	3	3
	Movement between reaches	3	3	3	3
	Movement within a reach	2	2	2	2
	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	2	2	2	2
	Impoundments	3	3	3	3
	Physico-chemical barriers	2	2	2	2
	Flow modifications	3	3	3	3
	Introduced/alien species	Su15	Au15	Sp15	Su16

Introduced/alien species	Introduced/alien predacious species 1	MSAL	MSAL	MSAL	MSAL
	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	-	-	-	-
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	3	3	3	3
	FROC of introduced competing spp?	3	2	3	3
	The impact of introduced habitat modifying spp?	0	0	0	0
	FROC of habitat modifying spp?	0	0	0	0
	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		3.9	7.1	11.6	11.6
EC: FRAI		F	F	F	F
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		48.5	54.7	51.4	57
EC: FRAI		D	D	D	D

Site Name	V1THUK-RAILB-RHP 36	**Assessor**	W Evans
River	Thukela	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC Su15	Au15	Sp15	Su16
AAEN	AWAOUS AENEOFUSCUS (PETERS 1852)		5.00	-	-	-	-
ABER	ACANTHOPAGRUS BERDA (FORSSKÅL, 1775)		2.24	-	-	-	-
ABIC	ANGUILLA BICOLOR BICOLOR MCCLELLAND, 1844		5.00	-	-	-	-

AMAR	ANGUILLA MARMORATA QUOY & GAIMARD 1824	5.00	-	-	-	-
AMOS	ANGUILLA MOSSAMBICA PETERS 1852	5.00	-	-	-	-
ANAT	AMPHILIUS NATALENSIS BOULENGER, 1917	2.24	-	-	-	-
BGUR	BARBUS GURNEYI GÜNTHER, 1868	2.24	-	-	-	-
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861	5.00	-	-	3	3
BPAU	BARBUS PALUDINOSUS PETERS, 1852	5.00	-	-	-	-
BTRI	BARBUS TRIMACULATUS PETERS, 1852	5.00	-	-	-	-
BVIV	BARBUS VIVIPARUS WEBER, 1897	2.24	-	-	-	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)	5.00	-	-	1	3
GAES	GILCHRISTELLA AESTUARIA (GILCHRIST, 1913)	5.00	-	-	-	-
GCAL	GLOSSOGOBIUS CALLIDUS SMITH, 1937	2.24	-	-	-	-
GGIU	GLOSSOGOBIUS GIURIS (HAMILTON-BUCHANAN, 1822)	2.24	-	-	-	-
LMCR	LIZA MACROLEPIS (SMITH, 1846)	5.00	-	-	-	-
LMOL	LABEO MOLYBDINUS DU PLESSIS, 1963	5.00	-	5	3	3
LRUB	LABEO RUBROMACULATUS GILCHRIST & THOMPSON, 1913	2.24	-	-	-	-
MCAP	MYXUS CAPENSIS (VALENCIENNES, 1836)	5.00	-	-	-	-
MCEP	MUGIL CEPHALUS LINNAEUS, 1758	5.00	-	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)	5.00	-	-	-	-
PPHI	PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)	5.00	-	-	-	3

RDEW	REDIGOBIUS DEWAALI (WEBER, 1897)	5.00	-	-	-	-
TSPA	TILAPIA SPARRMANII SMITH, 1840	5.00	-	-	3	3

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	4	3	2	3
	Fast-Shallow	2	2	1	2
	Slow-Deep	2	2	0	1
	Slow-Shallow	1	1	0	1
Cover features	Overhanging veg	3	3	2	2
	Undercut banks	3	3	3	3
	Substrate	1	1	1	1
	Instream veg	3	3	2	3
	Water column	3	3	2	3

	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	2	2	2	2
	Moderately intolerant to no flow	2	2	2	2
	Moderately tolerant to no flow	2	1	2	2
	Tolerant to no flow	1	1	1	1

	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	2	2	2	3
	Moderately intolerant to modified physico-chemical conditions	2	2	2	2
	Moderately tolerant to modified physico-chemical conditions	1	1	1	2
	Tolerant modified to physico-chemical conditions	1	0	1	1

	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	1	1	1	1
	Movement between reaches	2	2	2	2
	Movement within a reach	1	1	1	1

	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	2	2	2	2
	Impoundments	3	3	3	3
	Physico-chemical barriers	1	1	1	1
	Flow modifications	3	3	3	3
	Introduced/alien species	**Su15**	**Au15**	**Sp15**	**Su16**
Introduced/alien species	Introduced/alien predacious species 1	-	-	-	-
	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	-	-	CCAR	CCAR
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	-	-	0	0
	FROC of introduced competing spp?	-	-	0	0
	The impact of introduced habitat modifying spp?	-	-	3	3
	FROC of habitat modifying spp?	-	-	1	1
	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		14.7	25.1	26.2	28.8
EC: FRAI		F	F	E	E
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		62.3	63.3	68.8	63.2
EC: FRAI		C	C	C	C

Site Name	V1THUK-TUGEL-RHP 20	**Assessor**	W Evans
River	Thukela	**Reviewed**	G O'Brien

ABR	SPECIES			OBSERVED FROC

			REFERENCE FROC	Su15	Au15	Sp15	Su16
AAEN	AWAOUS AENEOFUSCUS (PETERS 1852)		4.95	-	-	-	-
ALAB	ANGUILLA BENGALENSIS LABIATA PETERS, 1852		4.95	-	-	-	-
AMAR	ANGUILLA MARMORATA QUOY & GAIMARD 1824		4.95	-	-	-	-
AMOS	ANGUILLA MOSSAMBICA PETERS 1852		5.00	-	-	1	1
ANAT	AMPHILIUS NATALENSIS BOULENGER, 1917		4.95	-	-	-	-
BANO	BARBUS ANOPLUS WEBER, 1897		4.95	-	-	-	-
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861		4.95	3	-	5	5
BTRI	BARBUS TRIMACULATUS PETERS, 1852		4.95	-	1	4	3
BVIV	BARBUS VIVIPARUS WEBER, 1897		4.95	3	-	-	1
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)		4.95	3	3	-	3
LMOL	LABEO MOLYBDINUS DU PLESSIS, 1963		4.95	-	1	5	3
LRUB	LABEO RUBROMACULATUS GILCHRIST & THOMPSON, 1913		4.95	3	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)		4.95	-	-	1	-
TSPA	TILAPIA SPARRMANII SMITH, 1840		4.95	-	-	-	-
PPHI	PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)		4.95	1	1	1	3
BPAU	BARBUS PALUDINOSUS PETERS, 1852		4.95	-	-	-	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity	Fast-Deep	2	3	3	3
Depth Metric	Fast-Shallow	1	2	3	3

Cover features	Slow-Deep	2	2	2	2
	Slow-Shallow	1	1	1	2
	Overhanging veg	1	1	2	2
	Undercut banks	2	2	1	2
	Substrate	1	1	1	1
	Instream veg	1	1	1	1
	Water column	1	2	2	2
	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	2	2	2	2
	Moderately intolerant to no flow	2	2	1	1
	Moderately tolerant to no flow	1	1	1	0
	Tolerant to no flow	0	0	0	0
	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	2	2	2	1
	Moderately intolerant to modified physico-chemical conditions	1	1	1	1
	Moderately tolerant to modified physico-chemical conditions	1	1	1	0
	Tolerant modified to physico-chemical conditions	1	1	0	0
	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	1	1	1	1
	Movement between reaches	1	1	1	1
	Movement within a reach	1	1	1	1
	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	1	1	1	1
	Impoundments	0	0	0	0
	Physico-chemical barriers	0	0	0	0
	Flow modifications	1	1	1	1
	Introduced/alien species	Su15	Au15	Sp15	Su16

Introduced/alien species	Introduced/alien predacious species 1	-	-	-	-
	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	-	-	-	-
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	-	-	-	-
	FROC of introduced competing spp?	-	-	-	-
	The impact of introduced habitat modifying spp?	-	-	-	-
	FROC of habitat modifying spp?	-	-	-	-

	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		29.2	22.5	41.1	38.6
EC: FRAI		E	E	D/E	D/E
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		75.2	72.4	74.4	74.6
EC: FRAI		C	C	C	C

Site Name	V2UNSP-KMBRG-RHP 15	**Assessor**	W Evans
River	Mooi/Mfulankomo	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC			
				Su15	Au15	Sp15	Su16
AMOS	ANGUILLA MOSSAMBICA PETERS 1852		4.94	-	-	-	-
BANO	BARBUS ANOPLUS WEBER, 1897		4.68	-	-	-	-
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861		4.68	-	-	-	-

	Response of species with a preference/tolerance to	Su1 5	Au1 5	Sp15	Su16
Velocity Depth Metric	Fast-Deep	-	2	2	2
	Fast-Shallow	-	1	1	2
	Slow-Deep	-	2	2	2
	Slow-Shallow	-	1	1	1
Cover features	Overhanging veg	-	1	1	1
	Undercut banks	-	2	2	2
	Substrate	-	1	1	1
	Instream veg	-	1	1	1
	Water column	-	2	2	2

	Response of species that are	Su1 5	Au1 5	Sp15	Su16
Flow dependence	Intolerant to no flow	-	2	2	2
	Moderately intolerant to no flow	-	1	1	2
	Moderately tolerant to no flow	-	1	1	1
	Tolerant to no flow	-	1	1	1

	Response of species that are	Su1 5	Au1 5	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	-	1	1	1
	Moderately intolerant to modified physico-chemical conditions	-	1	1	1
	Moderately tolerant to modified physico-chemical conditions	-	1	1	1
	Tolerant modified to physico-chemical conditions	-	1	0	0

	Response of which require	Su1 5	Au1 5	Sp15	Su16
Migration	Catchment scale movement	-	2	2	2
	Movement between reaches	-	2	2	2
	Movement within a reach	-	1	1	1

	Extent of the following in the reach	Su1 5	Au1 5	Sp15	Su16
Changes in connectivity	Weirs and causeways	-	2	2	2
	Impoundments	-	1	1	1

	Physico-chemical barriers	-	1	1	1
	Flow modifications	-	2	2	2
	Introduced/alien species	Su15	Au15	Sp15	Su16
Introduced/alien species	Introduced/alien predacious species 1	-	OMYK	OMYK	OMYK
	Introduced/alien predacious species 2	-	STRU	STRU	STRU
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	-	-	-	-
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	-	2	3	3
	FROC of introduced competing spp?	-	2	3	2
	The impact of introduced habitat modifying spp?	-	0	0	0
	FROC of habitat modifying spp?	-	0	0	0
	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		-	11.5	9.7	11.1
EC: FRAI		-	F	F	F
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		-	70.9	71	69.5
EC: FRAI		-	C	C	C

Site Name	V3BUFF-CONFL-RHP 29	**Assessor**	W Evans
River	Buffalo	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC			
				Su15	Au15	Sp15	Su16
AMOS	ANGUILLA MOSSAMBICA PETERS 1852		5.00	-	-	-	-

BANO	BARBUS ANOPLUS WEBER, 1897	0.05	-	-	-	-
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861	5.00	3	1	5	5
TREN	TILAPIA RENDALLI (BOULENGER, 1896)	5.00	-	-	1	-
BPAU	BARBUS PALUDINOSUS PETERS, 1852	5.00	1	-	5	-
BVIV	BARBUS VIVIPARUS WEBER, 1897	0.05	-	-	-	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)	5.00	3	1	1	5
LRUB	LABEO RUBROMACULATUS GILCHRIST & THOMPSON, 1913	0.05	-	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)	5.00	-	-	-	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	2	2	2	2
	Fast-Shallow	2	2	1	1
	Slow-Deep	0	0	2	2
	Slow-Shallow	1	1	1	1
Cover features	Overhanging veg	1	1	1	1
	Undercut banks	2	2	1	1
	Substrate	3	3	3	3
	Instream veg	2	2	1	2
	Water column	1	2	1	1

	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	2	2	2	2
	Moderately intolerant to no flow	1	1	1	1
	Moderately tolerant to no flow	1	1	1	1
	Tolerant to no flow	0	1	0	0

	Response of species that are	Su15	Au15	Sp15	Su16
	Intolerant to modified physico-chemical conditions	2	2	2	3

	Moderately intolerant to modified physico-chemical conditions	1	2	1	2
Physico-chemical conditions	Moderately tolerant to modified physico-chemical conditions	1	1	0	1
	Tolerant modified to physico-chemical conditions	1	1	0	1
	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	2	2	2	2
	Movement between reaches	1	1	1	1
	Movement within a reach	1	1	1	1
	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	2	2	3	3
	Impoundments	2	2	1	1
	Physico-chemical barriers	1	1	1	1
	Flow modifications	2	2	2	2
	Introduced/alien species	Su15	Au15	Sp15	Su16
Introduced/alien species	Introduced/alien predacious species 1	PRET	PRET	PRET	PRET
	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	PRET	PRET	PRET	PRET
	Introduced/alien habitat modifying species 2	CCAR	CCAR	CCAR	CCAR
	The impact of introduced competing spp?	2	2	1	1
	FROC of introduced competing spp?	2	2	1	1
	The impact of introduced habitat modifying spp?	3	3	4	4
	FROC of habitat modifying spp?	3	3	2	2
	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				

FRAI (%)		36.8	18.9	53.8	49
EC: FRAI		E	E/F	D	D
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		68.9	66.1	72.4	68.1
EC: FRAI		C	C	C	C

Site Name	V3NCND-LEYDN-RHP 28	**Assessor**	W Evans
River	Ncandu	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC			
				Su15	Au15	Sp15	Su16
AMOS	ANGUILLA MOSSAMBICA PETERS 1852		4.90	-	-	-	-
ANAT	AMPHILIUS NATALENSIS BOULENGER, 1917		3.13	3	3	3	1
BANO	BARBUS ANOPLUS WEBER, 1897		3.13	3	3	3	3
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861		4.74	-	-	-	-
BPAL	BARBUS PALLIDUS SMITH, 1841		1.25	-	-	-	-
BPAU	BARBUS PALUDINOSUS PETERS, 1852		4.74	-	-	-	-
BVIV	BARBUS VIVIPARUS WEBER, 1897		2.95	-	-	-	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)		4.74	-	-	-	-
LRUB	LABEO RUBROMACULATUS GILCHRIST & THOMPSON, 1913		2.95	-	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)		4.74	-	-	-	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	3	3	3	4
	Fast-Shallow	1	1	3	3
	Slow-Deep	3	3	3	3
	Slow-Shallow	1	1	2	2

Cover features	Overhanging veg	2	2	3	3
	Undercut banks	2	2	2	2
	Substrate	1	1	1	1
	Instream veg	3	3	3	3
	Water column	1	2	3	3
	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	3	3	3	3
	Moderately intolerant to no flow	2	2	2	3
	Moderately tolerant to no flow	1	2	2	2
	Tolerant to no flow	1	1	1	2
	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	3	3	3	3
	Moderately intolerant to modified physico-chemical conditions	2	2	2	2
	Moderately tolerant to modified physico-chemical conditions	1	1	1	1
	Tolerant modified to physico-chemical conditions	1	1	1	1
	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	2	2	2	2
	Movement between reaches	1	1	1	1
	Movement within a reach	1	1	1	1
	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	2	2	2	2
	Impoundments	1	1	1	1
	Physico-chemical barriers	1	1	1	1
	Flow modifications	2	2	2	2
	Introduced/alien species	Su15	Au15	Sp15	Su16
Introduced/alien species	Introduced/alien predacious species 1	-	MSAL	MSAL	MSAL

	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	-	-	-	-
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	-	3	3	3
	FROC of introduced competing spp?	-	1	2	2
	The impact of introduced habitat modifying spp?	-	0	0	0
	FROC of habitat modifying spp?	-	0	0	0
	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		39.4	35.8	34.9	23.4
EC: FRAI		D/E	E	E	E
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		65.5	60	54.5	51.5
EC: FRAI		C	C/D	D	D

Site Name	V3SAND-COTSW-RHP 26	**Assessor**	W Evans
River	Mzinyashana	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC			
				Su15	Au15	Sp15	Su16
AMOS	ANGUILLA MOSSAMBICA PETERS 1852		5.00	-	-	-	-
BANO	BARBUS ANOPLUS WEBER, 1897		5.00	3	3	3	5
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861		5.00	-	-	-	-
BPAL	BARBUS PALLIDUS SMITH, 1841		5.00	-	-	-	-
BPAU	BARBUS PALUDINOSUS PETERS, 1852		5.00	-	-	1	-

BVIV	BARBUS VIVIPARUS WEBER, 1897	5.00	-	-	-	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)	5.00	1	1	-	-
LRUB	LABEO RUBROMACULATUS GILCHRIST & THOMPSON, 1913	5.00	-	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)	5.00	-	-	-	-
TSPA	TILAPIA SPARRMANII SMITH, 1840	5.00	1	1	-	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	3	3	4	4
	Fast-Shallow	2	2	3	3
	Slow-Deep	3	3	3	3
	Slow-Shallow	2	2	2	2
Cover features	Overhanging veg	1	1	2	2
	Undercut banks	2	2	2	2
	Substrate	3	4	4	4
	Instream veg	3	3	3	3
	Water column	3	2	3	3

	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	3	3	4	4
	Moderately intolerant to no flow	2	2	4	4
	Moderately tolerant to no flow	2	2	3	3
	Tolerant to no flow	0	1	2	2

	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	3	3	3	3
	Moderately intolerant to modified physico-chemical conditions	3	3	3	3
	Moderately tolerant to modified physico-chemical conditions	2	2	2	2

	Tolerant modified to physico-chemical conditions	2	2	2	2
	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	2	2	5	5
	Movement between reaches	2	2	5	5
	Movement within a reach	1	1	3	3
	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	2	2	4	4
	Impoundments	1	1	1	1
	Physico-chemical barriers	3	3	3	3
	Flow modifications	3	3	5	5
	Introduced/alien species	Su15	Au15	Sp15	Su16
Introduced/alien species	Introduced/alien predacious species 1	-	-	-	-
	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	-	-	-	-
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	-	-	-	-
	FROC of introduced competing spp?	-	-	-	-
	The impact of introduced habitat modifying spp?	-	-	-	-
	FROC of habitat modifying spp?	-	-	-	-
	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		20.2	20.1	11.4	11.2
EC: FRAI		E/F	E/F	F	F
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		56.7	55.7	36.5	38.5
EC: FRAI		D	D	E	D/E

Site Name	V3SLNG NCHTW-RHP 33	**Assessor**	W Evans
River	Slang	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC			
				Su15	Au15	Sp15	Su16
AMOS	ANGUILLA MOSSAMBICA PETERS 1852		4.95	-	-	-	-
BANO	BARBUS ANOPLUS WEBER, 1897		3.05	3	5	1	3
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861		4.81	-	-	-	-
BPAL	BARBUS PALLIDUS SMITH, 1841		0.97	-	-	-	-
BPAU	BARBUS PALUDINOSUS PETERS, 1852		4.81	-	-	-	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)		4.81	-	-	-	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	3	3	3	3
	Fast-Shallow	1	1	2	2
	Slow-Deep	3	4	4	3
	Slow-Shallow	1	1	1	1
Cover features	Overhanging veg	2	2	2	2
	Undercut banks	1	1	1	1
	Substrate	3	3	3	3
	Instream veg	2	2	2	2
	Water column	2	2	3	3

	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	2	3	3	3
	Moderately intolerant to no flow	2	2	2	2
	Moderately tolerant to no flow	1	1	2	1
	Tolerant to no flow	1	1	1	1

	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	2	2	2	2
	Moderately intolerant to modified physico-chemical conditions	2	2	2	2
	Moderately tolerant to modified physico-chemical conditions	1	1	1	1
	Tolerant modified to physico-chemical conditions	1	1	1	1
	Response of which require	**Su15**	**Au15**	**Sp15**	**Su16**
Migration	Catchment scale movement	2	2	2	2
	Movement between reaches	2	2	2	2
	Movement within a reach	1	1	1	1
	Extent of the following in the reach	**Su15**	**Au15**	**Sp15**	**Su16**
Changes in connectivity	Weirs and causeways	2	2	2	2
	Impoundments	1	1	1	1
	Physico-chemical barriers	1	1	1	1
	Flow modifications	2	2	2	2
	Introduced/alien species	**Su15**	**Au15**	**Sp15**	**Su16**
Introduced/alien species	Introduced/alien predacious species 1	-	-	-	-
	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	-	-	-	-
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	-	-	-	-
	FROC of introduced competing spp?	-	-	-	-

	The impact of introduced habitat modifying spp?	-	-	-	-
	FROC of habitat modifying spp?	-	-	-	-

	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		22.7	27.9	17.5	24
EC: FRAI		E	E	E/F	E
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		65.3	63.8	60.5	66.5
EC: FRAI		C	C	C/D	C

Site Name	V7BUSH-MOORP-RHP 17	**Assessor**	W Evans
River	Bushmans	**Reviewed**	G O'Brien

ABR	SPECIES	REFERENCE FROC	OBSERVED FROC Su15	Au15	Sp15	Su16
AMOS	ANGUILLA MOSSAMBICA PETERS 1852	5.00	-	-	-	-
ANAT	AMPHILIUS NATALENSIS BOULENGER, 1917	5.00	1	3	-	-
BANO	BARBUS ANOPLUS WEBER, 1897	5.00	-	-	-	-
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861	5.00	3	3	3	5
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)	5.00	-	3	-	1
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)	5.00	-	-	-	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	2	2	3	3
	Fast-Shallow	1	1	2	2
	Slow-Deep	1	2	3	3
	Slow-Shallow	1	1	1	1
Cover features	Overhanging veg	1	1	2	3
	Undercut banks	1	1	2	2
	Substrate	2	2	2	2

	Instream veg	2	2	2	2
	Water column	1	2	3	3
	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	2	2	3	3
	Moderately intolerant to no flow	2	2	2	3
	Moderately tolerant to no flow	1	1	2	2
	Tolerant to no flow	1	1	1	1
	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	1	1	1	1
	Moderately intolerant to modified physico-chemical conditions	1	1	1	1
	Moderately tolerant to modified physico-chemical conditions	0	0	1	1
	Tolerant modified to physico-chemical conditions	0	0	0	0
	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	4	4	4	4
	Movement between reaches	3	3	3	3
	Movement within a reach	1	1	1	1
	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	2	2	2	2
	Impoundments	3	3	3	3
	Physico-chemical barriers	1	1	1	1
	Flow modifications	3	3	3	3
	Introduced/alien species	Su15	Au15	Sp15	Su16
Introduced/alien species	Introduced/alien predacious species 1	-	-	-	-
	Introduced/alien predacious species 2	-	-	-	-

	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	-	-	-	-
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	-	-	-	-
	FROC of introduced competing spp?	-	-	-	-
	The impact of introduced habitat modifying spp?	-	-	-	-
	FROC of habitat modifying spp?	-	-	-	-
	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		24	30.6	18.8	25.1
EC: FRAI		E	E	E/F	E
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		70.7	68.9	60.5	58.7
EC: FRAI		C	C	C/D	C/D

Site Name	W1EVTH-GINNE-RHP 18	**Assessor**	W Evans
River	Vutha/Matikulu	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC			
				Su15	Au15	Sp15	Su16
AAEN	AWAOUS AENEOFUSCUS (PETERS 1852)		5.00	-	-	-	-
ABER	ACANTHOPAGRUS BERDA (FORSSKÅL, 1775)		2.04	-	-	-	-
AMAR	ANGUILLA MARMORATA QUOY & GAIMARD 1824		5.00	-	-	-	-
AMOS	ANGUILLA MOSSAMBICA PETERS 1852		5.00	-	-	-	-
AMYA	APLOCHEILICHTHYS MYAPOSAE (BOULENGER, 1908)		5.00	-	-	-	-

BGUR	BARBUS GURNEYI GÜNTHER, 1868	5.00	-	-	-	-
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861	5.00	1	-	-	-
BPAU	BARBUS PALUDINOSUS PETERS, 1852	5.00	-	1	3	3
BTRI	BARBUS TRIMACULATUS PETERS, 1852	5.00	-	3	-	1
BVIV	BARBUS VIVIPARUS WEBER, 1897	5.00	-	-	-	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)	5.00	1	-	-	-
CTHE	CLARIAS THEODORAE WEBER, 1897	5.00	-	-	-	-
GCAL	GLOSSOGOBIUS CALLIDUS SMITH, 1937	2.04	1	-	1	-
GGIU	GLOSSOGOBIUS GIURIS (HAMILTON-BUCHANAN, 1822)	2.04	-	-	-	-
LMOL	LABEO MOLYBDINUS DU PLESSIS, 1963	5.00	-	-	-	-
MBRE	MESOBOLA BREVIANALIS (BOULENGER, 1908)	5.00	-	-	-	-
MCAP	MYXUS CAPENSIS (VALENCIENNES, 1836)	2.04	1	-	1	-
MCEP	MUGIL CEPHALUS LINNAEUS, 1758	2.04	-	-	-	-
MMAC	MARCUSENIUS MACROLEPIDOTUS (PETERS, 1852)	5.00	-	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)	5.00	-	3	5	-
PPHI	PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)	5.00	1	-	-	3
RDEW	REDIGOBIUS DEWAALI (WEBER, 1897)	2.04	-	-	-	-
TREN	TILAPIA RENDALLI (BOULENGER, 1896)	5.00	3	1	3	-

TSPA	TILAPIA SPARRMANII SMITH, 1840	5.00	1	-	-	5

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	3	3	3	3
	Fast-Shallow	2	2	3	3
	Slow-Deep	1	1	2	2
	Slow-Shallow	1	1	1	1
Cover features	Overhanging veg	2	2	2	2
	Undercut banks	2	2	3	3
	Substrate	4	4	4	4
	Instream veg	2	2	2	2
	Water column	2	2	2	3

	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	2	2	3	3
	Moderately intolerant to no flow	2	1	2	2
	Moderately tolerant to no flow	1	1	2	2
	Tolerant to no flow	0	0	1	1

	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	2	2	2	2
	Moderately intolerant to modified physico-chemical conditions	1	1	1	1
	Moderately tolerant to modified physico-chemical conditions	1	1	1	1
	Tolerant modified to physico-chemical conditions	1	1	1	1

	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	2	2	2	2
	Movement between reaches	2	2	2	2
	Movement within a reach	1	1	1	1

	Extent of the following in the reach	Su15	Au15	Sp15	Su16

Changes in connectivity	Weirs and causeways	2	2	2	2
	Impoundments	1	1	1	1
	Physico-chemical barriers	1	1	1	1
	Flow modifications	2	2	2	2
	Introduced/alien species	Su15	Au15	Sp15	Su16
Introduced/alien species	Introduced/alien predacious species 1	PRET	PRET	PRET	PRET
	Introduced/alien predacious species 2	-	-	MSAL	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	PRET	PRET	PRET	PRET
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	1	1	3	1
	FROC of introduced competing spp?	1	1	2	1
	The impact of introduced habitat modifying spp?	1	1	1	1
	FROC of habitat modifying spp?	1	1	1	1
	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		21.8	19.9	19.6	20.3
EC: FRAI		E/F	E/F	E/F	E/F
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		66.7	67.7	57.8	58.8
EC: FRAI		C	C	C/D	C/D

Site Name	W1MATI-NYEZA-RHP 43	**Assessor**	W Evans
River	Matikulu	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC			
				Su15	Au15	Sp15	Su16

AAEN	AWAOUS AENEOFUSCUS (PETERS 1852)	5.00	-	1	3	3
ABER	ACANTHOPAGRUS BERDA (FORSSKÅL, 1775)	2.04	-	-	-	-
AMAR	ANGUILLA MARMORATA QUOY & GAIMARD 1824	5.00	-	-	-	-
AMOS	ANGUILLA MOSSAMBICA PETERS 1852	5.00	-	-	-	-
AMYA	APLOCHEILICHTHYS MYAPOSAE (BOULENGER, 1908)	5.00	-	-	-	-
BGUR	BARBUS GURNEYI GÜNTHER, 1868	5.00	-	-	-	-
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861	5.00	-	-	-	-
BPAU	BARBUS PALUDINOSUS PETERS, 1852	5.00	-	-	-	-
BTRI	BARBUS TRIMACULATUS PETERS, 1852	5.00	-	-	3	-
BVIV	BARBUS VIVIPARUS WEBER, 1897	5.00	-	-	-	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)	5.00	-	-	-	-
CTHE	CLARIAS THEODORAE WEBER, 1897	5.00	-	-	-	-
GCAL	GLOSSOGOBIUS CALLIDUS SMITH, 1937	2.04	1	-	3	2
GGIU	GLOSSOGOBIUS GIURIS (HAMILTON-BUCHANAN, 1822)	2.04	-	1	-	-
LMOL	LABEO MOLYBDINUS DU PLESSIS, 1963	5.00	-	-	-	-
MBRE	MESOBOLA BREVIANALIS (BOULENGER, 1908)	5.00	-	-	-	-
MCAP	MYXUS CAPENSIS (VALENCIENNES, 1836)	2.04	3	-	3	3
MCEP	MUGIL CEPHALUS LINNAEUS, 1758	2.04	-	-	-	-

MMAC	MARCUSENIUS MACROLEPIDOTUS (PETERS, 1852)	5.00	-	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)	5.00	5	-	5	-
PPHI	PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)	5.00	-	3	-	3
RDEW	REDIGOBIUS DEWAALI (WEBER, 1897)	2.04	-	-	-	-
TREN	TILAPIA RENDALLI (BOULENGER, 1896)	5.00	5	-	1	-
TSPA	TILAPIA SPARRMANII SMITH, 1840	5.00	-	-	-	5
MFAL	MONODACTYLUS FALCIFORMIS LACEPÈDE, 1801	5.00	-	-	5	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	3	4	4	4
	Fast-Shallow	2	3	3	3
	Slow-Deep	1	1	1	1
	Slow-Shallow	1	1	1	1
Cover features	Overhanging veg	2	2	2	2
	Undercut banks	3	4	3	3
	Substrate	3	4	3	3
	Instream veg	2	2	2	2
	Water column	3	3	2	2

	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	2	2	2	2
	Moderately intolerant to no flow	1	1	2	2
	Moderately tolerant to no flow	1	1	1	1
	Tolerant to no flow	1	1	1	1

	Response of species that are	Su15	Au15	Sp15	Su16
	Intolerant to modified physico-chemical conditions	3	3	2	2

	Moderately intolerant to modified physico-chemical conditions	2	2	2	2
Physico-chemical conditions	Moderately tolerant to modified physico-chemical conditions	2	2	1	1
	Tolerant modified to physico-chemical conditions	1	1	1	0
	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	2	2	2	2
	Movement between reaches	2	2	2	2
	Movement within a reach	2	2	2	2
	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	2	2	2	2
	Impoundments	2	2	2	2
	Physico-chemical barriers	1	1	1	1
	Flow modifications	3	3	3	3
	Introduced/alien species	Su15	Au15	Sp15	Su16
Introduced/alien species	Introduced/alien predacious species 1	MSAL	MSAL	MSAL	MSAL
	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	-	-	-	-
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	3	2	2	2
	FROC of introduced competing spp?	3	2	2	2
	The impact of introduced habitat modifying spp?	0	0	0	0
	FROC of habitat modifying spp?	0	0	0	0
	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				

FRAI (%)		16.8	12.3	23.6	18.1
EC: FRAI		F	F	E	E/F
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		55.4	53.4	57.8	56.9
EC: FRAI		D	D	C/D	D

Site Name	W1MFLE-ELIZB-RHP 22	**Assessor**	W Evans
River	Mfule	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC			
				Su15	Au15	Sp15	Su16
AAEN	AWAOUS AENEOFUSCUS (PETERS 1852)		4.62	-	-	-	-
AMAR	ANGUILLA MARMORATA QUOY & GAIMARD 1824		4.25	-	-	-	-
AMOS	ANGUILLA MOSSAMBICA PETERS 1852		4.96	-	-	-	-
BGUR	BARBUS GURNEYI GÜNTHER, 1868		4.96	-	-	-	-
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861		4.96	5	3	-	-
BPAU	BARBUS PALUDINOSUS PETERS, 1852		4.96	-	1	-	-
BTRI	BARBUS TRIMACULATUS PETERS, 1852		4.96	-	3	-	-
BVIV	BARBUS VIVIPARUS WEBER, 1897		4.96	-	-	-	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)		4.62	-	-	-	3
LMOL	LABEO MOLYBDINUS DU PLESSIS, 1963		4.62	-	-	-	-
MMAC	MARCUSENIUS MACROLEPIDOTUS (PETERS, 1852)		4.25	-	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)		4.62	-	3	-	-

PPHI	PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)	4.96	-	-	-	-
TSPA	TILAPIA SPARRMANII SMITH, 1840	4.96	-	-	-	-
TREN	TILAPIA RENDALLI (BOULENGER, 1896)	4.96	5	-	-	5
BANN	BARBUS ANNECTENS GILCHRIST & THOMPSON, 1917	5.00	-	1	-	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	3	3	-	3
	Fast-Shallow	1	1	-	1
	Slow-Deep	3	4	-	3
	Slow-Shallow	1	1	-	1
Cover features	Overhanging veg	1	1	-	1
	Undercut banks	2	2	-	3
	Substrate	3	3	-	3
	Instream veg	2	2	-	2
	Water column	2	2	-	2

	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	2	3	-	2
	Moderately intolerant to no flow	2	2	-	2
	Moderately tolerant to no flow	1	1	-	1
	Tolerant to no flow	1	1	-	1

	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	2	2	-	2
	Moderately intolerant to modified physico-chemical conditions	2	2	-	2
	Moderately tolerant to modified physico-chemical conditions	1	1	-	1
	Tolerant modified to physico-chemical conditions	1	1	-	1

	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	2	2	-	2
	Movement between reaches	2	2	-	2
	Movement within a reach	1	1	-	1
	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	2	2	-	2
	Impoundments	1	1	-	1
	Physico-chemical barriers	2	2	-	2
	Flow modifications	3	3	-	3
	Introduced/alien species	Su15	Au15	Sp15	Su16
Introduced/alien species	Introduced/alien predacious species 1	-	-	-	-
	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	-	-	-	-
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	-	-	-	-
	FROC of introduced competing spp?	-	-	-	-
	The impact of introduced habitat modifying spp?	-	-	-	-
	FROC of habitat modifying spp?	-	-	-	-
	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		32.7	29.2	-	19.4
EC: FRAI		E	E	-	E/F
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		65.3	63.3	-	64.5
EC: FRAI		C	C	-	C

Site Name	W1MHLA-GWEIR-RHP 21	**Assessor**	W Evans
River	Mhlathuze	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC			
				Su15	Au15	Sp15	Su16
AAEN	AWAOUS AENEOFUSCUS (PETERS 1852)		5.00	-	-	-	-
ABIC	ANGUILLA BICOLOR BICOLOR MCCLELLAND, 1844		5.00	-	-	-	-
AJOH	APLOCHEILICHTHYS JOHNSTONI (GÜNTHER, 1893)		5.00	-	-	-	3
AMAR	ANGUILLA MARMORATA QUOY & GAIMARD 1824		5.00	-	-	-	-
AMOS	ANGUILLA MOSSAMBICA PETERS 1852		5.00	-	-	-	-
AMYA	APLOCHEILICHTHYS MYAPOSAE (BOULENGER, 1908)		5.00	-	-	-	-
BGUR	BARBUS GURNEYI GÜNTHER, 1868		5.00	-	-	-	-
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861		5.00	-	-	-	3
BPAU	BARBUS PALUDINOSUS PETERS, 1852		5.00	1	-	-	-
BTRI	BARBUS TRIMACULATUS PETERS, 1852		5.00	3	-	-	-
BVIV	BARBUS VIVIPARUS WEBER, 1897		5.00	-	-	-	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)		5.00	-	3	-	-
CMUL	CTENOPOMA MULTISPINE PETERS, 1844		5.00	-	-	-	-
CTHE	CLARIAS THEODORAE WEBER, 1897		5.00	-	-	-	-
GAES	GILCHRISTELLA AESTUARIA (GILCHRIST, 1913)		5.00	-	-	-	-
GCAL	GLOSSOGOBIUS CALLIDUS SMITH, 1937		5.00	3	3	-	3

GGIU	GLOSSOGOBIUS GIURIS (HAMILTON-BUCHANAN, 1822)	5.00	-	-	-	-
LCYL	LABEO CYLINDRICUS PETERS, 1852	5.00	-	-	-	-
LMOL	LABEO MOLYBDINUS DU PLESSIS, 1963	5.00	-	5	-	-
MMAC	MARCUSENIUS MACROLEPIDOTUS (PETERS, 1852)	5.00	3	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)	5.00	3	5	-	3
PPHI	PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)	5.00	3	3	-	5
RDEW	REDIGOBIUS DEWAALI (WEBER, 1897)	5.00	-	-	-	-
TREN	TILAPIA RENDALLI (BOULENGER, 1896)	5.00	3	-	-	-
TSPA	TILAPIA SPARRMANII SMITH, 1840	5.00	-	-	-	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	3	3	-	2
	Fast-Shallow	2	2	-	1
	Slow-Deep	3	3	-	2
	Slow-Shallow	1	1	-	1
Cover features	Overhanging veg	1	1	-	1
	Undercut banks	2	2	-	1
	Substrate	2	2	-	2
	Instream veg	2	2	-	2
	Water column	1	1	-	1

	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	2	2	-	1
	Moderately intolerant to no flow	1	2	-	1
	Moderately tolerant to no flow	1	1	-	1
	Tolerant to no flow	1	1	-	0

	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	2	2	-	2
	Moderately intolerant to modified physico-chemical conditions	2	2	-	1
	Moderately tolerant to modified physico-chemical conditions	1	1	-	1
	Tolerant modified to physico-chemical conditions	1	1	-	0
	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	3	3	-	3
	Movement between reaches	3	3	-	3
	Movement within a reach	2	2	-	2
	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	3	3	-	3
	Impoundments	2	2	-	2
	Physico-chemical barriers	1	1	-	1
	Flow modifications	2	2	-	2
	Introduced/alien species	Su15	Au15	Sp15	Su16
Introduced/alien species	Introduced/alien predacious species 1	PRET	PRET	-	PRET
	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	PRET	PRET	-	PRET
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	1	1	-	1
	FROC of introduced competing spp?	1	1	-	1

	The impact of introduced habitat modifying spp?	1	1	-	1
	FROC of habitat modifying spp?	1	1	-	1
	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		21.4	25.6	-	21.2
EC: FRAI		E/F	E	-	E/F
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		62.4	63.4	-	70.9
EC: FRAI		C	C	-	C

Site Name	W1NWKU-MTGLU-RHP 19	**Assessor**	W Evans
River	Nwaku	**Reviewed**	G O'Brien

ABR	SPECIES	REFERENCE FROC	OBSERVED FROC Su15	Au15	Sp15	Su16
AAEN	AWAOUS AENEOFUSCUS (PETERS 1852)	4.38	-	-	-	-
AMAR	ANGUILLA MARMORATA QUOY & GAIMARD 1824	2.48	-	-	-	3
AMOS	ANGUILLA MOSSAMBICA PETERS 1852	4.84	1	-	-	-
BGUR	BARBUS GURNEYI GÜNTHER, 1868	4.84	-	-	-	-
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861	4.84	1	-	1	1
BPAU	BARBUS PALUDINOSUS PETERS, 1852	4.84	-	-	-	3
BTRI	BARBUS TRIMACULATUS PETERS, 1852	4.84	-	-	-	-
BVIV	BARBUS VIVIPARUS WEBER, 1897	4.84	-	3	-	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)	4.38	-	1	3	3
CTHE	CLARIAS THEODORAE WEBER, 1897	4.38	-	-	-	-

MBRE	MESOBOLA BREVIANALIS (BOULENGER, 1908)	2.48	-	-	-	-
MMAC	MARCUSENIUS MACROLEPIDOTUS (PETERS, 1852)	2.48	-	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)	4.38	3	5	3	5
PPHI	PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)	4.84	3	3	4	3
TREN	TILAPIA RENDALLI (BOULENGER, 1896)	4.38	5	-	-	-
TSPA	TILAPIA SPARRMANII SMITH, 1840	4.84	-	-	-	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	2	2	3	2
	Fast-Shallow	2	2	2	2
	Slow-Deep	1	2	2	2
	Slow-Shallow	0	1	1	0
Cover features	Overhanging veg	1	1	1	1
	Undercut banks	1	1	1	1
	Substrate	2	2	2	2
	Instream veg	2	2	2	2
	Water column	2	2	3	2

	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	2	3	3	2
	Moderately intolerant to no flow	2	2	2	2
	Moderately tolerant to no flow	1	2	2	1
	Tolerant to no flow	1	1	1	1

	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	2	2	2	2
	Moderately intolerant to modified physico-chemical conditions	1	1	1	1

	Moderately tolerant to modified physico-chemical conditions	1	1	1	1
	Tolerant modified to physico-chemical conditions	1	1	1	1

	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	2	2	2	2
	Movement between reaches	2	2	2	2
	Movement within a reach	2	2	2	2

	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	3	3	3	3
	Impoundments	1	1	1	1
	Physico-chemical barriers	1	1	1	1
	Flow modifications	2	2	2	2

	Introduced/alien species	Su15	Au15	Sp15	Su16
Introduced/alien species	Introduced/alien predacious species 1	-	-	-	-
	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	-	-	-	-
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	-	-	-	-
	FROC of introduced competing spp?	-	-	-	-
	The impact of introduced habitat modifying spp?	-	-	-	-
	FROC of habitat modifying spp?	-	-	-	-

	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		28.7	22	24.2	31.9
EC: FRAI		E	E/F	E	E

	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE			
FRAI (%)	69.6	65.6	63.8	68.6
EC: FRAI	C	C	C	C

Site Name	W2BMFO-NGOLO-RHP 39	**Assessor**	W Evans
River	Black Mfolozi	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC			
				Su15	Au15	Sp15	Su16
AAEN	AWAOUS AENEOFUSCUS (PETERS 1852)		5.00	-	3	-	-
AKAT	APLOCHEILICHTHYS KATANGAE (BOULENGER, 1912)		5.00	-	-	-	-
AMAR	ANGUILLA MARMORATA QUOY & GAIMARD 1824		5.00	-	-	-	-
AMOS	ANGUILLA MOSSAMBICA PETERS 1852		5.00	-	-	-	-
ANAT	AMPHILIUS NATALENSIS BOULENGER, 1917		5.00	-	-	-	-
BANO	BARBUS ANOPLUS WEBER, 1897		5.00	-	-	-	-
BARG	BARBUS ARGENTEUS GÜNTHER, 1868		5.00	-	-	-	-
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861		5.00	-	2	-	-
BPAU	BARBUS PALUDINOSUS PETERS, 1852		5.00	-	1	-	-
BTRI	BARBUS TRIMACULATUS PETERS, 1852		5.00	3	5	-	-
BUNI	BARBUS UNITAENIATUS GÜNTHER, 1866		5.00	-	-	-	-
BVIV	BARBUS VIVIPARUS WEBER, 1897		5.00	-	-	-	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)		5.00	-	3	-	-

GCAL	GLOSSOGOBIUS CALLIDUS SMITH, 1937	5.00	-	-	-	-
LMOL	LABEO MOLYBDINUS DU PLESSIS, 1963	5.00	-	3	-	-
MACU	MICRALESTES ACUTIDENS (PETERS, 1852)	5.00	-	-	-	-
MBRE	MESOBOLA BREVIANALIS (BOULENGER, 1908)	5.00	-	-	-	-
MCAP	MYXUS CAPENSIS (VALENCIENNES, 1836)	5.00	-	-	-	-
MCEP	MUGIL CEPHALUS LINNAEUS, 1758	5.00	-	-	-	-
MFLU	MICROPHIS FLUVIATILIS (PETERS, 1852)	5.00	-	-	-	-
MMAC	MARCUSENIUS MACROLEPIDOTUS (PETERS, 1852)	5.00	-	-	-	-
NORT	NOTHOBRANCHIUS ORTHONOTUS (PETERS, 1844)	5.00	-	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)	5.00	5	3	-	3
OPLA	OREOCHROMIS PLACIDUS (TREWAVAS, 1941)	5.00	-	-	-	-
TSPA	TILAPIA SPARRMANII SMITH, 1840	5.00	-	-	-	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	3	2	-	1
	Fast-Shallow	1	1	-	1
	Slow-Deep	3	2	-	2
	Slow-Shallow	1	1	-	1
Cover features	Overhanging veg	2	2	-	1
	Undercut banks	2	2	-	2
	Substrate	3	3	-	2
	Instream veg	3	3	-	3
	Water column	3	2	-	2

	Response of species that are	Su15	Au15	Sp15	Su16

		Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	3	2	-	2
	Moderately intolerant to no flow	2	2	-	1
	Moderately tolerant to no flow	2	1	-	1
	Tolerant to no flow	1	0	-	0
	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	2	2	-	2
	Moderately intolerant to modified physico-chemical conditions	1	1	-	1
	Moderately tolerant to modified physico-chemical conditions	1	1	-	1
	Tolerant modified to physico-chemical conditions	1	1	-	1
	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	2	2	-	2
	Movement between reaches	1	1	-	1
	Movement within a reach	1	1	-	1
	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	1	1	-	1
	Impoundments	1	1	-	1
	Physico-chemical barriers	1	1	-	1
	Flow modifications	2	2	-	2
	Introduced/alien species	Su15	Au15	Sp15	Su16
Introduced/alien species	Introduced/alien predacious species 1	-	-	-	-
	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	-	-	-	-

Introduced/alien habitat modifying species 2	-	-	-	-
The impact of introduced competing spp?	-	-	-	-
FROC of introduced competing spp?	-	-	-	-
The impact of introduced habitat modifying spp?	-	-	-	-
FROC of habitat modifying spp?	-	-	-	-

	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		18.4	27.9	-	16.5
EC: FRAI		E/F	E	-	F
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		63.3	69.1	-	72.7
EC: FRAI		C	C	-	C

Site Name	W2MFOL-CONFL-RHP 23	**Assessor**	W Evans
River	Mfolozi	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC			
				Su15	Au15	Sp15	Su16
AAEN	AWAOUS AENEOFUSCUS (PETERS 1852)		5.00	-	3	-	1
ALAB	ANGUILLA BENGALENSIS LABIATA PETERS, 1852		5.00	-	-	-	-
AMAR	ANGUILLA MARMORATA QUOY & GAIMARD 1824		5.00	-	1	-	-
AMOS	ANGUILLA MOSSAMBICA PETERS 1852		5.00	-	-	-	-
BLAT	BRYCINUS LATERALIS (BOULENGER, 1900)		5.00	-	-	-	-
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861		5.00	1	3	-	1
BPAU	BARBUS PALUDINOSUS PETERS, 1852		5.00	-	-	-	-

BTRI	BARBUS TRIMACULATUS PETERS, 1852	5.00	1	1	-	-
BUNI	BARBUS UNITAENIATUS GÜNTHER, 1866	5.00	-	-	-	-
BVIV	BARBUS VIVIPARUS WEBER, 1897	0.78	-	-	-	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)	5.00	-	3	-	1
GCAL	GLOSSOGOBIUS CALLIDUS SMITH, 1937	5.00	-	1	-	-
GGIU	GLOSSOGOBIUS GIURIS (HAMILTON-BUCHANAN, 1822)	5.00	-	-	-	-
LMOL	LABEO MOLYBDINUS DU PLESSIS, 1963	5.00	-	3	-	1
MACU	MICRALESTES ACUTIDENS (PETERS, 1852)	5.00	-	-	-	-
MBRE	MESOBOLA BREVIANALIS (BOULENGER, 1908)	5.00	-	-	-	-
MCAP	MYXUS CAPENSIS (VALENCIENNES, 1836)	5.00	-	-	-	-
MCEP	MUGIL CEPHALUS LINNAEUS, 1758	5.00	-	-	-	-
MCYP	MEGALOPS CYPRINOIDES (BROUSSONET, 1782)	5.00	-	-	-	-
MFLU	MICROPHIS FLUVIATILIS (PETERS, 1852)	5.00	-	-	-	-
MMAC	MARCUSENIUS MACROLEPIDOTUS (PETERS, 1852)	5.00	-	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)	5.00	3	5	-	3
PPHI	PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)	5.00	-	-	-	-
TSPA	TILAPIA SPARRMANII SMITH, 1840	5.00	-	-	-	-
TREN	TILAPIA RENDALLI (BOULENGER, 1896)	5.00	1	-	-	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	2	2	-	3
	Fast-Shallow	1	1	-	2
	Slow-Deep	3	2	-	3
	Slow-Shallow	1	1	-	1
Cover features	Overhanging veg	2	1	-	2
	Undercut banks	2	2	-	2
	Substrate	3	2	-	3
	Instream veg	1	1	-	1
	Water column	3	2	-	3

	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	3	2	-	3
	Moderately intolerant to no flow	2	2	-	3
	Moderately tolerant to no flow	1	1	-	2
	Tolerant to no flow	1	0	-	1

	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	1	1	-	2
	Moderately intolerant to modified physico-chemical conditions	1	1	-	2
	Moderately tolerant to modified physico-chemical conditions	0	0	-	1
	Tolerant modified to physico-chemical conditions	0	0	-	1

	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	2	2	-	2
	Movement between reaches	2	2	-	2
	Movement within a reach	1	1	-	1

	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	2	2	-	2
	Impoundments	1	1	-	1

	Physico-chemical barriers	1	1	-	1
	Flow modifications	3	3	-	3
	Introduced/alien species	Su15	Au15	Sp15	Su16
Introduced/alien species	Introduced/alien predacious species 1	PRET	PRET	-	PRET
	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	PRET	PRET	-	PRET
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	2	2	-	2
	FROC of introduced competing spp?	2	3	-	3
	The impact of introduced habitat modifying spp?	1	1	-	1
	FROC of habitat modifying spp?	2	3	-	3
	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		17.6	29.6	-	17.2
EC: FRAI		E/F	E	-	F
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		65.8	71.2	-	56.4
EC: FRAI		C	C	-	D

Site Name	W2MVNY-P0016-RHP 25	**Assessor**	W Evans
River	Mvunyana	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC			
				Su15	Au15	Sp15	Su16
AMOS	ANGUILLA MOSSAMBICA PETERS 1852		5.00	-	-	-	-

BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861	5.00	5	1	-	-
BPAU	BARBUS PALUDINOSUS PETERS, 1852	5.00	-	-	-	-
BTRI	BARBUS TRIMACULATUS PETERS, 1852	5.00	-	-	-	-
BUNI	BARBUS UNITAENIATUS GÜNTHER, 1866	5.00	-	-	-	-
BVIV	BARBUS VIVIPARUS WEBER, 1897	5.00	-	-	-	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)	5.00	-	-	-	-
LMOL	LABEO MOLYBDINUS DU PLESSIS, 1963	5.00	-	-	-	-
MACU	MICRALESTES ACUTIDENS (PETERS, 1852)	5.00	-	-	-	-
MMAC	MARCUSENIUS MACROLEPIDOTUS (PETERS, 1852)	5.00	-	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)	5.00	-	-	-	-
TSPA	TILAPIA SPARRMANII SMITH, 1840	5.00	-	-	-	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	3	4	-	4
	Fast-Shallow	2	2	-	3
	Slow-Deep	3	4	-	4
	Slow-Shallow	1	1	-	2
Cover features	Overhanging veg	2	2	-	3
	Undercut banks	2	2	-	2
	Substrate	3	3	-	3
	Instream veg	3	3	-	3
	Water column	3	4	-	4

	Response of species that are	Su15	Au15	Sp15	Su16
	Intolerant to no flow	4	4	-	4

Flow dependence	Moderately intolerant to no flow	3	3	-	4
	Moderately tolerant to no flow	3	3	-	4
	Tolerant to no flow	2	2	-	3
	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	2	2	-	2
	Moderately intolerant to modified physico-chemical conditions	1	1	-	1
	Moderately tolerant to modified physico-chemical conditions	1	1	-	1
	Tolerant modified to physico-chemical conditions	1	1	-	1
	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	2	2	-	2
	Movement between reaches	1	1	-	1
	Movement within a reach	1	1	-	1
	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	2	2	-	2
	Impoundments	1	1	-	1
	Physico-chemical barriers	1	1	-	1
	Flow modifications	3	3	-	3
	Introduced/alien species	Su15	Au15	Sp15	Su16
Introduced/alien species	Introduced/alien predacious species 1	-	-	-	-
	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	-	-	-	-
	Introduced/alien habitat modifying species 2	-	-	-	-

The impact of introduced competing spp?		-	-	-	-
FROC of introduced competing spp?		-	-	-	-
The impact of introduced habitat modifying spp?		-	-	-	-
FROC of habitat modifying spp?		-	-	-	-

	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		26.9	18.1	-	14.7
EC: FRAI		E	E/F	-	F
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		58.3	55.5	-	49.7
EC: FRAI		C/D	D	-	D

Site Name W2SKWB-GRTGL-RHP 27 **Assessor** W Evans

River Sikwebezi **Reviewed** G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC			
				Su15	Au15	Sp15	Su16
AAEN	AWAOUS AENEOFUSCUS (PETERS 1852)		4.06	-	1	3	3
ALAB	ANGUILLA BENGALENSIS LABIATA PETERS, 1852		4.06	-	-	-	-
AMOS	ANGUILLA MOSSAMBICA PETERS 1852		4.82	-	-	-	-
AURA	AMPHILIUS URANOSCOPUS (PFEFFER, 1889)		4.06	-	3	-	-
BANO	BARBUS ANOPLUS WEBER, 1897		4.06	1	-	-	-
BARG	BARBUS ARGENTEUS GÜNTHER, 1868		4.06	-	-	-	-
BEUT	BARBUS EUTAENIA BOULENGER, 1904		4.06	-	3	4	-
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861		4.06	3	1	5	4

BTRI	BARBUS TRIMACULATUS PETERS, 1852	4.06	-	5	1	5
BUNI	BARBUS UNITAENIATUS GÜNTHER, 1866	4.06	-	-	-	-
BVIV	BARBUS VIVIPARUS WEBER, 1897	4.06	1	-	-	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)	4.06	3	3	1	-
CTHE	CLARIAS THEODORAE WEBER, 1897	2.97	-	-	-	-
LMOL	LABEO MOLYBDINUS DU PLESSIS, 1963	4.06	3	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)	4.06	-	-	-	-
PPHI	PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)	4.06	-	-	-	-
TSPA	TILAPIA SPARRMANII SMITH, 1840	4.06	-	-	-	3
GCAL	GLOSSOGOBIUS CALLIDUS SMITH, 1937	2.97	-	-	1	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	1	2	4	4
	Fast-Shallow	1	1	1	3
	Slow-Deep	1	1	3	3
	Slow-Shallow	0	1	1	1
Cover features	Overhanging veg	0	1	3	3
	Undercut banks	1	1	3	3
	Substrate	0	1	1	1
	Instream veg	1	1	2	3
	Water column	1	1	2	3

	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	1	2	2	2
	Moderately intolerant to no flow	1	1	2	2
	Moderately tolerant to no flow	1	1	1	1
	Tolerant to no flow	0	0	0	0

	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	1	1	1	1
	Moderately intolerant to modified physico-chemical conditions	1	1	1	1
	Moderately tolerant to modified physico-chemical conditions	0	0	0	0
	Tolerant modified to physico-chemical conditions	0	0	0	0

	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	1	1	1	1
	Movement between reaches	1	1	1	1
	Movement within a reach	0	0	0	0

	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	2	2	2	2
	Impoundments	1	1	1	1
	Physico-chemical barriers	1	1	1	1
	Flow modifications	0	0	0	0

	Introduced/alien species	Su15	Au15	Sp15	Su16
Introduced/alien species	Introduced/alien predacious species 1	-	-	-	-
	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	-	-	-	-
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	-	-	-	-
	FROC of introduced competing spp?	-	-	-	-

		Su15	Au15	Sp15	Su16
	The impact of introduced habitat modifying spp?	-	-	-	-
	FROC of habitat modifying spp?	-	-	-	-

	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		36.7	40.6	42.8	34.5
EC: FRAI		E	D/E	D	E
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		86.9	82.3	72.5	69.9
EC: FRAI		B	B	C	C

Site Name	W2WMFO-DINDI-RHP 40	**Assessor**	W Evans
River	White Mfolozi	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC Su15	Au15	Sp15	Su16
AAEN	AWAOUS AENEOFUSCUS (PETERS 1852)		5.00	1	1	-	3
AKAT	APLOCHEILICHTHYS KATANGAE (BOULENGER, 1912)		5.00	-	-	-	-
ALAB	ANGUILLA BENGALENSIS LABIATA PETERS, 1852		5.00	-	-	-	-
AMAR	ANGUILLA MARMORATA QUOY & GAIMARD 1824		5.00	-	-	-	-
AMOS	ANGUILLA MOSSAMBICA PETERS 1852		5.00	-	-	-	-
BGUR	BARBUS GURNEYI GÜNTHER, 1868		5.00	-	-	-	-
BLAT	BRYCINUS LATERALIS (BOULENGER, 1900)		5.00	-	-	-	-
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861		5.00	3	3	-	3
BPAU	BARBUS PALUDINOSUS PETERS, 1852		5.00	-	-	-	-
BTRI	BARBUS TRIMACULATUS PETERS, 1852		5.00	1	3	-	-

BUNI	BARBUS UNITAENIATUS GÜNTHER, 1866	5.00	-	-	-	-
BVIV	BARBUS VIVIPARUS WEBER, 1897	5.00	-	-	-	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)	5.00	-	3	-	-
GCAL	GLOSSOGOBIUS CALLIDUS SMITH, 1937	5.00	-	-	-	-
GGIU	GLOSSOGOBIUS GIURIS (HAMILTON-BUCHANAN, 1822)	5.00	-	-	-	-
LMOL	LABEO MOLYBDINUS DU PLESSIS, 1963	5.00	1	3	-	1
MCAP	MYXUS CAPENSIS (VALENCIENNES, 1836)	5.00	-	-	-	-
MCEP	MUGIL CEPHALUS LINNAEUS, 1758	5.00	-	-	-	-
MCYP	MEGALOPS CYPRINOIDES (BROUSSONET, 1782)	5.00	-	-	-	-
MFLU	MICROPHIS FLUVIATILIS (PETERS, 1852)	5.00	-	-	-	-
MMAC	MARCUSENIUS MACROLEPIDOTUS (PETERS, 1852)	5.00	-	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)	5.00	3	3	-	3
OPLA	OREOCHROMIS PLACIDUS (TREWAVAS, 1941)	5.00	-	-	-	-
PPHI	PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)	5.00	-	-	-	-
TSPA	TILAPIA SPARRMANII SMITH, 1840	5.00	-	-	-	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	2	3	-	2
	Fast-Shallow	1	2	-	2
	Slow-Deep	1	2	-	2
	Slow-Shallow	1	1	-	1
	Overhanging veg	2	2	-	2

Cover features	Undercut banks	2	2	-	2
	Substrate	4	4	-	4
	Instream veg	2	2	-	2
	Water column	3	3	-	3
	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	3	3	-	3
	Moderately intolerant to no flow	2	2	-	2
	Moderately tolerant to no flow	1	1	-	1
	Tolerant to no flow	1	1	-	1
	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	2	2	-	2
	Moderately intolerant to modified physico-chemical conditions	2	2	-	2
	Moderately tolerant to modified physico-chemical conditions	1	1	-	1
	Tolerant modified to physico-chemical conditions	1	1	-	1
	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	2	2	-	2
	Movement between reaches	1	1	-	1
	Movement within a reach	1	1	-	1
	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	1	1	-	1
	Impoundments	1	1	-	1
	Physico-chemical barriers	0	0	-	0
	Flow modifications	2	2	-	2
	Introduced/alien species	Su15	Au15	Sp15	Su16
Introduced/alien species	Introduced/alien predacious species 1	-	-	-	-

	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	-	-	-	-
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	-	-	-	-
	FROC of introduced competing spp?	-	-	-	-
	The impact of introduced habitat modifying spp?	-	-	-	-
	FROC of habitat modifying spp?	-	-	-	-
	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		24.9	32.5	-	26.2
EC: FRAI		E	E	-	E
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		66.3	63.3	-	64.3
EC: FRAI		C	C	-	C

Site Name	W3HLHW-HLWGR-RHP 24	**Assessor**	W Evans
River	Hluhluwe	**Reviewed**	G O'Brien

ABR	SPECIES	REFERENCE FROC	OBSERVED FROC			
			Su15	Au15	Sp15	Su16
AAEN	AWAOUS AENEOFUSCUS (PETERS 1852)	5.00	-	-	-	-
AMAR	ANGUILLA MARMORATA QUOY & GAIMARD 1824	5.00	-	-	-	-
AMOS	ANGUILLA MOSSAMBICA PETERS 1852	5.00	-	-	-	-
BANN	BARBUS ANNECTENS GILCHRIST & THOMPSON, 1917	5.00	-	-	-	-

BANO	BARBUS ANOPLUS WEBER, 1897	5.00	-	-	-	-
BARG	BARBUS ARGENTEUS GÜNTHER, 1868	5.00	-	-	-	-
BLAT	BRYCINUS LATERALIS (BOULENGER, 1900)	5.00	-	-	-	-
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861	5.00	-	1	-	5
BPAU	BARBUS PALUDINOSUS PETERS, 1852	5.00	-	1	-	-
BTOP	BARBUS TOPPINI BOULENGER, 1916	5.00	-	-	-	-
BTRI	BARBUS TRIMACULATUS PETERS, 1852	5.00	-	3	-	-
BUNI	BARBUS UNITAENIATUS GÜNTHER, 1866	5.00	-	-	-	-
BVIV	BARBUS VIVIPARUS WEBER, 1897	5.00	-	-	-	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)	5.00	-	1	-	3
CTHE	CLARIAS THEODORAE WEBER, 1897	5.00	-	-	-	-
GAES	GILCHRISTELLA AESTUARIA (GILCHRIST, 1913)	5.00	-	-	-	-
GCAL	GLOSSOGOBIUS CALLIDUS SMITH, 1937	5.00	-	-	-	-
GGIU	GLOSSOGOBIUS GIURIS (HAMILTON-BUCHANAN, 1822)	5.00	-	-	-	-
LCYL	LABEO CYLINDRICUS PETERS, 1852	5.00	-	-	-	-
LMOL	LABEO MOLYBDINUS DU PLESSIS, 1963	5.00	-	-	-	-
MBRE	MESOBOLA BREVIANALIS (BOULENGER, 1908)	5.00	-	-	-	-
MCAP	MYXUS CAPENSIS (VALENCIENNES, 1836)	5.00	-	-	-	-
MCEP	MUGIL CEPHALUS LINNAEUS, 1758	5.00	-	-	-	-

MCYP	MEGALOPS CYPRINOIDES (BROUSSONET, 1782)	5.00	-	-	-	-
MFLU	MICROPHIS FLUVIATILIS (PETERS, 1852)	5.00	-	-	-	-
MMAC	MARCUSENIUS MACROLEPIDOTUS (PETERS, 1852)	5.00	-	-	-	-
NORT	NOTHOBRANCHIUS ORTHONOTUS (PETERS, 1844)	5.00	-	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)	5.00	-	1	-	-
PPHI	PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)	5.00	-	-	-	-
RDEW	REDIGOBIUS DEWAALI (WEBER, 1897)	5.00	-	-	-	-
TSPA	TILAPIA SPARRMANII SMITH, 1840	5.00	-	-	-	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	-	4	-	4
	Fast-Shallow	-	3	-	4
	Slow-Deep	-	4	-	2
	Slow-Shallow	-	1	-	1
Cover features	Overhanging veg	-	1	-	1
	Undercut banks	-	3	-	3
	Substrate	-	4	-	4
	Instream veg	-	2	-	2
	Water column	-	2	-	2

	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	-	3	-	4
	Moderately intolerant to no flow	-	2	-	3
	Moderately tolerant to no flow	-	1	-	1
	Tolerant to no flow	-	1	-	1

	Response of species that are	Su15	Au15	Sp15	Su16

Physico-chemical conditions	Intolerant to modified physico-chemical conditions	-	2	-	2
	Moderately intolerant to modified physico-chemical conditions	-	1	-	1
	Moderately tolerant to modified physico-chemical conditions	-	1	-	1
	Tolerant modified to physico-chemical conditions	-	0	-	0

	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	-	3	-	3
	Movement between reaches	-	2	-	2
	Movement within a reach	-	2	-	2

	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	-	1	-	1
	Impoundments	-	3	-	3
	Physico-chemical barriers	-	1	-	1
	Flow modifications	-	2	-	2

	Introduced/alien species	Su15	Au15	Sp15	Su16
Introduced/alien species	Introduced/alien predacious species 1	-	-	-	-
	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	-	-	-	-
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	-	-	-	-
	FROC of introduced competing spp?	-	-	-	-
	The impact of introduced habitat modifying spp?	-	-	-	-

	FROC of habitat modifying spp?	-	-	-	-
	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		-	16.4	-	17.6
EC: FRAI		-	F	-	E/F
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		-	59.1	-	57.1
EC: FRAI		-	C/D	-	D

Site Name	W3MKZE-D0230-RHP 30	**Assessor**	W Evans
River	Mkuze	**Reviewed**	G O'Brien

ABR	SPECIES	REFERENCE FROC	OBSERVED FROC Su15	Au15	Sp15	Su16
ALAB	ANGUILLA BENGALENSIS LABIATA PETERS, 1852	4.66	-	-	-	-
AMAR	ANGUILLA MARMORATA QUOY & GAIMARD 1824	4.13	-	-	-	-
AMOS	ANGUILLA MOSSAMBICA PETERS 1852	4.86	-	-	-	-
AURA	AMPHILIUS URANOSCOPUS (PFEFFER, 1889)	4.86	-	-	-	-
BANO	BARBUS ANOPLUS WEBER, 1897	4.66	-	-	-	-
BARG	BARBUS ARGENTEUS GÜNTHER, 1868	4.86	-	-	-	-
BEUT	BARBUS EUTAENIA BOULENGER, 1904	4.66	-	-	-	-
BLAT	BRYCINUS LATERALIS (BOULENGER, 1900)	4.13	-	-	-	-
BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861	4.86	5	-	-	-
BPAU	BARBUS PALUDINOSUS PETERS, 1852	4.86	-	-	-	-
BTRI	BARBUS TRIMACULATUS PETERS, 1852	4.86	3	-	-	-

BUNI	BARBUS UNITAENIATUS GÜNTHER, 1866	4.66	-	-	-	-
BVIV	BARBUS VIVIPARUS WEBER, 1897	4.86	-	-	-	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)	4.66	-	3	-	4
LMOL	LABEO MOLYBDINUS DU PLESSIS, 1963	4.66	3	-	-	-
MACU	MICRALESTES ACUTIDENS (PETERS, 1852)	4.13	-	-	-	-
MBRE	MESOBOLA BREVIANALIS (BOULENGER, 1908)	4.13	-	-	-	-
MMAC	MARCUSENIUS MACROLEPIDOTUS (PETERS, 1852)	4.13	-	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)	4.66	3	3	-	3
TSPA	TILAPIA SPARRMANII SMITH, 1840	4.86	1	1	-	5
LCYL	LABEO CYLINDRICUS PETERS, 1852	4.66	1	-	-	3
BANN	BARBUS ANNECTENS GILCHRIST & THOMPSON, 1917	4.66	3	-	-	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	2	3	4	4
	Fast-Shallow	1	2	4	4
	Slow-Deep	2	3	3	3
	Slow-Shallow	1	1	1	1
Cover features	Overhanging veg	1	1	2	2
	Undercut banks	2	2	3	3
	Substrate	3	3	3	3
	Instream veg	2	2	2	2
	Water column	2	2	4	3

	Response of species that are	Su15	Au15	Sp15	Su16
	Intolerant to no flow	2	2	3	3

Flow dependence	Moderately intolerant to no flow	2	2	3	2
	Moderately tolerant to no flow	1	1	3	2
	Tolerant to no flow	1	1	1	1
	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	2	2	2	3
	Moderately intolerant to modified physico-chemical conditions	2	2	2	2
	Moderately tolerant to modified physico-chemical conditions	1	1	1	1
	Tolerant modified to physico-chemical conditions	0	1	1	0
	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	1	1	1	1
	Movement between reaches	1	1	1	1
	Movement within a reach	0	0	0	0
	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	2	2	2	2
	Impoundments	1	1	1	1
	Physico-chemical barriers	1	1	1	1
	Flow modifications	2	2	2	2
	Introduced/alien species	Su15	Au15	Sp15	Su16
Introduced/alien species	Introduced/alien predacious species 1	-	-	-	-
	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	-	-	-	-
	Introduced/alien habitat modifying species 2	-	-	-	-

	The impact of introduced competing spp?	-	-	-	-
	FROC of introduced competing spp?	-	-	-	-
	The impact of introduced habitat modifying spp?	-	-	-	-
	FROC of habitat modifying spp?	-	-	-	-
	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		33.7	21.7	17.3	26.3
EC: FRAI		E	E/F	F	E
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		71.3	68.3	58.1	60.9
EC: FRAI		C	C	C/D	C/D

Site Name	W3MKZE-DNYDR-RHP 31	**Assessor**	W Evans
River	Mkuze	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC Su15	Au15	Sp15	Su16
AAEN	AWAOUS AENEOFUSCUS (PETERS 1852)		5.00	-	-	-	-
ABER	ACANTHOPAGRUS BERDA (FORSSKÅL, 1775)		5.00	-	-	-	-
AKAT	APLOCHEILICHTHYS KATANGAE (BOULENGER, 1912)		5.00	-	-	-	-
ALAB	ANGUILLA BENGALENSIS LABIATA PETERS, 1852		5.00	-	-	-	-
AMAR	ANGUILLA MARMORATA QUOY & GAIMARD 1824		5.00	-	-	-	-
AMOS	ANGUILLA MOSSAMBICA PETERS 1852		5.00	-	-	-	-
BANN	BARBUS ANNECTENS GILCHRIST & THOMPSON, 1917		1.17	-	-	-	-
BLAT	BRYCINUS LATERALIS (BOULENGER, 1900)		5.00	-	-	-	-

BNAT	LABEOBARBUS NATALENSIS CASTELNAU, 1861	5.00	-	-	-	-
BPAU	BARBUS PALUDINOSUS PETERS, 1852	5.00	-	1	-	-
BTOP	BARBUS TOPPINI BOULENGER, 1916	1.17	1	-	-	-
BTRI	BARBUS TRIMACULATUS PETERS, 1852	5.00	3	-	-	-
BUNI	BARBUS UNITAENIATUS GÜNTHER, 1866	5.00	-	-	-	-
BVIV	BARBUS VIVIPARUS WEBER, 1897	1.17	3	-	-	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)	5.00	-	-	-	-
CTHE	CLARIAS THEODORAE WEBER, 1897	5.00	-	-	-	-
GCAL	GLOSSOGOBIUS CALLIDUS SMITH, 1937	5.00	-	1	-	-
GGIU	GLOSSOGOBIUS GIURIS (HAMILTON-BUCHANAN, 1822)	5.00	-	-	-	-
LCYL	LABEO CYLINDRICUS PETERS, 1852	5.00	-	-	-	-
LMOL	LABEO MOLYBDINUS DU PLESSIS, 1963	5.00	3	-	-	-
LROS	LABEO ROSAE STEINDACHNER, 1894 (LABEO ALTEVILIS)	1.17	-	-	-	-
MACU	MICRALESTES ACUTIDENS (PETERS, 1852)	5.00	-	-	-	-
MBRE	MESOBOLA BREVIANALIS (BOULENGER, 1908)	5.00	1	-	-	-
MMAC	MARCUSENIUS MACROLEPIDOTUS (PETERS, 1852)	5.00	-	-	-	-
NORT	NOTHOBRANCHIUS ORTHONOTUS (PETERS, 1844)	5.00	-	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)	5.00	3	5	-	-

PPHI	PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)	5.00	-	1	-	-
RDEW	REDIGOBIUS DEWAALI (WEBER, 1897)	5.00	-	-	-	-
SINT	SCHILBE INTERMEDIUS RÜPPELL, 1832	1.17	-	-	-	-
SZAM	SYNODONTIS ZAMBEZENSIS PETERS, 1852	1.17	-	-	-	-
TREN	TILAPIA RENDALLI (BOULENGER, 1896)	5.00	1	-	-	-
TSPA	TILAPIA SPARRMANII SMITH, 1840	5.00	-	-	-	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	4	4	-	-
	Fast-Shallow	2	4	-	-
	Slow-Deep	4	4	-	-
	Slow-Shallow	1	2	-	-
Cover features	Overhanging veg	1	2	-	-
	Undercut banks	3	3	-	-
	Substrate	3	3	-	-
	Instream veg	2	3	-	-
	Water column	3	4	-	-

	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	2	4	-	-
	Moderately intolerant to no flow	2	4	-	-
	Moderately tolerant to no flow	1	3	-	-
	Tolerant to no flow	1	2	-	-

	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	3	3	-	-
	Moderately intolerant to modified physico-chemical conditions	2	2	-	-

		Su15	Au15	Sp15	Su16
	Moderately tolerant to modified physico-chemical conditions	1	1	-	-
	Tolerant modified to physico-chemical conditions	1	1	-	-
	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	2	2	-	-
	Movement between reaches	2	2	-	-
	Movement within a reach	1	1	-	-
	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	3	3	-	-
	Impoundments	1	1	-	-
	Physico-chemical barriers	1	1	-	-
	Flow modifications	2	2	-	-
	Introduced/alien species	Su15	Au15	Sp15	Su16
Introduced/alien species	Introduced/alien predacious species 1	-	-	-	-
	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	-	-	-	-
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	-	-	-	-
	FROC of introduced competing spp?	-	-	-	-
	The impact of introduced habitat modifying spp?	-	-	-	-
	FROC of habitat modifying spp?	-	-	-	-
	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		25.7	18.5	-	-
EC: FRAI		E	E/F	-	-

	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		59.7	47.3	-	-
EC: FRAI		C/D	D	-	-

Site Name	W4BIVN-NTLSP-RHP 32	**Assessor**	W Evans
River	Bivane	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC			
				Su15	Au15	Sp15	Su16
AMAR	ANGUILLA MARMORATA QUOY & GAIMARD 1824		4.93	-	-	-	-
AMOS	ANGUILLA MOSSAMBICA PETERS 1852		5.00	-	-	-	-
AURA	AMPHILIUS URANOSCOPUS (PFEFFER, 1889)		5.00	-	-	1	-
BANO	BARBUS ANOPLUS WEBER, 1897		5.00	-	-	-	-
BARG	BARBUS ARGENTEUS GÜNTHER, 1868		5.00	-	-	-	-
BMAR	LABEOLABEOBARBUS MAREQUENSIS SMITH, 1841		5.00	-	-	-	-
BPAU	BARBUS PALUDINOSUS PETERS, 1852		5.00	-	-	-	-
BPOL	LABEOLABEOBARBUS POLYLEPIS BOULENGER, 1907		5.00	1	-	5	4
BTRI	BARBUS TRIMACULATUS PETERS, 1852		5.00	-	-	-	-
BUNI	BARBUS UNITAENIATUS GÜNTHER, 1866		5.00	-	-	-	-
CANO	CHILOGLANIS ANOTERUS CRASS, 1960		5.00	-	3	3	3
CEMA	CHILOGLANIS EMARGINATUS JUBB & LE ROUX, 1969		5.00	-	-	-	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)		5.00	-	-	-	-

CPAR	CHILOGLANIS PARATUS CRASS, 1960	5.00	-	-	-	-
CSWI	CHILOGLANIS SWIERSTRAI VAN DER HORST, 1931	4.93	-	-	-	-
LCYL	LABEO CYLINDRICUS PETERS, 1852	5.00	-	-	-	-
LMOL	LABEO MOLYBDINUS DU PLESSIS, 1963	5.00	-	-	1	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)	5.00	-	-	-	3
OPER	OPSARIDIUM PERINGUEYI (GILCHRIST & THOMPSON, 1913)	5.00	1	-	1	1
TREN	TILAPIA RENDALLI (BOULENGER, 1896)	5.00	-	-	-	-
TSPA	TILAPIA SPARRMANII SMITH, 1840	5.00	-	1	-	3
VNEL	VARICORHINUS NELSPRUITENSIS GILCHRIST & THOMPSON, 1911	2.49	-	-	-	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	2	2	2	2
	Fast-Shallow	1	1	2	1
	Slow-Deep	2	2	2	2
	Slow-Shallow	1	1	1	1
Cover features	Overhanging veg	1	1	2	1
	Undercut banks	1	1	1	1
	Substrate	2	2	2	2
	Instream veg	1	1	1	1
	Water column	1	0	1	1

	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	2	2	2	2
	Moderately intolerant to no flow	2	1	2	1
	Moderately tolerant to no flow	1	1	1	1
	Tolerant to no flow	1	0	1	0

	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	2	2	2	2
	Moderately intolerant to modified physico-chemical conditions	1	1	1	2
	Moderately tolerant to modified physico-chemical conditions	1	1	1	1
	Tolerant modified to physico-chemical conditions	0	1	1	1
	Response of which require	**Su15**	**Au15**	**Sp15**	**Su16**
Migration	Catchment scale movement	2	2	2	2
	Movement between reaches	1	1	1	1
	Movement within a reach	0	0	0	0
	Extent of the following in the reach	**Su15**	**Au15**	**Sp15**	**Su16**
Changes in connectivity	Weirs and causeways	2	2	2	2
	Impoundments	1	1	1	1
	Physico-chemical barriers	1	1	1	1
	Flow modifications	2	2	2	2
	Introduced/alien species	**Su15**	**Au15**	**Sp15**	**Su16**
Introduced/alien species	Introduced/alien predacious species 1	MSAL	MSAL	MSAL	MSAL
	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	-	-	-	-
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	2	2	3	3
	FROC of introduced competing spp?	3	3	3	3

	The impact of introduced habitat modifying spp?	0	0	0	0
	FROC of habitat modifying spp?	0	0	0	0

	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		16.4	18	21.3	25.7
EC: FRAI		F	E/F	E/F	E
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		70.7	71.7	66.9	68.7
EC: FRAI		C	C	C	C

Site Name	W4NGWV-D1840-RHP 35	**Assessor**	W Evans
River	Ngwavuma	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC			
				Su15	Au15	Sp15	Su16
ABER	ACANTHOPAGRUS BERDA (FORSSKÅL, 1775)		5.00	-	-	-	-
ABIC	ANGUILLA BICOLOR BICOLOR MCCLELLAND, 1844		5.00	-	-	-	-
ALAB	ANGUILLA BENGALENSIS LABIATA PETERS, 1852		5.00	-	-	-	-
AMAR	ANGUILLA MARMORATA QUOY & GAIMARD 1824		5.00	-	-	-	-
AMOS	ANGUILLA MOSSAMBICA PETERS 1852		5.00	-	-	-	-
BFRI	BARBUS AFROHAMILTONI CRASS, 1960		5.00	-	-	-	-
BIMB	BRYCINUS IMBERI (PETERS, 1852)		5.00	-	-	-	-
BMAR	LABEOLABEOBARBUS MAREQUENSIS SMITH, 1841		5.00	-	-	-	-
BPAU	BARBUS PALUDINOSUS PETERS, 1852		5.00	-	1	-	-
BRAD	BARBUS RADIATUS PETERS, 1853		5.00	-	-	-	-

BTOP	BARBUS TOPPINI BOULENGER, 1916	5.00	-	-	-	-
BTRI	BARBUS TRIMACULATUS PETERS, 1852	5.00	3	-	-	-
BUNI	BARBUS UNITAENIATUS GÜNTHER, 1866	5.00	-	-	-	-
BVIV	BARBUS VIVIPARUS WEBER, 1897	5.00	3	-	-	-
CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)	5.00	1	-	-	-
CPAR	CHILOGLANIS PARATUS CRASS, 1960	5.00	-	-	-	-
CSWI	CHILOGLANIS SWIERSTRAI VAN DER HORST, 1931	5.00	-	-	-	-
GCAL	GLOSSOGOBIUS CALLIDUS SMITH, 1937	5.00	-	-	-	-
HVIT	HYDROCYNUS VITTATUS CASTELNAU, 1861	5.00	-	-	-	-
LCON	LABEO CONGORO PETERS, 1852	5.00	-	-	-	-
LCYL	LABEO CYLINDRICUS PETERS, 1852	5.00	-	-	-	-
LMOL	LABEO MOLYBDINUS DU PLESSIS, 1963	5.00	1	-	-	-
LROS	LABEO ROSAE STEINDACHNER, 1894 (LABEO ALTEVILIS)	5.00	-	-	-	-
MACU	MICRALESTES ACUTIDENS (PETERS, 1852)	5.00	-	-	-	-
MBRE	MESOBOLA BREVIANALIS (BOULENGER, 1908)	5.00	-	-	-	-
MCAP	MYXUS CAPENSIS (VALENCIENNES, 1836)	5.00	-	-	-	-
MCYP	MEGALOPS CYPRINOIDES (BROUSSONET, 1782)	5.00	-	-	-	-
MFLU	MICROPHIS FLUVIATILIS (PETERS, 1852)	5.00	-	-	-	-
MMAC	MARCUSENIUS MACROLEPIDOTUS (PETERS, 1852)	5.00	-	-	-	-

NORT	NOTHOBRANCHIUS ORTHONOTUS (PETERS, 1844)	5.00	-	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)	5.00	3	1	-	-
OPER	OPSARIDIUM PERINGUEYI (GILCHRIST & THOMPSON, 1913)	5.00	-	-	-	-
PCAT	PETROCEPHALUS WESSELSI KR AMER & VAN DER BANK, 2000	5.00	-	-	-	-
PPHI	PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)	5.00	-	5	-	-
RDEW	REDIGOBIUS DEWAALI (WEBER, 1897)	5.00	-	-	-	-
SINT	SCHILBE INTERMEDIUS RÜPPELL, 1832	5.00	-	-	-	-
SZAM	SYNODONTIS ZAMBEZENSIS PETERS, 1852	5.00	-	-	-	-
TREN	TILAPIA RENDALLI (BOULENGER, 1896)	5.00	-	-	-	-
TSPA	TILAPIA SPARRMANII SMITH, 1840	5.00	-	-	-	-
AURA	AMPHILIUS URANOSCOPUS (PFEFFER, 1889)	5.00	1	-	-	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	3	4	-	-
	Fast-Shallow	2	3	-	-
	Slow-Deep	3	4	-	-
	Slow-Shallow	1	3	-	-
Cover features	Overhanging veg	2	2	-	-
	Undercut banks	3	3	-	-
	Substrate	4	4	-	-
	Instream veg	1	1	-	-
	Water column	4	4	-	-

	Response of species that are	Su15	Au15	Sp15	Su16
	Intolerant to no flow	5	5	-	-

Flow dependence	Moderately intolerant to no flow	3	3	-	-
	Moderately tolerant to no flow	2	2	-	-
	Tolerant to no flow	1	1	-	-
	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	2	3	-	-
	Moderately intolerant to modified physico-chemical conditions	1	2	-	-
	Moderately tolerant to modified physico-chemical conditions	1	2	-	-
	Tolerant modified to physico-chemical conditions	0	1	-	-
	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	2	2	-	-
	Movement between reaches	2	2	-	-
	Movement within a reach	1	1	-	-
	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	2	2	-	-
	Impoundments	1	1	-	-
	Physico-chemical barriers	1	1	-	-
	Flow modifications	3	3	-	-
	Introduced/alien species	Su15	Au15	Sp15	Su16
Introduced/alien species	Introduced/alien predacious species 1	-	-	-	-
	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	-	-	-	-
	Introduced/alien habitat modifying species 2	-	-	-	-

	The impact of introduced competing spp?	-	-	-	-
	FROC of introduced competing spp?	-	-	-	-
	The impact of introduced habitat modifying spp?	-	-	-	-
	FROC of habitat modifying spp?	-	-	-	-
	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		21.2	17.1	-	-
EC: FRAI		E/F	F	-	-
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		58.6	49.1	-	-
EC: FRAI		C/D	D	-	-

Site Name	W4PONG-N2PON-RHP 34	**Assessor**	W Evans
River	Pongolo	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC Su15	Au15	Sp15	Su16
AMAR	ANGUILLA MARMORATA QUOY & GAIMARD 1824		5.00	-	-	-	-
AMOS	ANGUILLA MOSSAMBICA PETERS 1852		5.00	-	-	-	-
BANN	BARBUS ANNECTENS GILCHRIST & THOMPSON, 1917		1.84	-	-	-	-
BMAR	LABEOLABEOBARBUS MAREQUENSIS SMITH, 1841		5.00	-	-	-	-
BPAU	BARBUS PALUDINOSUS PETERS, 1852		5.00	-	-	-	-
BTOP	BARBUS TOPPINI BOULENGER, 1916		1.84	-	-	-	-
BTRI	BARBUS TRIMACULATUS PETERS, 1852		5.00	-	-	-	-
BUNI	BARBUS UNITAENIATUS GÜNTHER, 1866		5.00	-	-	-	-

BVIV	BARBUS VIVIPARUS WEBER, 1897	1.84	-	-	-	-
CPAR	CHILOGLANIS PARATUS CRASS, 1960	1.84	-	-	-	-
CSWI	CHILOGLANIS SWIERSTRAI VAN DER HORST, 1931	1.84	-	-	-	3
GCAL	GLOSSOGOBIUS CALLIDUS SMITH, 1937	5.00	-	3	-	5
HVIT	HYDROCYNUS VITTATUS CASTELNAU, 1861	1.84	-	-	-	-
LCON	LABEO CONGORO PETERS, 1852	1.84	-	-	-	-
LCYL	LABEO CYLINDRICUS PETERS, 1852	5.00	-	-	-	3
LMOL	LABEO MOLYBDINUS DU PLESSIS, 1963	5.00	-	-	-	-
LROS	LABEO ROSAE STEINDACHNER, 1894 (LABEO ALTEVILIS)	1.84	-	-	-	-
MACU	MICRALESTES ACUTIDENS (PETERS, 1852)	5.00	-	-	-	5
MBRE	MESOBOLA BREVIANALIS (BOULENGER, 1908)	5.00	-	-	-	-
MMAC	MARCUSENIUS MACROLEPIDOTUS (PETERS, 1852)	5.00	-	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)	5.00	3	-	-	-
OPER	OPSARIDIUM PERINGUEYI (GILCHRIST & THOMPSON, 1913)	1.84	-	-	-	2
PPHI	PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)	5.00	-	-	-	-
SZAM	SYNODONTIS ZAMBEZENSIS PETERS, 1852	1.84	-	-	-	-
TREN	TILAPIA RENDALLI (BOULENGER, 1896)	5.00	3	3	-	3
TSPA	TILAPIA SPARRMANII SMITH, 1840	5.00	-	-	-	3

CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)	5.00	3	3	-	3

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	3	3	-	4
	Fast-Shallow	2	2	-	4
	Slow-Deep	3	3	-	3
	Slow-Shallow	1	1	-	1
Cover features	Overhanging veg	1	1	-	3
	Undercut banks	2	2	-	2
	Substrate	2	2	-	2
	Instream veg	2	2	-	2
	Water column	1	1	-	4
	Response of species that are	**Su15**	**Au15**	**Sp15**	**Su16**
Flow dependence	Intolerant to no flow	2	3	-	3
	Moderately intolerant to no flow	1	2	-	2
	Moderately tolerant to no flow	1	2	-	2
	Tolerant to no flow	0	1	-	2
	Response of species that are	**Su15**	**Au15**	**Sp15**	**Su16**
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	3	3	-	3
	Moderately intolerant to modified physico-chemical conditions	2	2	-	3
	Moderately tolerant to modified physico-chemical conditions	2	2	-	2
	Tolerant modified to physico-chemical conditions	1	2	-	2
	Response of which require	**Su15**	**Au15**	**Sp15**	**Su16**
Migration	Catchment scale movement	4	4	-	4
	Movement between reaches	2	2	-	2
	Movement within a reach	1	1	-	1
	Extent of the following in the reach	**Su15**	**Au15**	**Sp15**	**Su16**

Changes in connectivity	Weirs and causeways	1	1	-	1
	Impoundments	3	3	-	3
	Physico-chemical barriers	2	2	-	2
	Flow modifications	2	2	-	2

	Introduced/alien species	Su15	Au15	Sp15	Su16
Introduced/alien species	Introduced/alien predacious species 1	-	-	-	-
	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	-	-	-	-
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	-	-	-	-
	FROC of introduced competing spp?	-	-	-	-
	The impact of introduced habitat modifying spp?	-	-	-	-
	FROC of habitat modifying spp?	-	-	-	-

	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		17.9	16.2	-	39.9
EC: FRAI		E/F	F	-	D/E
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		64.2	57.9	-	49.1
EC: FRAI		C	C/D	-	D

Site Name	W4PONG-NDUMO-RHP 37	**Assessor**	W Evans
River	Phongolo	**Reviewed**	G O'Brien

ABR	SPECIES		REFERENCE FROC	OBSERVED FROC			
				Su15	Au15	Sp15	Su16

AAEN	AWAOUS AENEOFUSCUS (PETERS 1852)	5.00	-	-	-	-
ABER	ACANTHOPAGRUS BERDA (FORSSKÅL, 1775)	5.00	-	-	-	-
ABIC	ANGUILLA BICOLOR BICOLOR MCCLELLAND, 1844	5.00	-	-	-	-
AJOH	APLOCHEILICHTHYS JOHNSTONI (GÜNTHER, 1893)	5.00	-	-	-	-
AKAT	APLOCHEILICHTHYS KATANGAE (BOULENGER, 1912)	5.00	-	-	-	-
ALAB	ANGUILLA BENGALENSIS LABIATA PETERS, 1852	5.00	-	-	-	-
AMAR	ANGUILLA MARMORATA QUOY & GAIMARD 1824	5.00	-	-	-	-
AMOS	ANGUILLA MOSSAMBICA PETERS 1852	5.00	-	-	-	-
AMYA	APLOCHEILICHTHYS MYAPOSAE (BOULENGER, 1908)	5.00	-	-	-	-
BANN	BARBUS ANNECTENS GILCHRIST & THOMPSON, 1917	5.00	-	-	-	-
BFRI	BARBUS AFROHAMILTONI CRASS, 1960	5.00	-	-	-	-
BIMB	BRYCINUS IMBERI (PETERS, 1852)	5.00	3	-	-	-
BMAR	LABEOLABEOBARBUS MAREQUENSIS SMITH, 1841	5.00	-	-	-	-
BPAU	BARBUS PALUDINOSUS PETERS, 1852	5.00	1	-	-	-
BRAD	BARBUS RADIATUS PETERS, 1853	5.00	-	-	-	-
BTOP	BARBUS TOPPINI BOULENGER, 1916	5.00	-	-	-	-
BTRI	BARBUS TRIMACULATUS PETERS, 1852	5.00	-	-	-	-
BUNI	BARBUS UNITAENIATUS GÜNTHER, 1866	5.00	-	-	-	-
BVIV	BARBUS VIVIPARUS WEBER, 1897	5.00	3	-	-	-

CGAR	CLARIAS GARIEPINUS (BURCHELL, 1822)	5.00	3	-	-	-
CMUL	CTENOPOMA MULTISPINE PETERS, 1844	5.00	-	-	-	-
CTHE	CLARIAS THEODORAE WEBER, 1897	5.00	-	-	-	-
GCAL	GLOSSOGOBIUS CALLIDUS SMITH, 1937	5.00	1	-	-	-
HVIT	HYDROCYNUS VITTATUS CASTELNAU, 1861	5.00	-	-	-	-
LCON	LABEO CONGORO PETERS, 1852	5.00	-	-	-	-
LCYL	LABEO CYLINDRICUS PETERS, 1852	5.00	-	-	-	-
LMCR	LIZA MACROLEPIS (SMITH, 1846)	5.00	-	-	-	-
LMOL	LABEO MOLYBDINUS DU PLESSIS, 1963	5.00	-	-	-	-
LROS	LABEO ROSAE STEINDACHNER, 1894 (LABEO ALTEVILIS)	5.00	-	-	-	-
MACU	MICRALESTES ACUTIDENS (PETERS, 1852)	5.00	-	-	-	-
MBRE	MESOBOLA BREVIANALIS (BOULENGER, 1908)	5.00	-	-	-	-
MCAP	MYXUS CAPENSIS (VALENCIENNES, 1836)	5.00	-	-	-	-
MCYP	MEGALOPS CYPRINOIDES (BROUSSONET, 1782)	5.00	-	-	-	-
MFLU	MICROPHIS FLUVIATILIS (PETERS, 1852)	5.00	-	-	-	-
MMAC	MARCUSENIUS MACROLEPIDOTUS (PETERS, 1852)	5.00	-	-	-	-
NORT	NOTHOBRANCHIUS ORTHONOTUS (PETERS, 1844)	5.00	-	-	-	-
OMOS	OREOCHROMIS MOSSAMBICUS (PETERS, 1852)	5.00	3	-	-	-
PPHI	PSEUDOCRENILABRUS PHILANDER (WEBER, 1897)	5.00	1	-	-	-

RDEW	REDIGOBIUS DEWAALI (WEBER, 1897)	5.00	-	-	-	-
SINT	SCHILBE INTERMEDIUS RÜPPELL, 1832	5.00	-	-	-	-
SZAM	SYNODONTIS ZAMBEZENSIS PETERS, 1852	5.00	-	-	-	-
TREN	TILAPIA RENDALLI (BOULENGER, 1896)	5.00	-	-	-	-
TSPA	TILAPIA SPARRMANII SMITH, 1840	5.00	-	-	-	-

	Response of species with a preference/tolerance to	Su15	Au15	Sp15	Su16
Velocity Depth Metric	Fast-Deep	3	-	-	4
	Fast-Shallow	1	-	-	3
	Slow-Deep	3	-	-	1
	Slow-Shallow	0	-	-	1
Cover features	Overhanging veg	1	-	-	1
	Undercut banks	1	-	-	3
	Substrate	3	-	-	3
	Instream veg	2	-	-	2
	Water column	2	-	-	2

	Response of species that are	Su15	Au15	Sp15	Su16
Flow dependence	Intolerant to no flow	2	-	-	3
	Moderately intolerant to no flow	1	-	-	3
	Moderately tolerant to no flow	1	-	-	2
	Tolerant to no flow	1	-	-	1

	Response of species that are	Su15	Au15	Sp15	Su16
Physico-chemical conditions	Intolerant to modified physico-chemical conditions	3	-	-	3
	Moderately intolerant to modified physico-chemical conditions	2	-	-	3
	Moderately tolerant to modified physico-chemical conditions	2	-	-	2

	Tolerant modified to physico-chemical conditions	1	-	-	2
	Response of which require	Su15	Au15	Sp15	Su16
Migration	Catchment scale movement	4	-	-	4
	Movement between reaches	2	-	-	2
	Movement within a reach	1	-	-	1
	Extent of the following in the reach	Su15	Au15	Sp15	Su16
Changes in connectivity	Weirs and causeways	2	-	-	2
	Impoundments	3	-	-	3
	Physico-chemical barriers	1	-	-	1
	Flow modifications	3	-	-	3
	Introduced/alien species	Su15	Au15	Sp15	Su16
Introduced/alien species	Introduced/alien predacious species 1	-	-	-	-
	Introduced/alien predacious species 2	-	-	-	-
	Introduced/alien predacious species 3	-	-	-	-
	Introduced/alien habitat modifying species 1	-	-	-	-
	Introduced/alien habitat modifying species 2	-	-	-	-
	The impact of introduced competing spp?	-	-	-	-
	FROC of introduced competing spp?	-	-	-	-
	The impact of introduced habitat modifying spp?	-	-	-	-
	FROC of habitat modifying spp?	-	-	-	-
	AUTOMATED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		16.3	-	-	10.7
EC: FRAI		F	-	-	F
	ADJUSTED FISH RESPONSE ASSESSMENT INDEX SCORE				
FRAI (%)		63.5	-	-	53.4
EC: FRAI		C	-	-	D