Biology and Ecology of the Orange-Vaal Largemouth and Smallmouth Yellowfishes in the Vaal River

Gordon O'Brien & Pierre de Villiers (editors)

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Biology and ecology of the Orange-Vaal largemouth and smallmouth Yellowfishes in the Vaal River

Report to the
Water Research Commission

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1. An assessment of selected biology aspects of the two yellowfish species *Labeobarbus kimberleyensis* and *L. aeneus* from the Orange-Vaal River system, South Africa (WRC Project No. K8/678).
2. Effects of flow and temperature on spawning and recruitment of Largemouth (*Labeobarbus kimberleyensis*) and Smallmouth (*L. aeneus*) yellowfish (WRC Project No. K8/803).
3. Assessment of selected biological features associated with the breeding biology of the threatened Orange-Vaal River Largemouth yellowfish and the Orange-Vaal River Smallmouth yellowfish from the Orange-Vaal River system. (WRC Project No. K8/818).

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1. EXECUTIVE SUMMARY

This report documents the outcomes of three Water Research Commission consultancy studies that were carried out between 2006 and 2010 by the University of Johannesburg and River of Life Aquatic Health Services CC. The titles of the consultancies were:

- An assessment of selected biology aspects of the two yellowfish species *Labeobarbus kimberleyensis* and *L. aeneus* from the Orange-Vaal River system, South Africa (K8/678).
- Effects of flow and temperature on spawning and recruitment of Largemouth (*Labeobarbus kimberleyensis*) and Smallmouth (*L. aeneus*) yellowfish (K8/803).
- Assessment of selected biological features associated with the breeding biology of the threatened Orange-Vaal River Largemouth yellowfish and the Orange-Vaal River Smallmouth yellowfish from the Orange-Vaal River system (K8/818).

The combined aims of the study included:

1. Successfully develop the technology to implant radio telemetry tags and to track the two yellowfish species in the Orange-Vaal River system (K8/678).
2. Determine the home range of *L. aeneus* and *L. kimberleyensis* (K8/678).
3. Determine how environmental variables (flooding, drawdown and temperature) affect the movement and biological requirements of *L. aeneus* and *L. kimberleyensis* to changing environmental variables (K8/678).
4. Establish age-length relationships for larval and early juveniles of both species (K8/803).
5. Use hatch date analysis to determine the timing, duration and frequency of spawning by *L. aeneus* and *L. kimberleyensis* over a single season (K8/803).
6. Link the above information to the prevailing environmental conditions (temperature and flow) and to identify environmental cues and optimal conditions that promote spawning by the two species (K8/803).
7. Link the findings of this study to the movement of *L. aeneus* and *L. kimberleyensis* prior to, during and after spawning events (K8/803).
8. Use this knowledge to guide management and conservation frameworks and provide input to EWR studies currently underway in the Orange/Vaal River system (K8/803).
9. The aim of this study is to characterise selected biological features associated with the breeding biology of the threatened Orange-Vaal River Largemouth

Yellowfish and the Orange-Vaal River Smallmouth Yellowfish in the Vaal River and to produce yellowfish offspring for further scientific studies` (K8/818).

In the study, eight of the nine original aims established were achieved. Aims number six and seven required wild caught Largemouth yellowfish larvae and or fingerlings (>6 months old). Attempts were made to collect Largemouth yellowfish larvae and fingerlings within study areas unsuccessfully. Recent anecdotal observations show that the Largemouth yellowfish populations in the study area may be dominated by different age class cohorts. This suggests that successful recruitments of this species in to the Vaal River do not occur annually. More research on the recruitment of this species into the Vaal River is required. In addition to these aims, some new aims were established for the study and achieved included:

10. Assess selected behavioural ecology and biology features of the Vaal River yellowfishes including the daily, seasonal and annual movements, habitat use, migrations and possible territoriality behaviour of species.
11. Assess selected components of the conservation and management approaches adopted for the Vaal River yellowfishes by the Orange Vaal River Yellowfish Conservation and Management Association.
12. Finally, an aim of the study was developed to carry out a regional scale risk assessment of threats to the sustainability of the Largemouth yellowfish populations in the study area making use of the data obtained in this study.

The report itself presents a broad review of the known biology and ecology of the Vaal yellowfishes, including dedicated sections on species identification, taxonomy and notes on the evolutionary and phylogenetic development of the species, as well as the taxonomic history of the yellowfishes. The study then addresses the approaches adopted and the outcomes of three complementary reproduction, early development and growth studies of the Vaal River yellowfishes. These studies included assessments of the artificial reproduction, early development of and age validation of larval and juvenile Vaal River yellowfish. This includes the first documented findings of any formal early development and growth study of a yellowfish in southern Africa. The early development study has allowed for the characterisation of numerous developmental stages that yellowfish undergo which will contribute towards the life-cycle biology and conservation of these species. The work also presents some evidence of new ecological requirements and previously unknown behavioural features of yellowfish in the Vaal River. Finally, the study shows that distinct morphological features of the larvae and juveniles of each species occur. These features can be used to identify wild larvae and juvenile yellowfish. The age validation study showed that both species deposit daily growth rings that can be counted to accurately determine the age of wild caught yellowfish. This can be used to evaluate the importance of the volume, timing and durations of natural flows and other related ecosystem conditions, to ensure that good recruitment of yellowfish into the Vaal River occurs.

The next section of the report presents the outcomes of the first ecological behavioural assessment, carried out on Vaal River yellowfish using biotelemetry methods. This section details previously unknown behavioural biology and ecology features of the Vaal River yellowfishes. Specific findings include features of the daily, seasonal and annual movements, home ranges, habitat use, migrations and possible territoriality behaviour of Vaal River yellowfishes. In this part of the study, a database of information has been generated that can be used in the future to evaluate the consequences of changing environmental conditions in the Vaal River.

The study is completed with an assessment of components of the conservation and management of Vaal River yellowfishes. This includes a review of a socio-economic value assessment of Yellowfish in the Vaal River, and a study to addresses the possible impacts of angling on yellowfish populations in the Vaal River. This information, along with the historically known biology and ecology of the Vaal River yellowfishes and new information generated in this study was used to carry out a simplified regional scale risk assessment of the threats to Largemouth yellowfish in the Vaal River. This risk assessment shows that the excessive current use of the resources of the Vaal River is threatening the continued viability of these species. In addition, if management plans are not developed and implemented to balance between the use and protection of the resources of the Vaal River, there is a high probability that the conservation status of the Largemouth yellowfish will increase to endangered status.

This study has successfully developed our understanding of these three areas of the biology and ecology of the Vaal River yellowfishes, and demonstrates the value of this information in the conservation and management fishes in southern Africa.

In consideration of the outcomes of this study the following recommendation are made:

- The reproduction experiments showed that both of the Vaal River yellowfishes can relatively easily be cultured under artificial conditions. Outcomes show however that it is difficult to condition Largemouth Yellowfish in artificial environments. We recommend that a monitoring exercise be carried out in an artificial environment where the conditioning process and behavioural changes of both Largemouth and Smallmouth yellowfishes can be assessed.

- The study shows that distinct morphological features of the larvae and juvenile yellowfish from a set of adult broodstock of each species occur. If consistent, these features can be used to identify wild larvae and juvenile yellowfish. We recommend that an evaluation study be carried out to confirm that these morphological features are consistent and can be used to identify wild yellowfish in the Vaal River.
- The role that that flow plays in the recruitment of *L. aeneus* and *L. kimberleyensis* in the Vaal River is not well understood, but there is evidence that both species depend on optimal flow and temperature conditions for successful reproduction. Following from this study, which is an important preliminary step to aging wild-caught larval *L. aeneus* and *L. kimberleyensis,* a dedicated study that addresses the recruitment of yellowfishes into the Vaal River should be carried out.
- The behavioural monitoring study showed that biotelemetry methods can effectively be implemented to monitor the behaviour of yellowfishes in riverine ecosystems in South Africa. The study produced a range of new behavioural biology and ecology features of both of the Vaal River yellowfishes. Although valuable allot of behavioural events are still unexplainable. We recommend that the biotelemetry monitoring work on yellowfish in the Vaal River be continued, and expanded on into the Orange System and lentic ecosystems in the catchment.
- The outcomes of the simplified regional scale risk assessment show that some of the Largemouth yellowfish populations in the Vaal River may currently be unsustainable. In addition, this assessment suggests that the population structures and recruitment of juveniles into populations can be good indicators of the health of populations. In accordance, we recommend that an assessment of the Largemouth yellowfish population structures and recruitment of juvenile yellowfish into the populations should be carried out.

2. GENERAL INTRODUCTION

Two species of yellowfish naturally occur within the Vaal River namely the Orange-Vaal largemouth yellowfish *Labeobarbus kimberleyensis* (Gilchrist and Thompson, 1913), and the Orange-Vaal smallmouth yellowfish *L. aeneus* (Burchell, 1822). These yellowfishes are amongst the most widely distributed and most easily related to of our indigenous fishes in South Africa. They are actively targeted and utilised by various angling and subsistence fishing communities throughout the country, and used as indicator species in the management of aquatic ecosystems by resource managers (Skelton and Bills 2008; Brand et al., 2009). As a result these yellowfishes have a high ecological, economical and social value to South Africans (Brand et al., 2009). Although relatively well documented, in relation to some other fishes occurring in South Africa, very little of the biology and ecology of the Vaal River yellowfishes is known. This lack of information limits the ability of ecosystem managers of the Vaal River to address the conservation requirements these yellowfishes in a river catchment where ever increasing demands of ecosystem resources is placing pressure on the survivability of these species.

The Vaal River has been classified as South Africa's most economically valuable aquatic ecosystems and due to the excessive use of the resources of the system it is known as "Africa's hardest working river" (Braune and Rogers, 1987). This status of the Vaal River reflects the demands that have been placed on the ecological sustainability of the system including the survivability of the yellowfishes in the system (De Villiers and Ellender, 2008a; 2008b). In an attempt to direct conservation intervention towards declining populations of the more sensitive of the two Vaal River yellowfishes, the Orange-Vaal largemouth yellowfish has locally been listed as a vulnerable species (DEAT, 2007) and internationally as a near threatened species (IUCN, 2010).

The Vaal River catchment is approximately 192 000 km^2 and makes up approximately 30% of the Orange River catchment that covers 42% of South Africa (Braune and Rogers, 1987). Although smaller than the upper Orange River catchment, the Vaal River system contributes more than 50% of the discharge into the lower Orange River at the confluence of the Orange and Vaal rivers, primarily due to the augmentation programme of the Vaal River through as many as nine Inter-basin Transfer Schemes (IBTs) throughout the system (Kriel, 1972; Noble and Hemens, 1978; Midgley et al*.,* 1994; Davies and Day, 1998). The primary use of resources from the Vaal River ecosystem is associated with the provision of water and removal of waterborne wastes from Gauteng, Africa's largest economic centre (Schwartz, 1969; De Villiers and Ellender, 2008a; 2008b). Identified impacts include water quality alterations, water quantity alterations in terms of volumes, timing and duration of flows, barriers and habitat modifications, disturbance to wildlife, productivity impacts and the impacts associated with alien and invasive species (Davies and Day, 1998; Van Wyk, 2001; RHP 2003a; 2003b; Nel et al., 2004). Along with the rest of the aquatic biodiversity in the Vaal River the Vaal River yellowfishes are being negatively impacted on by this excessive use of the resources associated with the Vaal River (Mulder, 1973). From the late 1960's decreasing populations of yellowfish in the Vaal River were considered by the then Transvaal Provincial Fisheries Institute (Mulder, 1973), but to date no recoveries in the yellowfish populations have been documented.

The Orange-Vaal largemouth yellowfish and the Orange-Vaal smallmouth yellowfish are often referred to simply as Largemouth and Smallmouth yellowfishes respectively (De Villiers and Ellender, 2008a; 2008b). and will be referred to as such in this report Figure 1 presents a photograph of a typical adult Orange-Vaal smallmouth yellowfish and Figure 2 that of a typical adult Orange-Vaal largemouth yellowfish. Both of these large barbine cyprinids belong to the small-scaled yellowfish family that is endemic to temperate regions of southern Africa. In southern Africa both the Largemouth and Smallmouth yellowfish are endemic to the Orange-Vaal River System (OVRS), but now have an increased distribution due to inter-basin transfer schemes and accidental and intentional relocations (Jubb and Farquharson, 1965; Cambray and Jubb, 1977a). Figure 3 presents the distribution of the Vaal River yellowfishes in southern Africa (Scott et al*.,* 2006; De Villiers and Ellender, 2008a; 2008b). The distribution of the Largemouth yellowfish is generally confined to the main-stem rivers, large tributaries and dams of the Orange-Vaal System. The Smallmouth yellowfish distribution extends into the small tributaries, rivers and streams of the Orange-Vaal System. Along with all other yellowfishes the Vaal River yellowfishes are slow growing, late maturing fishes that are relatively long lived (Mulder, 1973), growing to relatively large sizes: the Largemouth yellowfish in particular reaches as much as 20 to 30 kg in mass (Gilchrist and Thompson, 1913; Jubb, 1967; Tomasson et al., 1984; Skelton, 2001, Skelton and Bills, 2008).

Figure 1: Photograph of a typical Orange-Vaal smallmouth yellowfish (*Labeobarbus aeneus*) from the Vaal River bearing a radio transmitter.

Figure 2: Photograph of a pleased angler holding a typical Orange-Vaal largemouth yellowfish (*Labeobarbus kimberleyensis*) from the Vaal River bearing a radio transmitter.

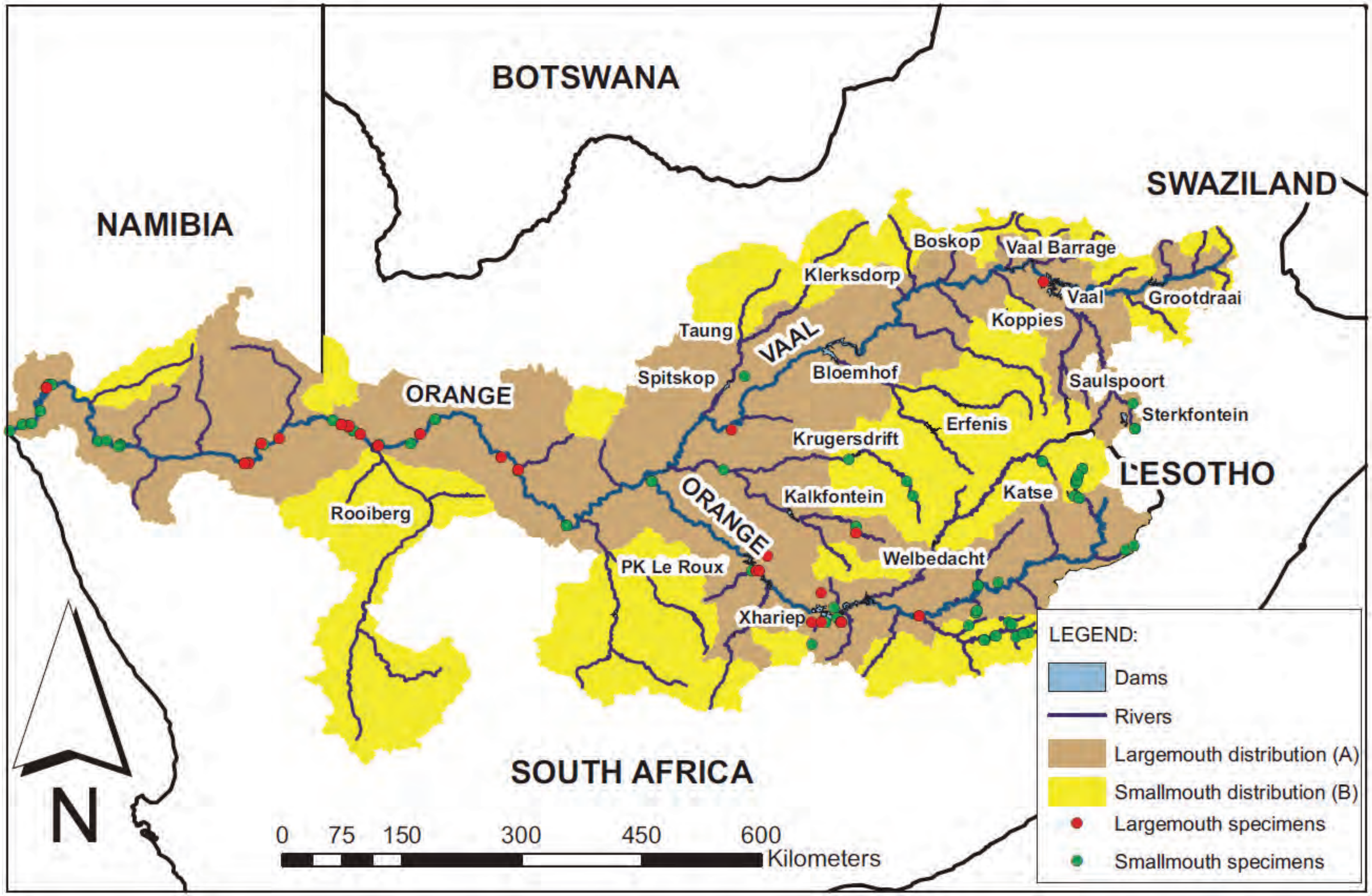

Figure 3: Distribution of *Labeobarbus aeneus* (A) and *L. kimberleyensis* (B) based on voucher records (De Villiers and Ellender 2008a; 2008b).

The yellowfishes of the Vaal River are considered to be two of South Africa's most socially and economically important freshwater fishes as they are well known charismatic species that are an important food source for many informal and formal communities within South Africa and support a large multimillion Rand per annum sport angling fishery in South Africa (De Villiers and Ellender, 2008a; 2008b; Brand et al., 2009). In addition, the Largemouth yellowfish is used as an important indicator, flagship freshwater fish species for the management of the Orange-Vaal River System (De Villiers and Ellender, 2008b). Despite this, the literature record for Vaal River yellowfish (Largemouth yellowfish in particular) is poor and key aspects of its biology and ecology are poorly understood.

The aim of this study is to address selected aspects of the biology and ecology of the Vaal River yellowfishes to allow for better management of the Vaal River ecosystem and the conservation of the yellowfishes within the system. Selected aspects of the biology and ecology of the Vaal River yellowfishes that will be considered in this study include:

- Revision of the known biology and ecology of the Vaal River yellowfishes.
- Aspects of the reproductive biology, early development and age validation of the Vaal River yellowfishes.
- Assessment of the home ranges, habitat use, migrations and general behaviour of the Vaal River yellowfishes using biotelemetry behavioural monitoring methods.
- Response of Vaal River yellowfishes to changing environmental conditions using biotelemetry behavioural monitoring methods.
- Assessment of conservation and management needs of the Vaal River yellowfishes.

This investigational report presents the approaches adopted, the findings obtained and conservation and management implications of these outcomes for the biology and ecology of the Vaal River yellowfishes.

3. SPECIES IDENTIFICATION, TAXONOMY AND NOTES ON EVOLUTIONARY AND PHYLOGENETIC DEVELOPMENT.

Although the yellowfishes in the Vaal River look very similar, there are useful morphological features of both species that can be used to easily distinguish the species from each other. Some difficulty in the identification of selected individuals has however been noted where so-called hybrids have been obtained that share features of both species. These hybrid individuals are rare and attempts have been made to address the speciation and genetic relationships between the two Vaal River yellowfishes to understand these so called hybrids (Bloomer et al., 2007). This section presents a summary of the taxonomic history of the two Vaal River yellowfishes and presents some useful features that can be used to identify both species. Finally, some outcomes of recent evolutionary and phylogenetic relationship assessments of the Vaal River yellowfishes are presented.

3.1. TAXONOMIC HISTORY OF THE VAAL RIVER YELLOWFISHES

3.1.1. Orange-Vaal smallmouth yellowfish

Historically the Orange-Vaal smallmouth yellowfish (*Labeobarbus aeneus*) has been known by as many as six other names from 1822 to date (De Villiers and Ellender, 2008a). This occurred possibly due to the large distribution of the species and the high variations in morphology of the species. Burchell (1822) initially described specimens of Smallmouth yellowfish from the Zak River as *Cyprinus aeneus*, while other specimens from the Vaal River were then described as *Barbus gilchristi* by Boulenger (1911), and still others from the Modder River were described as *Barbus holubi* (Steindachner, 1894). Lastly, a population from a reservoir in Kimberley was described as *Barbus mentalis* in by Gilchrist & Thompson (1913). In 1943, Barnard moved all species into the *Barbus* genus and all were re-classified as *Barbus holubi* (Hocutt and Skelton, 1983; De Villiers and Ellender, 2008a). In 1996, the genus and species names of the Smallmouth yellowfish was changed to *Barbus aeneus* by Berrebi et al., (1996) and finally in 2001 the genus of all true yellowfishes was changed to *Labeobarbus sp.* Smallmouth yellowfish are therefore currently known as *Labeobarbus aeneus* (Skelton, 2001).

3.1.2. Orange-Vaal largemouth yellowfish

Only 91 years after the first Smallmouth yellowfish was described, the first Largemouth yellowfish from a reservoir close to Kimberley was described as *Barbus kimberleyensis* (Gilchrist & Thompson, 1913). Much later another population in the Vaal River was described as *Barbus pienaarii* (Fitzsimons, 1949) but both have recently been grouped into the *Labeobarbus kimberleyensis* genus and species (Skelton, 2001).

3.2. SPECIES IDENTIFICATION

There are currently 12 species of indigenous fishes that occur within the Vaal River and at least four alien species (Figure 4, Skelton 2001). Apart from the two yellowfishes, another six indigenous cyprinids occur within the Vaal River and two alien cyprinids. Of the six indigenous cyprinids, four are barbs and two are mudfishes or *Labeo spp*., while the two alien cyprinids comprise the Common carp and the Grass carp. In addition to the cyprinids, two cichlids (the Southern mouthbrooder and the Banded tilapia) and two siluriformes (the Sharptooth catfish and the Rock catfish) occur within the Vaal River. The remaining alien fishes that are found within the Vaal River include the Largemouth bass and the Mosquito fish. As indicated the yellowfish and an additional eight cyprinids occur in the Vaal River. The yellowfishes, mudfishes, common carp and Grass carp include cyprinids that grow above 150 mm (standard length). As such these large cyprinids do not include the barbs which are relatively easy differentiated from one another. Numerous identification guides for the large cyprinids in the Vaal River are available and easy to use including the *dummies* guide to large cyprinids in the Vaal River presented in Appendix 1. In order to identify the ten cyprinids smaller than 150 mm in the Vaal River including the four barbs, a more detailed identification guide should be considered such as the Complete Guide to the Freshwater Fishes of Southern Africa (Skelton, 2001).

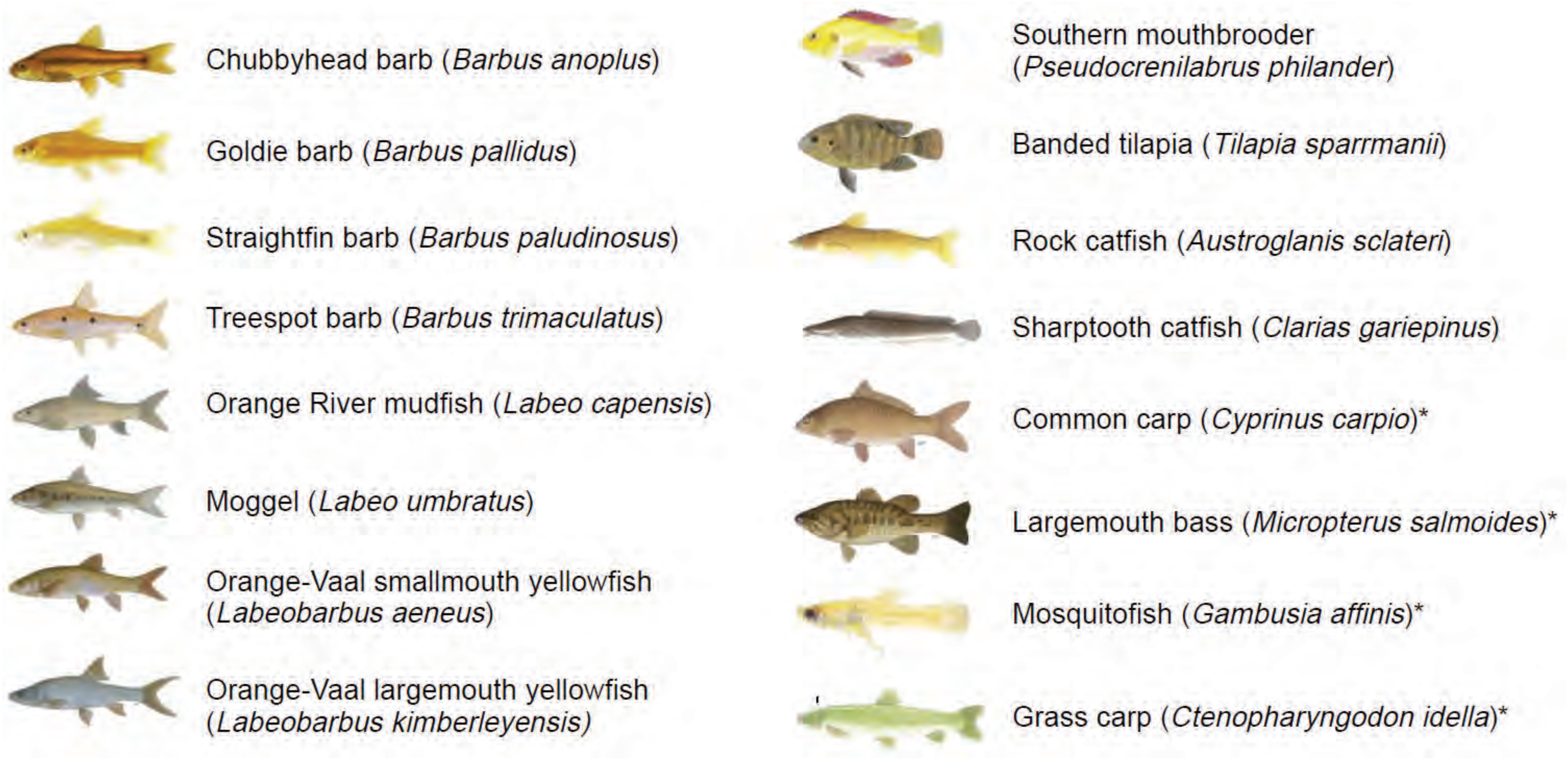

Figure 4: Drawings of the fishes that occur within the Vaal River including the alien species denoted with.

The Vaal River yellowfish are strong bodied and spindle-shaped, enabling them to make effective use of a wide variety of fast and slow flowing habitats within the Vaal River. Their fins are short-based (with relatively few rays) and the dorsal fin has a simple (i.e. not serrated) bony anterior ray (Skelton and Bills, 2008). They show no sexual dimorphism apart from females being plumper in breeding condition and both sexes develop small pimple-like nuptial tubercles on the head and sometimes all over the body during breeding conditions (Skelton and Bills, 2008). The scales of both species are strong and well developed with numerous parallel striations, and there is a lateral line running from head to tail (Skelton and Bills, 2008). The mouths of each species differs somewhat in that the mouth of the Smallmouth yellowfish is generally sub-terminal with variable lips from large fleshy lips (called rubberlips, when the fish is adapted to grubbing between pebbles and cobbles) to thin, straight, keratinized lips (also known as “varicorhinus” or razor-lipped mouth) a form that is used to scrape and chisel food from rocks and other hard surfaces (Crass, 1964; Jubb, 1967; Skelton, 2001; Skelton and Bills, 2008). As with all cyprinids both yellowfish have no jaw teeth, but have strong pharyngeal teeth in three rows, that are also varied in form from heavy rounded (molariform) crushing teeth, to slender and hooked teeth.

Summaries of at least 12 morphological and or coloration differences between the Largemouth and Smallmouth yellowfishes that can be used to identify species are presented in Table 1 (Mulder, 1971; Skelton, 2001). Figure 5 presents some of these distinguishing features for easy identification. Characteristic features include head morphology where the snout to eye to pre-operculum groove lengths of each species differs, mouth position and size, head shape and position of the eyes. Other distinguishing morphological features that can be considered include; scale counts, head size in relation to body depth, caudal peduncle shape and length, fin shapes, thickness of dorsal fin spines and the number of gill rakers. The differences in the colouration of each species can also be considered where juveniles (>5 cm) and sub-adults of the Largemouth yellowfish are usually silver and change to a dull olive-yellow in adults. In contrast the juveniles (>5 cm) and sub-adults of Smallmouth yellowfish are usually olive-grey with dark blotches as juveniles and change to olive-yellow to bright yellow with or without blotches as adults.

Table 1: Summary of the twelve morphological and or colouration differences between the Orange-Vaal largemouth and smallmouth yellowfishes (*Labeobarbus kimberleyensis* and *Labeobarbus aeneus*) from the Vaal River (Sources: Mulder, 1971; Skelton, 2001).

Orange-Vaal largemouth yellowfish (*Labeobarbus kimberleyensis*)	**Orange-Vaal smallmouth yellowfish (*Labeobarbus aeneus*)**
1a. Dorsal surface of the head is flattened. Interorbital region flattened.	1b. Dorsal surface of the head rounded. Surface of interorbital region concaved.
2a. Distance between the eye and the snout smaller than the distance between the eye and the preoperculum groove.	2b. Distance between the eye and the snout greater than the distance between the eye and the preoperculum groove.
3a. Mouth terminal, large and wide with lips characteristically thin.	3b. Mouth sub-terminal, not noticeably large or wide lips with highly variable lips from rubberlip form to thin or varicorhinus form.
4a. Distinguishable long head. Head-length longer than body depth.	4b. Relatively short head. Head-length shorter than body depth.
5a. Eyes dorso-lateral, not visible from below.	5b. Eyes lateral, visible from below.
6a. Caudal peduncle long and slender.	6b. Caudal peduncle shorter and thicker than *L. kimberleyensis.*
7a. Gill rakers twelve or less.	7b. Gill rakers twelve or more.
8a. Lateral line scale count 37-45, usually 42.	8b. Lateral line scale count 36-44, usually 40.
9a. Doral fin formula: 4 rigid spines with 8 to 9 soft branched rays.	9b. Doral fin formula: 4 rigid spines with 7 to 9 soft branched rays.
10a. First spines of dorsal fin rigid only slightly flexible.	10b. Dorsal fin spines rigid and stout and spinous, fourth spine usually enlarged.
11a. Hind edge of both the dorsal and pelvic fins slightly curved.	11b. Hind edge of both the dorsal and pelvic fins usually straight.
12a. Colouration: juveniles (>5cm) and sub-adults are characteristically silver. Adults are usually olive-gray or light olive yellow, rarely bright yellow in clear water.	12b. Colouration: juveniles (>5cm) and sub-adults are olive-yellow with numerous black blotches Adults are usually bright yellow in turbid waters and copper yellow in clear water usually with black spots.

Figure 6 presents a series of photographs of Smallmouth yellowfish to illustrate some of the morphological characteristics that can be used to identify the species. Figure 6A and Figure 6E highlight the variation in body-form compared with the fin sizes of Smallmouth yellowfish. These fishes were obtained from different parts of the Orange-Vaal System suggesting that regional differences in the external morphology of isolated populations of this species exist (Bloomer et al., 2007). Variations in the mouth forms are presented in Figure 6 (B, C, D, I and L) showing a range of variation in forms from the rubber lip form Figure 6 (B and C) to the thin lipped form Figure 6 D. The characteristic olive-yellow to yellow colouration of the juveniles and sub-adults are illustrated in Figure 6(A, E and M), and the variation in colour from olive-yellow to bright yellow is presented in the figure. Additional characteristic features including the head shape, snout to eye length compared with the pre-operculum groove length and mouth positions are shown as is the caudal peduncle size and length. Finally photographs of the nuptial tubercles that develop on the head and body of mature conditioned Smallmouth yellowfish are presented in Figure 6 (G and J). The occurrence of Vaal River yellowfish with well developed nuptial tubercles from shallow >1 m habitats in the Vaal River seem to be limited to Smallmouth yellowfish (anecdotal observations).

Figure 7 presents some photographs of selected Largemouth yellowfish to illustrate key morphological characteristics. These characteristics include the head and mouth shapes and sizes and the large flattened heads of Largemouth yellowfishes with terminal wide, large mouths Figure 7 (B, H and K). Variations in the body form of individuals are presented in Figure 7 (E, F, G and H). Some Largemouth yellowfish are long and relatively slender with some having extremely large heads in relation to body size (noticeably Figure 7 F), others are short and plump with smaller heads in relation to body size (Figure 7 E and G). Surprisingly, these differences would presumably be associated with different populations within the Orange-Vaal System or due to seasonality and food availability, but both forms were regularly observed at the same locations in the Vaal River during the same season (winter). As indicated, these differences may be associated with sexual dimorphism, as female individuals prepare for the impending spawning period in spring. Figure 7 also includes photographs that illustrate the colour variations of the Largemouth yellowfishes as well as the characteristically silver colouration of juveniles and sub-adults Figure 7 (A and D) and the olive-yellow adults.

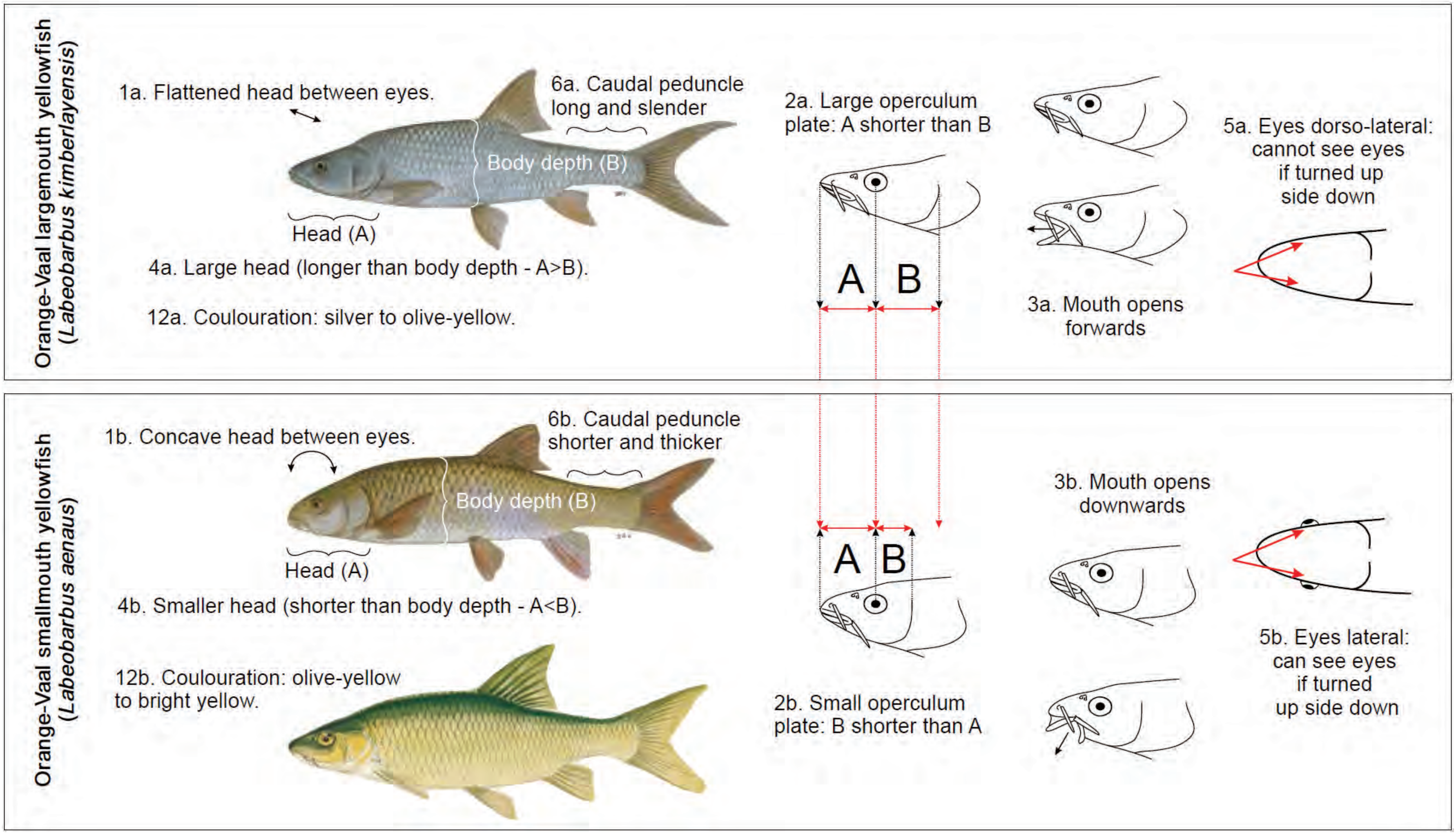

Figure 5: Selected key features (refer to Table 1) of the Orange-Vaal largemouth and smallmouth yellowfishes (*Labeobarbus kimberleyensis* and *L. aeneus*) that can be use to differentiate between the two species (fish diagrams obtained from Skelton (2001) and Le Roux and Steyn (1968)).

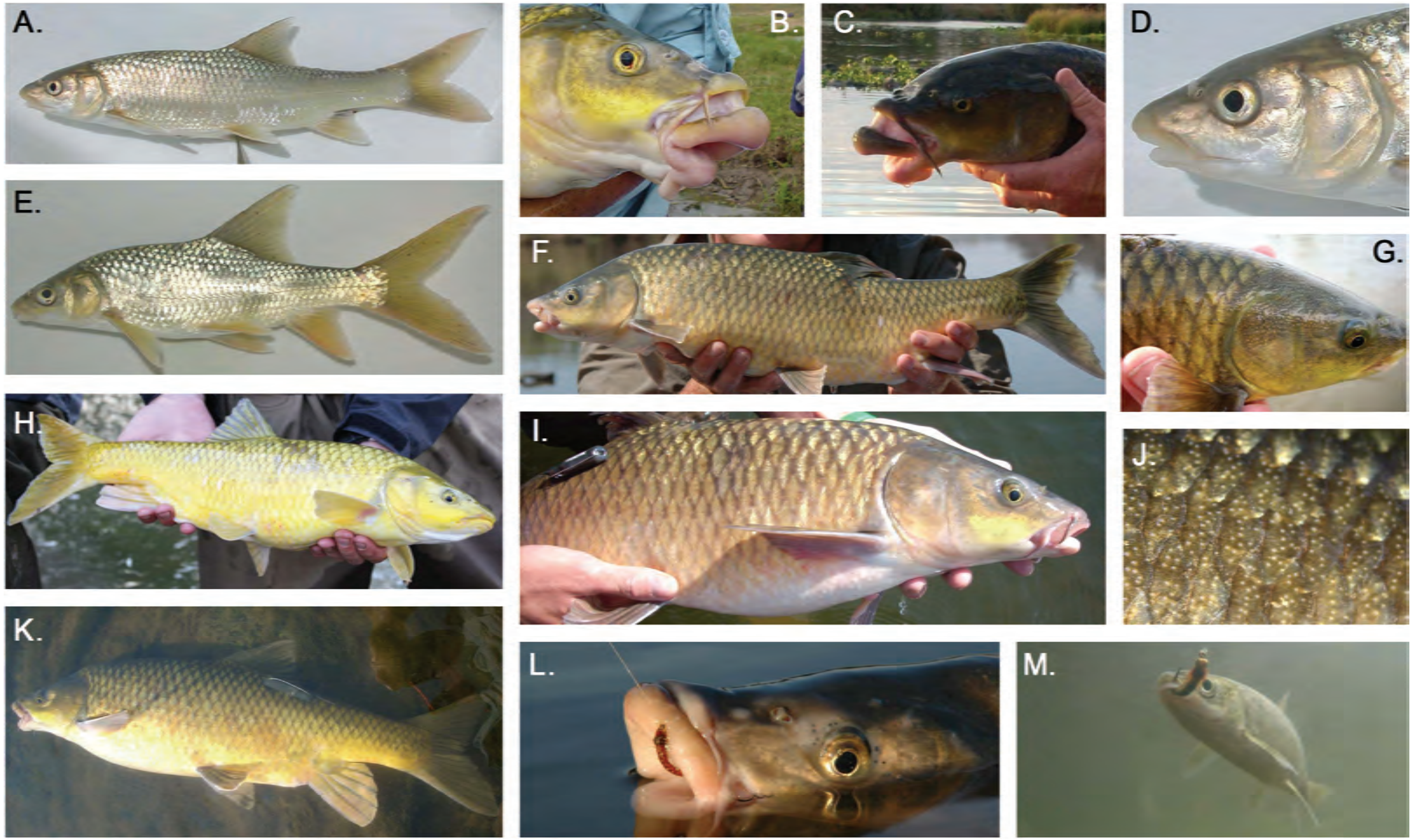

Figure 6: Photographs of Smallmouth yellowfish initially presenting differing body forms in relation to fin sizes (A and E (Skelton and Bills, 2008)), mouth forms (B and C as well as D (Skelton and Bills, 2008)) colour variations of adults in different part of the Vaal River (F, H, I and K), note the radio transmitters on individuals (I and K), nuptial tubercles on the head and body of mature conditioned individuals (G and J) and adult and juvenile individuals caught by anglers with artificial flies in their mouths.

Figure 7: Photographs of Largemouth yellowfish including pictures of juvenile, immature and mature yellowfish (A, D and E), mouth forms (B and K), variations in the head to body ratios of yellowfish from the same location in the Vaal River (F and G), large adults bearing radio transmitters (H and I), spindle-shaped profiles of Largemouth yellowfish (C and I).

On rare occasions individual yellowfish that do not clearly conform to the morphological characteristics of either species are obtained, such as the individuals presented in Figure 8. Both of these specimens were identified as Smallmouth yellowfish, but clearly contain morphological features that are characteristic of Largemouth Yellowfish. The specimen depicted in Figure 8 A was collected in the Vaal River close to Parys and has the shape and colour of a Smallmouth yellowfish, having a small operculum plate that is characteristic of this species. This individual did, however, have a large head and terminal mouth with dorso-lateral eyes that are characteristic of a Largemouth yellowfish. The specimen shown in Figure 8 B was collected in the Vaal River close to Orkney and similarly has the body form and colouration of a Smallmouth yellowfish with a small operculum plate. However, this individual also contained a large terminal mouth with dorso-lateral eyes. These individuals may be evidence that hybridisation between the two species could be occurring (Bloomer *et al.* 2007).

Figure 8: Photographs of possible hybrid yellowfish collected in the Vaal River. Although both can be identified as Orange-Vaal smallmouth yellowfish many morphological features of Orange-Vaal largemouth yellowfish can be identified.

3.3. NOTES ON EVOLUTIONARY AND PHYLOGENETIC DEVELOPMENT

Endemic African yellowfishes (*Labeobarbus* spp) include a lineage of about 80 large cyprinid fishes, many of which contain some distinctive traits and characteristics (Skelton and Bills, 2008). They occur in all the larger rivers in sub-Saharan Africa, including the Nile, Niger, Congo and Zambezi systems and in the Great Rift Valley lakes and other lakes of East Africa, south to KwaZulu-Natal in the east and the Orange and Clanwilliam/Olifants systems in the west of southern Africa. As such, the African yellowfishes are widespread throughout Africa and have been present in the rivers and lakes of the continent for a long period of time (Skelton and Bills, 2008).

Historical accounts, including the fossil record of the yellowfishes, are poor with a few initial records being obtained from East Africa that were dated to the mid-Miocene period (Skelton and Bills, 2008). Although the dating of fossils is useful, a better indicator of the age of the lineage of yellowfishes may be obtained by estimating the time when now independent river systems were connected in relation to the speciation of the yellowfishes (Skelton and Bills, 2008). An example of this includes the presence of related small-scale yellowfishes namely *L. capensis* from the Western Cape rivers and *L. aeneus* and *L. kimberleyensis* from the Orange-Vaal System that provides evidence that these systems were once connected. Geologists now estimate the last linkage between these systems occurred during the early Miocene period allowing for an indication of the possible diversification period of the species. When more than one species of yellowfish occur in the same system, an assessment can determine which drivers of the ecosystem were influential in driving the speciation (Skelton and Bills, 2008). Such occurrences allow for the consideration of the nature of the species and the available drivers of the ecosystem within which the species occur. An example of this approach includes the consideration of the 15 or so yellowfishes (*Labeobarbus* spp) that occur within Lake Tana in Ethiopia. Within these yellowfishes a large variation in head and body morphology occurs which has been associated with different feeding strategies and habitat use for numerous biological processes such as spawning procedures (Nagelkerke and Sibbing, 1997). Similarly, the yellowfishes from the Vaal River show clear differences in the morphologies, biology and ecology of species (Skelton and Bills, 2008). The Smallmouth yellowfish is known to have a generalised form with variable morphological characteristics in terms of mouth form and body shape. The Largemouth yellowfish is essentially a predator with a far more consistent body and mouth form. The two species are known to have distinctly different feeding and breeding strategies (Mulder, 1973; Tómasson, 1984).

In southern Africa there are two groups of yellowfish that are simply described as large-scale and small-scale forms (Skelton and Bills, 2008). At present the relationship between these groups is uncertain because elsewhere in Africa both large and small-scale forms also exist and co-exist. The two large-scale yellowfishes include the Lowveld largescale yellowfish *L. marequensis* (Smith, 1841) from the lowveld rivers (Phongolo to Limpopo and further north) and upper Zambezi yellowfish *L. codringtonii* (Boulenger, 1908) from the upper Zambezi, Okavango and Kunene systems (Skelton and Bills, 2008). The small-scale group is endemic to the Orange-Vaal and surrounding rivers in southern Africa. Evolutionary and phylogenetic relationships between these species are still being established, but the currently accepted concept is that the Orange-Vaal basin was once more extensive than it is today and is that it was presumably the location where a common ancestral yellowfish existed (Skelton and Bills, 2008). The surrounding rivers gradually captured parts of the Orange-Vaal drainage and with each capture some of the common ancestral population was separated, eventually resulting in the speciation of the small-scale yellowfish group from that ancestor (Skelton, 1986; 1988; Skelton and Bills, 2008). Within the Vaal River itself components of the population were partially or completely isolated through habitat preference and feeding biology as indicated. Over time these populations diverged to the point of not being able to interbreed, therefore resulting in the speciation of the Largemouth and Smallmouth yellowfishes. Recent genetic analyses of these yellowfishes shows that they are closely related and that there has either been introgression or incomplete separation (Bloomer and Naran, 2007; Bloomer et al., 2007).

These findings suggest that either the Vaal River yellowfishes may have separated recently, or are currently hybridising (Bloomer et al., 2007). At this stage experts can only speculate, but it may well be that the environmental pressures in the Orange-Vaal system have so affected the riverine environment that the two species can no longer function independently and are, therefore, interbreeding and hybridising (Skelton and Bills, 2008). The environmental processes responsible include the effects of dam and weir construction, the extensive abstraction of water and other habitat destruction through pollution and other interventions.

4. REPRODUCTIVE BIOLOGY AND EARLY DEVELOPMENT

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4.1. INTRODUCTION

In order to manage, conserve or use a species as an indicator species for the management of an ecosystem, a good understanding of the breeding biology and early development of that species is required. The success of a species is not only dependent on the ability of the species to breed successfully, but includes the successful recruitment of sufficient offspring into the population. Although the reproductive biology of the two Vaal River yellowfish species have similar characteristics, differences exist that may affect the ability of each species to sustain itself in the Vaal River. Vaal River yellowfishes have been considered to be an important angling species within southern Africa for the last century (Jubb, 1967). Due to the value of these species for angling purposes, interest in their breeding biology arose in the late 1940s, resulting in the development of artificial culturing methods for the smallmouth yellowfish and a subsequent initiation of a regional distribution campaign of the species (Jubb, 1967; Mulder and Franke, 1973). These initial experiments focused on the generation of yellowfish fingerlings for the development and maintenance of the regional angling industry that was being threatened by the over-exploitation of the resources of the Vaal River (Mulder and Franke, 1973). Initial interest in the breeding biology of the Vaal River yellowfishes was initiated in the 1950s where aspects of the spawning requirements and early development of the smallmouth yellowfish were considered (Groenewald, 1961). These experiments were followed by a number of research endeavours that included both Vaal River yellowfishes, resulting in the development of a relatively good understanding of the reproductive biology of the Smallmouth yellowfish, but a more limited understanding of the Largemouth yellowfish's reproductive biology (see for example Groenewald, 1961; Jubb, 1967; Mulder and Franke,1973; Tómasson et al., 1984).

This chapter includes the following components:

- A review of the known reproductive biology of the Vaal River yellowfishes,
- The findings of an artificial reproduction experiment carried out at the Free State hatchery at Xhariep on the Orange River at the Xhariep Dam and
- The limited findings of the reproductive behavioural biology experiment carried out on the Vaal River using biotelemetry methods.

4.2. REVIEW OF THE KNOWN REPRODUCTIVE BIOLOGY OF THE VAAL RIVER YELLOWFISHES

Detailed assessments of the reproductive biology of the Vaal River yellowfishes have been carried out by Mulder (1973), Mulder and Franke (1973), Tómasson et al. (1984), De Moor & Bruton (1988) and Stadtlander (2006). Findings suggest that both species require very specific environmental conditions for successful reproduction and recruitment of juveniles into the population to take place (Tómasson et al., 1984). Enabling environmental conditions such as suitable water temperatures and flows with associated habitat conditions of the Vaal River have furthermore been documented to influence the reproductive biology, growth and maturation of the Vaal River yellowfishes (Tómasson et al., 1984; for example). Both species are considered to be serial spawners that may reproduce more than once a season (Skelton 1972; De Villiers and Ellender, 2008a; 2008b). Stadtlander (2006) observed numerous egg sizes within the gonads of a single yellowfish suggesting that the eggs become ripe at different intervals throughout the spawning season. Considered to be linked to the serial spawning ability, some adults remain in spawning areas for extended periods of time such as the events observed by Sterkfontein Dam where large shoals of breeding yellowfish remain in small tributaries that contain suitable breeding areas for several months (De Villiers and Ellender, 2008a). During a series of artificial culturing experiments Mulder and Franke (1973) documented the first spawning events of Smallmouth yellowfish initiated in October, with a possible second spawning event in January. The maturation timing of eggs within gonads of wild Smallmouth yellowfish supports these observations and suggests that the spawning events of Largemouth yellowfish are initiated much later on in the seasons during January or February (Mulder, 1973; Tómasson et al., 1984).

In both species the males mature at a younger age and smaller size than the females (De Villiers and Ellender, 2008a; 2008b). Tommasson et al. (1984) found that Largemouth yellowfish males mature after 6 years and females matured after 8 years. Maturation rates of Smallmouth yellowfish were determined to be similar to Largemouth yellowfish but locality specific and included individuals larger than 300 mm (Allanson and Jackson, 1983; Laurenson et al., 1989; Mulder, 1973; Tómasson et al., 1984). Length at maturity of Smallmouth yellowfish ranged from 340 to 360 mm for females and 220 to 260 mm for males (Stadtlander, 2006). A 50 cm female of either species has been observed to carry up to 60 000 eggs (Tómasson et al., 1984). Tómasson et al. (1984) noted that the total number of eggs in a gonad was positively correlated with length.

The spawning season for Smallmouth yellowfish is from October to January depending on locality where these environmental conditions may change (deMoor & Bruton, 1988; Mulder, 1973; Tómasson, 1984; Laurenson et al., 1989) and appears to be primarily controlled by temperature (Tómasson et al., 1984). Smallmouth yellowfish require a minimum temperature requirement of 18.5^{o}C to spawn (De Moor and Bruton 1988) and characteristically make use of gravel or cobble dominated glides, riffles and rapid habitats (Mulder 1973, Tómasson et al. 1984). Although successful reproduction of the species occurs within dams and has been observed in gravel beds in stillwaters (Gaigher, 1976) when access is available yellowfish migrate into rivers to spawn in these ideal habitats (Mulder, 1973; Tomasson et al., 1984; De Villiers and Ellender, 2008a; 2008b). In dams where spawning activity of yellowfish has been observed, wind action is considered to be important to create turbulent water conditions that are required by yellowfish over gravel or cobble beds. Smallmouth yellowfish are oviparous and either lay eggs directly into gravel and or cobble substratum where the eggs fall into the interstitial crevices between substratum or lay their eggs into a shallow saucer-like nest that has been constructed in the gravel using the snout and caudal fin (Tómasson et al., 1984; De Moor and Bruton, 1988). When they are ready to spawn large numbers of Smallmouth yellowfish usually move upstream to the spawning sites (Jubb, 1966). Courtship behaviour has been observed for Smallmouth yellowfish and it is suspected that spawning occurs before or closely after sunrise (De Moor and Bruton, 1988; De Villiers and Ellender, 2008a). Males seem to hold in spawning areas while females and on occasion other males hold in pools nearby. It is suspected that critical pre-spawning behaviour takes place in these areas. Individual females then move to the spawning beds where each spawns with up to seven males. Conditioned males usually and females occasionally develop nuptial tubercles prior to spawning events that give their skin a rough texture (De Villiers and Ellender, 2008a). During spawning a frenzy of activity is observed during spawning events as eggs and sperm are released (De Villiers and Ellender, 2008a).

The reproductive biology of the Largemouth yellowfish is considered to be similar to that of the Smallmouth yellowfish (Tóasson et al. 1984), but very little evidence is available. In Lake Le Roux (now Van der Kloof), Tómasson et al. (1984) found that Largemouth yellowfish spawned four to six weeks later than the more cold-tolerant Smallmouth yellowfish. Using catch per unit effort data and gonad analysis, Tómasson et al. (1984) showed that during floods in spring and summer, Largemouth yellowfish migrated out of the dam up the Orange River to spawn in well oxygenated sections of the river where the water flows over clean gravel beds within the river channel. Tomasson et al. (1984) hypothesised that: in continuously flowing regulated rivers, the time of spawning of Largemouth yellowfish was governed primarily by water temperature.

In captivity for the successful cultivation of both species the provision of flowing water over gravel or cobble beds is required to provide ecological cues for the broodstock to initiate spawning (Jubb, 1966/67). Experiments show that both species have been cultured successfully, but that Largemouth yellowfish are considered to be relatively difficult to condition suggesting that there are additional, unknown ecological cues that are required by this species to condition successfully (Mulder, 1973).

Once laid the eggs of both species may become covered with gravel whereafter fertilisation takes place in the water (Tómasson et al., 1984). Embryo development requires high levels of oxygen, and is influenced by temperatures taking approximately 5 days at temperatures of 20^{o}C to 22^{o}C (De Moor and Bruton, 1988). The egg shells are transparent but have a yellow to golden tinge. Initially, the slightly adhesive eggs have an average diameter of 1.8 mm and swell to about 2.5 mm once fertilised (De Moor and Bruton, 1988). The adhesive eggs can withstand a steady flow of water but any sudden surge will dislodge them. They are negatively buoyant and once dislodged do not retain their adhesive properties. They have a double eggshell – the outer shell can be ruptured and the larvae will still be able to develop and hatch in the inner shell (De Moor and Bruton, 1988). After hatching, the larvae remain within the gravel beds during the early stages of their life cycle and are dependant on nutrients absorbed from their yolk sac. About 72 hours after hatching, if water temperatures remain between 23ºC and 25°C, the larvae become mobile and start to swim actively about 72 hours after hatching. They develop an olive-green to grey dorsal colouring, with characteristic black spots over the entire body, and a silvery white ventral colouring.

Tómasson et al. (1984) observed that recruitment into the Vanderkloof Dam from successful spawning events upriver were generally good for both yellowfishes, but that unseasonal release of cold water from Lake Xhariep may cause poor reproductive success.

4.3. ARTIFICIAL REPRODUCTION EXPERIMENT

4.3.1. Introduction

From approximately 1999 to 2004 the Free State Nature Conservation's departmental fish hatchery, located at Xhariep Dam, developed methodologies to artificially condition and spawn both yellowfishes from the Vaal River system in captivity with relative ease. Although these conditioning and spawning exercises were repeated frequently during this five year period no formal procedures were documented to allow for these exercises to be replicated. The expert knowledge gained was however still available and was used to carry out a culturing experiment in this study. The aim of this experiment was to obtain sufficient offspring of both yellowfish species to allow for the characterisation of their early development. Thereafter the study aimed to document the procedural steps of the exercise to allow for the development of formal procedural methodologies for culturing yellowfish at this facility.

4.3.2. Materials and methods

Initially, an assessment of the procedural steps that have been used to carry out similar experiments was undertaken. This was accomplished by reviewing the methodologies used to artificially propagate other *Larbeobarbus spp.* in South Africa (Le Roux, 1968; Wright and Coke, 1975a; 1775b; Bok, 1992; Bok and Immelman, 1998). Considerations of the procedures carried out at Xhariep in the past was also considered. As a result the basic procedures for the experiment were established to be as follows:

1. Obtaining suitable yellowfish adults: this component involves the safe capture, sedation, transport and release of suitable adult Largemouth and Smallmouth yellowfish brood-stock from the Orange-Vaal River system into the hatchery at Xhariep.
2. Condition yellowfish broodstock: this component of the study involved carrying out a conditioning programme to prepare the broodstock for the artificial propagation experiments.
3. Artificially spawning and the production of yellowfish offspring: this step includes the preparation of the facilities and the broodstock prior to the experiments and the experiments themselves as well as the production of sufficient yellowfish offspring for the remainder of the study.
4. Re-condition and release of broodstock: following the completion of the experiments, this step involves the recovery, release and ultimately, the fate of the broodstock used in the experiments.

Having established a basic procedural process for this component of the study plans could be established implement them out and attempt to culture yellowfishes.

The Free State Nature Conservation's departmental fish hatchery located at Xhariep was chosen as the experimental location for this component of the study. Initially the suitability for the experiments to be undertaken at this facility had to be established. A layout of the facility is presented in Figure 9. The facility is located adjacent to the Orange River just downstream of the Xhariep Dam, Free State. The facility has access to untreated river water from the Orange River and to treated water from the local municipality which is fit for human consumption. Only indigenous fishes and one exotic fish (Common Carp, *Cyprinus Carpio*) obtained locally, have ever been or are currently being maintained at the facility.

Only minimal alterations to the existing facilities were required in order to make the facility suitable for the experiments. Fortunately, large populations of both yellowfishes occur within the Xhariep Dam and broodstock were available to be captured and relocated to the nearby hatchery. Facilities at the hatchery that were available for use included numerous large river fed broodstock conditioning ponds, some with the potential of being covered with shade net, grow out ponds and the breeding facilities within the hatchery.

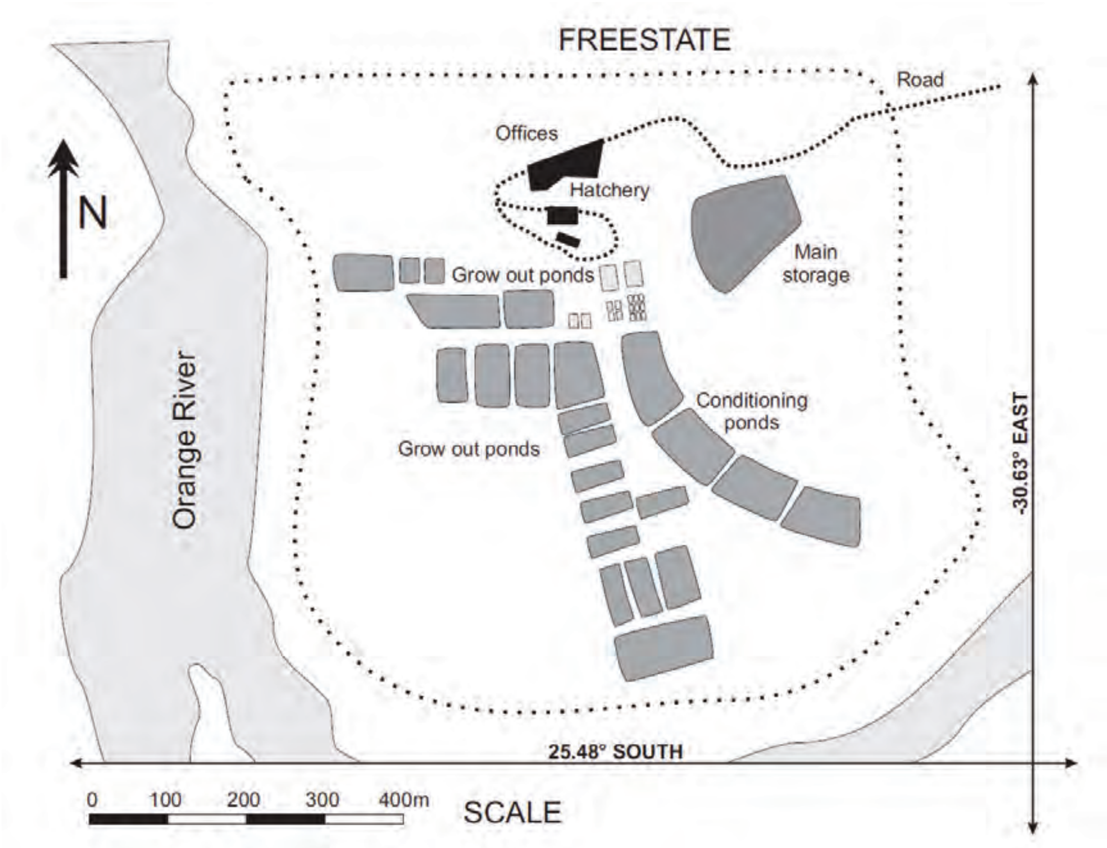

Figure 9: Diagrammatic areal layout of the Free State Nature Conservation's departmental fish hatchery located at Xhariep, Free State.

Step 1: Obtain suitable yellowfish adults

Yellowfish are slow growing and only mature from six to eight years (males and females respectively) when they exceed a fork length of about 300 mm (Tómasson et al., 1984). As a result, only mature Vaal River yellowfish individuals exceeding a fork length of 450 mm were considered for use as broodstock in this study. During 2008, in order to ensure that sufficient time was available to condition broodstock, mature individuals of both yellowfishes were captured in the Xhariep Dam using seine nets and angling techniques. Once captured the broodstock were partially anaesthetised using either 2-phenoxy ethanol (0.4 $ml.l^{-1}$) or clove oil (0.5 $ml.l^{-1}$) to minimise stress during the relocation procedure. Captured broodstock were then relocated to the fish hatchery in an aerated transport tank and then released immediately thereafter into prepared conditioning ponds at the hatchery (Figure 10 and Figure 11). Differences in the temperature of the water at the Xhariep Dam and the hatchery were monitored during the relocation process to ensure that individuals were not subjected to rapid temperature changes of more than 3^{o}C per hour. The monitoring of any additional water physico-chemical quality parameters were deemed to be unnecessary as the

Xhariep Dam is the source of the water that was used in the hatchery and as such considered to be uniform. The broodstock were maintained within the hatchery for at ten months allowing for individuals to acclimatise to the conditioning ponds and to ensure that they would learn to accept artificial food required during the conditioning process.

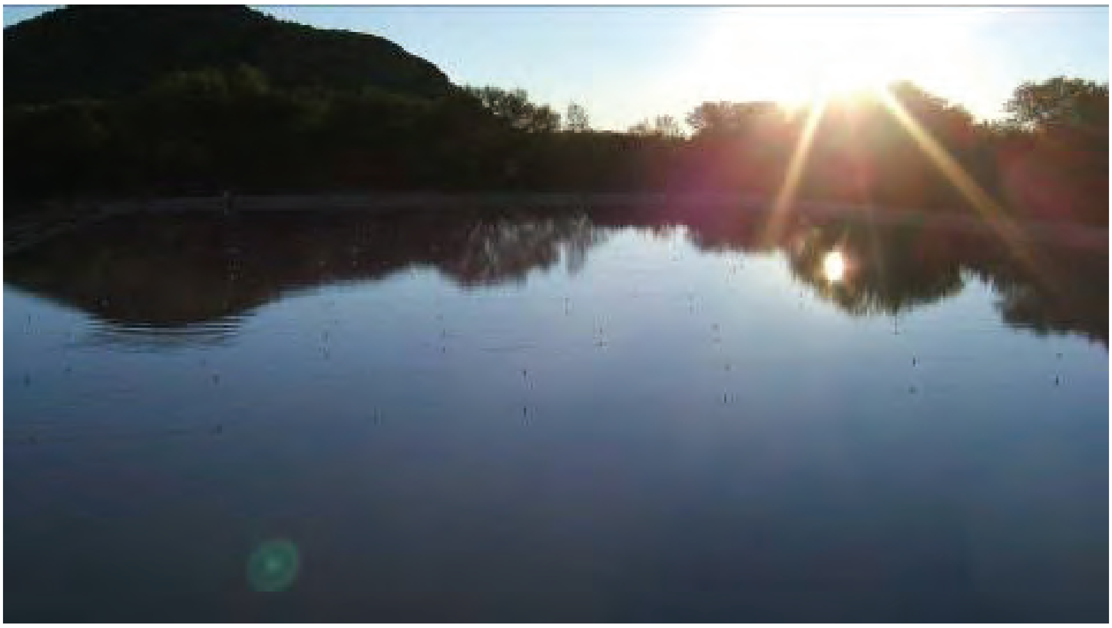

Figure 10: Orange-Vaal Largemouth yellowfish broodstock conditioning ponds at the Free State Nature Conservation's departmental fish hatchery located at Xhariep.

Figure 11: Orange-Vaal Smallmouth yellowfish broodstock conditioning ponds at the Free State Nature Conservation's departmental fish hatchery located at Xhariep.

For the experiments, a population of about 100 mature Smallmouth yellowfish and 25 Largemouth yellowfish were captured, relocated and maintained at the hatchery in conditioning ponds.

Step 2: Conditioning yellowfish broodstock

The timing of the conditioning procedures was synchronised with the natural conditioning processes of wild yellowfish (Mulder, 1971; Mulder, 1973). This was carried out in an attempt to allow for any unknown ecological cues that are required by Largemouth yellowfish in particular to be available during the conditioning procedure. The established conditioning procedure takes four potential environmental or biological cues that are considered to be required for the yellowfish to spawn (Mulder, 1971; Tómasson et al., 1984). These cues are:

- the increase in available energy reserves of the broodstock proceeding the spawning period,
- increase in length of day,
- availability of fast flowing water and
- increasing water temperatures.

Under natural conditions mature yellowfish in the Vaal River are known to respond to the reduction in flows, water temperatures and day length during the winter periods (Tómasson et al., 1984). During this period the metabolisms of the mature individuals are considered to slow although the fish still feeds actively. After winter as the water temperatures and day lengths increase, the metabolisms of the mature individuals increase rapidly to build up protein reserves for the production of gametes in preparation of impending spawning period. The conditioned state of individuals is externally evident and can be recognised by a change in the condition, colour of the mature yellowfish and the development of nuptial tubercles predominantly on the male individuals which precedes the spawning of both yellowfishes (Figure 12). In addition to these external changes the behavioural of the broodstock changes. In accordance with the known temporal differences in spawning periods of the yellowfishes, experiments of the Smallmouth yellowfish were initiated from October to December (2008) and the Largemouth yellowfish conditioned procedures were completed approximately six weeks later from January to February 2009.

Figure 12: Photograph of a mature conditioned Orange-Vaal Smallmouth yellowfish exhibiting numerous tubercles, an external indication of the condition of the individual.

The broodstock in the conditioning ponds were fed with a stock feed daily, at a rate of approximately 2% body weight. The feed contained a ratio of 6.4:1 proteins to lipids and carbohydrates respectively. Towards the end of August (2008) when water temperatures began to increase the feed was changed and the volume was increased to two feeds per day. The new feed contained a ratio of 8:6:1, proteins to lipids and carbohydrates respectively, to facilitate gamete production. In September 2008 the Smallmouth yellowfish broodstock were relocated from the conditioning pond to a maturation pond (Figure 13). The maturation pond was a matured reservoir that contained a high abundance of filamentous algae and a barricaded channel along one side of the system. This barricade was used to create a current in the pond for the final conditioning process of the broodstock.

After the broodstock were transferred to the maturation ponds, their behaviour was monitored for signs of spawning intent. In November 2008 signs of final maturation and spawning intent by the Smallmouth yellowfish broodstock became evident in that they began to congregate at the entrance of the flow channel enter the channel frequently. Another week was allowed for conditioning and then the artificial propagation experiments for the Smallmouth yellowfishes were initiated on 3rd of December 2008 and were completed on 9 December 2008.

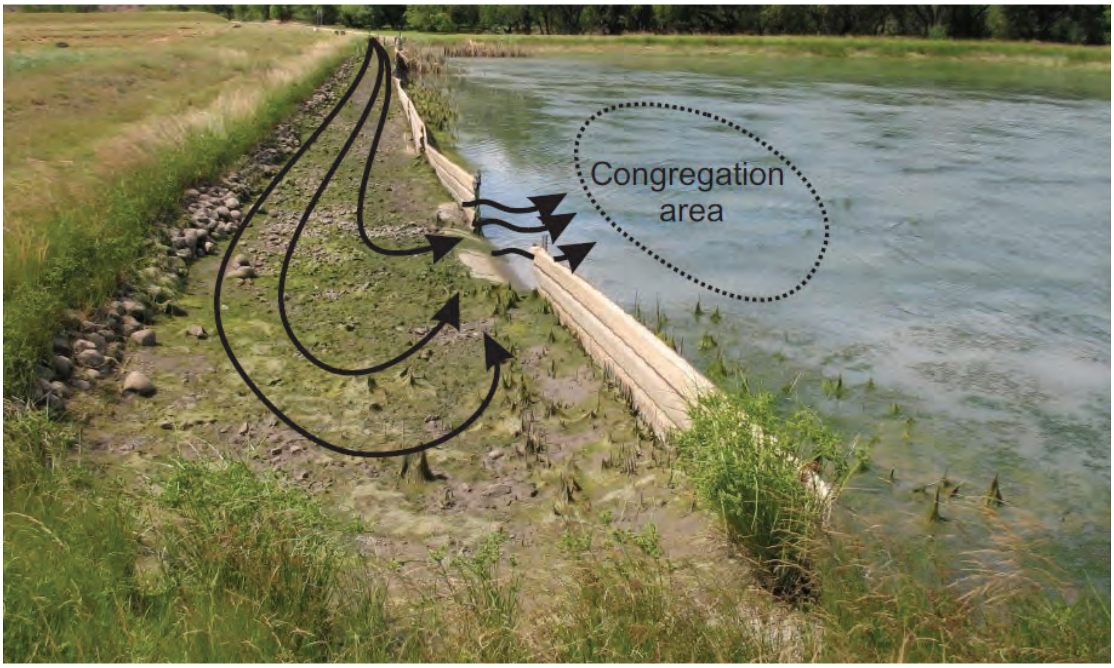

Figure 13: Maturation pond when water level is reduced. Flow channel clearly indicated by arrows showing flow movement. Mature yellowfish congregation area at the discharge point of the channel indicated.

After the completion of the Smallmouth breeding experiments they were recaptured in the final conditioning pond and returned to a maintenance pond. Thereafter, the Largemouth yellowfish were moved to the final maturation pond where the maturation procedure was repeated. Although behavioural changes in Largemouth yellowfish have been observed in this system prior to previous artificial culturing exercises in the past (2004-2006), no spawning behaviour was exhibited by the Largemouth yellowfish in this experiment. Largemouth yellowfish were allowed to condition in the final conditioning pond until the 11th of February 2009 when the propagation experiments were initiated without behavioural indications of final maturation.

Step 3: Artificial spawning experiments and production of yellowfish offspring

The artificial propagation experiments were undertaken from 3-9 December 2008 for the Smallmouth yellowfish experiments and from 11-16 February 2009 for the Largemouth yellowfish. The artificial spawning procedures included the following phases:

- Phase 1: Preparation of the hatchery for the artificial experiments
- Phase 2: Capture, sedation and movement of broodstock to breeding containers
- Phase 3: Sexing of the broodstock and hormonal treatment

Phase 4: Testing for the production of ova

Phase 5: Stripping of gametes and artificial fertilisation

Phase 6: Incubation of embryos and relocation

A detailed description of these phases is as follows:

Phase 1 (Smallmouth yellowfish): Preparation of the hatchery for the artificial experiments. On 3 December holding/breeding containers and embryo channels in a temperature controlled breeding room at the hatchery were prepared for the breeding experiments to house the broodstock for the experiments and maintain the embryos obtained. Local Xhariep Municipality treated water was initially used within the breeding room which was aerated constantly and regulated to the same temperature (20^{o}C) as the final maturation pond where the Smallmouth yellowfish were being maintained (Figure 14 (A-D)). Initial experiments failed as the water in the breeding room was toxic and resulted in the mortalities of most of the broodstock used in the initial experiments. After this unsuccessful attempt to use the temperature controlled indoor breeding rooms on 4 December outdoor breeding containers were filled with matured river water from the storage dam at the hatchery and used for the remaining experiments (Figure 14 F). At the same time glass aquaria for the experiment were filled with mature river water, placed in a laboratory at the hatchery and heated with 50 A fish tank heaters (Figure 14 E). Baskets made of stainless steel (0.5 mm) mesh were used to suspend the embryos above the floor of the glass tanks.

Phase 1 (Largemouth yellowfish): Preparation of the hatchery for the artificial experiments: On 9 February 2009, without any attempts to use the indoor facilities, outdoor breeding containers were filled with matured river water from the storage dam at the hatchery and used for the experiments (Figure 14F). At the same time the glass tanks used in the Smallmouth yellowfish experiments were cleaned filled with mature river water, placed in a laboratory at the hatchery and heated with 50 A fish tank heaters (Figure 14 E). Similarly cleaned stainless steel 0.5 mm mesh baskets were used to suspend the embryos approximately 30 mm above the floor of the glass tanks.

Phase 2 (Smallmouth yellowfish) Capture, sedation and movement of broodstock to breeding containers. On 4 December 2009, 24 mature Smallmouth yellowfish were captured using a single pull of a large seine net. The fish were then sedated in a transport container and moved from the final maturation dam into the breeding room and released into the holding/breeding containers where they were allowed to recover (Figure 14 A). Within four hours 19 broodstock individuals died within the holding/breeding containers. The remaining broodstock were returned to the maturation ponds and not used in the remainder of the experiment. On 5 December 2009 to obtain a second group of broodstock for the second experiment the maturation pond was partially drained (Figure 13). Sixteen adult yellowfish were used in this experiment. The adults, many of which were showing signs of breeding readiness in that they had developed nuptial tubercles, were partially sedated and moved to the outdoor breeding containers (Figure 14F). The sexes of the broodstock were easily identified at this stage as all of the males were producing milt and as such classified as ripe and running. Four containers were used and stocked with 4 males, 3 males, 5 females and 4 females respectively, of which all weighed between 2 kg and 4 kg. The condition of these adult yellowfish were monitored continuously for the first six hours, in order to prevent mortalities similar to those encountered during the first experiment. High oxygen levels were maintained in these flow-through breeding containers by allowing water that was sprayed into the containers to circulate through the containers from the main storage dam on the facility.

Phase 2 (Largemouth yellowfish) Capture, sedation and movement of broodstock to breeding containers. On 11 February 2009 five Largemouth yellowfish were captured, sedated and relocated into the outdoor breeding facilities in a manner similar to that used for the Smallmouth yellowfish.

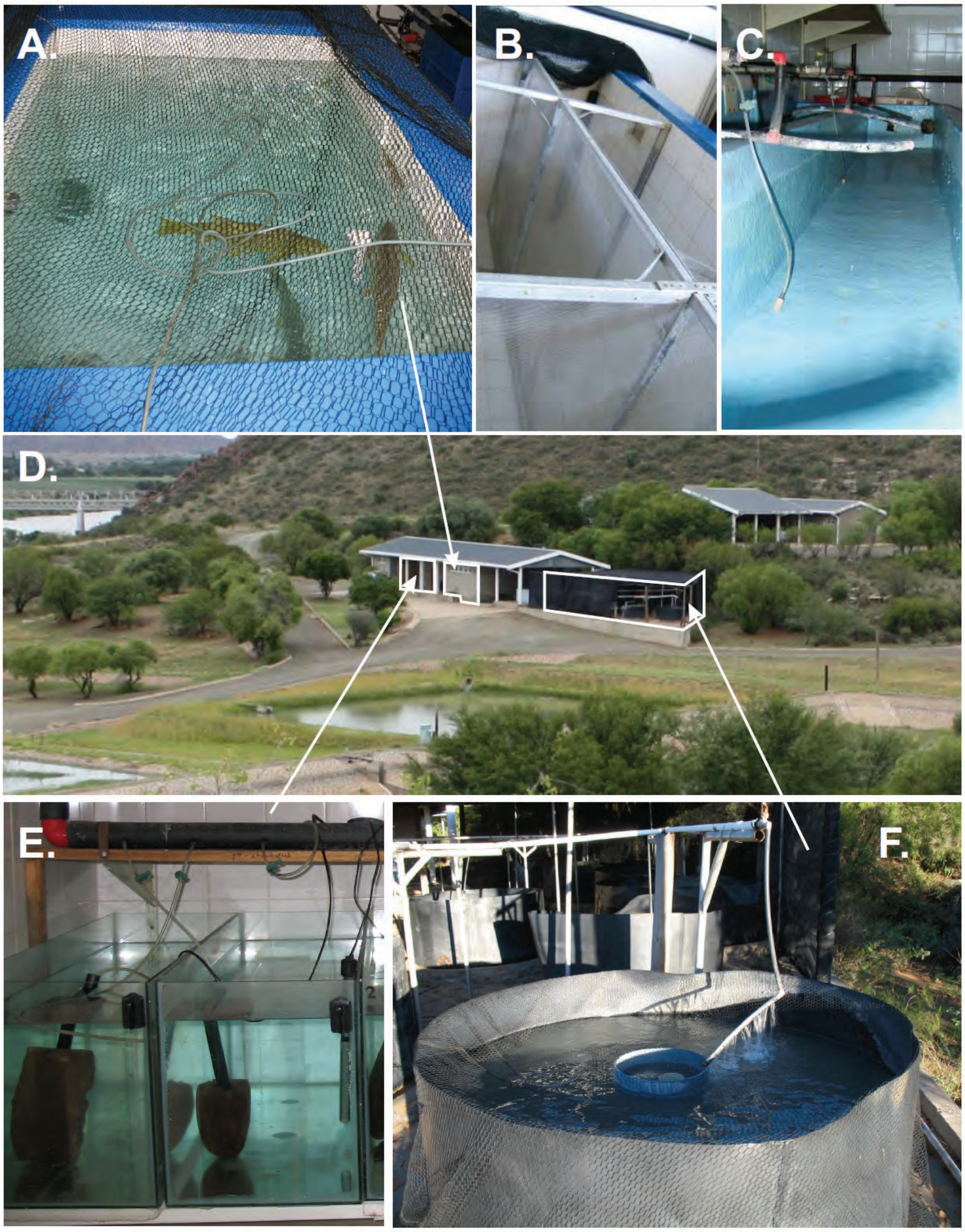

Figure 14: Facilities at the Free State departmental hatchery used for the artificial propagation experiments. Photographs of the temperature controlled, indoor holding/breeding containers (A and B) and the embryo development channels (C) indicated. As well as the outdoor holding/breeding containers and the simple non-temperature regulated embryo development glass tanks (E and F). Finally the location of these facilities at the hatchery is indicated in photograph D an image of the whole facility.

Phase 3 (Smallmouth yellowfish): Sexing of the broodstock and hormonal treatment. Having already determined the sexes of the broodstock the hormonal treatment was initiated six hours after the relocation of the yellowfish into the breeding containers. In the experiment a hormone treatment was administered to stimulate ovulation and spermation in the broodstock. In this study a synthetic stimulator namely Aquaspawn (Spawnrite Ltd) and a natural stimulator namely homogenised Common carp (*Cyprinus carpio*) pituitaries were used. Aquaspawn contains two active ingredients namely synthetic Gonadotropin-releasing hormone agonist (GnRH-a) and domperidone in a liquid form that is administered intramuscularly. The formulation is unique in that it prevents overdosing. Common carp pituitaries were obtained from wild caught Common carp from the Xhariep Dam and administered at a concentration of approximately 3-4 mg/kg body weight of broodstock as per Brzuska (2003). Hormonal treatment was initiated by removing all of the broodstock from the breeding containers individually, examination the individual for signs of gamete production and thereafter hormone administration. Initially a dose of 0.5 ml/kg of Aquaspawn was administered to each individual intramuscularly in front of the dorsal fin at an angle avoiding the risk of piercing any organs. After administration of the Aquaspawn, the administration area was treated with a small amount of an iodine based antiseptic cream.

Phase 3 (Largemouth yellowfish): Sexing of the broodstock and hormonal treatment. After relocating the Largemouth yellowfish to the outdoor breeding containers, the following morphological data were collected from each individual while sedated:

Individual no	Sex	Lengths (total, fork, standard)	Girth	Weight
Largemouth 1	♂	62, 55 and 51 cm	33 cm	2.5 kg
Largemouth 2	♂	58, 53.5 and 49.5 cm	29 cm	2.0 kg
Largemouth 3	♀	65, 57 and 55.5 cm	33 cm	2.5 kg
Largemouth 4	♀	68, 58 and 56 cm	32 cm	2.7 kg
Largemouth 5	♂	44.5, 39.5 and 38 cm	25 cm	0.9 kg

Hormone treatment of the Largemouth yellowfish are summarised in Table 2. Where deemed necessary up to three treatments of Aquaspawn or Common Carp pituitary were administered.

Table 2: Overview of the hormone treatment used to stimulate gamete production in the Largemouth yellowfish used in the experiment.

		Treatment 1		Treatment 2		Treatment 3
Individual	Weight	Aquaspawn []ml	[] per kg	Aquaspawn []ml	[] per kg	Pituitary glands
Largemouth 1	2.5	1.9	0.76	-	-	-
Largemouth 2	2	1.5	0.05	-	-	-
Largemouth 3	2.5	1.9	0.76	1.25	0.5	7.5mg
Largemouth 4	2.7	2	0.74	1.5	0.56	8.1mg
Largemouth 5	0.95	0.75	0.79	-	-	-

Phase 4 (Smallmouth yellowfish): Testing for the production of ova. Following the initial hormone treatment, the broodstock were returned to the breeding containers. Approximately 12 hours later the broodstock were captured again, sedated and examined for the production of gametes. The sedated individuals were placed onto a wet towel, inverted and examined for gamete production by applying pressure to the abdomen of the yellowfish ventrally in an anterior to posterior direction from the base of the pectoral fins to the anus. On the first observation (6 December 2008) some individuals were revealed to be ripe and running in that they were producing gametes. Some females that were not producing ova were administered with homogenised pituitaries diluted in 2 ml of saline and returned to the breeding containers. These individuals were again examined on 7 December 2008 and were found to be producing gametes.

Phase 4 (Largemouth yellowfish): Testing for the production of ova. All five individuals were treated with an initial dose of Aquaspawn (hormone treatment 1) ranging between 0.74 ml and 0.79 ml of Aquaspawn per kilogram of receiving individual at 18h30 on 11 February 2009 (Table 2). At 07h00 on 12 February 2009 (approximately 12 hours later) all individuals were checked for condition and individuals number 1 and 2 were observed to be ripe and running males. The remaining large individuals (yellowfish 3 and 4) were checked again at 11h00 (16 hours after hormone treatment) and were observed not producing eggs. These two females were treated with another dose (hormone treatment 2) of between 0.5 and 0,56 ml of Aquaspawn per kilogram of receiving individual (Table 2). The two females (yellowfish 3 and 4) were again checked at 18h00 (24 hours after initial treatment and seven hours after second treatment) on 12 February 2009 and were found to still not producing any eggs. On the 13 February 2009 at 06h00 (36 hours after initial treatment and 19 hours after second treatment) females no 3 and 4 were again checked for eggs which were not present. At 08h25 on 13 February

2009 females no 3 and 4 were treated with a single dose of pituitary gland (3-4 mg/kg body weight) obtained from two donor Common carp (*C. carpio*) individuals (treatment 3: Brzuska, 2003). At 18h30 the females were again checked for egg development and were found not to be releasing any eggs, 48 hours after initial treatment of Aquaspawn, 31 hours after second treatment and 10 hours after treatment with pituitaries. On the 14 February 2009 at 08h30 females number 3 and 4 were checked once again (58 hours after the initial treatment and 45 hours after the second treatment and 24 hours after the third treatment) and at this point Largemouth yellowfish number 3 produced eggs while individual no 4 was still not producing eggs.

Phase 5 (Smallmouth yellowfish): Stripping of gametes and artificial fertilisation. Ripe running females were initially hand-stripped of ova in the same manner used to examine the broodstock for gamete production. Ova were stripped into a cleaned, dry plastic bowl. Milt from the males was then added by stripping the males of milt into the bowl containing the ova. The ova and milt were mixed with a clean dry feather where after water was added to activate the sperm and to allow for the fertilisation of gametes. Fertilisation was allowed to take place for a few minutes before the excess milt was washed off the now fertilised embryos that were subsequently poured into incubation tanks.

Phase 5 (Largemouth yellowfish): Stripping of gametes and artificial fertilisation. Ova produced by Largemouth no 3 were stripped into a clean, dry bowl in a manner similar to that used in the Smallmouth yellowfish experiment. Milt from the still ripe and running Largemouth yellowfish male no 1 was then added to the ova, mixed using a clean feather and activated by adding water. On the morning of 15 February 2009 a final attempt was made to induce female number 4 to produce eggs, after no eggs where produced the experiment was concluded.

Phase 6 (Smallmouth yellowfish): Incubation of embryos and relocation. Following the first and second fertilisation experiments on 6 and 7 December 2009, fertilised embryos were gently deposited onto a fine (0.5 mm) mesh in the glass embryo incubation tanks. Temperatures in these tanks were regulated at 22^{o}C using 50 A heaters and the oxygen levels were maintained by aerating the incubation tanks with air stones fitted with foam diffusers to minimise the disturbance to the embryos while maintaining good oxygen saturation. Embryos were monitored for 24 hours during which time all unfertilised ova and or dead embryos were removed by siphoning them out of the incubation tanks. Thereafter developing embryos were packed into 10 l plastic bags containing approximately 4 litres of water each which were aerated with oxygen and individually sealed. On 8 December 2008 approximately 500 developing embryos were packed into each bag and transported either to the Zebra Research Aquaria in Randfontein or to the South African Institute for Aquatic Biodiversity in Grahamstown in large polystyrene boxes. Approximately 5000 developing embryos in total were successfully transported for eight hours to the Zebra Research Aquaria and released into prepared glass maintenance containers of well-matured aerated borehole water maintained at 22°C. These individuals were raised for another 12 months with only a 10% mortality rate during the entire project under the care of Mr. Stephan v.d. Walt[1]. Another 500 or so developing embryos were transported to the South African Institute for Aquatic Biodiversity.

Phase 6 (Largemouth yellowfish): Incubation of embryos and relocation. On 14 February 2009, 19 grams of Largemouth yellowfish eggs were produced, fertilised and gently deposited onto a fine (0.5 mm) mesh in the glass embryo incubation tanks. Temperatures in the incubation tanks were regulated at 22°C using 50 A heaters while oxygen levels were maintained by aerating the incubation tanks with air stones fitted with foam diffusers to minimise the disturbance to the embryos while maintaining good oxygen saturation. Embryos were monitored for 24 hours during which time all unfertilised ova and dead embryos were removed by siphoning them out of the incubation tanks. Thereafter developing embryos were packed into two 10 litre plastic bags containing approximately 4 litres of water each which were aerated with oxygen individually as before and sealed. Approximately 250 developing embryos were packed into each bag and transported to the Zebra Research Aquaria in Randfontein in large polystyrene boxes to regulate the temperature during the transportation. On 15 February 2009, approximately 500 developing embryos were successfully transported for eight hours to the Zebra Research Aquaria and released into prepared glass incubation tanks containing well matured aerated borehole water maintained at 22°C. These individuals were raised for another 12 months with only a 10% mortality rate during the entire project under the care of Mr. Stephan v.d. Walt.

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[1] Mr. Stephan van der Walt. Senior technician. Zebra Research Aquaria. Randfontein.

Step 4: Re-conditioning of and release considerations of broodstock

Following the completion of the experiments, this step involves the release of, recovery and ultimately the fate of the broodstock used in the experiments. Following the experiments carried out on the Smallmouth yellowfish, broodstock were released into the conditioning pond and allowed to recover from the experiment. No mortalities of broodstock adults were recorded and no further culturing experiments were attempted during the 2009/10 spawning period. Five Largemouth yellowfish individuals were used in the culturing experiment of which four were released into the conditioning ponds at the Xhariep State Hatchery and one female was lost as injuries sustained during the culturing experiment were considered to be too severe.

4.3.3. Results

As indicated the culturing experiments of the Smallmouth yellowfish resulted in the production of approximately 7500 viable embryos of which approximately 5000 were successfully relocated for eight hours to the Zebra Research Aquaria and released into prepared glass incubation tanks containing well matured aerated borehole water maintained at 22^{o}C. Of the remaining 2500 viable embryos, approximately 500 were successfully relocated to the Department of Ichthyology and Fisheries Sciences facility, Rhodes University, Grahamstown. Monitoring the state of the embryos provided insight into the survivability of embryos. The transfer process was designed to keep changing environmental variables at a minimum. The embryos were transported in the same water that was used for spawning and activation process. Plastic bags were filled with fresh water and saturated with pure oxygen. The bags were sealed and placed in a large polystyrene box to minimise temperature fluctuations. A sealed bag of ice, wrapped in a towel, was placed in the polystyrene box with the embryos to keep the water cool during the five hour relocation to Grahamstown. The remaining Smallmouth yellowfish at the Xhariep State Hatchery were relocated into larval development ponds at the hatchery. The Largemouth yellowfish culturing experiment resulted in the production of approximately 750 Largemouth yellowfish embryos of which approximately 500 embryos were successfully transported to the Zebra Research Aquaria and released into prepared glass incubation tanks containing well matured aerated borehole water maintained at 22^{o}C on the 15 February 2009. The remaining 250 or so Largemouth yellowfish remained at the Xhariep State Hatchery where they were successfully raised with minimal mortalities. All of the yellowfish relocated to the Zebra Research Aquaria were raised for approximately one year during which time eight Largemouth and ten Smallmouth yellowfish were collected weekly to bi-weekly for the age validation study (findings presented in this report). Following the completion of the collections for the age validation study the remaining yellowfish were relocated to the aquarium at the National Zoological Gardens in Pretoria where they are now being used in a display for educational purposes.

In order to document and test the conditions of the breeding experiment selected environmental variables were monitored throughout the experiment. These variables included temperatures, oxygen, pH and conductivity.

Initially, hourly temperature readings were recorded from the yellowfish conditioning pond at the Gariep State fishery. Hobo® temperature loggers were deployed into the maintenance pond on 23 January 2009 and recovered on the 11th of February 2009. 475 reading were taken and a basic statistical assessment carried out (Table 3 and Figure 15). Findings indicated that the maximum readings (27-28^{o}C) were obtained between 12h44 and 20h44. Lowest readings were obtained during 00h44 and 08h44 (21-22^{o}C). Table 3 presents a graphical overview of the changes in temperatures during the study period. This data review indicates that the conditions that the brood stock were exposed to in the conditioning dams relates to midsummer conditions that would be obtained in the natural environment.

Table 3: Overview of the statistical assessment of the temperature logger data collected from the conditioning pond where the brood stock where maintained between 23 January 2009 and 11 February 2009. (Measurements in ^{o}C).

	0h44	1h44	2h44	3h44	4h44	5h44	6h44	7h44	8h44	9h44	10h44	11h44	12h44	13h44	14h44	15h44	16h44	17h44	18h44	19h44	20h44	21h44	22h44	23h44
Count	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19	19
75 percentile	25	25	25	25	24	24	24	24	25	25	26	26	26	26	26	27	26	26	26	26	26	26	25	25
Mean	24	24	24	24	24	24	23	24	24	24	25	25	26	25	26	26	26	26	26	25	25	25	25	25
25 percentile	24	24	23	23	23	23	23	23	23	24	24	24	25	25	25	25	25	25	25	25	25	24	24	24
Min	22	22	21	21	21	21	21	21	22	23	23	23	24	23	24	24	24	24	24	24	24	24	23	23
Max	26	26	25	25	25	25	25	25	25	26	26	26	27	28	28	28	28	28	27	27	27	26	26	26

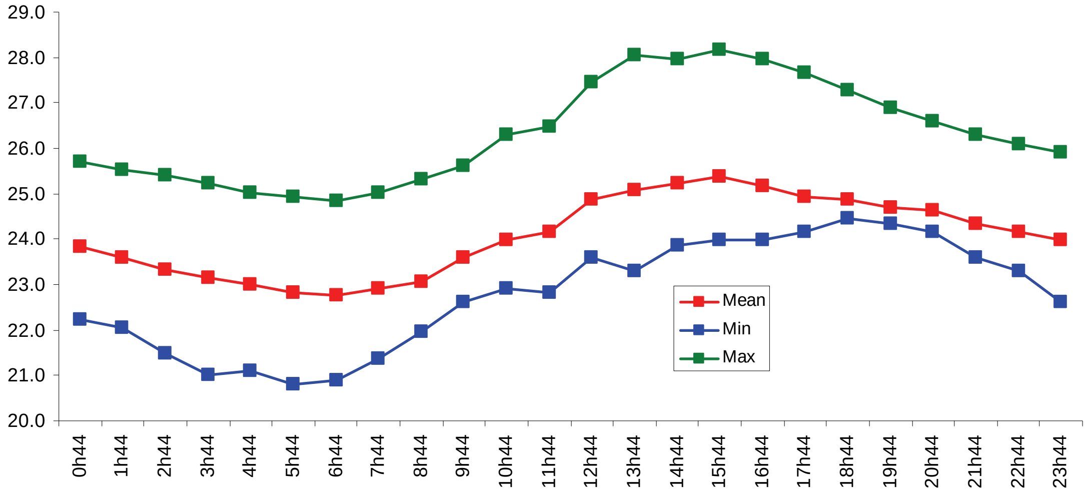

Figure 15: Hourly mean, maximum and minimum temperature readings recorded in the monitoring exercise from 23 January 2009 and 11 February 2009.

In addition, the temperature, conductivity, oxygen concentrations and pH of the broodstock holding facility within the hatchery and the embryo maintenance tanks were recorded. The temperatures remained between 20°C and 22°C which is considerably lower than the conditioning ponds. However this was deemed to not pose a problem to the experiment. The oxygen concentrations of the facilities were maintained above a 90% saturation level throughout the experiment and the conductivity and pH remained at 134.7 µS/cm and 8.8 respectively.

4.4. EARLY DEVELOPMENT OF YELLOWFISHES

4.4.1. Introduction

Early ontogeny studies of fishes have contributed to a wide range of biological and ecological studies such as developmental biology, growth bioenergetics, early life behaviour, species identification and to the development of recruitment models (Gozlan et al., 1999). The outcomes of many early ontogeny assessments have been shown to be of particular importance for the development of species as indicators of river ecosystem function as well as contributing to the conservation of fish species (Gozlan et al., 1999). In this study, the concept of non-gradual ontogeny of fishes was adopted, as initially proposed by Vasnetsov (1953) and Kryzhanovsky et al. (1953), that included stimulated investigations to identify objective boundaries for distinguishing different intervals of fish development. The theory of saltatory ontogeny considers development as a sequence of stabilised states (steps) and rapid changes (thresholds). Morphological transitions are often associated with physiological and behavioural shifts and all these changes are usually used to distinguish and discuss developmental intervals (Balon, 1979). Morphological, early life ontogeny in fish can be described according to developmental periods and steps (Balon, 1971, 1999), or quantitatively scaling developmental events against a selected criterion (Rombough, 1985; Fuiman, 1994; Fuiman et al., 1998). Describing key developmental events of the early stages of fish life chronologically, can improve the techniques used to rear progeny during this critical period, provide comparative data, as well as provide information for addressing some fisheries conservation and management issues.

Although many yellowfish have been artificially cultured as indicated by Mulder and Franke (1973), for example, no artificially produced offspring have been used to characterise the early development of the species. Furthermore no early development studies of any southern African yellowfish have received much attention in the past (Cambray et al., 1997; Roux, 2006). The aim of this study is to characterise the early development of artificially cultured Largemouth and Smallmouth yellowfish. In order to reach this aim the following objectives were established:

1. Obtain newly hatched Largemouth and Smallmouth yellowfish from the propagation experiment at Xhariep during the 2009/10 breeding season for early development assessments.
2. Rear known aged fish – for the purpose of age validation.
3. Provide species specific early development characteristics and features which can be used to confirm the species identity. These determinations will contribute towards the identification of the larval and juvenile fish field based collections.
4. Observe behaviour of larvae and early stage juveniles to allow for speculation with regard to their distribution, ecological and environmental requirements, habitat and niche preferences. These observations will assist with the sampling approaches for early stage fish.

4.4.2. Materials and methods

The artificial spawning and larval studies were planned to run concurrently so that the yellowfish offspring produced by the artificial spawning studies would be immediately available to researchers to document the early development of the yellowfish.

On 7 December 2009 approximately 500 Smallmouth yellowfish embryos were obtained from the successful propagation experiment conducted at Xhariep State Hatchery. The development of the embryos was initiated on site at this hatchery and then relocated within thirty six hours after fertilisation to glass aquaria at the Department of Ichthyology and Fisheries Sciences facility, Rhodes University, Grahamstown. Embryos were transferred in well aerated plastic bags and chilled slightly during the transportation in an attempt to minimise mortalities whilst not noticeably affecting the development rate of embryos. The embryos were released into the aerated glass aquaria filled with water transported from the Xhariep experiment, they were incubated on plastic mesh hatching trays. Following the initial relocation, weekly water changes (20 l) were carried out during which time the water temperature was maintained between 17°C -20°C.

Embryo development was observed and photographed following a schedule that included initial, two, four and then six hourly monitoring intervals after fertilisation for a two-week period following fertilisation. Thereafter observations were made at 24 hour intervals for 3-4 week period and then at 48 hour intervals from week 5 to 16. Observations were made using a stereomicroscope Leica E24D and Wild Heerburgg fitted with a digital camera (Olympus 4.1 megapixel) under a range of magnifications. Larval measurements were taken using an objective micrometer. During this phase, sub-samples of embryos including larval to early stage juveniles were collected as voucher specimens and deposited at South African Institute for Aquatic Biodiversity in Grahamstown. The samples were fixed in 99% buffered ethanol and in 4% buffered formalin. The embryonic development of the Largemouth yellowfish was initiated 72 hours after fertilisation, which did not allow for the documentation of the initial development prior to 72 hours for this species, using the offspring obtained for this study. Video footage in their early development was subsequently used to describe the initial development of the species for the period prior to 72 hours of development.

4.4.3. Results and discussion

After the five hour journey from Xhariep to Grahamstown, embryos were transferred to glass aquaria filled with Xhariep River water. The water temperature of the transported embryos was acclimatized to 19°C over a period of 3 hours. The overall effect of the reduction in temperature during the transportation process appeared to slow the rate of development down, consequently extending the hatching period of the embryos by 24-30 hours. Within the aquaria, developing embryos were maintained at a water temperature of 19°C to 23°C. The embryos, larvae and juveniles were kept under a fluorescent light, with approximately 12-14 hours of darkness. After hatching, larvae were fed newly hatched Brine shrimp, *Artemia salina* nauplii in excess quantities twice a day. Un-consumed brine shrimp were siphoned off after each feed using a thin (5 mm) tube. Older larvae and juveniles were later weaned onto a diet of fish flakes and blood worms (chironomidae larvae).

The developmental stages of the embryos consisted of five key steps including (E1) activation, (E2) cleavage, (E3) epiboly, (E4) organogenesis and (E5) onset of blood circulation. The time from activation to hatching lasted between 84.5 hours and 153 hours or 3.5 days to 6 days.

Early development of the Smallmouth yellowfish

Following the approach adopted in similar early development studies, the ontogenetic development of Vaal River yellowfish in the study follows the development stages used for other cyprinids by Gozlan et al. (1999) and Pinder (2005). Smallmouth yellowfish eggs are relatively large, spherical, pale yellow and are negatively buoyant. Embryonic development includes five steps including an activation stage (E1), cleavage stage (E2), epiboly stage (E3), organogenesis stage (E4) and circulation stage (E5) as follows:

Embryo stage E1: Activation phase. After activation the eggs become slightly adhesive to the tray and to each other and began to swell (Figure 16 A). Stage E1, activation, began at 0.58 hours after fertilisation on 7 December 2008. During this step the eggs rapidly took in water and increased in size until the diameter measured between 0.22 mm and 0.24 mm. The swelling of the eggs also caused them to change from their initial spherical form, becoming slightly oval in shape and flattened on the surfaces that adhered to other eggs in the strip. During this step the perivitelline space was created

Embryo stage E2: Cleavage phase. Although onset of certain initial steps of the cleavage phase were not observed due to technical problems. The result of the cleavage phase was the blastula formation, where cells divide and begin to surround the yolk (Figure 16 B and C). The phase ends with the descending blastula to encircle the yolk. This marks the onset of the next phase.

Embryo stage E3: Epiboly. Epiboly had commenced by 20h00 with the onset of the cell layer migrating across the yolk surface. The morula became progressively smaller and more flattened in shape and by 07h35 the embryonic shield, which surrounded 75% of the circumference of the yolk, was evident. At this stage, the cell layer covered approximately three-quarters of the yolk surface. Closure of the germ ring occurred around 31 hours after fertilisation (Figure 16 D).

Embryo stage E4: Organogenesis. This stage began with the development of the neural plate and cephalization of the embryo. This is a complex step where the optic vesicle becomes evident in the majority of embryos and myomeres begin to form. There was separation of the caudal section from the yolk, which started to divide into a large anterior section and a more slender posterior section (Figure 16 E). The extension of the tail region has the effect of stretching the yolk sac, where the posterior section is slender than the anterior section.

Embryo stage E5: Circulation. The onset of blood circulation had developed with the first muscular contraction being observed, the process ended with hatching. During this stage the brain became visible while the first pigment became visible in the eyes. At four to six days the initial formation of the optic vesicles and the rudimentary buds of the pectoral fins were first evident. At this stage otoliths were first visible and the blood began to take on a red colour. The pectoral lobes then became evident and began to move. This step gives way to the onset of the free embryo phase (Figure 17).

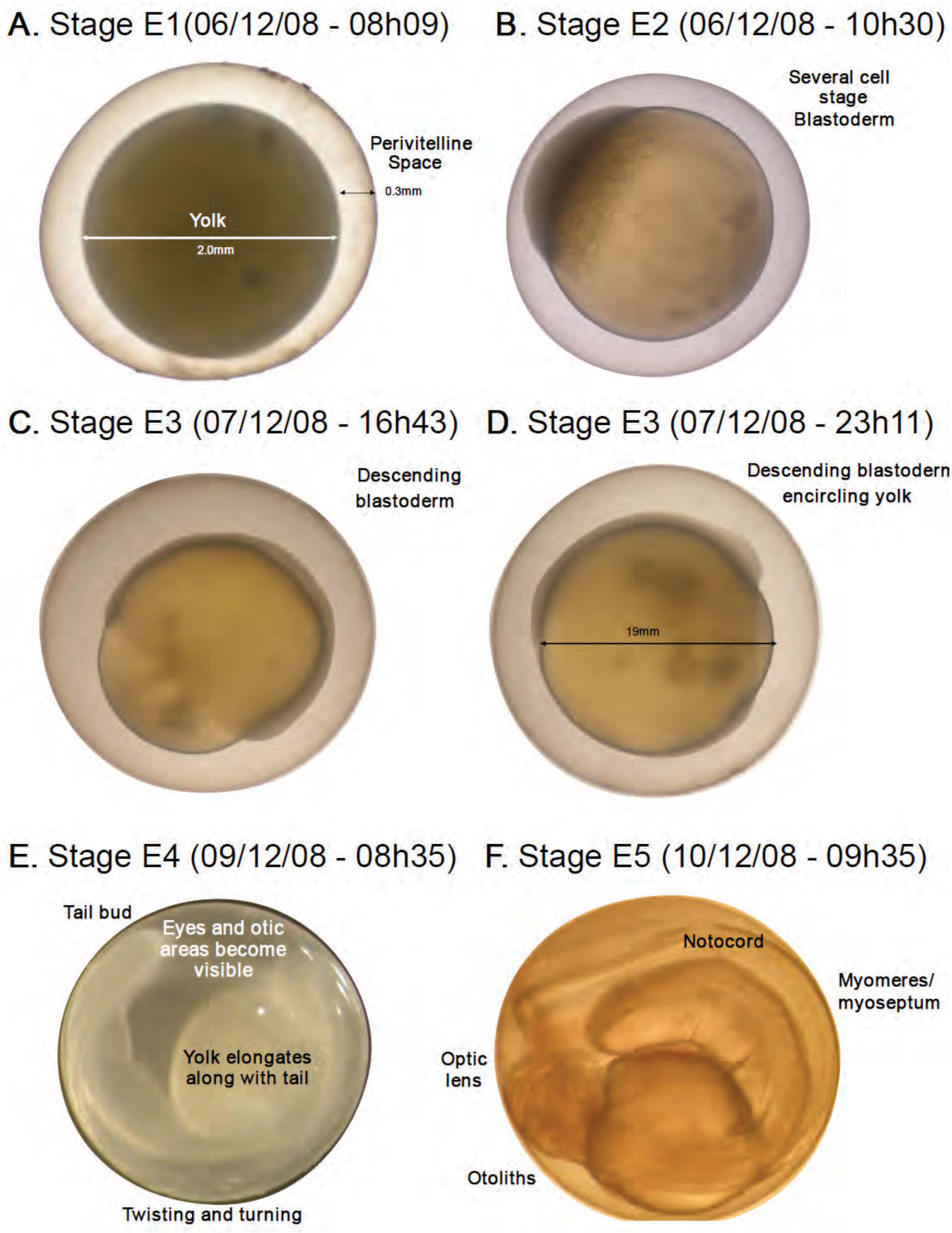

Figure 16: Photographs of the five embryonic development steps (A-F) for Orange-Vaal Smallmouth yellowfish (*Labeobarbus aeneus*) embryos observed in the study.

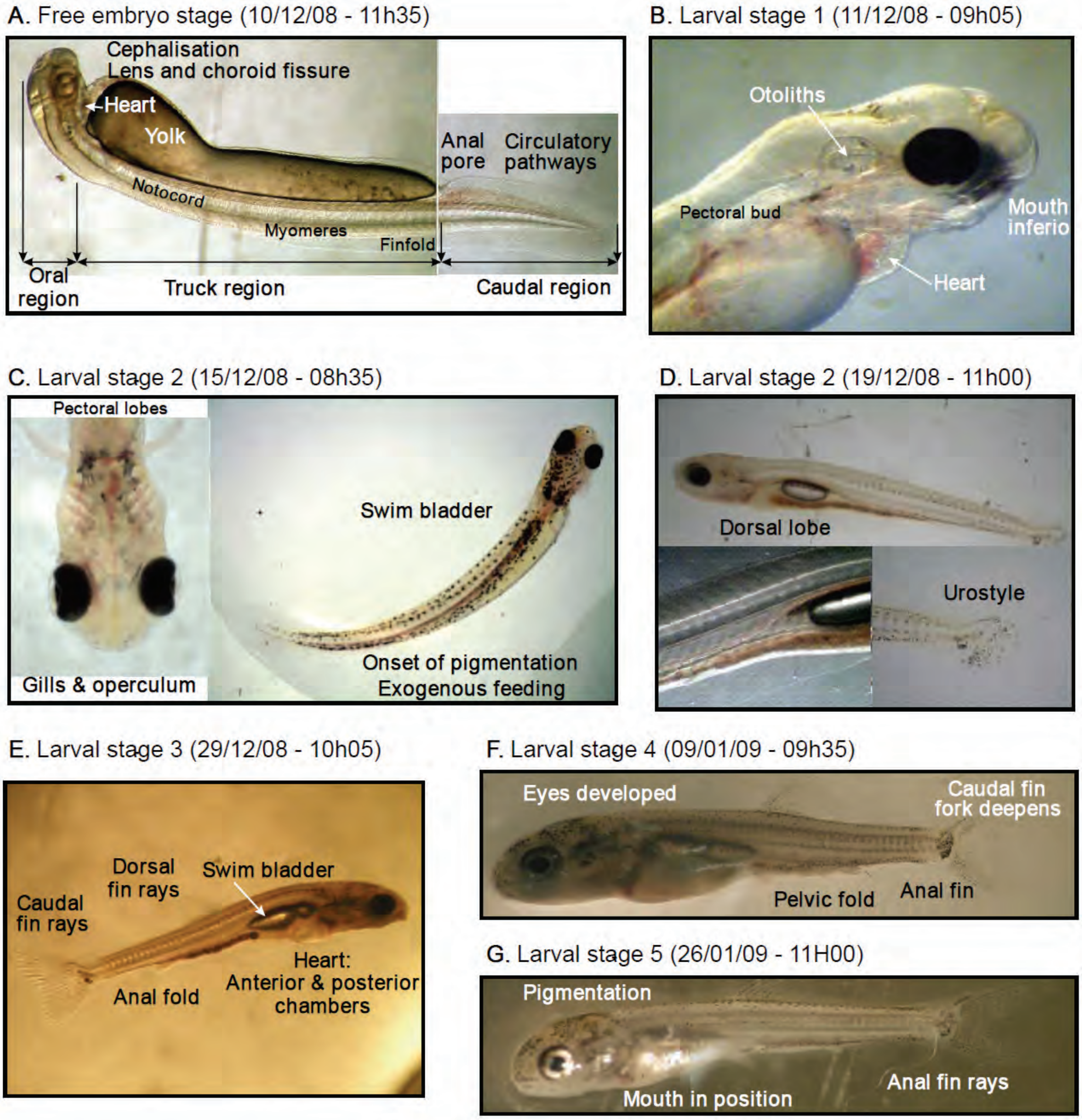

Figure 17: Photographs of the larval (post-hatching) to juvenile development steps (A-G) for Orange-Vaal Smallmouth yellowfish (*Labeobarbus aeneus*) observed in the study.

After hatching, free embryos and larvae in the aquarium were subjected to temperatures ranging between 19°C and 22°C. This period of development consisted of one free embryo stage and five larval stages. The time scale from activation to the end of the larval period, when the first larvae became juveniles, lasted 69-73 days. The extended periods of development could have been due to the lower water temperature and the feeding regime of twice per day. The larval developmental period was divided into five developmental stages including a free embryo stage, namely four larval stages including: a young larval stage (L1), an intermediate larval stage (L2) an older larval stage (L3) and a young juvenile stage (L4). The larval development phase was completed with the larvae becoming juveniles. An overview of the larval development stages for the Smallmouth yellowfish obtained in this study includes:

Free embryo stage. This phase follows the embryonic developmental stage E5. The phase began with hatching and ended with the onset of exogenous feeding. Hatching occurred between 84.5 hours and 153 hours, on the 10-12 December 2008. 4 to 6 days after activation. Post hatched embryos were 7.2 mm long and a substantial yolk reserve. The following features were also evident with the cephalisation, oral region with a pore, lens and choroid areas, heart otoliths, the notochord is surrounded by myomeres and the anal pore is distinguished. Post-hatching, free embryos generally displayed varying degrees of swimming capability. The earliest embryos to hatch were only able to perform sudden bursts of activity and appeared to be able to swim a few centimetres from the bottom before sinking again. Those embryos that hatched later, however, were able to perform more sustained swimming and were soon able to swim to the surface. Upon hatching, the embryos were with the head bent down over the yolk and only very un-pigmented. During this step various developmental processes were taking place, including the jaw and gill structures, the gradual straightening of the head and the formation of the chambers of the swimbladder, fin fold transition to fin rays (Figure 17 A).

Larval stage L1: Young larvae phase 1. This phase was characterized by the onset of exogenous feeding and ended with the onset of flexion of the urostyle and the switch to purely exogenous nutrition. The first free embryos reached this step after 2 days. The ability of L1 larvae to open their mouths corresponded with the ability to swim to the surface and begin gulping air to inflate the anterior and posterior chamber of the swimbladder. This consequently resulted in the ingestion of ‘air’ and the mouth becoming functional. The opening of the mouth also coincided with the onset of branchial respiration and the functionality of the gills. At the beginning of L1, larvae still had a large pear-shaped yolk sac and the mouth remained in a sub-terminal position. A few days later (fifth and sixth day post hatching, the head was straight and the body took on a yellow colouration. Melanophores also became evident on the head, heart region and the ventro-visceral and medio-ventral lines with faint dashes of pigment just becoming evident on the lateral line. As this step progressed, these pigments became more obvious. By day 9 to 11, the mouths had migrated into terminal positions and Artemia nauplii were first found in the gut. At this stage, only a small amount of yolk reserves remained to be absorbed. (Figure 17B).

Larval stage L2. Young larvae phase 2. This step, started from the 15 December 2008, the ninth day after fertilisation, with the switch to purely exogenous nutrition and the beginning of flexion of the urostyle (Figure 17C). This step proceeded until the onset of inflation of the anterior chamber of the swimbladder. By the 19 December, rays were beginning to develop below the urostyle within the caudal finfold. From the beginning of this step, melanophores became distributed on the head, lips and opercula. Pigment also became evident above the notochord. After 16 days the dorsal finfold was showing the first signs of differentiation and later starting to form in both the dorsal and anal fins. The onset of this step also corresponded with a clear shift in behaviour of the Smallmouth yellowfish. While the remaining L1 larvae were still swimming at the surface, L2 larvae were forming a shoal between 5 and 10 cm from the bottom of the tank. The larvae were 9.7 mm in length (Figure 17D).

Larval stage L3: Intermediate larva stage. By day 16-20, air was first evident in the anterior chamber of the swimbladder. This signified the beginning of larva step L3 with the end of this step indicated by the dorsal finfold no longer being connected to the dorsal fin. By day 22, flexion was complete and the caudal fin was forked and almost fully developed. By now pigment was well developed both above and below the notochord and rudiments of the pelvic fins were first evident. During this step the mouth began to migrate towards the sub terminal position. Exogenous feeding was observed alone (Figure 17E).

Larval stage L4: Older larval stage. By day 23- 28 the dorsal finfold first became separated from the dorsal fin, indicating the beginning of larva step L4. By now all individuals had pelvic buds present rays were forming in the pectoral fins. At the end of this stage all fins except for the pelvic fins were fully formed and only a small amount of pelvic finfold remained. The mouth was almost in the final, sub terminal position. The scales were evident just below the lateral line (Figure 17F).

Larval stage L5: Young juvenile. Complete disappearance of the finfold, indicating the beginning of larva step L5 and completion of fin formation, was first evident by day. The mouth was now in its final, sub terminal to inferior position. Scales were first evident just below the lateral line by day (Figure 17G).

The first fully scaled Smallmouth yellowfish with a complete lateral line were observed in mid to late January. At this point the transition from larvae to young juvenile was completed with the disappearance of the fin fold and the ray formations in the fins. The development of the scales, with full coverage over the body, indicating the transition from larvae to juveniles. Juveniles are not quite silvery, but rather well pigmented.

Early development of the Largemouth yellowfish

Largemouth yellowfish eggs are similarly relatively large, spherical, pale yellow and are negatively buoyant like Smallmouth yellowfish eggs. Similarly the embryonic development of Largemouth yellowfish embryos consisted of five steps including an activation stage (E1), cleavage stage (E2), epiboly stage (E3), organogenesis stage (E4) and circulation stage (E5). In this study the early (pre 72 hours) embryology of Largemouth yellowfish embryos were not available from generated offspring so video footage was used to describe the initial development prior to the E4 stage. Findings of this assessment showed that the embryonic development stages of Largemouth yellowfish were comparable to the Smallmouth yellowfish which is recorded in the preceding section of this report. First observations of embryos produced for this study were initiated 72 hours after fertilisation that were in the organogenesis stage of development as follows:

Embryo stage E4: Organogenesis. By 72 hours Largemouth yellowfish embryos are well developed and are moving by occasional flexing within the chorionic membrane. At this stage the caudal and tail areas had developed and extended past the yolk sac to accommodate the caudal area. As this area elongates the yolk sac stretches forming a slender shape at the tail end. The bulkier anterior area, yolk sac appears as rounded oval mass, the head, optic regions are discernable (Figure 18A). Cephalisation, neural plate and myomere bands are also beginning to become visible at this stage. Onset of circulation and blood streams is visible with slight straw coloured vesicles moving about (Figure 18A). At this stage the time from fertilization is approximately 4 days (14/02/2009-16 /02/2009). The Embryo is 2.5-2.7 mm in diameter and spherical. At this stage only a few embryos are moving by occasionally flexing and pulsing indicating that these actions were just being initiated.

Embryo stage E5: Circulation. Onset of blood circulation, had developed with the first muscular contraction being observed, this stage ended with embryo hatching. At this stage the brain is visible with pigments initially visible in the otic region. As the embryos develop faint pigments then become evident around the eye lens. With the onset of circulation, on the 4th day the embryo pulses every 20-30 seconds. At this stage the notocord, mouth pore and myomere bands are visible. The embryo diameter is approximately 5.8 mm at this stage of development. Observations made every 2-3 hours indicate that organ differentiation continues during this phase including the development of organs such as the eyes, heart, vertebrae and muscle bands that become larger. Around midday on the 4th day otoliths become evident approximately 100hrs after activation (Figure 18B).

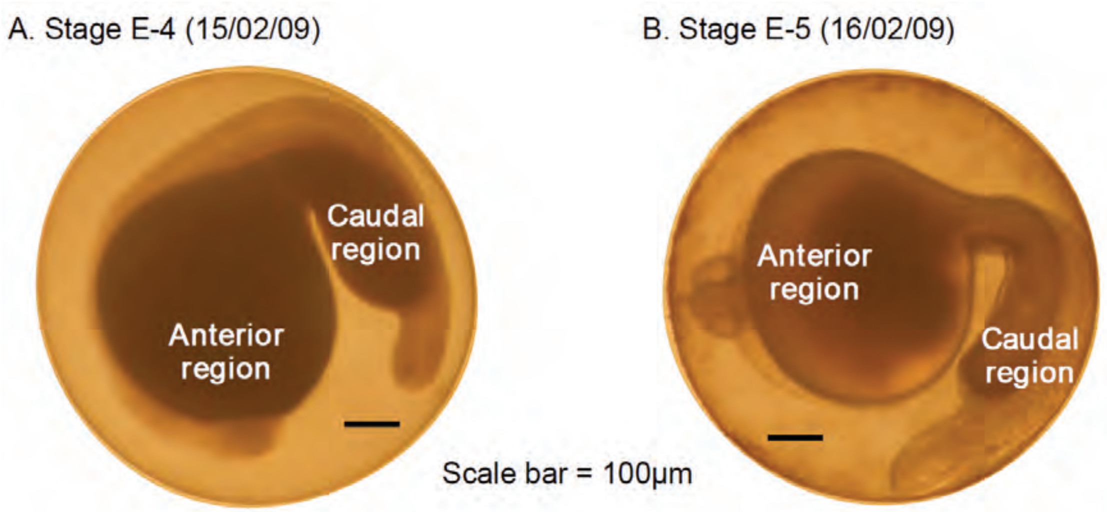

Figure 18: Photographs of two of the five embryonic development steps (A and B) for Orange-Vaal Largemouth yellowfish (*Labeobarbus kimberleyensis*) obtained in the study.

Similarly to the approach adopted in the assessment of the Smallmouth yellowfish larval development the Largemouth yellowfish larval development has been divided into five developmental stages. Approximately 6% of the embryos hatched by 08h45 on the 18 February 2009 five days after fertilisation. Newly hatched embryos had yolk sacs and were moving occasionally by wriggling. Generally newly hatched embryos were able to move a few centimetres off bottom surface, but mostly remained on the bottom of the aquarium. The newly hatched embryos were transparent, and were difficult to detect. Finfolds were not visible after hatching, however circulation of straw-coloured blood was evident. The heart was pulsing and pumping blood through main vessels around the body. Otoliths are clearly visible at this stage (Figure 19A).

Surprisingly, a mass die off of developing Largemouth yellowfish larvae occurred five days after fertilisation at the initiation of the larvae development phase (18/02/2009). This observation may indicate that the developing larvae are extremely sensitive during this phase of development. On the same day (18/02/2009), approximately 40% of the remaining embryos had hatched by 20h45.

The time scale from fertilisation to the end of the larva period when the first larvae became juveniles lasted up to 4 weeks (28-35 days). Similarly to the Smallmouth development, the developmental periods may inadvertently have been extended due to reduced water temperature for example. The embryos were separated to in response to the project objectives. In addition some discrepancies in the development period may have occurred due the inclusion of a second batch of developing larvae that has been initially raised at the Zebra Research Aquaria in Randfontein (Pers. comm.: S. v.d. Walt[2]) where the feeding regime included three daily feedings compared to the two daily feeds that were carried out in Grahamstown.

The larval period in Largemouth yellowfish can be distinguished by several developmental milestones. These steps include the onset of exogenous feeding, and functionality of the digestive system, onset of respiration, gill functionality, inflation of swimbladder, formation of rays and articulation of the fins and free swimming. The larval developmental period has been divided into five developmental stages including a free embryo stage, and four larval stages including; a young larval stage (L1), an intermediate larval stage (L2) an older larval stage (L3) and a young juvenile stage (L4). The larval development phase is completed with the larvae becoming juveniles. An overview of the larval development stages for the Smallmouth yellowfish obtained in this study includes:

Free embryo stage: This phase commenced with hatching and terminated with the onset of exogenous feeding. Hatching occurred from day 4 to 6 days after activation (96hrs to 144hrs) on the 17 to 19 February 2009. Post hatched embryos retained a large amount of yolk reserves. Typically the yolk reserve lasted for a further 2-3 days. During this period several developmental milestones were also evident including: cephalisation, oral region, lens and choroid areas, heart and circulation extent, otoliths, the notochord, myomere and the anal pore development. The body changed from translucent to varying degree of opaqueness, as the tissues and organs developed. Onset

[2] Mr. Stephan van der Walt. Senior technician. Zebra Research Aquaria. Randfontein.

of melanophores and pigmentation marking were observed along the dorsal and mid ventral line. Fin ray and cartilage formations were also noted at this stage. By day 6 (19/02/2009) most of the embryos had hatched. Newly hatched larvae were approximately 7.0-8.3 mm total length. Newly hatched larvae were able to move by flicking the caudal region. The movement appeared as short pulses or wriggles, along the bottom of the aquarium. Outer edges of the eye and lens were beginning to pigment, lens appear to be well formed, otoliths are clearly visible through the transparent head region, and its positioned behind the cephalic lobe. Only the largest pair of otoliths, the saggitae are visible (Figure 19 B to D). By day 7 (20/02/2009) the larvae are very active and sustained wriggling actions and short bursts of activity. At this stage larvae became negatively phototaxic and responded to light by finding cover and moving away from the light source. Larvae remained mostly on the bottom of the aquarium and were transparent and not easily visible. At this stage larvae congregated in large masses. The 3-4 gill membranes are visible and operculum flap is distinguishable. Pectoral fin flap is evident just above the yolk sac (Figure 19C). After hatching, free embryos generally displayed a range of swimming capabilities. The earliest embryos to hatch were only able to perform sudden bursts of activity and appeared to be able to swim a few centimetres from the bottom before sinking again, exerting effort to wriggle up and then passively drift down to the bottom substrate. Embryos that hatched later, however, were able to perform more sustained swimming and were soon able to swim to the surface. Upon hatching, the embryos were with the head bent down over the yolk and only very lightly pigmented. The pigmentation initially started along the dorsal region, then the head and later along the swim bladder. During this step various developmental processes were taking place, including the jaw and gill structures, the gradual straightening of the head and the formation of the chambers of the swim bladder, fin fold transition to fin rays (Figure 19 E and F).

Larval stage L1: Young larvae phase 1. The onset of L1 included the onset of exogenous feeding, switch to purely exogenous nutrition and the onset of flexion of the urostyle, head position, and body transparency. Large mouth yellowfish typically started exogenous feeding within 2-4 days after the free embryo stage. There is a range of variation in the onset of exogenous feeding which corresponds to the hatch time, and to the level of activity the free embryos underwent. Several late hatched embryos were stronger and more active with a shorter period leading to exogenous feeding, and time and may have started the exogenous feeding within 24 hrs of hatching. The responses may have been triggered by the availability of food (*Artemia nauplii*). The ability of L1 larvae to open their mouths corresponded with the ability to swim to the surface and begin gulping air to inflate the anterior chamber of the swimbladder. This consequently resulted in the ingestion of 'air' and the mouth becoming functional. The opening of the mouth also coincided with the onset of branchial respiration and the functionality of the gills. At the beginning of L1, larvae still had a large pear-shaped yolk sac and the mouth remained in a sub-terminal position. A few days later (5-6 days) post hatching, the head was straight and the body took on a pale opaque and yellow colouration. Melanophores also became evident on the head, heart region and the ventro-visceral and medio-ventral lines with faint dashes of pigment just becoming evident on the lateral line (Figure 20A). As this step progressed, these pigments became more obvious. By day 9-11, the mouths had migrated into terminal positions and *Artemia nauplii* were first found in the gut. At this stage, only a small amount of yolk reserves remained to be absorbed (Figure 20B).

Larval stage L2. Young larvae phase 2. The switch to purely exogenous feeding and beginning of flexion of the urostyle initials the start of this step. In the artificially reared largemouth embryos this step was recorded on the 11-14 days after fertilisation. This step proceeded until the onset of inflation of the anterior chamber of the swimbladder. Also evident during this step are the formations of the rays on the posterior urostyle within the caudal finfold, improved articulation and strengthening of the pectoral finfold, melanophores on the head, lips and opercula at the beginning of this step was observed. Pigments also became apparent above the notochord and internal pigmentation on the swim bladder. After 16 days the first signs of differentiation of the dorsal finfold were apparent and later on, starting to form the dorsal and anal fins (Figure 20 B, C and D). The onset of this step also corresponded with a clear shift in behaviour. While the remaining L1 larvae were still swimming at the surface, L2 larvae were forming a shoal between 5 and 10 cm from the bottom of the tank and responding to food particles, light and avoiding capture by net. The larvae were 9.7 mm in length (Figure 20E).

Larval stage L3: Intermediate larva stage. The anterior chamber of the swimbladder was inflated by day 16-20, signifying the beginning of larva step L3. The end of this step is indicated by the separation of dorsal finfold to the dorsal fin. By day 22, flexion was complete and the caudal fin was forked and almost fully developed. By now pigment was well developed both above and below the notochord and rudiments of the pelvic fins were first evident. During this step the mouth began to migrate towards the sub terminal position. Exogenous feed only, digestive system becomes fully functional (Figure 20 F, G and H).

Larval stage L4: Older larval stage. Separation of the dorsal finfold from the extended finfold becomes evident by day 23-28, and marks the beginning of larva step L4. At this stage all individuals have pelvic buds present, and rays were forming in the pectoral fins. At the end of this stage all fins except for the pelvic fins were fully formed and only a small amount of pelvic finfold remained. The mouth was almost in the final, sub terminal position. Scales become evident just below the lateral line (Figure 20H and Figure 21 A to E).

Larval stage L5: Young juvenile. Complete disappearance of the finfold, completion of fin formation indicating the beginning of larva step L5. Mouth has reached its final, sub terminal to inferior position. Scales, formation continues and is evident below the lateral line. Scales are initially transparent, picking up pigmentation as they develop. This step was first evident by day 25-30. (Figure 21 F, G and H).

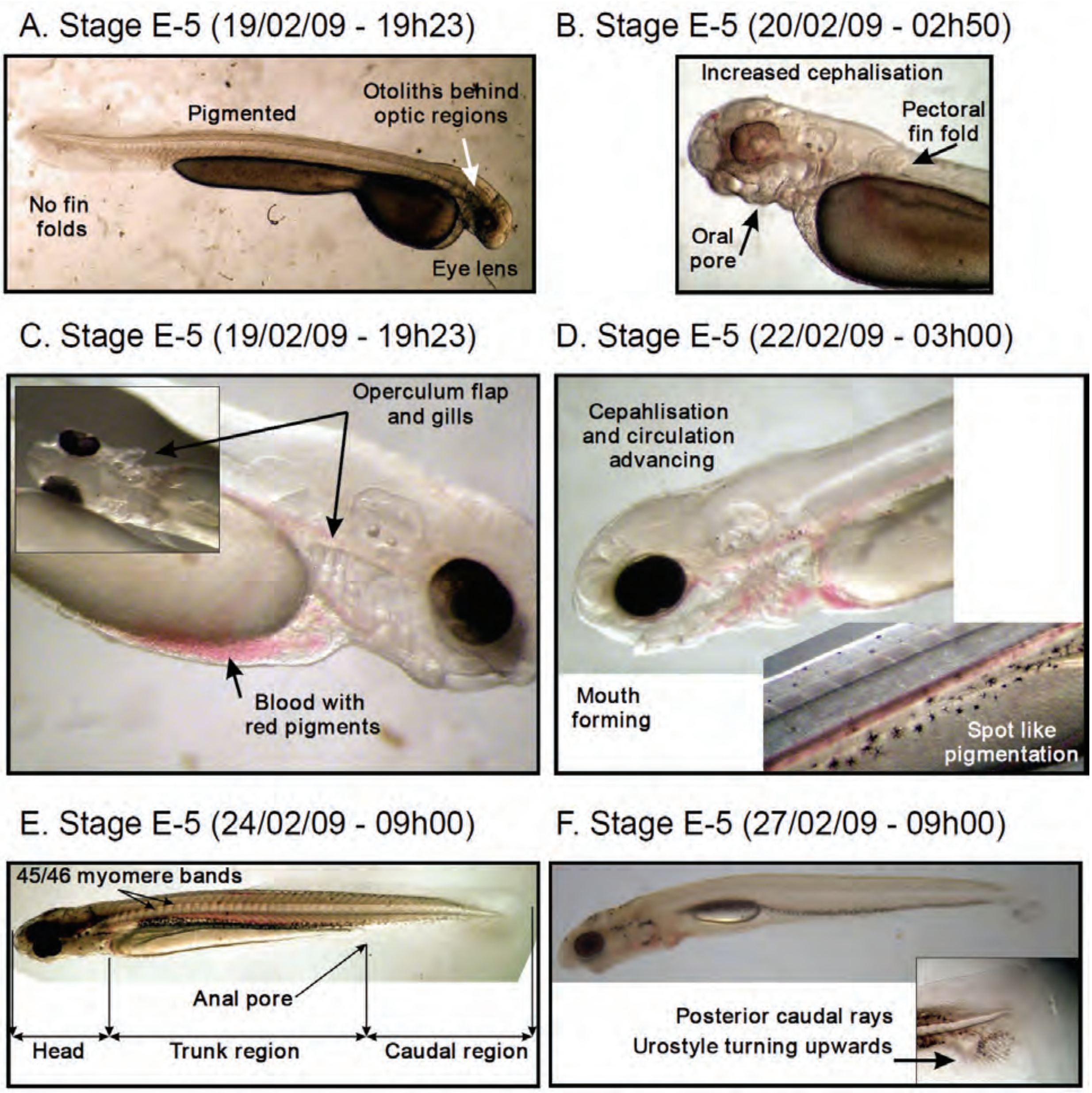

Figure 19: Photographs of the free embryo stage of developing Orange-Vaal Largemouth yellowfish (*Labeobarbus kimberleyensis*) obtained in the study.

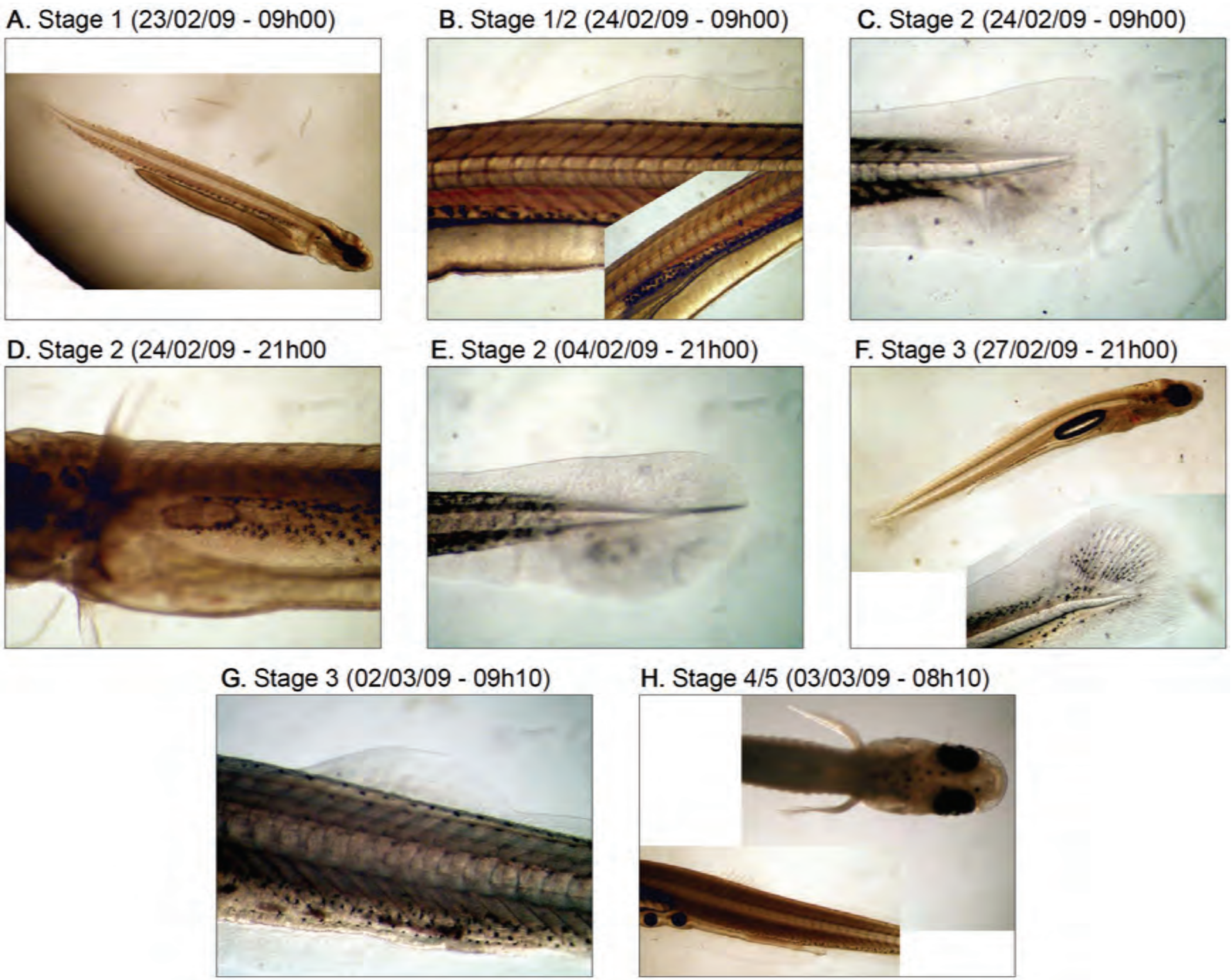

Figure 20: Photographs of the larval development stages L1 to L5 (A to H) of Orange-Vaal Largemouth yellowfish (*Labeobarbus kimberleyensis*) obtained in the study.

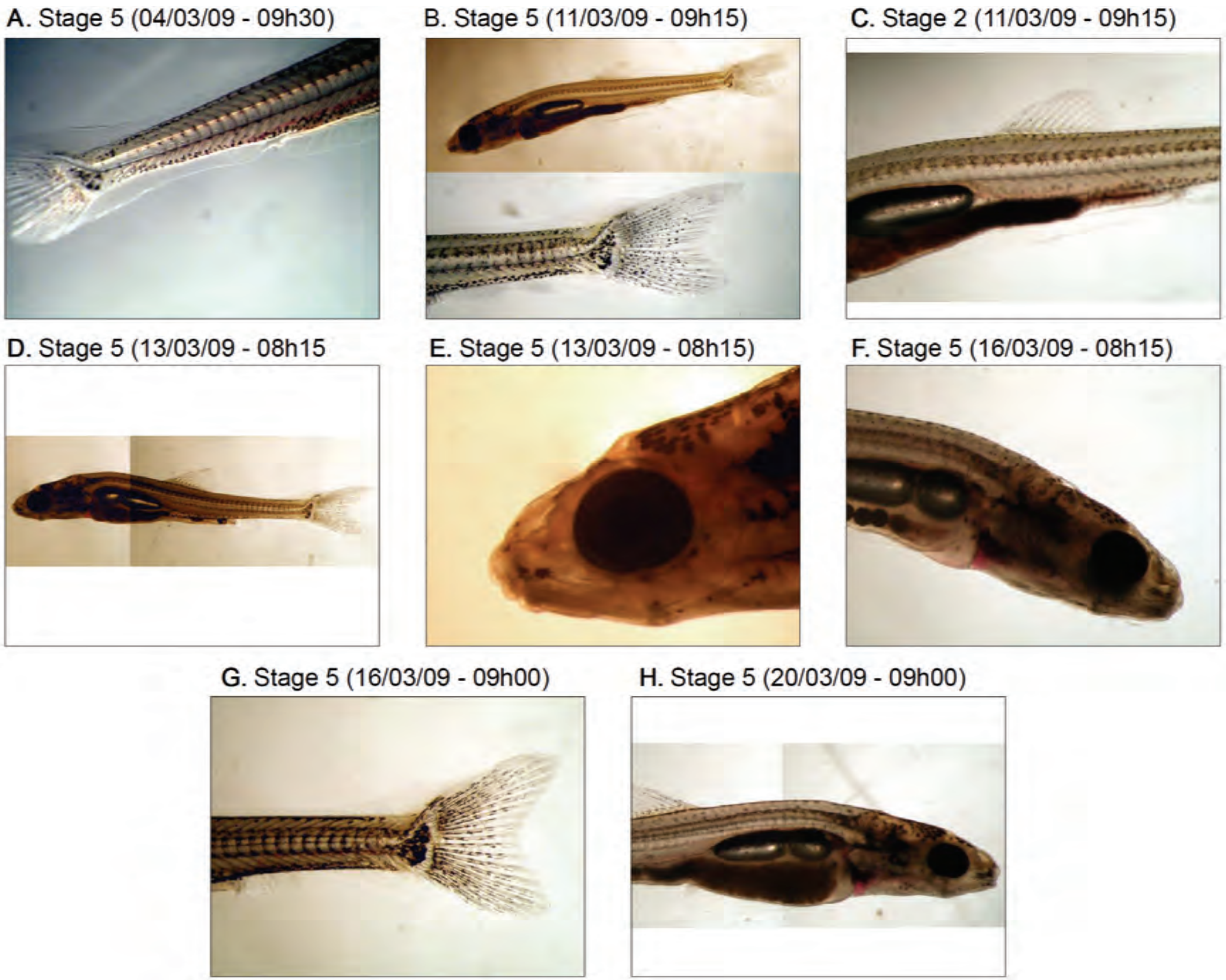

Figure 21: Photographs of the larval development stage L5 (A to H) of Orange-Vaal Largemouth yellowfish (*Labeobarbus kimberleyensis*) obtained in the study.

For the Largemouth yellowfish the juvenile period was reached when fully scaled fish, with fully formed lateral lines were observed in mid to late January (Figure 22). The transition from larvae to young juvenile is completed with the disappearance of the fin fold and the ray formations in the fins. The scale development is completed when there is full coverage over the body. Juveniles are not quite silvery, but rather well pigmented, the body is pale yellow and opaque with no transparent areas.

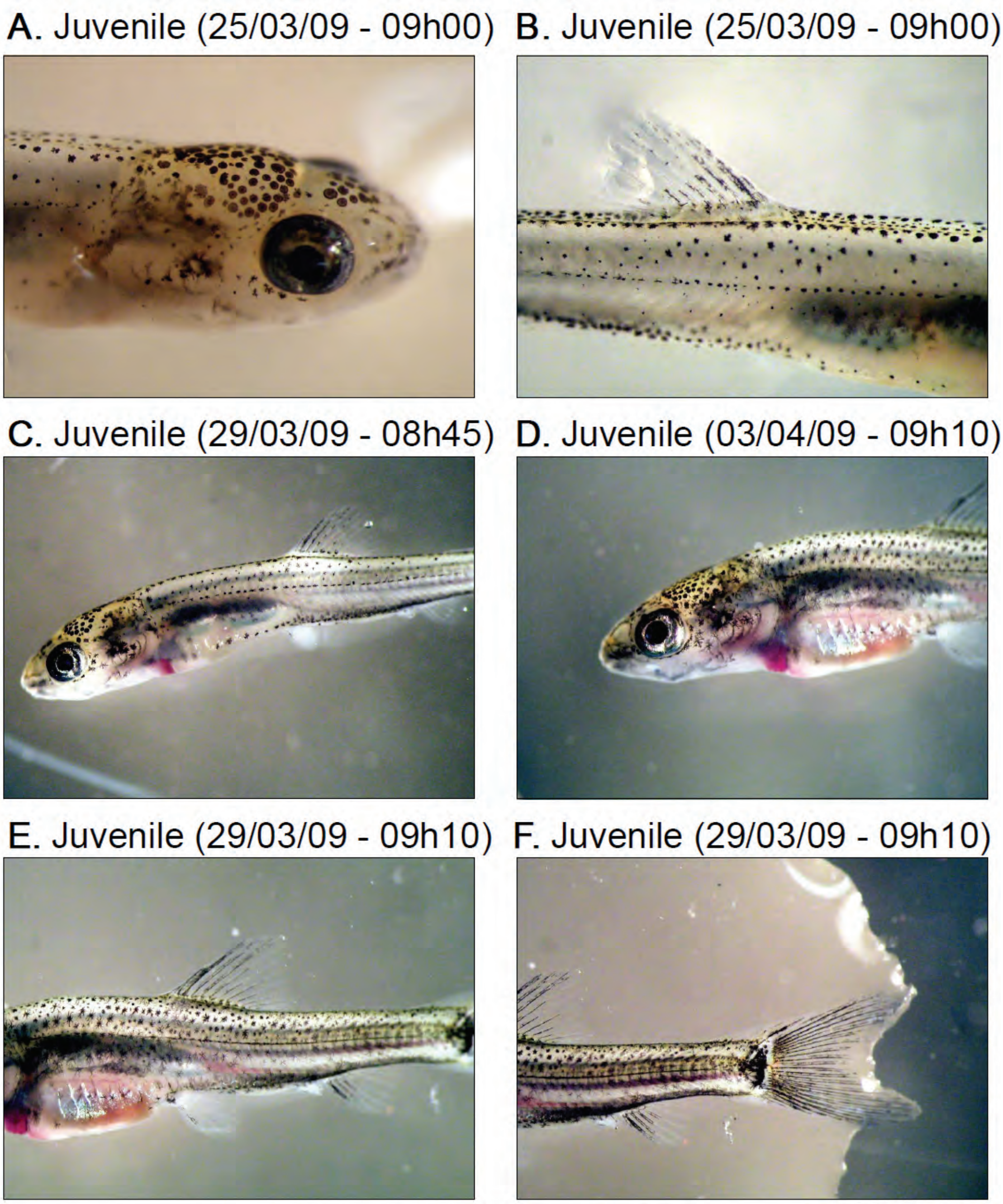

Figure 22: Photographs of the juvenile Orange-Vaal Largemouth yellowfish (*Labeobarbus kimberleyensis*) obtained in the study.

4.4.4. Conclusions

The ova of both Vaal River yellowfishes ova are relatively large, spherical, pale yellow and are negatively buoyant. They are slightly adhesive until the initial embryonic development stages are reached during which time they lose their adhesiveness. This occurs within a few hours of fertilisation and is considered to facilitate with the protection and initial stabilisation of the embryo in preparation of development (De Moor & Bruton 1988). Once the adhesiveness of the egg is lost the negatively buoyant eggs settle into crevices within cobbles and gravel in the natural environment where further development takes place. During this period, up until at least five days after fertilisation the developing embryos of the Largemouth yellowfish in particular seem to be extremely sensitive to abnormal environmental conditions that may include sudden changes in water physico-chemical conditions. The free embryos of both yellowfish have relatively small yolk sacs and as a result developing steps are short and the developing yellowfish need to find food rapidly. Findings of this study support assessments that the spawning period of Smallmouth yellowfish is in spring, and should occur within areas that are rich in plankton.

Under laboratory conditions, newly hatched larvae remained at the bottom of the aquarium suggesting that a similar behaviour would be adopted in the environment. Newly hatched larvae were sensitive to flow and displayed short periods of activity, by wriggling around the bottom of the tank. This suggests that larvae that would be caught in the current would be negatively impacted on and that by remaining close to the substrate developing larvae may be able to avoid turbulent flows. This activity was observed soon after hatching and emergence of the larvae. A rudimentary pectoral fin fold is detected from the fifth (E5) embryonic development stage. Appearance of certain organs and structures such as eyes, pectoral and dorsal-anal finfolds, and the notochord may enable the embryos to avoid predators from an early stage. Larvae developed photophobia by hiding under the mesh net in the aquaria. In the wild, free embryos have been found lodged in gravel beds (Cambray et al., 1997). This behaviour may again facilitate larvae from entering unfavourable habitats and or allow larvae to avoid predators. The development of dark spot like pigments by the larvae of both yellowfishes and the darkening of juveniles from transparent to opaque prior to the initiation of feeding may facilitate defence against predation.

The embryo to larval transition of yellowfish is marked by the onset of exogenous feeding and followed by the development of melanophore pigments, finfold transition to fully functional fins with rays. Larval to young juvenile stage is followed when all of the fins are completely developed. This process is also marked by increased activity as the fish are able to manoeuvre themselves. Under experimental conditions, this stage was marked by low mortalities but is considered to be a vulnerable life cycle stage of wild fish in the natural environment. A few days after hatching, larvae ascend to the surface and exhibit longer period of swimming activity. Some were seen gulping air in order to fill their swim bladders. Once the swimbladders become functional larvae were capable of free swimming. By day 3-5 yolk sacs were fully absorbed and most larvae established exogenous feeding. In the natural environment this action is proposed to result in the migration of larvae from spawned areas into slow flowing, protected habitats where larvae can initiate feeding.

Although not specifically addressed in this study the characterisation of the early development of both yellowfish species was able to allow for the identification of species unique morphological features that should be validated with field studies. These features included the relative size and location of the mouth of the yellowfish larvae, the snout length and the position of the eye in relation to the head in young juvenile yellowfish. These features are consistent with those that are used to differentiate adult Vaal River yellowfish.

5. AGE VALIDATION

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5.1. INTRODUCTION

Hypolimnetic releases from dams have been found to the affect spawning of both *L. kimberleyensis* and *L. aeneus*. Allanson and Jackson (1983) reported that *L. kimberleyensis* require higher temperatures for spawning and therefore spawned four to six weeks later than *L. aeneus* in the Orange River and hypolimentic releases from the Gariep Dam during summer have been reported to have resulted in late spawning and a weakened year-class among both species (Tómasson et al. 1984). Subsequent to these studies which were conducted in the 1980s, no further studies into the reproductive requirements of these species have been undertaken.

Assessing the effects of flow and temperature regimes on the recruitment of the yellowfishes in the Vaal River, requires a more detailed understanding of their life history and ecological requirements – most critically, information on their reproductive biology and early development. Between 1966 and 1984 a considerable amount of work was undertaken in an attempt to characterise the reproductive biology. However the bulk of the reproduction related findings are widely criticised today (Jubb 1967, Mulder 1973, Allanson and Jackson 1983, Tómasson et al. 1984, Laurenson et al. 1989). Between 1999 to 2004 the Free State Nature Conservation departmental fish hatchery located at Gariep Dam successfully developed the methodologies to artificially condition and spawn both species of yellowfishes from the Orange-Vaal River system in captivity (De Villiers and Ellender 2008). Although the methodologies for the artificial propagation of both of the yellowfishes have been developed and applied from 1999 to 2004 no formal methodologies are available.

In order to investigate the effect of river flow and temperature on the recruitment of the two species, the development of a formal artificial propagation method is required. Once the artificial propagation methodologies are available, individuals of both yellowfishes can be obtained to characterise aspects of their life history and biology – in particular their early development and growth. This information can then be used to examine of the timing, frequency and duration of spawning of wild fish in the Vaal River.

Counts of daily increments deposited on the otoliths of 0-age fish provide an effective means of investigating the timing, frequency and duration of spawning in relation to environmental variability in river systems (Graham and Orth 1986, Wilson and Smith 2002, Humphries 2005, Koehn and Harrington 2006). These techniques have been successfully applied in South Africa to investigate the optimal flow and temperature requirements for spawning by indigenous cyprinids in the Western Cape (Paxton and King 2009).

Aging adult fish by means of enumerating annual growth increments laid down in their otoliths is a commonly employed method for establishing age-length relationships for fish species and providing information on their growth, maturity and mortality (Booth et al. 1995, Newman et al. 2000, Campana and Thorrold 2001, Winker et al. 2010a). Annual rings in adult fish otoliths (annuli) are deposited as alternating opaque and translucent bands that result from the differential deposition of calcium carbonate and a protein (otolin). Opportunities for investigating the growth rates of much younger fish first became apparent when Panella (1971) revealed that larval and juvenile fish laid down increments on a regular daily cycle visible at magnification under a light microscope as concentric translucent and opaque bands in the otoliths of age 0+ fish. Since then, the presence of daily increments has been verified in numerous fish species and the technique has been developed for *inter alia*: estimating the spawning, hatch and settlement dates (Pitcher 1988, Fowler 1989, Durham and Wilde 2005) and for investigating the effect of food (Campana 1983) and environmental variability on age 0+ fish growth (Houde 1989, Bestgen and Bundy 1998).

In South Africa, the use annuli on scales, otoliths or pectoral spines to age adult fish in South Africa's inland water ecosystems has received some attention (van Rensburg 1966, Straub 1971, Quick and Bruton 1984, Winker et al. 2010a, Winker et al. 2010b), as has their early growth and development (Cambray 1983, Cambray and Meyer 1988, Cambray 1990, Cambray et al. 1997). However, few studies have explored the potential for daily growth increments in otoliths of young fish to reveal aspects of their ecology (but see Paxton and King 2009). This oversight is noteworthy considering that larval fish are acutely susceptible to environmental perturbations and that early life history processes play a central role in determining recruitment success (Pitcher and Hart 1982, Welcomme 1985, Houde 1987, Cushing 1990, Fairweather 1991, Myers 1998, Britton et al. 2004, Houde 2009, Galindo-Cortes et al. 2010). Elucidating the early growth and development of native freshwater fish species in South Africa is therefore considered to be a valuable tool and essential step for investigating the role that river regulation plays in freshwater fish recruitment. Such knowledge will enhance management efforts designed to restore wild populations where they have been impacted by such changes.

Prior to estimating the ages of wild fish populations, however, validation experiments are required to ensure the accuracy of age estimates. This is particularly important for larval fish where daily and sub-daily rings can be easily confused. Studies have shown that a major source of error in age estimation can be attributed to incorrectly assigning a frequency to the rate of increment deposition (Beamish and McFarlane 1983, Geffen 1992, Campana 2001) – although recent opinions have swayed toward a more strategic approach in instances where time and resources are limited (Choat et al. 2009). However, where a taxonomic group has not been studied before, validation should be considered prudent. For species that cannot be reared in a laboratory, validation can be achieved by marking the otoliths of wild fish with chemicals such as oxytretacycline hydrochloride (e.g. Lang and Buxton 1993). However, rearing known-age captive-bred larvae under conditions similar to those they would experience in the wild has considerable advantages including the ability to ascertain age-at-first increment deposition (Miller and Storck 1982, Jones and Brothers 1987).

As a prelude to investigating the timing of spawning, hatching and the age and growth of wild populations of *L. kimberleyensis* and *L. aeneus* in relation to temperature and flow conditions in the wild therefore, this component of the study aimed to rear known-age larvae of both species under hatchery conditions in order to ascertain the age-at-first increment deposition and validate the rate of increment deposition in the larval and early juveniles of both species.

5.2. MATERIALS AND METHODS

Eggs and milt were collected from one pair of adult ripe-and-running *L.aeneus* and one pair of *L. kimberleyensis* on 7 December 2008 and 14 February 2009 respectively taken from the Lake Gariep State Hatchery (30°37'23.32"S; 25°30'22.36"E) on the Orange River, South Africa. The eggs and milt of both species were artificially mixed and fertilisation was activated by adding river water. Thirty-six hours after activation, the fertilised embryos were transferred to glass aquaria at the Department of Ichtyology and Fisheries Sciences (DIFS), Rhodes University, Grahamstown where they were incubated on plastic mesh hatching trays. During the five hour journey from Lake Gariep, the temperature of the water dropped 15ºC, but for the course of the experiment, water temperatures varied between 17 and 20ºC. After hatching, larvae were fed newly hatched brine shrimp (*Artemia salina nauptilii*) in excess quantities twice a day. The excess brine shrimp were removed after each feed using a thin (5 mm) siphoning tube. Older larvae and juveniles were later weaned onto a diet of fish flakes and blood worms (chironomid larvae).

A total of 53 *L. kimberleyensis* larvae and 51 *L.aeneus* larvae were collected over a period of seven months from the dates of fertilisation to the 9 July 2009. Total Lengths (L_T) were measured to the nearest millimetre using a Wild Heerbrugg stereomicroscope. Samples kept for taxonomic purposes were fixed in 4 % buffered formalin and samples kept for aging were fixed in 99 % buffered ethanol. Selected sub-samples of embryos, larvae and early stage juveniles were collected as voucher specimens for deposition at the South African Institute of Aquatic Biodiversity (SAIAB) (Registration number 2009/277).

Both left and right lapillae and sagittae were extracted from the vestibular apparatus of the fish either by dissection or with the aid of a lysing agent (diluted sodium hydroxide). Once the non calcareous tissue was lysed, the otolith was rinsed in distilled water and mounted on a glass slide. Otoliths were then fixed to the slide with thermoplastic cement (Crystalbond 509®, SPI Supplies, West Chester, USA). Early investigations suggested that the lapilli were more suitable for aging since the growth increments weren't found to be more easily readable than on either the sagittae, or asterisci.

Once removed from the fish, the lapilli were examined under transmitted visible light at 100-400 × magnification by means of a Nikon compound microscope fitted with a polarizing filter. In most instances the lapilli of early stage larval fish (up to 10 days old) only required optical sectioning, i.e. focusing to the plane of maximum clarity (Brothers et al. 1976). In instances where the otoliths of older juveniles required sectioning, the otoliths were polished along the transverse plane to the primordium using 15 µm and 1 µm lapping film (3M™). Two blind counts by different counters were made and a third count was made if there was a large discrepancy between the first and second counts. Both left and right lapilli in each individual fish were removed for counting and the mean estimated age from the two otoliths were used in subsequent analyses.

The estimated age of each fish was then compared to its known post-hatch age. To test the correspondence between known age post-fertilisation and estimated age (increment counts), the SPSS © statistical programme was employed to fit a linear regression model of the form:

$$Y = ß_0 X + ß_1$$

Where Y refers to the known age post-fertilisation (days) and X the age estimated from increment counts. Tables of raw data used in this assessment are presented in Appendix 2 to Appendix 8.

5.3. RESULTS AND DISCUSSION

5.3.1. Larval development and hatching

Artificial spawning of *L. aeneus* and *L. kimberleyensis* commenced on the 7 Dec 2008 and 14 February 2009 respectively at Gariep Dam Hatchery and yielded viable eggs and sperm. *L. aeneus* eggs were activated at 00h32 on the 7 Dec 2008 and commenced hatching on the morning of the 10 December at between 09h00-10h00, roughly 80 hours after fertilisation. The majority (80%) of the embryos hatched on the 12 December around 15h00-16h00 (~130 hours post-fertilisation). *L. kimberleyensis* eggs were activated at approximately 08h00 on the 14 February 2009 and started hatching on the 18 February at 14h20, 96 hours post-fertilisation. The majority of the embryos hatched out on the 20 February 09h10 (~160 hours post-fertilisation). Otoliths were clearly visible in the otic capsule of yellowfish embryos (48 hours post fertilization) as well as in post-hatched larvae (Figure 23).

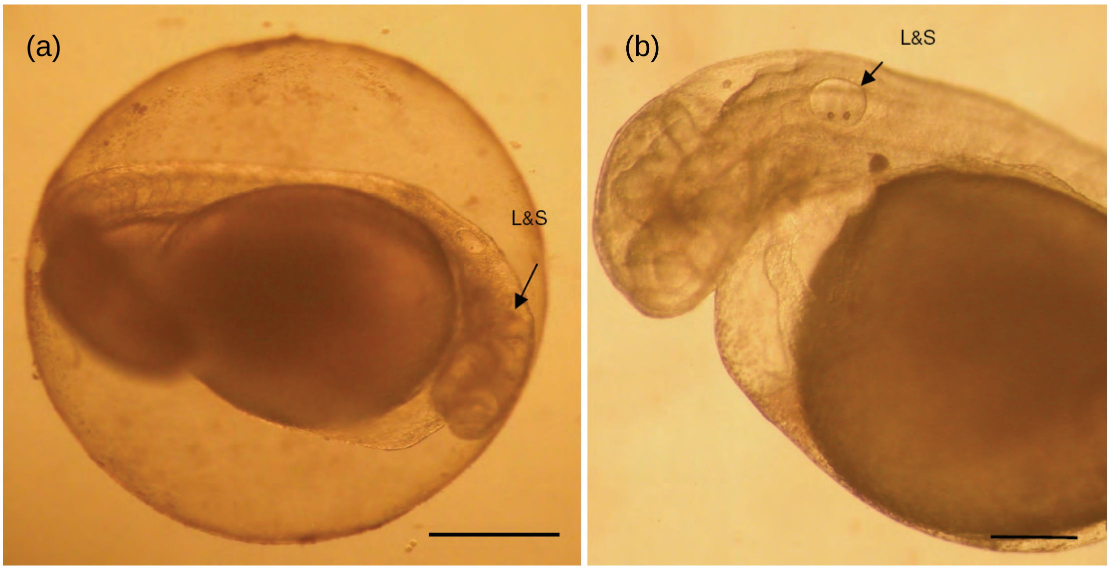

Figure 23: *L. kimberleyensis* embryos at (a) 08h00 17 February 2009 (72 hours post-fertilisation) and (b) newly hatched larvae at 16h30 18 February 2009 (92 hours post-fertilisation). The position of the sagitus (posterior) and lapillus (anterior) in the otic capsule is indicated (Scale bar = 100 μm).

During the embryo and post hatching stage it was possible to differentiate the saggitae and lapilli through their positioning – lapilli were anteriorly and dorsally situated, where as saggitae were posterior were ventral. As the larvae ages, the sagitta become circular and develop convex-concave cross-sections and the lapillus increasingly become ovoid. The primordium was visible at centre of each otolith as an opaque area (Figure 24).

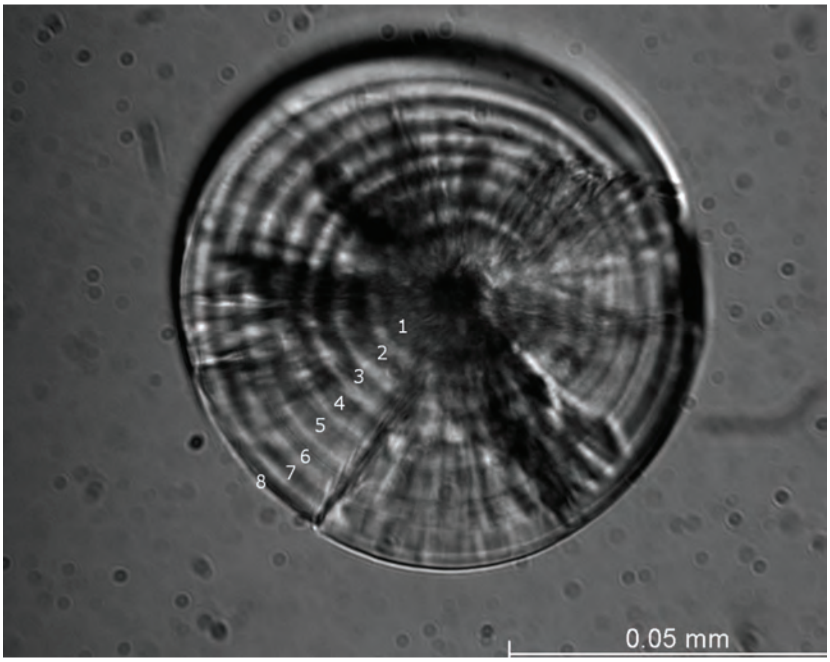

Figure 24: Micrograph of hatchery-reared *L. kimberleyensis* larvae sagittal otolith, eight days post-fertilisation. The alternating opaque and hyaline bands are clearly visible as originating from the primordium (Scale bar = 0.05 mm).

5.3.2. Age validation

Ages based on daily growth increment counts were estimated for a total of 52 *L. aeneus* and 42 *L. kimberleyensis* otoliths. Daily increments of hatchery-reared larval and juvenile 0+ *L. kimberleyensis* and *L. aeneus* were clearly resolvable beneath compound light microscope as alternating opaque and hyaline bands for larvae of up to 100 days old (Plate 2). Thereafter, banding became too closely spaced to be resolvable under the LM and counts of increments from larvae > 100 days old were therefore excluded from the analysis. In most instances, i.e. with larvae exceeding 10 days in age, larval otoliths could not be read whole and needed to be sectioned to the primordium using lapping film.

The relationship between known post-hatch age and the age estimate based on increment counts is shown in Figure 1 for *L. kimberleyensis* and Figure 2 for *L. aeneus*. Data were available for 31 *L. aeneus* larvae aged one to 95 days old. The regression model explained 98 % of the variability in estimated age from increment counts (df = 29; P <0.001) (Figure 25, Table 4). The slope of the regression was 0.85 and significantly different from zero (95 % CI: 0.78-0.92). This was not significantly different from 1.00 as would be expected if estimated and actual ages were to yield identical ages.

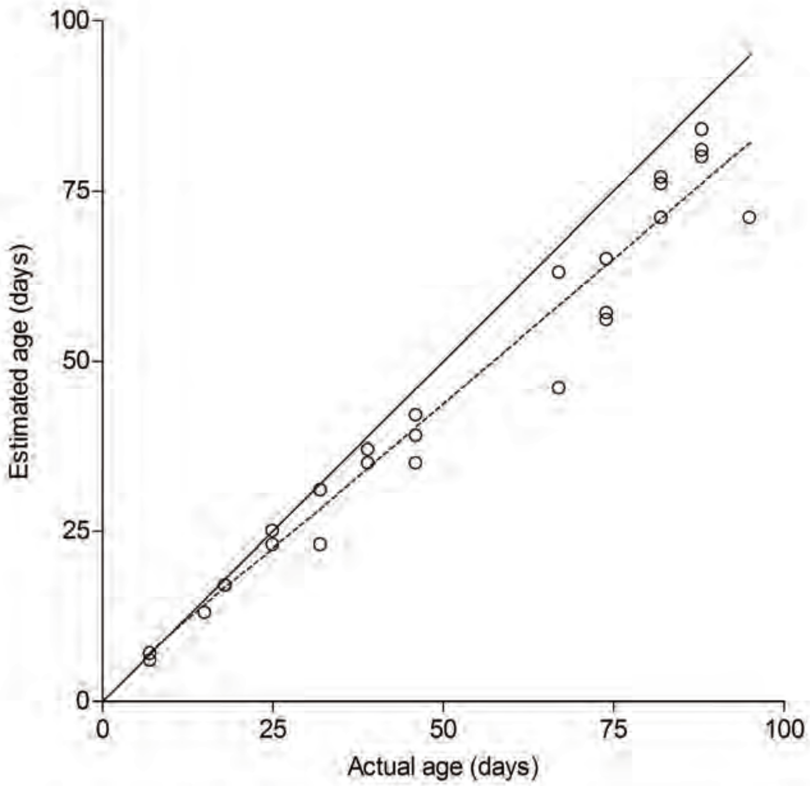

Figure 25: Regression of known age laboratory-reared *L. aeneus* larvae (<100 day-old against increment counts (broken line). The regression line is described by the equation: known age post-fertilisation (days) = 0.854 [increment count] + 1.049 (r^2 = 0.98, n = 31).

Data were available for 33 *L. kimberleyensis* larvae aged one to 95 days old. The regression model explained 94 % of the variability in estimated age from increment counts (df = 31; P <0.001) (Figure 26, Table 4). The slope of the regression was 0.75 and significantly different from zero (95 % CI, 0.68-0.82). As with *L. aeneus*, this was not significantly different from 1.00 as would be expected if estimated and actual ages were to yield identical ages.

Table 4: Parameter estimates from the linear regression analysis of actual age against ages estimated from increment counts for *L. aeneus* and *L. kimberleyensis* reared under hatchery conditions.

Species	N	$ß_0$	$(ß_0)$	$ß_1$	$(ß_1)$	R^2	P
L. aeneus	31	1.05	1.83	0.85	1.83	0.96	<0.001
L. kimberleyensis	33	3.49	1.87	0.75	0.04	0.94	<0.001

The precision of the age estimates for both species, but particularly for *L. kimberleyensis* were not as good for older fish as they were for younger fish, with differences in the former being up to 30 days. This is believed to be attributable to two factors; firstly, overall growth rates in aquaria would not have been as high as they would have been in the wild and growth increments were therefore closely spaced and difficult to differentiate under an LM. Secondly, both species were reared indoors under hatchery conditions and diel temperature variations would have been considerably moderated compared with those that would be experienced in the wild. Paxton and King (2009) showed that diel temperature variations had a strong influence on the clarity of increment formation and the increments in instances where diel temperatures were lower increments were difficult to discern.

For both species, the *y*-intercept of the model was not considered a reliable indicator of the onset of increment formation since the increasing uncertainty of aging older fish at the extreme end of the curve has a strong influence on its slope. Growth increments counts of the otoliths of younger larvae, however, suggest that first increment is formed upon hatching.

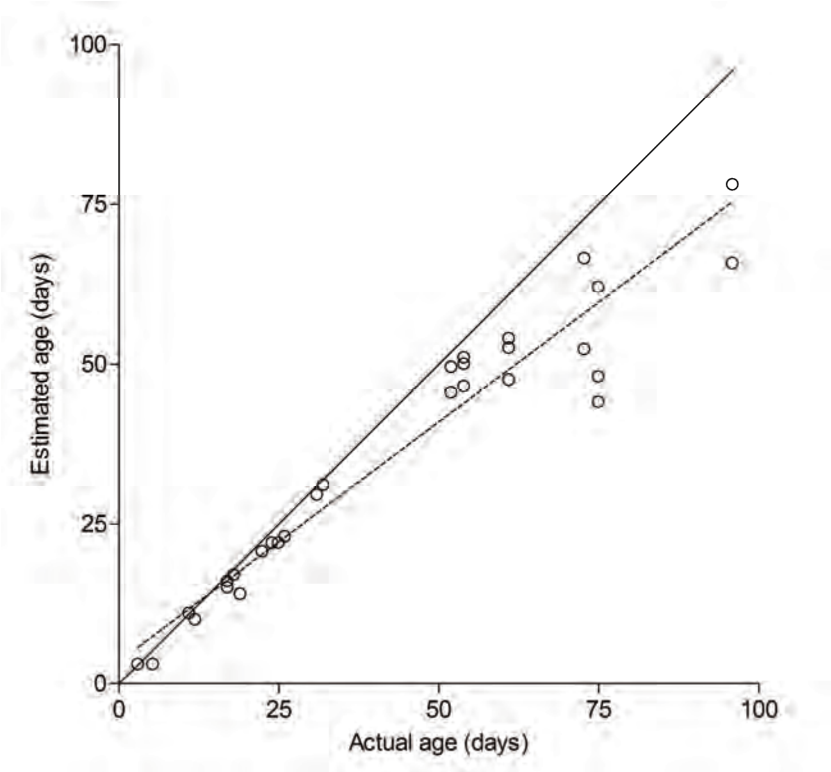

Figure 26: Regression of known age laboratory-reared *L. kimberleyensis* larvae (<100 day-old against increment counts (broken line). The regression line is described by the equation: known age post-fertilisation (days) = 0.75 [increment count] + 3.49 (r^2 = 0.98, n = 33).

5.4. CONCLUSIONS

The results of this study have provided substantive evidence that growth increments in two Vaal River fish species, *L. aeneus* and *L. kimberleyensis*, are laid down in larval otoliths at daily intervals as suggested by Pannella (1971). Despite the poor clarity and differentiation of the rings in older fish (especially > 100 days old), there was found to be a proportional relationship and not significantly different from 1.00 between actual age in both species as determined by spawning and hatching dates and increment counts. It is likely that aging wild caught larvae will be greatly facilitated by the fact that the clarity and differentiation of increments will be higher because optimal feeding and growth conditions, together with greater diel temperature variations will give rise to clearer and more widely-spaced increments.

Much of the thinking that has focussed attention on the importance of the natural flow regime for river fish populations, both in South Africa and elsewhere in the world, has been centred around the contribution that river flow makes to fish recruitment (Cambray et al. 1997, Poff et al. 1997, King et al. 1998, Humphries et al. 1999, Wilson and Smith 2002, Koehn and Harrington 2006). The role that flow plays in the recruitment of *L. aeneus* and *L. kimberleyensis* is not well understood, but there is evidence that both species depend on optimal flow and temperature conditions for successful reproduction. This study is an important preliminary step to aging wild-caught larval *L. aeneus* and *L. kimberleyensis* and elucidating the relationships between flow and recruitment patterns.

6. HOME RANGES, HABITAT USE, MIGRATIONS AND GENERAL BEHAVIOUR

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6.1. INTRODUCTION

The behavioural ecology of freshwater fishes is a relatively young discipline that has already significantly contributed to our understanding of the approaches that fishes adopt to; optimise the utilisation of ecosystem resources, reproduce effectively and survive natural and anthropogenic changes in ecosystem conditions (*sensu* Gross, 1984; Godin, 1997). These studies are generally concerned with the diverse behavioural strategies that freshwater fishes exhibit, which is usually phenotypic in nature and includes; habitat selection, territoriality, foraging and antipredation tactics and reproductive systems including mating systems, competition for mates and growth strategies for example (Godin, 1997). The characterisation and use of these ecological features of the freshwater fishes can contribute greatly towards the conservation and management of aquatic ecosystems and the biodiversity that is dependent on these systems.

Numerous behavioural ecology studies of fishes have been carried out regionally that have contributed towards our understanding of the spatial habitat use of ecosystems by fishes, as well as reproductive strategies, mate choices, territoriality, strategic fighting, diet selection, antipredator adaptations and parental care of species (Barlow, 1993; Godin, 1997). Very little however, of the life cycle behavioural ecology of any southern African freshwater fishes has been documented (Paxton, 2004). The information that is available is largely based on visual observations of species and specialist inferences (Roux, 2006; Venter et al., 2009). Only a very limited amount of dedicated freshwater fish behavioural ecology studies have locally been carried out in southern Africa. Of the studies that have been undertaken the majority been restricted to the Upper Zambezi River system in Namibia (Thorstad et al., 2001; Næsje et al., 2007) and the estuaries of the Eastern Cape in South Africa (Childs et al., 2008; Cowley et al., 2008). This section presents the approach adopted, and the outcomes of the first dedicated behavioural ecology study of the two Vaal River yellowfishes *Labeobarbus kimberleyensis* and *L. aeneus*, from two locations in the Vaal River from 2007 to 2010 using radio telemetry methods.

The use of radio telemetry methods or biotelemetry in fish behavioural studies originated in the early 1970s (Dunn and Gipson, 1977). This approach has opened the proverbial door of behavioural ecology studies of fishes in environments that have historically been too hostile for these types of studies. To date biotelemetry methods are currently the preferred fish behavioural ecology monitoring methods of biologists worldwide (Winter, 1996). Following the initial popularisation of biotelemetry methods for fish behavioural studies, biotelemetry methods have been extensively used throughout the world in a wide range of ecosystems on many species (Dunn and Gipson, 1977; Stasko and Pincock, 1977; Lucan and Baras, 2000).

Biotelemetry studies generally involve the use of small transmitters or tags that are either inserted into the muscle or body cavity, for example, of a fish, or externally attached. The so called tagged individuals are then released and tracked or monitored, usually over an extensive period of time (Dunn and Gipson, 1977; Lucan and Baras, 2000; Paxton 2004). Biotelemetry approaches for fish are generally classified according to the transmitters used, including passive and active transmitters (Prentice et al., 1990; Lucan and Baras, 2000). Passive transmitters or passive integrated transponders are extremely small electronically coded transmitters that are implanted usually intramuscular into fish and read by dedicated transmitters that have to be within close proximity, up to few meters of the tagged fish (Prentice et al., 1990). This approach is relatively cost effective and has been extensively used in mark and recapture studies predominantly as well as in species migration studies (Lucas et al., 1999). Active transmitters or signal propagation, and the detection of battery powered transmitters are transmitters that produce a coded signal usually themselves that can be detected by a dedicated receiver from long ranges including satellite detection in certain cases (Lucan and Baras, 2000). Active transmitter methods include the use of acoustic signal transmitters (usually 30-300 kHz), radio signals including VHF signals (usually 30-170 MHz) or ultra-high UHF signals. Various advantages and disadvantages are associated with the application of the different apparatus including the relative size of the species under investigation and the nature of the ecosystem in which the study is being carried out. The environmental conditions that affect the application of various biotelemetry methods include; variables that affect signal generation and detection. These variables include the depth of the system, the conductivity of the water and geology of the substrate, and the presence of acoustic noise such as the noise generated by riffles and rapids in ecosystems (Lucan and Baras, 2000).

The Vaal River yellowfishes provide users of the system with numerous economic, social and ecological benefits (De Villiers and Ellender 2008a; 2008b; Brand et al., 2009). Socio-economic benefits include the maintenance of a large dedicated angling and subsistence fishery in the Vaal River. Ecological benefits include the use of yellowfish as indicators of the ecological well being of the Vaal River, and as an umbrella species for many aquatic organisms (Ellender, 2008; De Villiers and Ellender, 2008a; 2008b). Finally, the Largemouth yellowfish have locally been listed as a vulnerable species (DEAT, 2007) and internationally as a near threatened species (IUCN, 2010) indicating that the population stability of the species is at risk due to the excessive, unsustainable anthropogenic use of the goods and services of the system (Mulder, 1973; Ellender, 2008; De Villiers and Ellender, 2008a; 2008b for example). In order to address the conservation status of the Largemouth yellowfish, and contribute towards the development of the ecological value of these fishes, more life cycle biology information including the behavioural biology and ecology of these yellowfishes is required. In this study a series of behavioural biology and ecology experiments of the Vaal River yellowfishes were carried out using biotelemetry methods. The aim of the study is to characterise the general behavioural ecology of the Vaal River yellowfishes including the home ranges, habitat use and migration requirements. In order to reach these aims the objectives of the study include:

- Develop suitable biotelemetry behavioural monitoring methods for the yellowfishes at two locations in the Vaal River to meet the aim of the study.
- Capture, tag and monitor a statistically viable number of Largemouth and Smallmouth yellowfishes and monitor the behaviour of these individuals for at least one complete season at each location.
- Monitor the intra- and interspecies differences of tagged yellowfish and relate the movements to known ecology of the system.
- Monitor a range of environmental conditions to enable an assessment of the behavioural ecology of the Vaal River yellowfishes.

6.2. MATERIALS AND METHODS

The materials and methods are based on the aim and established objectives of the study. As this study was the first of its kind in South Africa, a developmental approach was followed resulting in the approaches being adapted during different phases of the study. Figure 27 depicts a flow chart of the methodology followed to carry out the biotelemetry study. Initially the study entailed an assessment of the suitability of the locations selected to carry out the study. This included considerations of the physical characteristics of the location, the availability of yellowfish for the study, the accessibility of the study area to observers and local land use activities. The outcomes of these considerations are presented in the study area review below. Thereafter the study involved the capture, tagging with radio transmitters and release of yellowfish within the study areas for later tracking and observation surveys. The type of radio transmitters and associated equipment as well as the capturing and tagging procedures are presented in the biotelemetry monitoring methods and the yellowfish used sections below.

The monitoring exercise methodologies are presented in Figure 27 and include approaches for the known and unknown general locations where tagged fish occurred. If the general location of tagged fish was known a monitoring exercise on foot, along the bank of the river, or in a boat in the river was carried out. During these surveys fish were either detected and monitored or undetected and searched for on another monitoring survey. If tagged fish were not obtained after numerous surveys, the known location status of the individual was changed to unknown, and an aerial survey was carried out to search for the missing individual. If the general location of the tagged fish was obtained from the aerial survey the new location was listed as the new known location for the individual, which was then surveyed on foot or by boat. If the missing individual was not obtained during an aerial survey, no further dedicated searches were carried out for the individual, however non-dedicated searches were regularly carried out during the searches for other individuals. If a tagged individual was obtained the type of signal being emitted by the transmitter was considered initially, as two types of signals are possible. If a mortality signal was observed from the tag an additional 30 minutes were allowed for the individual to become active again without disturbances during which time the signal would change from a mortality signal to a normal signal. If after 30 minutes no change in the state of the signal were observed, the area was disturbed in an attempt to frighten the tagged individual to test the status of the individual. If no movements or change in the signal state occurred, attempts were then made to recover the rejected tag or dead fish and no further actions were taken to monitor the individual. If the transmitter was emitting a normal signal, indicating that movement had occurred within the last six hours, the location of the individual was determined to within a few meters, using directional Yagi antennae. Once the location of the tagged individual was obtained the location was recorded using a GPS, a geo-referenced map or a geo-referenced spatial imaging system on a hand held GeoExplorer® 3000 Trimble. Thereafter the activity, spatial movement and associated environmental data of the individual were documented (Table 5). These monitoring surveys were carried out randomly or deliberately during dedicated 24 hour surveys, and when the responses of individuals to changes in selected environmental variables were tested. Throughout these surveys comprehensive diaries of anecdotal observations pertaining to the behavioural events of tagged fish were kept by the observers and used to describe the behavioural biology of the species in consideration of historical information and with advice from experts.

Table 5: Spatial movement and habitat data associated with the observed locations and activity of the tagged yellowfish monitored in the study.

Movement (meters in 10 min)	Activity	Substrate	Surface types	Habitat availability	Colour	Weather
Stationery	Holdling	Silt	No flow	Under cut bank or root wads	Clear	Clear
>10 meters	Feeding	Sand	Barely perceptable flow	Dead and or submerged trees	Opaque	Overcast
10-50m	Spawning	Gravel	Smooth and turbulent	Substrate (general - boulders etc)	Light brown	Cloudy
50-100m	Migrating	Cobble	Ripple Surface	Substrate (rocky outcrop)	Dark chocolate	Light rain
>100m	Flee from observer	Boulder	Undular or broken standing waves	Substrate (underwater ridge)	Other - explain	Heavy Rain
	Other - explain	Bedrock	Free falling	Marginal vegetation (reed dominated)		Other - explain
		Other - explain	Chaotic flow	Marginal vegetation (tree dominated)		
			Verticle flow	Marginal vegetation (shrub dominated)		
			Ripple surface (wind driven)	Aquatic Vegetation (filamentous algae)		
			Other - explain	Aquatic Vegetation (other)		
				Emergent vegetation		
				Emergent vegetation (Hycinths)		
				Water coloum		
				Islands		
				Pool - tail out		
				Top of pool		
				Other - explain		

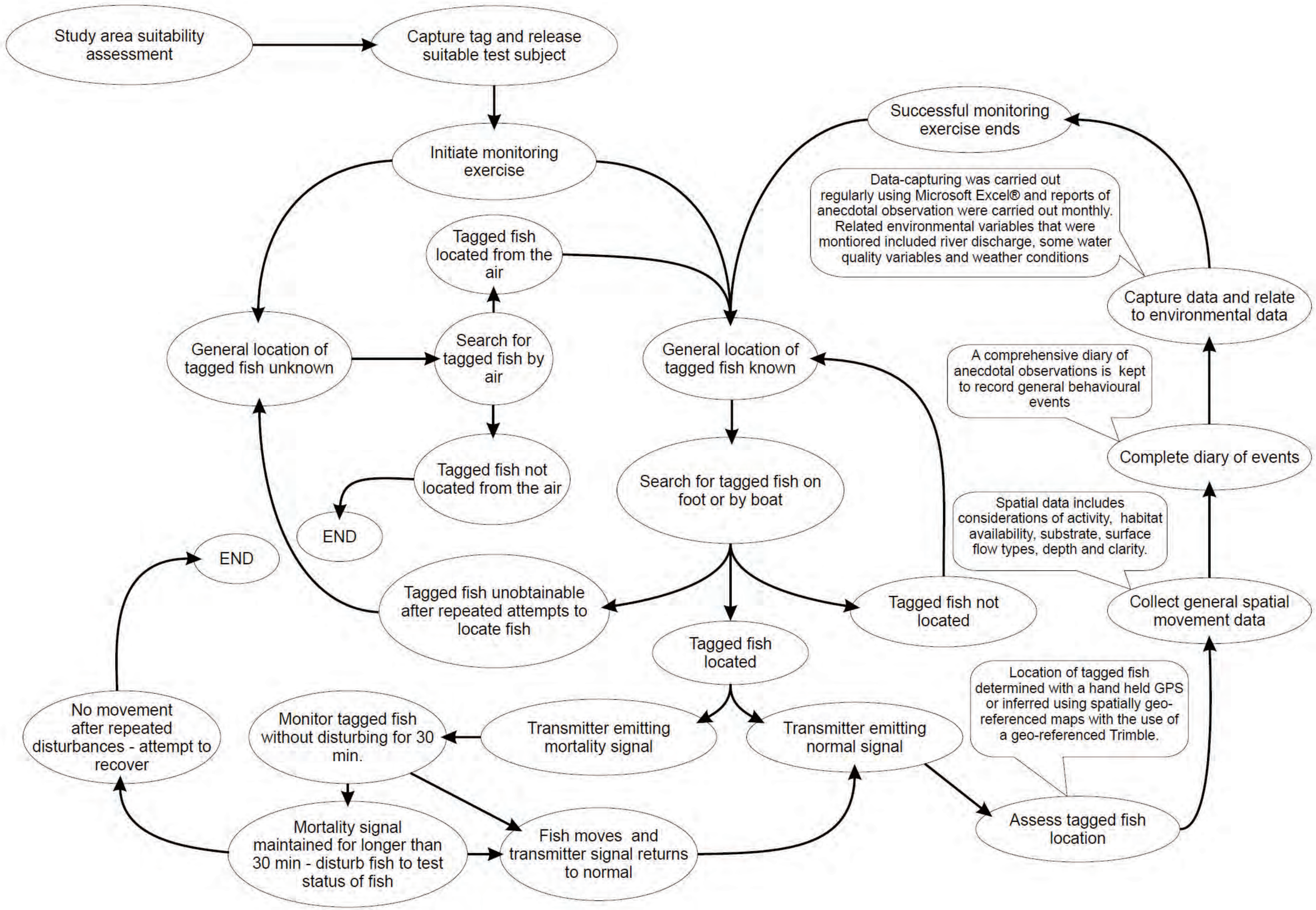

Figure 27: Flow chart of the methods followed to carry out this biotelemetry behavioural study of Vaal River yellowfish.

6.2.1. The study area

The study was carried out at two locations (Figure 28) on Vaal River namely location 1, a 20 km or so reach of the Vaal river positioned downstream of the Orkney weir, upstream of the Bloemhof Dam and location 2, a 55 km reach of the Vaal River from Parys downstream below the Schoemansdrift Weir towards the Scandinavierdrift Weir. Both localities are located within the Orange-Vaal Conservation and Management Association (OVRYCMA) area and were chosen due to the wealth of knowledge available from members of OVRYCMA, many of whom make use of the goods and services of the Vaal River including angling for the yellowfish, in these areas.

Locality 1 is situated within a wilderness area that is controlled by members of the OVRYCMA members (Figure 28B). This allowed for the area to generally be closed to other water related recreational activity users for the duration of the experiment thereby minimising any disturbance to wildlife impacts to the yellowfish monitored in the study. The reach contains a large diversity of habitat types no barriers to the movement of yellowfish potentially allowing for the characterisation of close to natural behavioural activities of yellowfish in the Vaal River. This area is known to maintain a large abundance of both yellowfish species, evident by the recent capture of numerous large specimens of both species by catch and release anglers. Other potential drivers of ecosystem conditions in this reach included water quality impacts from numerous upstream users and partial flow regime alterations from the upstream augmentation programme of the Vaal River (Lenhard and Du Plooy, 1965; Steyn and Toerien, 1976; Grobler et al., 1982; Grobler et al., 1983; Grobler et al., 1986; Midgley et al., 1994; Davies and Day, 1998; Van Wyk, 2001). A dedicated researcher was commissioned to carry out this study with support from a team of experts from the University of Johannesburg. The study was based at Wag ‘n Bietjie Eco-centre where the dedicated researcher was based.

The land use activities of the second locality was dominated by the wilderness areas of the Vredefort Dome Conservancy and included a large portion of the urban community of Parys (Figure 28 A). Access to this area was not controlled to allow for the comparative assessments of the impact of disturbance to wildlife by a wide range of recreational users of the Vaal River. Similarly to locality 1, the reach included a large diversity of habitats and one noticeable artificial barrier to the usptream movement of fish, namely the Schoemansdrift Weir. Recent catch records of anglers from this reach indicate that this reach also maintains a large abundance of both yellowfish species which is evident by the annual hosting of the Bells Orange-Vaal Largemouth and Smallmouth yellowfish angling festivals. This area is also impacted on by a range of stressors that affects the ecosystem conditions, including the water quality impacts associated with the excessive use of the Vaal River goods and services in the vicinity of the Vaal Barrage area, 50 km upstream of this study area where numerous fish kill events have recently been observed and reported on (DWAF 2010).

6.2.2. Biotelemetry monitoring methods

In this study the yellowfish were tagged with externally attached radio transmitters obtained from Advanced Telemetry Systems Inc. (ATS) USA, Table 6). Two types of transmitters were used including ATS model 2030 and 2120 (Table 6). The cylindrical ATS-2030 transmitters had a weight of 10.1 g in water and dimensions of 50 mm in length and 12 mm in diameter. The rectangular ATS-2120 transmitters had a weight of 16 g in water and dimensions of 42 mm in length and 21 mm in width. The transmitter weight in relation to the body weight of the yellowfish used in the study ranged between 0.16% and 0.96%, consistently below the recommended carrying capacity of fishes (1%). The transmitters emitted signals within the 142.017 to 142.466 MHz band where transmitters used at each locality were not spaced within 10 kHz of each other. As indicated, tagged fish were tracked by foot from the bank of the river, with a boat in the river or from the air using portable ATS-R2100 and ATS-R4500 receivers connected to a directional 4-element Yagi antenna.

The methods used to capture suitable yellowfish adults for the study included the use of various netting techniques, angling techniques and the use of electro-fishers (electro narcosis) to capture yellowfish in the Vaal River (Figure 29). The netting techniques included the use of gill nets (Figure 29 A) that were deployed in the evening and early morning in suitable habitats and monitored until visible movement of the nets indicated that fish had entered the net. Thereafter large fyke net traps (Figure 29F) were deployed in suitable areas to trap suitable individuals that could be used in the study and finally seine nets were used in deep areas that were dominated by sand substrates to collect yellowfish for the study.

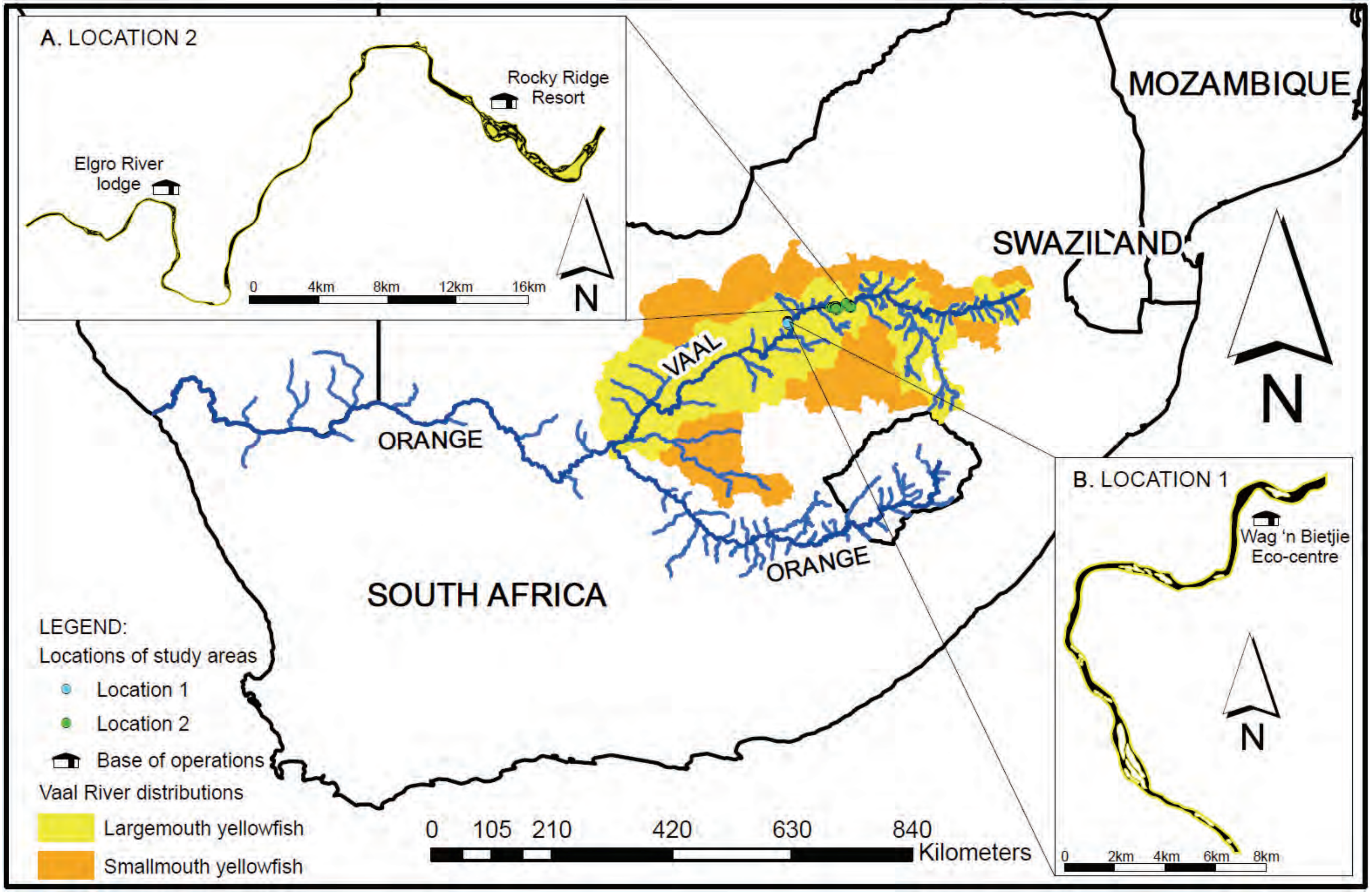

Figure 28: Map of Orange-Vaal River system with the distribution of the yellowfishes in the Vaal River highlighted. Locations where the study was carried out including location 2(insert A) and location 1(insert B).

Figure 29: Methods used to capture yellowfish in the study including the use of nets (A and F) angling methods (C, D and E) and electro narcosis (B and G).

Angling techniques used in the study included various fly-fishing techniques, the use of bait and artificial lures to capture yellowfish for the study. In this study experienced anglers were invited to assist with the capture of suitable adults for the study which resulted in great success as the majority of the yellowfish monitored in the study were captured by experienced anglers. Finally two types of electro-fishers were used in the study to capture yellowfish including a boat operated high voltage (up to 1200 V) electro-fisher and a low voltage (220 V) electro-fisher used in wadable areas where operators wade into relatively shallow areas (>1.2 m) with the apparatus (Figure 29 B and G).

Figure 30 presents photographs of the tagging process carried out in the study. Captured fish were immediately submersed into an aerated anaesthesia container containing 2-phenoxy ethanol ($0.4\ ml.l^{-1}$) or clove oil ($0.5\ ml.l^{-1}$) and sedated until signs of narcosis became evident (Figure 30 C, D and E). Transmitters were attached by inserting two anchoring wires through the body of the yellowfish at the base of the dorsal fin (Figure 30 J, K and L). Two large syringe needles were pushed through the sedated yellowfish and threaded with the wires of the transmitter (Figure 30 F). While treaded the wires of the transmitter were coated with an antibiotic (Terramycin® containing oxytetracycline) before the attachment needles were removed leaving the wires threaded through the yellowfish. A plastic washer and metal sleeve was then attached to the loose end of each wire which was secured in place and then clipped of or clamped together to form a closed ring (Figure 30 G and H). The sedated yellowfish was then revived until it could swim away strongly and then released. Although the early recovery and initial behavioural responses of the tagged yellowfish to the capturing and tagging process was monitored, a month was allowed for each individual to recover from the capture and tagging process before perceived natural behavioural activities were documented.

As indicated yellowfish were monitored from foot on the banks of the Vaal River where possible, from a boat on the water where downstream drifts were carried out and from the air using light aircraft and a helicopter (Figure 31).

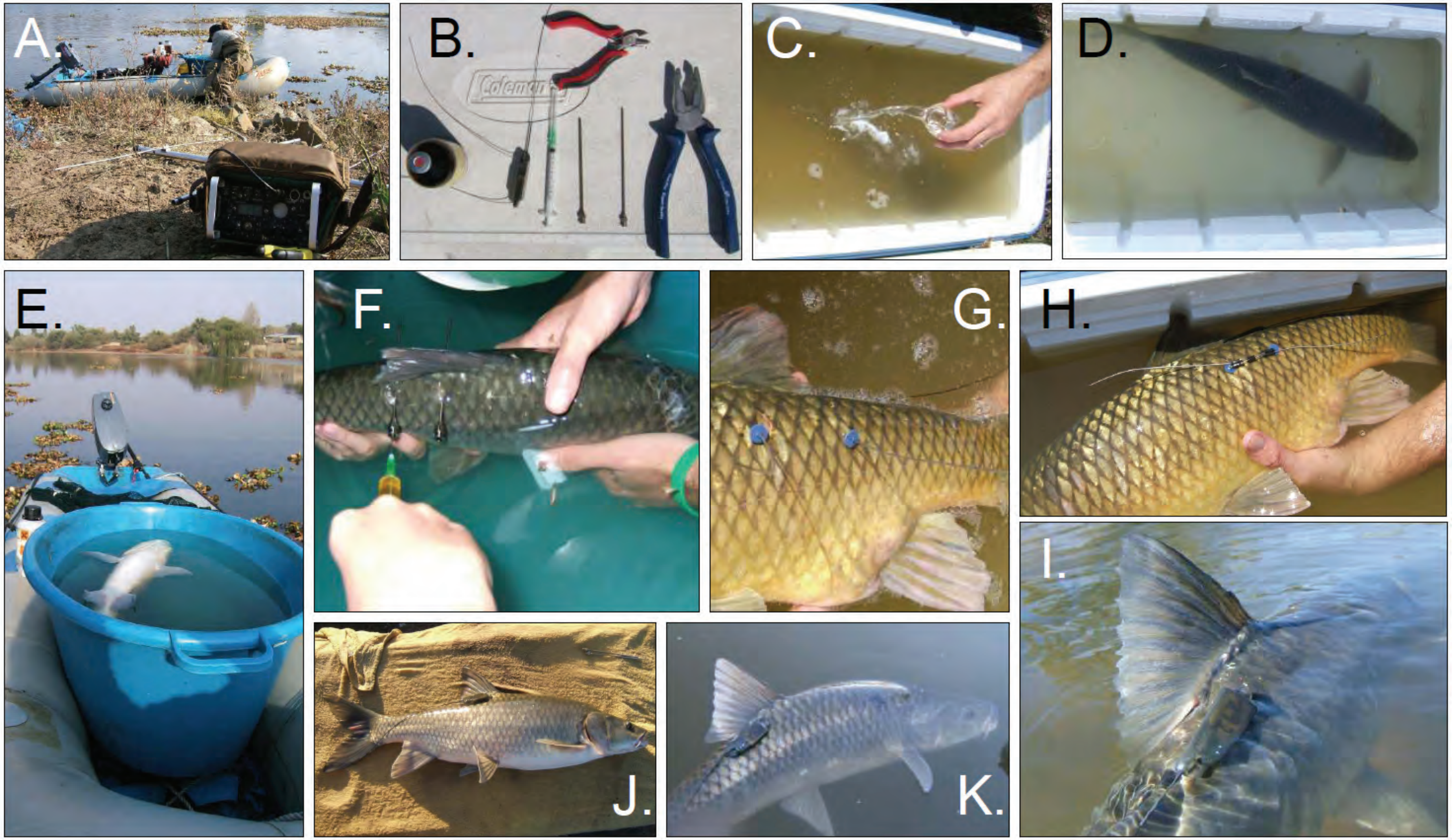

Figure 30: Tagging methods followed in the study including the equipment (A, B and E), the use of anaesthesia (C) to sedate captured individuals (D and E) and the use of needles for the attachment of transmitters (F) fitted with coated wires (G.), attached with plastic washers and metal sleeves (G and H) and then the recovery and release of tagged individuals (J, K and L).

Figure 31: Monitoring methods used in the study including tracking from a boat (A and B), day and night land based tracking methods (D and F) and the use of aircraft (C, E and G).

6.2.3. Yellowfishes used in the study

A summary of the individual yellowfish used in the study is presented in Table 6. A total of 41 yellowfish were used in the study including 13 Smallmouth and 12 Largemouth yellowfishes at location 1 and one Smallmouth yellowfish and 15 Largemouth yellowfish at location 2. The mass of the yellowfish used in the study ranged from 1050 g to 6200 g with the bulk of the yellowfish mass ranging from 2200 g to 3900 g. All individuals that weighed more than 1600 g and were measured to be longer than 490 mm (total length) were considered to be adults (Mulder, 1973; Tomasson et al., 1984). As such this study is concerned with the behavioural ecology of adult yellowfish in the Vaal River. Although some visual observations suggested that the condition of the yellowfish used at Location 2 was better than those from Location 1, a simple condition assessment using the mass to length relationship of the yellowfish showed that no clear differences in condition between locations were obtained (Figure 32).

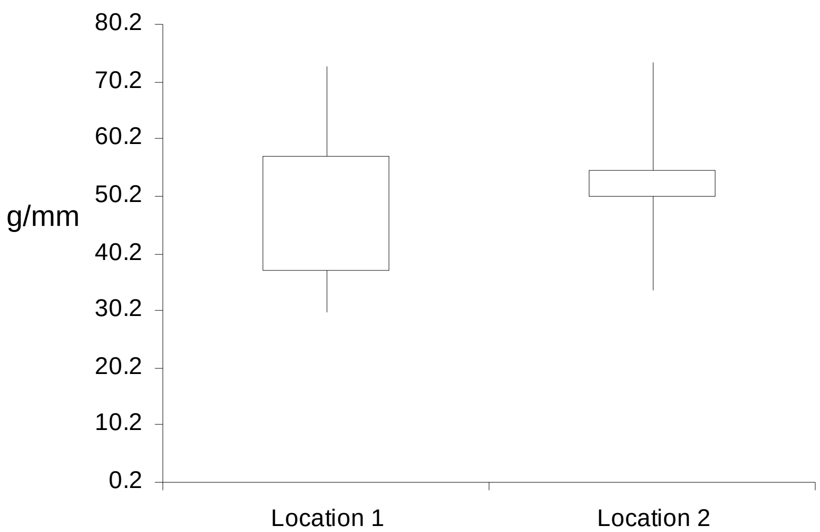

Figure 32: Graphical box and whisker plot representation of the condition of the yellowfish used in the study based on weight/length relationships. The box extremities are based on 25th and 75th percentiles while the wisher extremes are based on 5th and 95th percentiles.

Table 6: Overview of the yellowfishes used in the biotelemetry study from each location, including transmitter (tags) information capture and last monitored dates, general information of each individual and number of observations per individual.

Tag frequency	Date tagged	Last date monitored	Mass (g)	Total length (mm)	Fork length (mm)	Girth (mm)	Transmitter model	Number of observations	% Contribution
Location 1 Orange-Vaal smallmouth yellowfish (*Labeobarbus aeneus*)									
142.017	23-Sep-06	24-May-07	3200	590	550	300	ATS-2030	60	23.3%
142.026	9-Nov-06	29-Jun-07	3881	690	640	420	ATS-2030	32	12.4%
142.045	4-Nov-06	11-Jan-07	1715	560	500	290	ATS-2030	5	1.9%
142.056	5-Nov-06	22-Feb-07	1050	350	310	210	ATS-2030	18	7.0%
142.083	2-Sep-06	21-Sep-06	3300	580	520	310	ATS-2030	11	4.3%
142.094	9-Nov-06	9-Nov-06	2715	620	560	380	ATS-2030	0	0.0%
142.203	19-Sep-07	17-Oct-07	2100	610	550	310	ATS-2030	5	1.9%
142.322	9-Aug-06	11-Dec-06	3381	660	610	350	ATS-2030	49	19.0%
142.333	7-Apr-07	26-Oct-07	2215	590	550	330	ATS-2030	42	16.3%
142.363	30-Aug-07	3-Nov-07	3000	690	625	350	ATS-2030	3	1.2%
142.435	12-Sep-07	8-Mar-08	2000	565	515	310	ATS-2030	14	5.4%
142.456	14-May-07	3-Nov-07	4100	710	645	350	ATS-2030	4	1.6%
142.466	2-Sep-07	20-Jan-08	1600	555	490	310	ATS-2030	15	5.8%
Location 1 Orange-Vaal largemouth yellowfish (*Labeobarbus kimberleyensis*)									
142.036	9-Nov-06	7-Jul-07	4381	720	670	380	ATS-2030	42	21.6%
142.064	9-Nov-06	7-Jul-07	2215	590	540	330	ATS-2030	24	12.4%
142.074	9-Nov-06	20-Jun-07	5047	760	700	400	ATS-2030	25	12.9%
142.224	13-May-07	23-May-07	1900	560	520	310	ATS-2030	0	0.0%
142.234	15-Apr-07	3-Nov-07	2215	590	540	340	ATS-2030	19	9.8%
142.262	2-Jun-07	26-Feb-08	6200	850	770	390	ATS-2030	29	14.9%
142.351	14-May-07	20-May-07	3400	680	620	370	ATS-2030	3	1.5%
142.373	14-May-07	3-Nov-07	1700	570	520	300	ATS-2030	7	3.6%
142.383	30-Aug-07	30-Jan-08	5000	745	680	410	ATS-2030	10	5.2%
142.402	7-Jul-07	31-Aug-07	4900	750	690	430	ATS-2030	10	5.2%
142.424	14-May-07	3-Nov-07	3000	630	570	350	ATS-2030	14	7.2%
142.442	7-Jul-07	3-Nov-07	2900	670	600	360	ATS-2030	11	5.7%
Location 2 Orange-Vaal smallmouth yellowfish (*Labeobarbus aeneus*)									
142.402	3-Apr-09	16-May-10	2700	629	573	346	ATS-2120	546	100.0%
Location 2 Orange-Vaal largemouth yellowfish (*Labeobarbus kimberleyensis*)									
142.213	27-Jun-09	12-Jul-09	3300	690	630	355	ATS-2120	4	1.8%
142.242	20-Jul-09	7-May-10	3500	690	630	365	ATS-2120	18	8.0%
142.253	26-Jul-09	2-Feb-10	3000	610	580	340	ATS-2120	78	34.5%
142.261	7-Oct-10	24-Aug-10	3000	600	550	330	ATS-2120	32	14.2%
142.272	22-Jul-09	7-May-10	3500	660	590	380	ATS-2120	2	0.9%
142.281	22-Jul-09	8-Dec-09	3700	710	640	380	ATS-2120	26	11.5%
142.283	21-May-09	22-Sep-09	2000	590	530	310	ATS-2120	8	3.5%
142.292	27-Jun-09	27-Jun-09	3800	760	670	385	ATS-2120	1	0.4%
142.302	22-May-09	7-May-10	4200	680	610	380	ATS-2120	2	0.9%
142.322	26-May-09	16-Nov-09	5800	790	710	435	ATS-2120	26	11.5%
142.331	26-Jul-09	7-May-10	4100	680	610	395	ATS-2120	18	8.0%
142.351	29-Jun-09	2-Aug-09	3500	675	620	380	ATS-2120	1	0.4%
142.371	20-Jul-09	20-Jul-09	3500	690	620	365	ATS-2120	1	0.4%
142.422	29-Jun-09	22-Sep-09	4500	720	630	490	ATS-2120	8	3.5%
142.442	27-Jun-09	27-Jun-09	3400	670	610	355	ATS-2120	1	0.4%

6.2.4. Environmental conditions monitored

Some environmental variables including water quality and quantity, habitat, lunar cycles and weather variables have been identified to possibly influence the behaviour of yellowfish in the Vaal River. In an attempt to characterise any existing relationships between the environmental variables and the yellowfish tracked in the study these variables were monitored and assessed using a range of techniques.

It is widely known that the water physico-chemical quality state of the Vaal River has been altered primarily through the excessive use of the ecological goods and services associated with the Vaal River and to a lesser extent through various activities such as the numerous inter-basin transfer schemes that donate water from other catchments to the Vaal River (Braune and Rogers, 1987; Davies and Day, 1998; Van Wyk, 2001). Furthermore it is known that the fish communities in the Vaal River, including the yellowfish populations have been affected by the altered water physico-chemical quality state (Skelton 1986; Cambray et al., 1986; De Villiers and Ellender 2008a; 2008b; DWA 2010 for example). This study is not directly concerned with the impact of the altered water physico-chemical quality state on the yellowfishes of the Vaal River but is concerned with the responses of individuals to changes in selected water physico-chemical quality variables. In this study water temperatures and turbidity were specifically addressed in relation to the behaviour of yellowfish monitored. Temperatures were recorded during the surveys using HOBO pendant temperature data loggers that were submerged into the river and calibrated to record hourly temperature readings. Turbidity was monitored with the use of a secchi disk during all monitoring exercises.

Water quantity variables included discharge that was obtained from the South African Department of Water Affairs gauging stations number C2H007Q01 (Vaal River at Pilgrims estate, Orkney) and C2H018Q01 (Vaal River at De Vaal or Schoemansdrift). Discharge readings were obtained on the 26th of February 2011 from the Department of Water Affairs (Pers. Comm.: Erasmus 2010[3]).

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Habitat variables that were considered in the study included the availability and use or selection of physical habitat biotopes or Geomorphical habitat units as defined in Hirschowitz et al. (2007) and DWA (2009). The habitat biotopes included the consideration of the use of and/or availability of backwater areas, pools, glides, riffles, runs and rapids by tagged yellowfish. Additional habitat cover features included the consideration of the use of and/or availability of undercut banks or root wads, dead and or submerged trees complex substrate types such as boulder beds, rocky outcrops and underwater ridges, marginal, aquatic and emergent vegetation, islands, water column and the top of or tail out of pools. In addition to recording or scoring the habitat availability and use in the study three-dimensional digital terrain models of important reaches of the study area were generated to facilitate with the assessment. These models were generated using ARC GIS ®, from data that was collected from a Hummingbird ® 789CI side scan fish finder.

Apart from the general weather conditions of each day that were monitored by observers who documented the amount of cloud cover and recent or current rainfall events the atmospheric temperatures and atmospheric pressure were recorded using calibrated SILVA ADC summit weather station/anemometer.

6.2.5. Data analyses methods

Three main types of data were collected in this study including (a) general behavioural data collected from tagged and monitored fish and associated environmental variables, (b) other environmental variables that were monitored continuously such as temperatures, discharge and relative atmospheric pressure and related to the general behavioural data at a later stage, and finally (c) a diary of events documenting the anecdotal behaviour of the tagged yellowfish allowed for the assessment of specific behavioural strategies of yellowfish at each location in the Vaal River.

The general behavioural data that were collected regularly were analysed using spatial analyses software namely ARC GIS ®, this approach enables the assessment of the home ranges of individuals, assessments of any focused or preferred areas and the spatial and temporal relationships between the location of the tagged fish and general environmental variables.

Another approach used in the study to relate the location of individual fishes with the state, presence and or availability of various environmental variables included the use of multivariate statistical ordination techniques using Canoco version 4.5 software package. The ordination techniques operate on the original behavioural data sets and are related to explanatory environmental variables for analysis (Van den Brink et al. 2003). Environmental variables considered in this assessment included seasons, habitat biotopes, discharge ($m^3.s^{-1}$) and depth. This approach allows for the direct interpretation of the behavioural patterns of tagged and monitored fish in the study. These techniques allow for the assessment of complex behavioural patterns obtained in the study and then when combined with Monte Carlo permutation testing, the statistical significance of hypothesised differences in the behavioural patterns could be tested (Ter Braak and Smilauer 2002). The ordination approach allows for the expression of the behavioural data of each individual without the need for correlating environmental or explanatory data. In this approach the variation in the behavioural data is optimised to reflect the underlying structure of the data set (Ter Braak 1995). In this study, the largest part of the total variance of the data sets were used to establish a first latent variable and then a second were established that relies on the largest part of the remaining variance in the data set (Van den Brink et al. 2003). These two latent variables were used to construct an ordination diagram forming two axes. Individuals of each monitoring observation were initially presented in the diagram as points at the location of the values on the latent variables. Individuals with nearly identical or behavioural patterns are located close together while samples located far apart represent those individuals that have differing behavioural patterns (Van den Brink et al. 2003). Thereafter tri-plots were established that present arrows of environmental data which point in the direction of higher values where correlations between the environmental variables and the individuals (Van den Brink et al. 2003). In this study direct or constrained analyses were undertaken which involves overlaying captured variance of the explanatory environmental variables onto behavioural pattern ordination diagrams. The linear response mode used to achieve this is a redundancy analyses (RDA), a derivative of principle component analyses (PCA) using the Canoco version 4.5 software package (Ter Braak 1994). Data sets used in this assessment include the 1065 observed monitoring points of the individual yellowfish tracked at location 2. Information considered included the movement and activity variables of the individual as well as the biotope selection of the individual. Movement were considered as the distance the individuals was moving during a ten minute period while activity and habitat use were considered according to the presence absence of the activity or habitat associated with the observation. The data were assessed without transformation (Van den Brink et al. 2003).

Finally, known behavioural ecology principles of fishes were considered and compared to the behavioural observations from the study. The behavioural ecology principles of fishes presented by Godin (1997) were considered in this part of the study. This enabled the assessment of components of the general behavioural biology and ecology of the Vaal River yellowfishes, and for the specific considerations of the habitat use, migrations and possible territoriality of these fishes.

6.3. GENERAL BEHAVIOURAL BIOLOGY AND ECOLOGY

Being the first behavioural study of its kind concerning yellowfish in South Africa, this study has produced in an extremely large amount of behavioural information. The study has been carried out over a four year period from 2006 to 2010 and has resulted in 41 yellowfish being monitored. During the first phase of the study 13 Smallmouth and 12 Largemouth yellowfish were captured, tagged, released and monitored resulting in 453 observations and a diary of continuous events. During the second phase only one Smallmouth yellowfish was captured, tagged, released and monitored from the 3rd of April 2009 to the 16th of May 2010 during which time the individual was observed on 546 occasions. During the same phase 16 Largemouth yellowfish were captured, tagged, released and monitored on 226 occasions. During the second phase a large amount of anecdotal observations were diarised and reported on here. The raw spatial data from the behavioural study is presented in Appendix 9 to Appendix 16 (phase 1 at location 1) and in Appendix 17 to Appendix 35 (phase 2 at location 2). The home ranges and general physical biotope use as well as photographs of the yellowfish considered in this assessment are presented in Appendix 36 to Appendix 58 (phase 1 at location 1) and in Appendix 59 to Appendix 70 (phase 2 at location 2). In this section attempts are made to analyse and present as much of the relevant findings from the study as possible in this review of the behavioural biology and ecology of the Vaal River yellowfishes. The outcomes of the assessment were separated into five sections including; individual behavioural patterns, home ranges, habitat use, coordinated migrations of species and flight responses of the monitored individuals.

6.3.1. Consideration of individual behavioural patterns.

The majority of the yellowfish monitored in the study exhibited clear daily, seasonal and annual behavioural patterns that were influenced by changing environmental conditions. Although the daily behavioural patterns of species differed there was a large amount of individual or intraspecies variation. In particular, noticeable intraspecies variations between the two study locations were observed suggesting that local environmental conditions influence the behaviour of yellowfish in the Vaal River. Seasonal variations were also observed where individuals adopted different daily behavioural patterns during different species due to direct changes in the environmental conditions of the Vaal River between seasons and indirectly as a response to changes in other ecosystem components of the system such as the change in habitat use of prey items for Largemouth yellowfish in the system due to changes in the environmental conditions of the system. Differences in the intraspecies and interspecies behaviour between seasons were not as extreme as the differences between high and low flow periods. Finally, the study showed that annual behavioural patterns were evident where some individuals readopted behavioural patterns carried out during the previous season in the same location.

General behavioural activities of the yellowfish observed from both locations reveal that the species adopt predictable daily behavioural patterns in any given reach of the Vaal River when the ecosystem is in a ‘state of equilibrium’. We refer to this state of equilibrium as any period when a range of selected ecosystem components including; flows, water quality components namely temperatures and oxygen levels for example, as well as water clarity, atmospheric pressure and the biology of other species are in a relatively stable state. During what we call periods of state of flux where selected ecosystem components are changing considerably the predictable daily behavioural patterns of the yellowfish are disrupted and the individuals either vacate the area or move to refuge areas until the ecosystem components return to a stable state. In this study the Largemouth yellowfish were observed to be noticeably more sensitive to these state of flux events in comparison to the Smallmouth yellowfish. In addition, this section is concerned with the sensitivity of mature, adult yellowfish to changing variables and does not consider sensitivities of other age groups. The changes in ecosystem states occurred during all seasons monitored in the study and were responded to by numerous individuals. A review of the responses of yellowfish to individual variables that caused the system to enter a status of flux is presented as follows:

- Flow fluctuations including rapid increases in discharge were observed to be the most important driving variable of behavioural response changes of Largemouth yellowfish. Rapid, noticeable increases in discharge consistently caused individuals to take refuge in usually deep well structured areas. The yellowfish remained in these areas until the velocities reduced and or flows stabilised at which point they would either re-establish characteristic behavioural patterns or vacate the area until conditions became suitable at which point the yellowfish would establish similar behavioural patterns in the new area. Often even slight increases in flows would elicit a response from the tagged individuals. Smallmouth yellowfish were noticeably less sensitive to flow changes but would on occasion move to more suitable areas.
- Some changes in the water quality variables such as rapid decreases in temperatures and or oxygen levels resulted in similar responses by the monitored yellowfish. Rapid changes temperatures by approximately 3^{o}C in one hour that occurred locally following heavy rain fall and hail storms caused yellowfish being monitored to move into deep presumably more stable areas locally or vacate the area in a manner similar to that observed by individual following changes in the flows of the system. On other occasions when oxygen levels in some areas of the Vaal River reduce to very low concentrations (>2 mg/l) presumably due to chemical pollution or the anaerobic decomposition of large abundances of Water Hyacinths in winter yellowfish were observed to vacate the areas. These findings show that the behaviour of yellowfish can be used to monitor changing water quality and quantity conditions in river and other aquatic ecosystems. In this case the sudden vacation of an area by a resident Largemouth yellowfish was investigated and finally correlated to changing water quality variables which were determined to be the only variable that changes noticeably.
- On some occasions individual yellowfishes were observed to be sensitive to sudden decreases in water clarity which elicited a response from the individuals.
- Changes in atmospheric pressure during winter and spring in particular were determined to cause changes in the behaviour of yellowfish in the Vaal River. Usually during sudden increases in atmospheric pressure (6 to 10 mb in 12 hours) which preceded weather pattern changes, yellowfish would abandon

normal behavioural patterns and take refuge in deep presumably more stable habitats for the duration of the weather event that can last for up to ten days. After the event when pressures stabilise the yellowfish re-establish behavioural patterns. Interestingly the first noticeable change in pressure at the onset of winter that elicits this response from Largemouth Yellowfish results in the initiation of characteristic winter behaviour of the yellowfish. This behavioural change may occur in response to the migration of fodder fish from shallower habitats during the warmer months of the year to deeper habitats after the first noticeable cold front of the winter in the Vaal River.

- As indicated, other species including the movement of fodder fish as indicated above has been determined to be an event which causes a change in the behaviour of Largemouth yellowfish in the Vaal River. Other species such as otters seems to cause a noticeable change in behaviour, especially when otters become very active in areas that were utilised by yellowfish. During these occasions the yellowfish vacate the area.
- Finally, some forms of disturbances by anthropogenic activities including recreational activities can cause behavioural changes to yellowfish in the Vaal River. The Smallmouth yellowfish observed in the study seemed to be relatively tolerant to disturbances and the majority of Largemouth yellowfish monitored appeared to be very sensitive to disturbances. All of the Largemouth yellowfish monitored at location 1 were deemed to be sensitive to disturbances as were all of the largemouth yellowfish monitored in the lower reaches of location 2 (close to Elgro River Lodge), only a few individuals monitored in the upper reaches of location 2 (Parys) were deemed to be relatively tolerant to disturbances. In general once disturbed, it seemed the Largemouth yellowfish would move to a locally pre-determined refuge area. On occasions where disturbances were repeated regularly (such as those made by the monitoring team before realising that the tagged individuals were sensitive to disturbances) individuals would vacate the area and become increasingly sensitive to similar disturbances. On the contrary one Largemouth yellowfish observed in the study seemed to become habituated to regular disturbances made by the monitoring team. This individual actually responded to the observation team by changing its behaviour in favour of moving towards the observation team and remained in close proximity to the team until the team moved away. This necessitated a change in monitoring method from being water borne on a boat to monitoring on foot where 'normal' behaviour was observed.

In response to these disruptions in ecosystem equilibrium Largemouth yellowfish would move in either an upstream or downstream direction generally for the duration of the disturbance. These actions often resulted in the movement of some individuals over large distances (up to 20km) in a few days. During these movements some Largemouth yellowfish often moved out of accessible monitoring areas of observers. On some occasions these individuals were found during aerial surveys of the river far upstream or downstream of the observation areas. The on some later occasions individuals returned to observation areas after other state of flux events. These findings suggests that if regular disturbances occur in some reaches of the Vaal River, the Largemouth yellowfish in particular may eventually vacate the area and reside in more stable, suitable reaches of the Vaal River.

In consideration of the daily behavioural patterns of each species, one of the most striking observations made includes the discovery that individuals are extremely aware of their locations and of a large area in the Vaal River which they can possibly identify. This discovery was made after two Smallmouth yellowfish were relocated from an area of the Vaal River approximately 10 km upstream of a convenient monitoring location where they were captured and relocated downstream. The individuals were captured on the same day, sedated and relocated in a small aerated transport tank downstream to an area where other tagged individuals were already being monitored. This suggests that the area that they were relocated to was suitable for them to establish themselves in. The individuals were tracked immediately after being released to document the recovery of the individuals from the capture, relocation and tagging procedures. Two days after their release at the new location one of the individuals could not be located and then the following day the second could not be located. For the next two days the local area upstream and downstream of the release point was searched in an attempt to locate the two individuals unsuccessfully. Six days after the relocation exercise, four days after the one individual went missing and three days after the second individual went missing we decided to repeat the experiment only to find both individuals within 10 m of the original capture point, approximately 10 km upstream of the release point. Additional evidence included the observations of the responses of many Largemouth yellowfish in particular at location 1 that were sensitive to disturbances by the monitoring team. On many occasions the flight response of individuals entailed the initial movement to some preselected feature and then the movement into a usually deep area that often offered some form of cover such as an underwater rift. This behaviour was tested on an individual that would venture upstream and downstream to forage regularly during different times of the day. After observing the behaviour of the individual we would purposefully disturb the individual and monitor its response. It must be noted that some of the Largemouth yellowfish monitored at location 2 were considerably less sensitive to surface disturbances from the monitoring team and other activities such as anglers and canoeists compared to those at locality 1. Although these individuals were considerably less sensitive they were observed to be sensitive to artificial lures, flies and bait as after a short period of trying to re-capture tagged individuals they would leave the area and become sensitive to this activity. No fish were recaptured during this study although numerous attempts were made, including attempts when tagged individuals could be seen by observers. These findings suggest that yellowfish may be able to learn from past capture experiences and avoid artificial lures and bait in the future at least for one season.

During the study many dedicated 24 hour monitoring observations of selected Smallmouth and Largemouth yellowfish individuals were undertaken. In this section the behavioural patterns of two yellowfish which optimises the daily behavioural patterns of the species is presented. The daily behavioural patterns of the Largemouth yellowfish tagged with transmitter 142.253 that was monitored at location 2 (Parys) is presented graphically in Figure 33. The 24 hour monitoring surveys of this individual were usually initiated at 5 am and carried out for at least 24 hours. Early in the mornings from about 1 am to approximately 5 am, the yellowfish made use of a 2 m or so, deep pool in close proximity to diverse cover features including fallen trees, water hyacinths and undercut bank and roots that provided the yellowfish with cover. The individual was frequently observed to move very close to the bank well within the available structure in areas where a depth of at least 2 m was available. During this time the activity of the fish was limited to small infrequent movements of less than meters at most. From 5 am to 8am the location of the yellowfish generally remained the same but the activity increased noticeably. The yellowfish remained close to the bank during this period presumably pursuing fodder fish or other prey items. Small bait fish were present within these habitats and often observed. It was not uncommon for the yellowfish to make movements of 50 m to 100 m along or across the river in between these habitats during this time of the day. On a few occasions the tagged yellowfish was seen breaching the surface as it moved along the river banks feeding close to the surface. From about 8 am the fish characteristically moved into deeper water and generally became less active taking up a holding activity. During these periods uncommon rapid movements were observed suggesting that the individual adopts an opportunistic behaviour that may have included ambushing prey. The holding behaviour in deeper areas during this these periods may be done to avoid predators such as fish eagles which frequented the area. The fish maintained this behaviour and moved in an area less than 10 m, not actively looking for food. This holding behaviour was generally maintained until approximately 2 pm, at which point the activity began to increase again. From 2 pm to 4 pm the activity of the fish increased noticeably where movement of 50 m or more were frequently observed. During this period the yellowfish may have became less wary of threats and was often observed in very shallow habitats. At sunset from about 4 pm to 7 pm, hatches of ephemerpoteran and tricropterans predominantly induced surface feeding behaviour. On occasion when the hatches occurred in relatively unfavourable areas the monitored yellowfish would still venture into these areas to feed on the hatching insects. During these excursions the yellowfish would become very sensitive to disturbances and flee into deeper habitats if disturbed. This behaviour would continue into darkness normally on bright moonlit nights, but even during moonless nights, on occasions until as late at 10 pm. On occasions when insect hatch events did not continue into the night the activity of the yellowfish reduced and it retreated to the deep refugia habitats close to the river banks. The yellowfish generally remained in these habitats with some infrequent movements (>10 m) until early morning activity was initiated again at approximately 5 am.

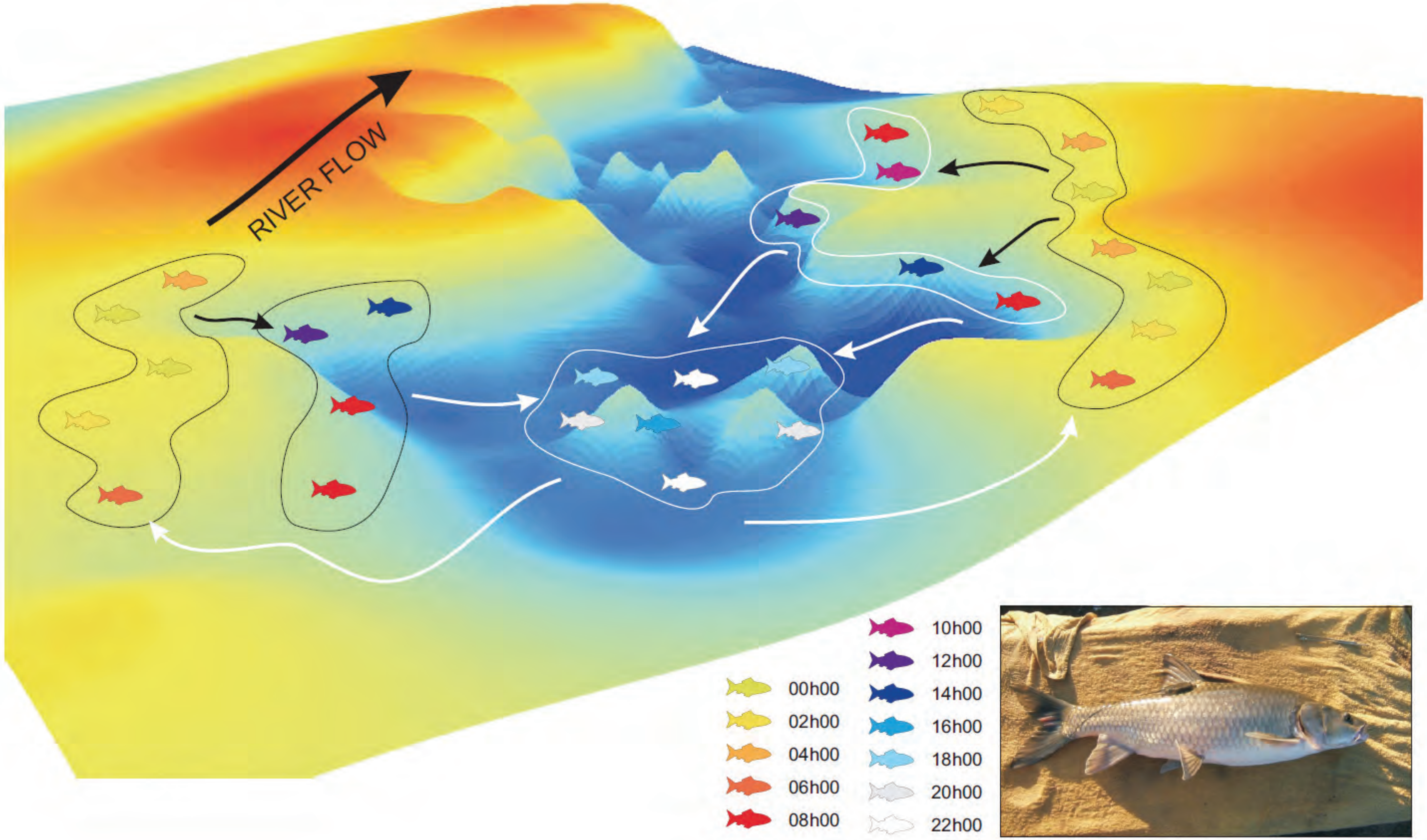

Figure 33: Characteristic 24 hour behavioural patterns of the Largemouth yellowfish tagged with transmitter 142.253 and monitored at location 2 in the study.

The general daily behavioural patterns of the Smallmouth yellowfish tagged with transmitter 142.402 is presented in Figure 34. Similarly the 24 hour surveys were initiated at approximately 5 am. In the early mornings from approximately 1 am to 5 am the Smallmouth yellowfish seemed to take refuge in very shallow, slow flowing areas along numerous islands where diverse substrates such as cobbles and boulders were available but limited cover was available. Movements of less than 10 m were infrequently observed during this time. At dawn from approximately 5 am to approximately 8 am the activity of the individual increased noticeably and it moved into fast flowing riffle habitats to feeding actively by foraging in the cobble and boulder substrates. This active movement was carried out in areas of approximately 50 m. During winter a similar behaviour was observed in these riffle habitats but instead of foraging amongst cobbles and boulders the yellowfish selected the filamentous alga which is common during this season. From 8 am to 2 pm the activity of the Smallmouth yellowfish reduced to less than 10 m. During these periods it frequently moved into sheltered areas behind large usually submerged boulders in the riffles that out of the main current. During these periods very little concern for predators was shown as the individual remained relatively close to the surface and breached the surface on occasion feeding opportunistically. These habitats were rarely deeper than 1 meter. On occasions, during high flow periods when the current speed of the river increased this characteristic behaviour was still carried out. This indicates that large changes in flows do not necessarily affect the general daily behaviour of these relatively tolerant yellowfish. From 2 pm to 4 pm this yellowfish would either remain in the current or move back to the islands or river banks and forage amongst the reeds, undercut banks and roots or boulders and cobbles. From 4 pm to sunset the characteristic behaviour included the movement of the yellowfish into the fast flowing riffle and rapid habitats to feeding by foraging amongst cobble and boulders or feeding actively in the water column on drifting insects presumably. Just before sunset until approximately 8 pm the Smallmouth yellowfish would then favour flowing habitats close to marginal and emergent vegetation associated with cobble and boulder substrates. These habitats were similarly relatively shallow, rarely deeper than 1 meter. From approximately 8 pm to midnight the Smallmouth yellowfish consistently returned to the refuge areas adjacent to the islands.

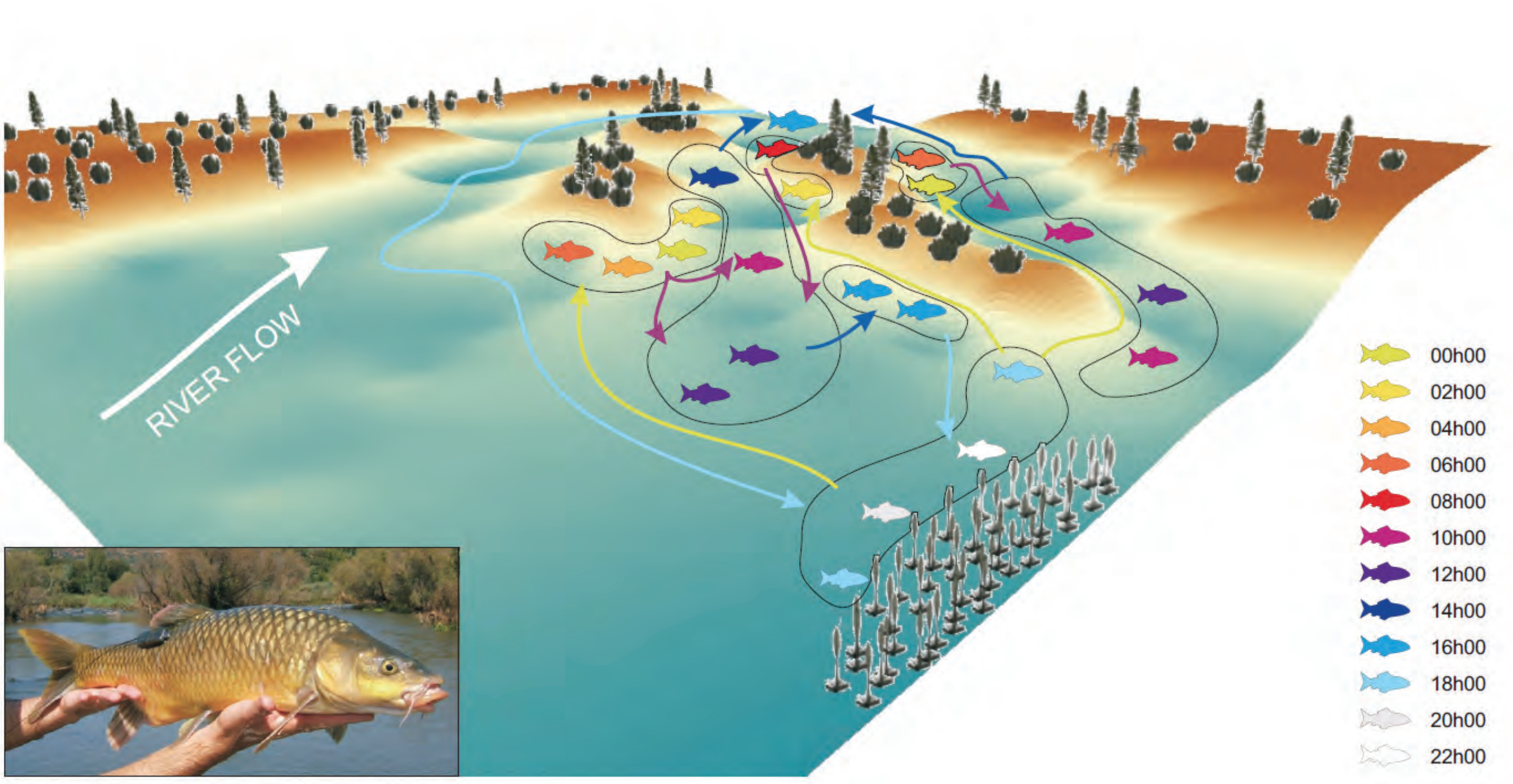

Figure 34: Characteristic 24 hour behavioural patterns of the Smallmouth yellowfish tagged with transmitter 142.402 and monitored at location 2 in the study.

Outcomes of the multivariate statistical assessment of the yellowfish behaviour observed at location 2 in study are presented in the RDA tri-plot in Figure 35. Although the plot is based on the 1065 individual observation points, these points are not shown in the tri-plot but a label for each individual is included based on a best fit location by including the labels as a nominal variable for each observation. In addition to the locations of individuals, true behavioural variable information are plotted on the plot according to individual observation points with selected explanatory environmental variables superimposed. The plot shows that clear differentiations between the behavioural patterns of the species were obtained. All of the Largemouth yellowfish individuals were plotted in the upper quadrants while the only Smallmouth yellowfish considered at location 2 was located in the lower quadrants. The findings shows that there may be two types of Largemouth yellowfish behaviour as two groups of individuals have been formed on the tri-plot. The groups include a group of closely plotted individuals (individuals tagged with transmitters 142.213, 142.331, 142.281 and 142.242 (Group I)) in the upper right quadrant and a broad group containing the remaining Largemouth yellowfishes in the upper left quadrant (Group II). The habitat use behavioural variable is strongly associated with the Largemouth yellowfish groups and the substrate is strongly associated with the Smallmouth yellowfish. These outcomes show that the Largemouth yellowfish have a high requirement for specific habitat types including deep pools and glides and not substrate type. The converse is shown for Smallmouth yellowfish that have been determined to be cosmopolitan in their habitat use but highly selective of substrate types namely cobble and boulder habitats. These behavioural ecology outcomes where similar to the habitat use of Largemouth at location 1 where individuals were frequently found in pool and glide habitats with varying substrate types. Similarly the Smallmouth yellowfish monitored at location 1 appeared to select cobble and boulder dominated glides, riffles and runs. The RDA tri-plot shows that the activity and distance moved between observations for the yellowfish at location 2 were plotted close to the centre of the graphs and is as such weakly associated with the behaviour of either species. The majority of the explanatory environmental variables were shown to be strongly associated with the Smallmouth yellowfish quadrants or either of the Largemouth yellowfish groups. The backwater and spring environmental variables were shown to be strongly correlated with Largemouth Group I, while the summer variable was weakly associated with this group. The pool, depth and winter environmental variables were strongly associated with Group II Largemouth yellowfish. Although these findings show which individuals were focused on during the winter (Group II) vs. spring and summer (Group I) seasons individuals from both groups were monitored during all seasons. These findings further support the associated use of pools with sufficient depth by Largemouth yellowfish in winter and relatively more shallow habitats in spring and summer. The run and riffle habitat variables were closely correlated to both the Smallmouth yellowfish and the Largemouth yellowfish (Group I). This outcome shows that the Largemouth yellowfish in Group I demonstrate a behaviour that is different to the Smallmouth yellowfish but makes use of similar habitats during similar seasons as the Smallmouth yellowfish. Finally the tri-plot shows that the individuals that were well documented including the Largemouth yellowfish tagged with transmitter 142.253 (78 observations 34.5% of all observations) and the Smallmouth yellowfish tagged with transmitter 142.402 (546 observations) were plotted close to the centre of the graph. These outcomes suggest that although different, there are noticeably more variations in the behaviour of these individuals indicating that large amount of monitoring data is required to characterise the total variation in behaviour of either yellowfish species.

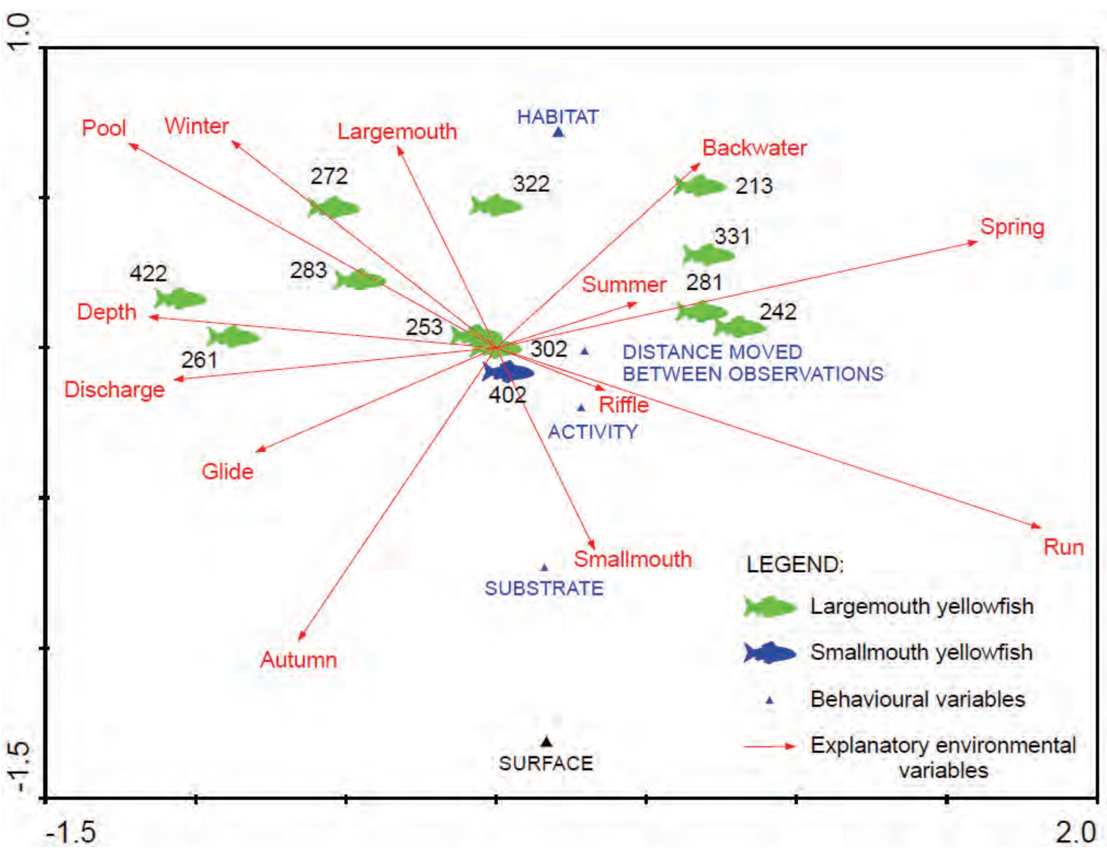

Figure 35: Redundancy analyses plots showing dissimilarity based on the individual observations of each yellowfish monitored in the study with seasons, habitat biotopes, discharge and depth superimposed as environmental variables (red arrows). The tri-plot describes 89.2% of the variation in the data where 79.3% is displayed on the first axis and an additional 9.9% on the second axis

6.3.2. Home ranges

The home range evaluations showed that Largemouth yellowfish from location 1 and the lower portion of location 2 were included areas of approximately 10 km to 15 km. The home ranges of Largemouth yellowfish from the upper part of location 2 were however considerably smaller (2 km to 5 km). The home ranges of the Smallmouth yellowfish observed at both locations ranged from 2 km to 10 km but were consistently smaller than the Largemouth yellowfish individual observed in the study. Table 7 presents and overview of the sizes of the focus areas and intermediate ranges if demonstrated by individuals, as well as the total areas or home ranges of yellowfish monitored in the study. **Error! Reference source not found.** presents box and whisker graphs of the sizes of the focus areas and home ranges of the yellowfish individuals monitored both locations.

Outcomes of this assessment revealed that the Smallmouth yellowfish generally remained with focus areas of home ranges of about 10 km. The focus areas of many individuals were restricted to 500 m-1.5 km of the Vaal River. Some Largemouth yellowfish were observed to have defined focus areas while others did not. Generally the Largemouth Yellowfish from location 1 and the lower portions of location 2 were very active and would move up and down the within the home range of the individual. The Largemouth yellowfish in the upper parts of location 2 had much smaller home ranges compared to the other Largemouth yellowfish and made extensive use of focus areas. Most of the Largemouth yellowfish periodically vacated the defined focus areas and or even home ranges on regular occasions. This suggests that the home ranges of some of the Largemouth yellowfish presented here may be based on the observer areas and not the true home ranges of this species which may be considerably greater that the areas presented in this study.

Table 7: Overview of the sizes, in meters, of the focus areas and intermediate ranges as well as the total areas or home ranges of yellowfish monitored in the study.

	Transmitter	Focus area (m)	Intermediate area (m)	Home range (m)
LAEN (1)	142.017	1500	-	5500
LAEN (1)	142.026	2000	-	3500
LAEN (1)	142.045	500	-	9500
LAEN (1)	142.056	500	-	5000
LAEN (1)	142.083	500	-	1500
LAEN (1)	142.203	-	-	5000
LAEN (1)	142.322	800	1500	4000
LAEN (1)	142.333	750	2000	4500
LAEN (1)	142.435	1000	-	6500
LAEN (1)	142.466	2000	-	5000
LKIM (1)	142.036	1500	3000	5000
LKIM (1)	142.064	2500	-	3500
LKIM (1)	142.074	1500	-	4000
LKIM (1)	142.224	-	-	4000
LKIM (1)	142.234	4000	-	7500
LKIM (1)	142.262	1000	-	1200
LKIM (1)	142.373	-	-	8500
LKIM (1)	142.383	1500	-	7500
LKIM (1)	142.402	-	-	12500
LKIM (1)	142.424	2500	-	8000
LKIM (1)	142.442	2500	-	7000
LAEN (2 - Elgro)	142.402	350	-	1500
LKIM (2 - Parys)	142.213	-	-	2500
LKIM (2 - Parys)	142.242	4000	-	7500
LKIM (2 - Parys)	142.253	-	-	1500
LKIM (2 - Parys)	142.261	-	-	1500
LKIM (2 - Elgro)	142.272	1000	-	10000
LKIM (2 - Elgro)	142.281	1500	-	7500
LKIM (2 - Elgro)	142.283	-	-	6500
LKIM (2 - Elgro)	142.322	2500	-	3000
LKIM (2 - Elgro)	142.302	-	-	12000
LKIM (2 - Elgro)	142.331	1500	-	4000

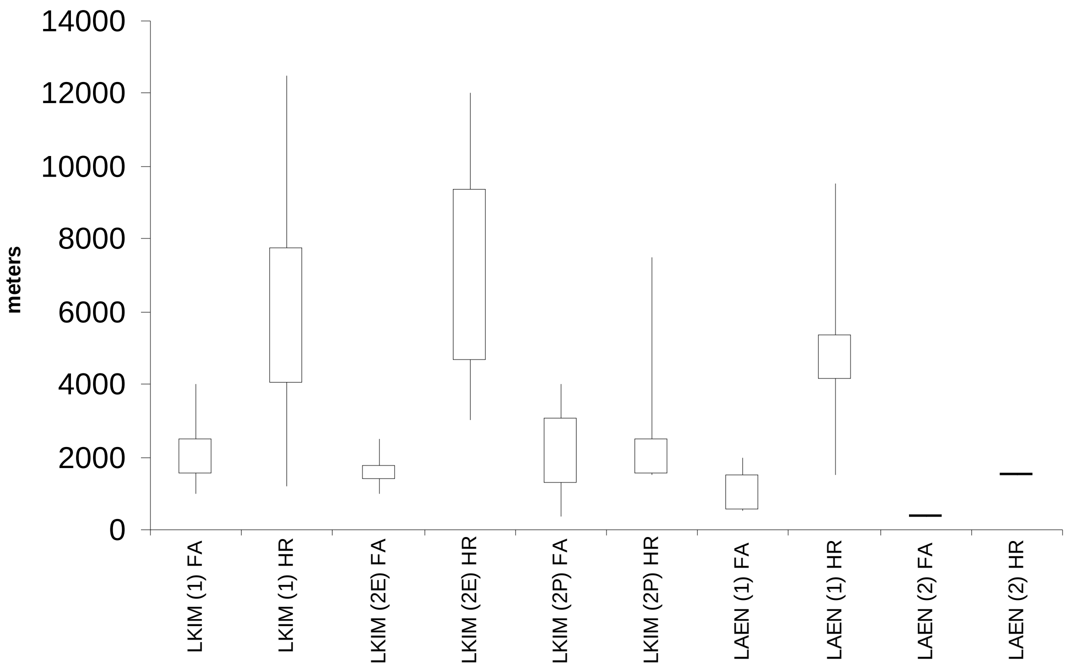

Figure 36: Graphical representation of the focus areas (FA) and home ranges (HR) of the *L. kimberleyensis* (LKIM) and *L. aeneus* (LAEN) individuals monitored at location 1 (1), and the upper (2P) and lower (2E) parts for location 2. Box and whisker plots include 25th and 75th percentiles (boxes) and 5th and 95th percentiles (whiskers).

6.3.3. Habitat use

As indicated, yellowfish behaviour is sensitive to changing environmental conditions either directly which cause an immediate response or indirectly when something else responds to the changing conditions which then cause yellowfish to respond. These two types of responses were observed in the study. Initially, the habitat biotope use of the yellowfish during different seasons showed clear differences (Table 8, Figure 37 and figure 38. Table 8 presents the seasonal frequency that the Largemouth and Smallmouth yellowfishes monitored in the study were observed in different habitat biotopes in the study at location 1 during 2006 to 2008 and at location 2 during 2009/10. Figure 37 presents the percentage frequency of habitat use by the Largemouth yellowfish during each season from both locations. Figure presents the percentage frequency of habitat use by the Smallmouth yellowfish during each season from both locations. Results show that the Smallmouth yellowfish generally make use of shallower glide habitats predominantly and pools particularly in winter compared to the largemouth yellowfish that make use of the deeper pools throughout the year and riffle habitats in summer primarily and in spring to a lesser extent. At location 1 during 2006 to 2008 the Largemouth yellowfish were commonly found in deep glide and pool areas during the cool autumn and winter seasons and in the riffles and glide habitats during spring and summer. After the hot summers in this temperate part of South Africa when water temperatures begin to decrease towards 20^{o}C the Largemouth yellowfish monitored at location 1 occupied glides and pools most of the time but frequented backwater areas and the faster flowing run and riffle areas. At location 2 the Largemouth yellowfish occupied pools 71% of the time possibly during autumn but frequented glide habitats as well. During winter, potentially in response to cooling water temperatures the locations of these yellowfishes included pools for almost 50% of the time, glides 25% to 32% of the time and infrequently in riffles and runs at location 1 and backwater areas at location 2. It is suspected that due to the improved water clarity during winter and the availability of fodder fishes in the pools that also prefer the more stable deeper areas, the Largemouth yellowfish can hunt better in pools during the winter months. In spring the water temperatures begin to rise towards 20^{o}C from lows of below 15^{o}C in winter. This change in environmental conditions as well as changing ecosystem conditions which include the movement of fodder fished into shallower habitats, the Largemouth yellowfish begin to move out of the deeper pools at location 1 into the riffle areas predominantly (58% of the time). At location 2 Largemouth yellowfish still dominate the pool areas in spring where it is assumed that sufficient food is available to the habitat in the area. Other habitats used during spring by Largemouth yellowfish from both areas include; runs and riffles. In summer the temperatures continue to increase and the water clarity decreases. During these periods the Largemouth yellowfishes from both areas were predominantly found in relatively shallower, faster flowing riffle areas. The water clarity of the river at both locations during summer was limited to less than 10 cm (secchi disk reading) which possibly forces the Largemouth yellowfish into habitats where they could forage effectively without using sight to feed.

Table 8: Review of the habitat biotope use by the Largemouth yellowfish (*L. kimberleyensis*) and Smallmouth yellowfish (L. aeneus) monitored in this Biotelemetry study.

	Backwater	Glide	Pool	Riffle	Run	Count
LKIM autumn 2006 - 2008	2	18	15	5	8	48
LKIM Spring 2006 - 2008	0	5	4	19	5	33
LKIM Summer 2006 - 2008	0	20	3	20	6	49
LKIM Winter 2006 - 2008	0	16	31	10	7	64
LAEN Autumn 2006 - 2008	1	11	4	10	4	30
LAEN Spring 2006 - 2008	2	47	13	22	37	121
LAEN Summer 2006 - 2008	0	18	3	31	22	74
LAEN Winter 2006 - 2008	0	15	8	4	7	34
LKIM autumn 2009 - 2010	1	17	46	0	0	64
LKIM Spring 2009 - 2010	2	28	68	15	21	134
LKIM Summer 2009 - 2010	0	0	2	6	0	8
LKIM Winter 2009 - 2010	43	94	149	0	7	293
LAEN Autumn 2009 - 2010	0	200	16	0	208	424
LAEN Spring 2009 - 2010	0	11	48	0	1	60
LAEN Summer 2009 - 2010	0	17	16	0	15	48
LAEN Winter 2009 - 2010	0	9	5	0	0	14

Note: LKIM abbreviation used for *L. kimberleyensis*
LAEN abbreviation used for *L. aeneus*

In this study although the habitat use assessment of the Smallmouth yellowfish from location 2 is based on almost twice the number observations (546) compared to location 1 (258) is all based on the observations of one individual compared to 13 individuals from location 1. Findings showed that the Smallmouth yellowfish made use of very different habitat biotope types during all seasons when compared to the Largemouth Yellowfish. Smallmouth yellowfish in both areas occupied flowing and often shallower habitats more frequently throughout the year in comparison to Largemouth yellowfish. In autumn Smallmouth yellowfish were frequently found in the glide habitats and in the riffle (location 1 predominantly) and run (location 2 predominantly) habitats. Although Smallmouth yellowfish were obtained in other habitats such as back water areas and pools during autumn these events were rare. In winter the frequency of glide use increased from autumn in both locations but the use in pool habitats increased (noticeably by yellowfish from location 2).

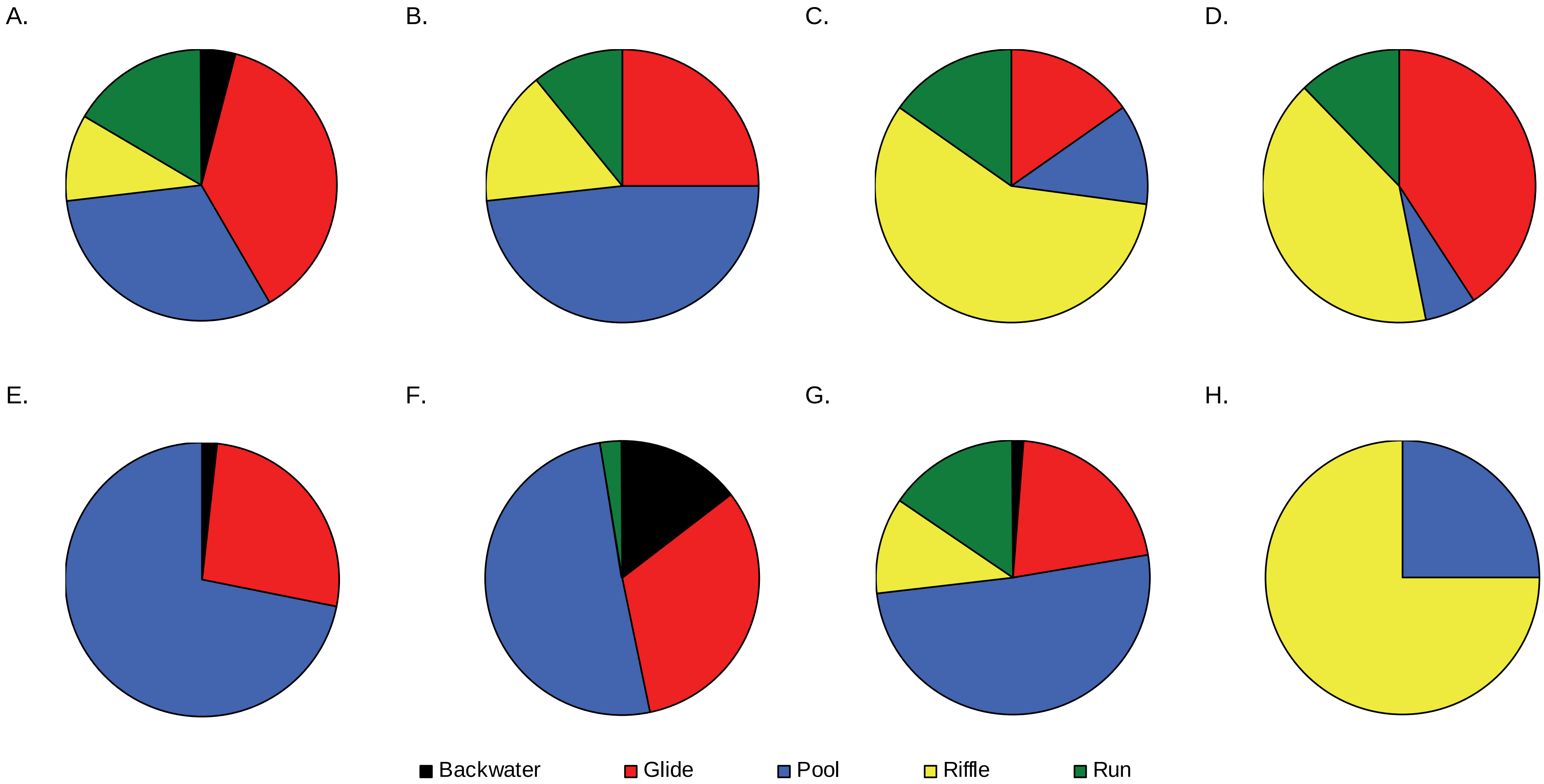

Figure 37: Graphical representation of the physical biotope use as a percentage by the Largemouth yellowfish (*L. kimberleyensis*) from location 1 during 2006-8 (A-D) and location 2 during 2009/10 (E-H) for autumn (A and E), winter (B and F), spring (C and G) and summer (D and H) in the study.

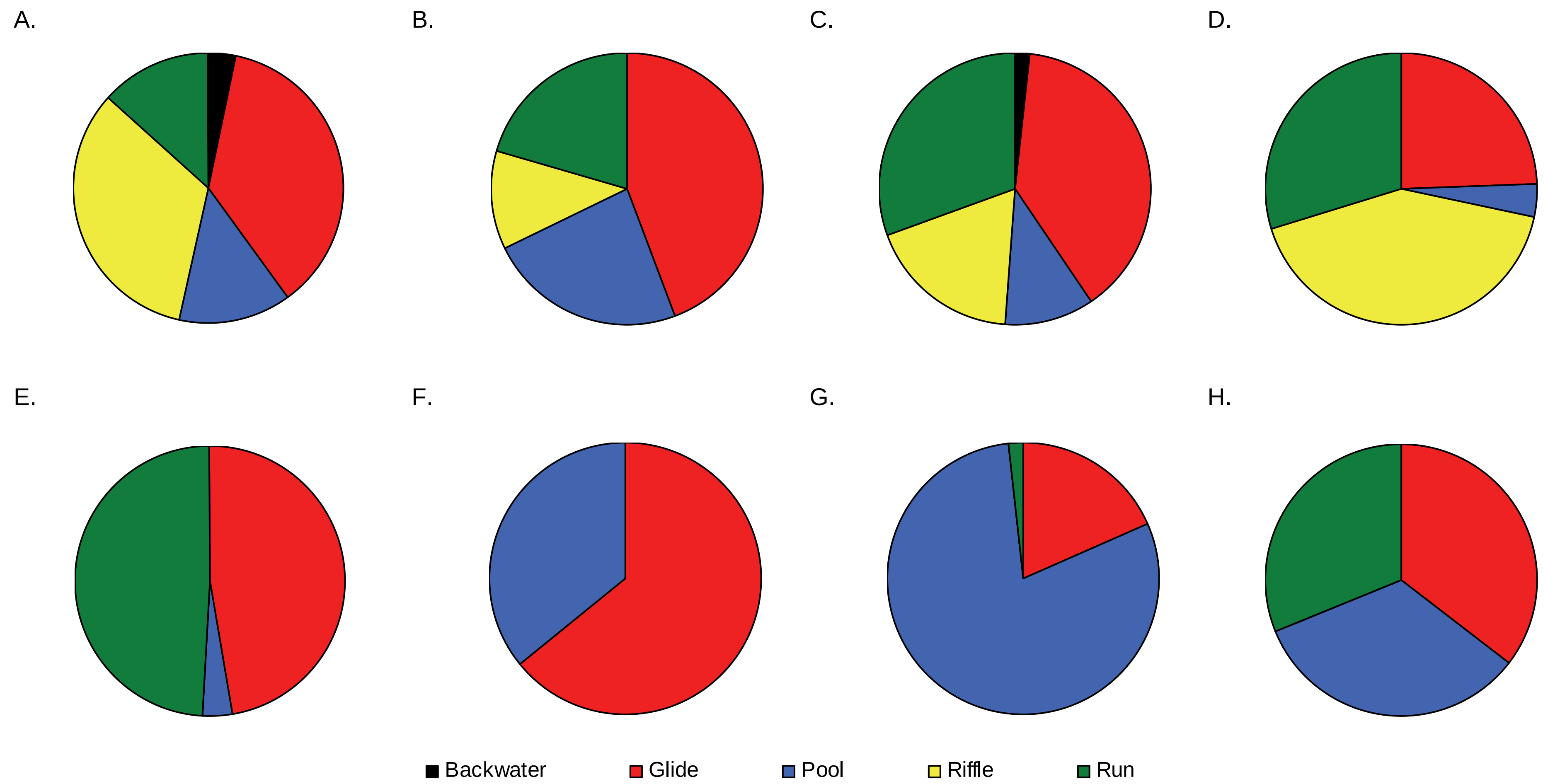

Figure 38: Graphical representation of the physical biotope use as a percentage by the Smallmouth yellowfish (*L. aeneus*) from location 1 during 2006-8 (A-D) and location 2 during 2009/10 (E-H) for autumn (A and E), winter (B and F), spring (C and G) and summer (D and H) in the study.

In location 2 the frequency of run habitat use reduced from 49% in autumn to 0% in winter while the frequency of occurrence in pools increase from 4% to 36%. The use of pools by Smallmouth yellowfish in location 1 from autumn to winter increased from 13% to 24%. During spring the habitat use of the Smallmouth yellowfish from location 1 was similar to the winter use but included a slight reduction in glide habitat use and an increase in riffle and noticeably run habitat use. In summer the Smallmouth yellowfish from location 1 reverted to frequencies similar to the autumn use where riffle use dominated habitat use. The Smallmouth yellowfish habitat use from location 2 in spring was dominated (80% of the time) surprisingly by pool use which contradicts the habitat use of the Smallmouth from location 1 clearly. In summer the percentage use of glide and run habitats by this Smallmouth yellowfish was dominant which is comparable with the habitat use from location 1. This surprising habitat use from this Smallmouth yellowfish from location 2 may be indicative of the unique habitat preferences of this individual which may differ from other individuals of this species in this area.

6.3.4. Coordinated migrations

From the early 1900s large scale spawning migration events of adult Orange-Vaal Largemouth and Smallmouth yellowfishes have been documented in various parts of the Orange-Vaal system (Shortt-Smith, 1963; Jubb, 1966; Mulder ,1973; Tomasson et al., 1984;). The majority of these migration events included the co-ordinated movement of large portions of the adult yellowfish populations into the upper reaches and tributaries of the Orange-Vaal River system to spawn (Shortt-Smith, 1963; Jubb, 1966). Then from the 1930s, the long distance spawning migrations of the Vaal River yellowfishes have been disrupted to the extent that co-ordinated large scale migrations of any yellowfishes in the Vaal River catchment are rare (Mulder, 1973; De Villiers and Ellender, 2008a; 2008b). Yellowfish migrations in the Vaal River have been affected by the establishment of physical and chemical barriers and changes in ecosystem conditions that disrupt the ecological cues needed to induce spawning migrations (De Villiers and Ellender, 2008a; 2008b).

Fish migration behaviour deals with the behaviour associated with the coordinated movement a group of individuals of one species that move from one place to another place for numerous ecological purposes (Dodson, 1997). True migrations of fishes differ from mere dispersal movements when it is a coordinated movement by all members of a select age class or sex, for example, of a species which is repeated under similar environmental conditions (Dodson, 1997). Migrations can include short and long distance movements between habitats, between reaches of systems and on large scales including catchment wide migrations. The co-ordinated migrations of adults fishes are well known (consider review in Dodson, 1997), but other migration events of species are poorly described although important to the life-cycle biology and thus the conservation and management of the species and the system in which they occur. Fish migrations form apart of the survival strategy of species and as such are usually species specific. Apart from well known spawning migrations of adult yellowfishes, other identified migration events of the yellowfishes include the co-ordinated movement of larvae and juvenile yellowfish, and the seasonal migrations of sub-adult and adult yellowfishes due to changing ecosystem conditions.

Spawning migrations

Yellowfish spawning migration behaviour can contribute to their survival strategies in numerous ways. Initially, co-ordinated migration events would allow different yellowfish populations to come into contact with each other and reproduce thereby enhancing the flow of genes through the populations. Yellowfish are large, slow growing fishes that mature relatively late. Species that attain large sizes are often able to store relatively more somatic reserves for migrations compared to other species. This makes some species better candidates for migrations compared to others (Beamish, 1978). By maturing late only large adult yellowfish respond to ecological cues to initiate spawning migrations thereby ensuring that the chances of successfully reaching spawning areas with sufficient reserves are good. In addition, large individuals are usually associated with a higher relative fecundity in that larger females can potentially produce more eggs that smaller individuals (sensu Bagenal, 1978). In combination the relatively large size of the mature Vaal River yellowfishes that carry out spawning migrations have the reserves needed to cover large distances to join other adults in the upper reaches of the catchment. There they can release large numbers of eggs in areas where the offspring will not have the same threats and competition that the adults are subjected to. Finally, yellowfish are relatively long lived and as such can carry out numerous spawning migrations during the sexually viable part of their life histories. These behavioural strategies have enabled the Vaal River yellowfishes to become two of the most dominant, successful species in the Vaal River prior to the influence of anthropogenic activities which has impacted on these migrations. Although the Vaal River yellowfishes still generally attempt to carry out spawning migrations and gain access to the upper reaches of the Vaal River system, these areas are inaccessible due to numerous physical and chemical barriers. In consideration of this spawning migration scenario assessment, outcomes from this biotelemetry assessment resulted in very little indication that coordinated spawning migrations were required by the yellowfish monitored. On at least two occasions however during spring/summer of 2010 tagged Largemouth yellowfish individuals did attempt to move upstream beyond their normal home ranges. One was successful and moved upstream of the Department of Water Affairs gauging weir at Schoemansdrift. The other was an individual that was tagged below Elgro River lodge that moved soon after being tagged downstream of the study area beyond the range of the observation team. During the spring/summer period of 2010 this individual reappeared in within the study area and proceeded to move in an upstream direction. These two invalidated observations may be the initiation of attempted spawning migrations. There is in addition the possibility that other individuals attempted to carry out spawning migrations as many Largemouth yellowfish individuals in particular suddenly disappeared from observation areas during the spring/summer period. All of these events coincided with sudden increases in the flow discharge in the river.

Migrations of larvae and juvenile yellowfish

The yellowfish early development section of the study has presented a comprehensive review of the development of Largemouth and Smallmouth yellowfishes from eggs to juveniles. Here a review of the migration behaviour of the larvae and juvenile yellowfishes is provided. Only from the initiation of the larval stage in yellowfish development when exogenous feeding is established does migrations behaviour of yellowfishes commence. Approximately eight to ten days after fertilisation, after the completion of the free embryo phase, both yellowfishes were observed to swim to the surface of the observation aquaria. In the wild this developmental step represents the first coordinated migration activity of larval yellowfish. This initial coordinated migration activity will cause all of the larval yellowfish to move out of the interstitial spaces between boulders and cobbles where they have been deposited and be transported in the current downstream away from spawning beds. At this point of development the larvae remain on the surface and start feeding. This behaviour is maintained for a few days until another shift in behaviour occurs when the larvae begin to shoal and return to the substrate or take refuge within aquatic vegetation. Within these refugia areas the larval yellowfish mature into juveniles remaining in shoals. Finally, approximately four to six weeks after fertilisation another noticeable behavioural change in the growing yellowfish fingerlings were observed (Pers. comm.: S.P. van der Walt 2009[4]). Within this period the Largemouth yellowfish fingerlings exclusively began to attempt to move into the filters of the maintenance aquaria during the night alone. Changes in the aquaria systems were required to minimise fatalities. These observations may be indicative of a final coordinated migration event that yellowfish fingerlings take to move away from juvenile grow out areas that is undertaken at night to minimise predation. The location to where these juveniles would migrate to is unknown.

Seasonal migrations of adult yellowfishes

Findings of the biotelemetry behavioural study showed that there are clear differences in the habitat selection of adult yellowfish. As presented adult Smallmouth and Largemouth yellowfish make use of similar habitats during the warm summer months, when the clarity of the Vaal River is low. This habitat use is considered to be closely associated with the foraging behaviour of both species. During the cooler autumn months the water clarity begins to improve and this allows the Largemouth yellowfish in particular to change their feeding modes from foraging to a piscivorous diet. This diet change coincides with a change in habitat use when the Largemouth yellowfish being to prefer deeper slower flowing habitats. After the first noticeable cold front in winter the Largemouth yellowfish then predominantly occupy deep pools and favour these habitats until water temperatures begin to increase in spring and the fodder fish presumably move into shallow habitats. In a assessment of fish migrations, Dodson (1997) suggests that all fish migration activities can be linked to a survival strategy that allows the species to occupy a particular niche in an ecosystem. In this case the seasonal migration behaviour of adult Largemouth yellowfish appears to maximise the potential of this species to occupy the niche of pinnacle predator within the Vaal River ecosystem.

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6.3.5. Comments on possible territoriality behaviour of Vaal River yellowfishes.

Fish like other animals often exhibit defensive behaviour to defend food, shelter, mates, nest sites, spawning sites and offspring (Noakes 1978). This behaviour involves the defence of a particular sociogeographic area against competing organisms and is referred to as territorial behaviour. Although some references indicate that yellowfish are generally non-territorial (Roux, 2006 for example), some territorial behaviour of the yellowfish monitored in the study was observed and as such is reported on here.

The occurrence of territorial behaviour of the yellowfish monitored in the biotelemetry study was based on the theory of economic defendability of animals (Brown, 1964). This theory suggests that the yellowfish in this study may defend a territory if the fitness benefits of the defence exceed the costs, or if the net benefits of the defence exceed the net benefit of not defending. There are six key ecological variables that affect the economic defensibility of a resource which is predicted to increase with; decreasing competitor densities, increasing resource densities, increasing spatial clumping of resources, decreasing temporal clumping of resources, increasing spatial predictability of resources and temporal predictability of resources (Grant, 1997). The converse is true which suggests that the economic defendability should decrease; at extremely low levels of competitor densities, or when extremely high levels of resources densities or spatial clumping occurs. These ecological variables that affect the economic defendability of resources were considered in relation to selected behavioural patterns of the yellowfish monitored in the study.

Many observations of the behaviour patterns of both Smallmouth and Largemouth yellowfish in the study led to the idea that territorial behaviour may occur. These include:

- Although some of the individual Smallmouth and Largemouth yellowfish were monitored in the same area where productive feeding areas and optimal refuge areas were identified, the individuals were rarely observed to be in the same area at the same time. This suggests that some yellowfish may defend their preferred areas from other individuals. On numerous occasions in this study individual Smallmouth yellowfish and less frequently a Largemouth yellowfish individual would occupy the primary position in particular habitat that would allow the individual to maximise feeding and resting activities. This involved the movement of a yellowfish between the fast flowing water in a glide for example at the tail out of a pool, an area where drift feeding would be optimised and a refuge area close by. This behaviour would take place in the evenings before sunset when feeding activity was at a peak. Other individuals in the area would occupy less optimal feeding areas and or make use of the optimal feeding areas during different times. This behaviour suggests that the yellowfish individuals that made use of the optimal area may be dominant individual that were able to defend the optimal feeding areas.

- Furthermore, only rarely were individuals observed together. This does not mean that individuals did not make use of the same areas; many did make use of the same areas, but never at the same time. This allowed the observers to characterise certain habitats as important for the species. The Vaal River yellowfishes are however, known to congregate in large shoals, a phenomenon that was frequently observed in the study. On at least two occasions a small group of Largemouth yellowfish were seen to be cooperatively hunting a small shoal of what appeared to be barbs. On other occasions large shoals of Smallmouth yellowfish were observed feeding together on recently hatched mayflies (Ephemeroptera) on the surface of the water. On yet other occasions, particularly during winter, shoals of large Largemouth and Smallmouth yellowfish individuals were observed together.

7. ASPECTS OF THE CONSERVATION AND MANAGEMENT OF VAAL RIVER YELLOWFISHES

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The Orange-Vaal River Yellowfish Conservation and Management Association is the only regional conservation endeavour that is exclusively concerned with the management of and conservation of the Vaal River yellowfishes. To allow this conservation endeavour to adopt 'best practice' conservation and management approaches for the Vaal River yellowfishes, information on the socio-economic value and threats of the resource use to yellowfish were required. This section presents a review of the socio-economic value assessment of the yellowfishes in the Vaal River (Brand et al., 2009). Thereafter a review of the assessment of the impact of angling on yellowfish of the Vaal River, a recommendation from the socio-economic value assessment is provided. Finally another recommendation of the socio-economic value assessment, a simplified relative risk assessment of the threats of ecosystem users to the Vaal River yellowfishes is presented.

7.1. REVIEW OF THE SOCIO-ECONOMIC VALUE ASSESSMENT OF YELLOWFISH IN THE VAAL RIVER

This section presents an overview of the outcomes of the socio-economic value assessment of the Vaal River yellowfishes that was carried out by Brand et al., (2009). The aim of this study was to characterise the social and economic benefits and implications associated with the use of the Vaal River by yellowfish dependent angling activities and yellowfish related conservation initiatives.

The approach used to reach the aim of the study included the use of valid economic and social assessment methodologies currently used by local and international ecosystem managers (Dobbs, 1993; Turpie and Joubert, 2001). The economic component of the study was carried out by making use of questionnaire based surveys and personal interviews. The social component of the study involved a comprehensive desktop review of the historical findings of studies addressing fish conservation and recreation and their social benefits. The social component of the study also included a field survey where various stakeholders of the use and or conservation of yellowfish in the Vaal River ecosystem were interviewed.

The findings of the Brand et al. (2009) study showed that the estimated value of the yellowfish dependant angling industry on the Vaal River is just over R133 million per season. Of this total economic value the equipment sector is worth R14.6 million, the amount spent on travel is R41.4 million, accommodation costs total R75.5 million, other costs carried out while undertaking angling trips totalled R2.2 million a season and membership fees paid by anglers to belong to clubs etc. totalled R500 thousand per season. Findings of the social assessment showed that by harvesting yellowfish for food, promoting yellowfish in regional ecotourism endeavours, and using yellowfish as a flagship, indicator species in the management and conservation of the Vaal River, numerous social benefits that yellowfish provide to communities were characterised, including;

- yellowfish are an important source of protein to local communities,
- communities benefit from the improvement of the overall health of the river through the use of yellowfish as indicator of river ecosystem health,
- yellowfish conservation promotes social cohesion of communities,
- yellowfish allow local communities to carry out recreational activities,
- local communities obtain revenue from the yellowfish dependent angling industry, and
- through local stewardship programmes, community upliftment and engagement programmes for yellowfish use and conservation, the quality of life of many South Africans are improved.

Brand et al. (2009) also showed that the current social and economic value of the Vaal River yellowfishes is threatened due to inadequate or non-existing management plans for the species in the Vaal River. Activities of yellowfish managers and conservators are limited due to the lack in operational resources. The findings further suggest that it is not the absence of laws/policies required to protect the Vaal River and the yellowfish that is lacking, but rather the enforcement and implementation of these policies/laws. These findings indicate, as such, that local and regional government is incapable of maintaining the social and economic values of yellowfish in the region and should encourage involvement from civil society.

The recommendations made by Brand et al. (2009) included the establishment of an integrated use and associated conservation plan for the yellowfish in the Vaal River, and the assessment of the risk posed to the continued survival of the Largemouth yellowfish in the Vaal River in particular. Other recommendations include need for an assessment of the ecologically friendly practice of catch-and-release of yellowfish.

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7.2. REVIEW OF THE IMPACT OF ANGLING ON YELLOWFISH OF THE VAAL RIVER

In 2009, Gerber addressed one of the recommendations that Brand et al. (2009) made by assessing the possible impacts of catch and release angling activities on yellowfish in the Vaal river (Gerber, 2009). The study was one of only two assessments of the physiological effects of catch and release angling activities on fishes in southern Africa. The aim of the study was to assess the effects that selective catch and release angling activities may have on Smallmouth yellowfish populations in the Vaal River. Outcomes of the study showed that the physiological response of *L. aeneus* to angling is significant. Within 2 minutes of hook-up physiological stress manifests itself in Smallmouth yellowfish. Additional outcomes showed that the yellowfish caught by anglers are commonly exposed to negative sub lethal physiological impacts which may affect the feeding and reproductive biology of the species. Furthermore the study showed that water temperatures and angling times were additional factors that affect the physiological stress of yellowfish in catch and release practices. Finally large individuals were discovered to experience longer angling durations thereby accumulate greatest levels of angling stress within populations. These outcomes show that the mature adults of a population of yellowfishes are relatively vulnerable to angling stress.

To limit the impact of catch and release activities in the Vaal River by fly-fishermen Gerber (2009) proposed the following catch, revive and release guidelines for yellowfish:

- When targeting smallmouth yellowfish a minimum of 5/6 weight fly rods to be used, as well as appropriate line (prevent breaking).

- Barbless hooks are recommended because they are easier to remove and therefore decrease handling times as well as air exposure times.
- Avoid angling during extreme water temperatures – specifically the upper extremes (upwards of 25ºC).
- Fish exhaustion should be prevented by retrieving fish as quickly as possible therefore angling times should be kept under three minutes for the species.

When landing and handling a fish the following should be considered:

- Fish should be landed by hand where possible, if a net is used a soft knotless rubber net should be used as these have been shown to have the least effect on fish when compared to other net types.
- When large fish are being landed a fish cradle should be employed in the landing process (large fish are usually more difficult to land and can cause mechanical damage to themselves when jumping around).
- Minimise air exposure by keeping the fish in the water as much as possible – air exposure have been shown to already have a marked effect.
- Never place your fingers through the gills or in the eyes of the fish.
- The jaws and vertebrae of large fish may be damaged when holding them by the jaw. Hold large fish horizontally and support the body so as not to cause damage to internal organs. Avoid using lip-grips for yellowfish in the Vaal River.
- Use wet hands or wet cloth gloves when handling a fish – to protect the fish's protective outer mucus layer.
- Preferably photograph the fish while it is in the water, if this cannot be done the camera should be ready prior to the fish being landed so that air exposure times can be minimised.
- Remove the hook as quickly as possible, with the fish underwater, and where necessary use long nosed pliers and be sure to keep them at hand.

When reviving the fish it is important to keep the following in mind:

- If current is available keep the fish upright with its head facing into the current.
- When no current is available, the fish should be moved slowly back and forth till gill movements are stable and the fish is able to maintain its balance in the water.
- Let the fish swim away when it starts to show increased activity (struggle).

There is a risk of negatively impacting yellowfish populations thorough catch and release activities. however, this approach is considered to be an ecologically friendly alternative to catch and kill practices as the vast majority of released individuals survive and re-establish natural behavioural activities within a few days of being captured. Thus the ecological, social and economic benefits associated with the maintenance of a yellowfish dependent, catch and release angling industry, in the Vaal River, is considered to out-weigh the risk of negative impacts on the populations by catch and release activities. Management actions that include the establishment of sound catch, revive and release guidelines such as those proposed here, should be adopted by the angling industry as a priority to minimise the risk of these activities in the Vaal River.

7.3. SIMPLIFIED REGIONAL SCALE RISK ASSESSMENT OF THE THREATS LARGEMOUTH YELLOWFISH IN THE VAAL RIVER.

In an attempt to address another recommendation made by Brand et al. 2009, a simplified regional scale, ecological risk assessment of threats to the sustainability of the Largemouth yellowfish populations in the Vaal River has been carried out. This section of the study presents the approach adopted and the outcomes of the simplified regional scale risk assessment approach, proposed by Landis and Wiegers (1997) for Largemouth yellowfish in the Vaal River.

7.3.1. Introduction

Risk assessments involve the allocation of magnitudes and probabilities to the adverse effects of anthropogenic activities or natural catastrophes referred to as hazards (Suter, 1993). The existence of a hazard and the related uncertainty of the hazards effects, result in the formulation of risk. Risk is the probability or likelihood of a prescribed undesired effect occurring and impacting an environment (Suter 1993). Ecological Risk Assessment therefore is the process that evaluates the likelihood that adverse effects may occur or are occurring as a result of exposure to one or more stressors (Suter 2001). As a result, it is concerned with the causal relationship between stressors and effects and deals with the consequences of alternative decisions. A Regional Scale Risk Assessment is a form of ecological risk assessment that is carried out on a spatial scale that considers multiple sources of multiple stressors affecting multiple endpoints where allowance is made for the characteristics of the landscape that may affect the risk estimate (Landis, 2005). A Landis and Wiegers (1997) developed a Regional Scale Risk Assessment method using the Relative Risk Model (RRM) which may be carried out to assess the risk posed by one stressor of concern to one endpoint, at a regional scale, or multiple stressors acting upon a range of assessment endpoints can be considered within the RRM framework (Landis and Wiegers 1997). In this study a Regional Scale Risk Assessment suing the RRM has been carried out with ecological endpoints that are based on the sustainability of Largemouth populations and use of these populations by anglers in the Vaal River.

7.3.2. Materials and methods

The approach adopted in the study is based on the relative risk model approach presented by Landis (2005). The presentation of this regional scale risk assessment approach is based on the five phases of the ecological risk assessment framework as done by Obery and Landis (2002). This approach included the ranking of identified source and stressor combinations and habitats for subareas of the study area named risk regions (RRs). The study evaluates the potential for ecological impacts to occur or risks to (1) each risk region, (2) by stressors, (3) to habitats defined habitats. Risks were based on the analysed interactions between identified sources, calculated stressors and chosen habitats. The structure of the materials and methods is based on four of the five established parts of an ecological risk assessment namely the problem formulation, exposure assessment, effects assessment and risk characterisation (USEPA, 1998). In this simplified relative risk assessment the ten step framework of the RRM (Landis and Wiegers 1997) was followed.

Problem formulation

Any regional scale risk assessment is designed to address defined management issues of an area by establishing unique endpoints for the study that addresses these issues. This study has been designed to carry out an assessment of the multiple sources or activities that operate within the Vaal River catchment and their associated stressor combinations that affect the health of the Vaal River. These source-stressors combinations are assessed in relation to habitats and ecological endpoints associated with the conservation and use of Largemouth yellowfish in the

Vaal River. The outcomes of the assessment include the total risk of current impacts to selected endpoints per RR, where the dynamics of the ecosystem structure and function, as well as the known biology and ecology of the Largemouth yellowfish are considered. Apart from the current risk of activities to endpoints, the outcomes of the RRM allow for the evaluation of alternative scenarios. In this study, three alterative risk scenarios are presented including:

- The risk of known activities during the early 1900s to the selected endpoints of the study in the Vaal River prior to the establishment of large dams or inter-basin water transfer schemes.
- the consequences of increased use of the goods and services of the upper Vaal River ecosystem by the mining sector (alterative scenario 1), and
- The consequences of some mitigated impacts that are currently affecting the health of the Vaal River.

Study area

The study area includes the distribution of the Largemouth yellowfish in the Vaal River system, as indicated in Figure. Nine RRs were selected for this study according to differences in habitat types, local ecosystem use activities, Largemouth yellowfish population boundaries and management unit boundaries of the OVYCMA.

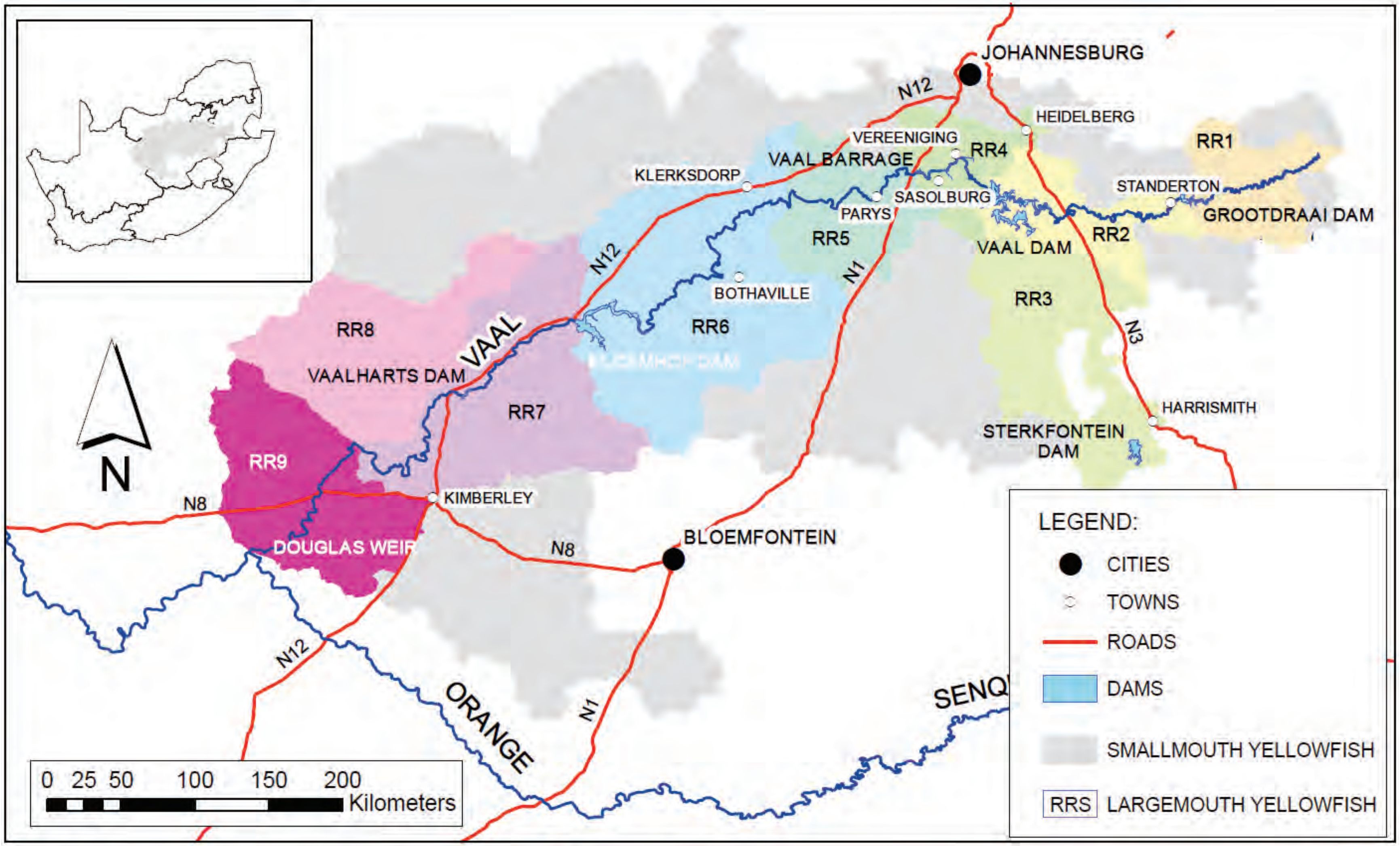

Figure 39: The portions of the Vaal River catchment considered in this relative risk assessment. Established risk regions (1-9) are portions of the distribution of the Largemouth yellowfish (*Labeobarbus kimberleyensis*) in the Vaal Catchment.

Ecological assessment endpoints

In a relative risk assessment the ecological endpoints include any management goals, objectives or targets selected to address identified management issues in the study (Landis, 2005). Ecological endpoints include explicit expressions of the environmental value that is to be protected, operationally defined by and ecological entity and its attributes. (USEPA 1998). In this study four ecological endpoints have been selected including:

- Maintain healthy populations of Largemouth yellowfish: this endpoint includes the requirement for suitable abundances of Largemouth yellowfish to be maintained in the populations, and includes requirements for abundances of different size classes required for population stability.
- Ensure good, regular recruitment of individuals into the population: this endpoint includes the requirement for regular (within every three years), successful spawning events and associated recruitment of spawned juveniles into the populations to ensure population sustainability.
- Maintain physiologically healthy individuals: this endpoint includes the requirement for individuals within populations to be in an acceptably good physiological state of health required to survive and reproduce successfully to maintain population viability.
- Support the angling industry: this user endpoint has been included in the study according to the importance of maintaining this industry for local social and economic upliftment of local communities, and due to the value of the conservation efforts associated with this activity for the maintenance of the species. Similar to the other endpoints, this one is concerned with the maintenance of healthy viable yellowfish populations, which the angling industry is dependent on.

Habitat identification

In a regional scale risk assessment, the habitat refers to the location where the receptor or group of receptors of the stressors assessed in the RRM lives. They are the physical ecosystem component/s that integrate the effects of stressors impacting on the system (Landis, 2005). In order to allow for the assessment of the endpoints selected in this study three habitats have been identified including:

- Spawning locations and habitat for early development: these habitats include the habitats believed to be required for spawning by adults and include stimulation flows required by the yellowfish for final conditions procedures.
- Feeding and growth habitats: these habitats include the habitats determined in the biotelemetry study to be preferred by largemouth yellowfish and include seasonal changes in these preferences.
- Over winter refuge area: this habitat includes the deep pools and associated glides or related habitats required by the largemouth to over winter.

Source and associated stressor identification

In this study a source is referred to as an entity, action or activity that releases to the environment or imposes on the environment a chemical, physical, or biological stressor or stressors (USEPA 1998). A stressor on the other hand is physical, chemical or biological entity that can induce an adverse response to the structure and function of an ecosystem (USEPA 1998). In this study five types of broad types of sources and four types of stressors were considered. These source and stressor variables and the relations between them in this study are based on a similar source-stressor relationship assessment included in a recent, more detailed regional scale risk assessment of a part of the Vaal River (Figure, DWA, 2010).

Conceptual site model

The conceptual model presented schematically in Figure. The conceptual model delineates the potential relationships between sources, stressors, habitat and endpoints that will be used in the assessment of each risk region (Landis, 2005). A well constructed and informative conceptual model acts as an extension of the basic framework for the RRM with sources providing stressors into particular habitats.

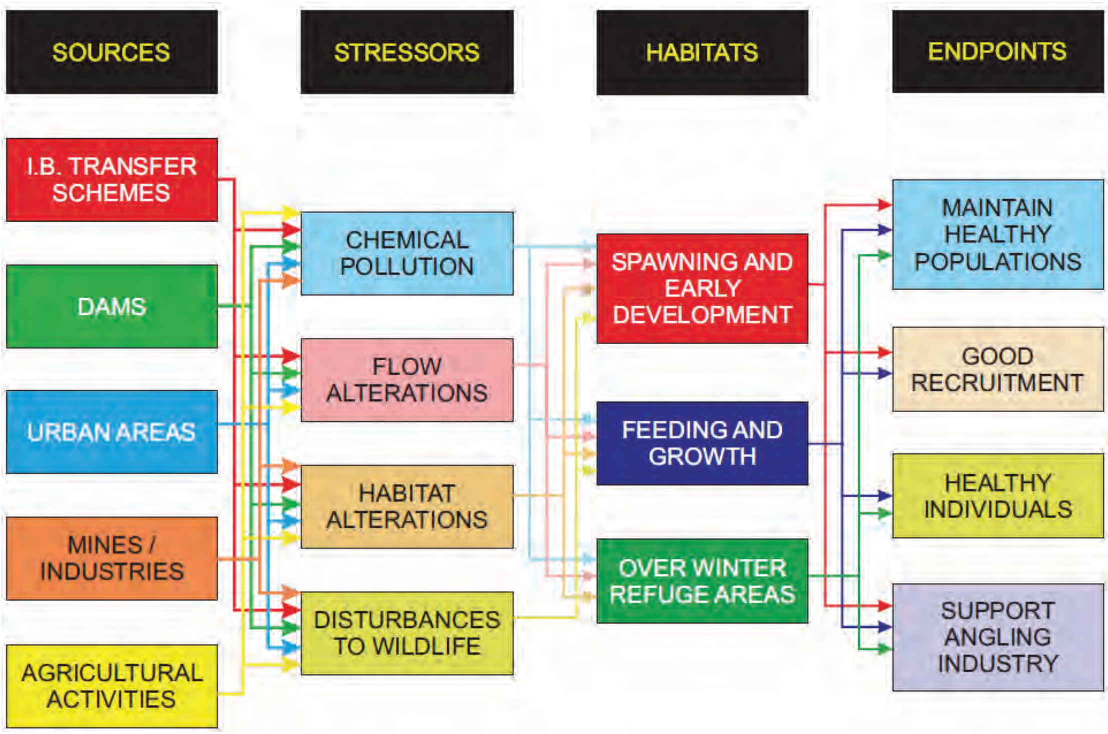

Figure 40: Schematic diagram of the sources, stressors, habitats and endpoints considered in the study and the relationships between the components.

Ranking system

This step involves the establishment of a ranking system that allows for the calculations of relative risks to each assessment endpoint. The initial process involves the establishment of a ranking scheme for each source, stressor and habitat that then in turn contributes to the establishment of the relative risks to each assessment endpoint (Landis, 2005). In this step data are converted into non-dimensional ranks so that effects of the various stressors to the various endpoints can be measured and compared (Landis, 2005). In the establishment of a ranking scheme for each source, stressor and habitat, each source/stressor and habitat is ranked between sub areas so as to indicate whether the diversity/abundance or intensity of the variable it is high, moderate or low within the context of the region. Ranks are assigned using criteria that is specific to the study region and are generally assigned according to the size and frequency of the sources and the availability of habitat. Through the traditional RRM approach, ranks are assigned on a two point scale from 0 to 6, where 0 indicates no habitat or source and 6 indicates the greatest amount (Landis, 2005). The criteria for each non-dimensional ranking system should be chosen according to the type and amount of information concerning the variable. In this part of the assessment a weight of evidence approach is suggested to be implemented (Hall et al., 2000; Smith et al., 2002). In some instances where adequate concentration, response and fate of stressor data are available to assign ranks to an identified source, this information must be used to establish the criteria for the ranking system (Landis, 2005). The criteria used to assign ranks to the stressors and habitats of each risk region considered in the study is presented in Table 9 and Table 10.

Table 9: Ranking criteria for the assignment of ranks to the stressors considered within each risk region in the study.

Chemical pollution ranks:		
	High (Rank = 6)	Numerous large urban areas or Gauteng Many noticible mines/industrial activities
	Moderate (Rank = 4)	Many noticible large agricultural activities Other urban areas Some mines/industrial activities
	Low (Rank = 2)	Some agricultural activities Any inter-basin transfer schemes Any dams affecting flows upstream
	None (Rank = 0)	None of the above
Flow alteration ranks:		
	High (Rank = 6)	Downstream of Lesotho inter-basin transfer scheme Downstream of major dams
	Moderate (Rank = 4)	Downstream of other inter-basin transfer scheme. Downstream of Gauteng Downstream of large agricultural areas
	Low (Rank = 2)	Downstream of other urban areas Downstream of major mines/industries Downstream of any agricultural areas
	None (Rank = 0)	None of the above
Habitat alteration ranks:		
	High (Rank = 6)	More than 50% of RR inundated by large dams
	Moderate (Rank = 4)	Many large urban areas Dams occur within RR Large agricultural activities dominate banks Other urban areas Below inter-basin transfer schemes
	Low (Rank = 2)	Mines and industries Other agricultural activities
	None (Rank = 0)	None of the above
Disturbances to wildlife		
	Moderate (Rank = 4)	Many large urban areas
	Low (Rank = 2)	Large dam occur within RR Any inter-basin transfer scheme Other urban areas Agricultural activities Mines and industries Other dams occur within RR
	None (Rank = 0)	None of the above

Table 10: Ranking criteria for the assignment of ranks to the habitats considered within each risk region in the study.

Spawning and early development		
	High (Rank = 6)	Ideal habitat for successful recruitment
	Moderate (Rank = 4)	Some habitat for successful recruitment
	Low (Rank = 2)	Poor habitat for successful recruitment
Feeding and growth		
	High	Good habitat diversities high productivity
	Moderate (Rank = 4)	Good habitat diversities low productivity
	Low (Rank = 2)	Limited habitat diversities
Over winter & refuge areas		
	High (Rank = 4)	Many deep areas / dams
	Low (Rank = 2)	Limited deep areas / dams

Risk characterisation

In this relative risk assessment the source-stressors combination that may result in impacting activities within each risk region are compared to the habitats, to establish whether the chance of occurring impacts are greater in one risk region or another. In this study the risk ranks or comparative risk estimates are used to identify the locations where the greatest probability of impacts to selected endpoints occur. Comparative risk estimates are based on the following assumptions (Landis and Wiegers 1997, Wiegers et al. 1998, Obery and Landis 2002, Landis 2005):

1. The greater the relative distribution of a source-stressor combination in a risk region area, the greater the potential for exposure to habitats in that risk region.
2. Source/stressor combinations are limited to those with the greatest potential for adverse impacts.
3. For an endpoint to be adversely impacted a complete exposure pathway from source to habitat must be established.
4. Multiple stressors that impact on assessment endpoints are additive in their relative ranks. This assumption was made out of convenience and lack of knowledge and literature.
5. Surrogate data applied in place of actual stressor measurement and habitat monitoring data are representative of site conditions.

Risk characterisations were used to rank complete exposure pathways established in the conceptual site model to the endpoints selected for each risk region. Relative ecological ranks were summarised by the (1) sum of the relative ranks per stressor, (2) sum of relative ranks per habitat, (3) sum of relative risk per endpoint , and (4) relative risks per risk area,

Final risk scores (RS) are calculated for each subarea by multiplying the ranks by the appropriate weighting factor as indicated in the following equation (Equation 1):

$$RS = Sij \times Hij \times Wjk \qquad \text{(Equation 1)}$$

Where:
i = the subarea series (Region 1,2,3, etc.),
j = the source series (discharge…, shoreline activity),
k = the habitat series (mudflat…, stream mouth),
Sij = rank chosen for sources between subareas,
Hik = rank chosen for habitats between subareas,
Wjk = weighting factor established by the exposure or effect filter.

The result is a matrix of risk scores related to the relative exposure or effects associated with the source and habitat in each subarea. The potential risk resulting from a specific source (Equation 2) and occurring within a specific habitat (Equation 3) can be summarised for each subarea by adding the related scores,

$$RS_{source} = \sum(Sij \times Hik \times Wjk) \text{ for } j = 1 \text{ to } n, \qquad \text{(Equation 2)}$$
$$RS_{habitat} = \sum(Sij \times Hik \times Wjk) \text{ for } k = 1 \text{ to } n. \qquad \text{(Equation 3)}$$

7.3.3. Results and discussion

Sum of the relative ranks per stressor

The total relative risk obtained in the study from each stressor to the selected endpoints is presented in Figure 41**Error! Reference source not found.**. The outcomes show that the chemical pollution, flow alteration and habitat alteration related stressors were determined to pose high risks of probable impacts to the endpoints of the study. Of these three groups of stressors the water physico-chemical group named the chemical pollution group was determined to pose the largest threat to the viability of the Largemouth yellowfishes. Thereafter the flow altering and finally, habitat altering stressors are all shown to cause risks to the viability of the Largemouth yellowfish. Only the disturbances to wildlife related stressors which include recreational angling activities were shown to result in low to moderate risks.

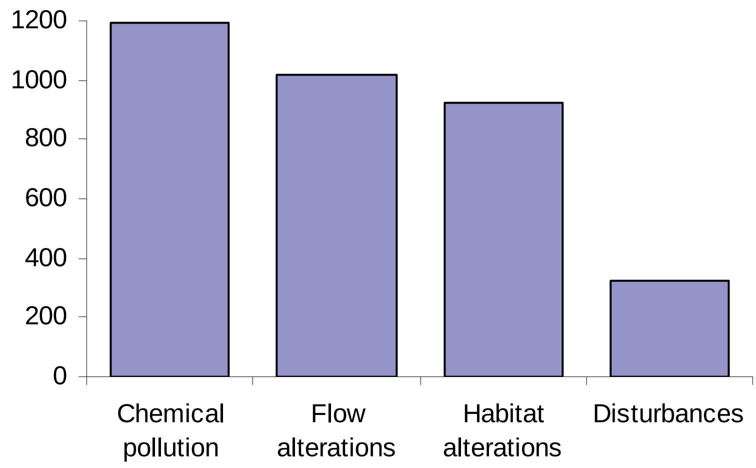

Figure 41: Total risk of stressor groups to the established ecological endpoints in the study.

Sum of relative ranks per habitat

Figure 42 presents the relative risks of potential threats to the habitat selected in the study. These finding show that moderate to high risks to the feeding and refugia habitats occur with very high risk of threats by source-stressor combinations, to the spawning habitats of the Largemouth yellowfish.

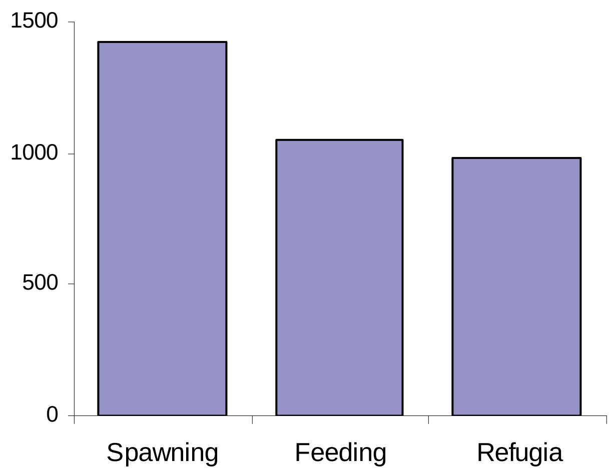

Figure 42: Total risk to habitat groups from source-stressor combinations in relation to the established ecological endpoints in the study.

Sum of relative risk per endpoint

Figure 43 presents the total relative risk of impacts to the selected endpoints of the study. Findings indicate that high risks of impacts to the recruitment endpoint and population state or health endpoint were observed. Low to moderate risks of individual health impacts and threats to the angling industry were obtained. These outcomes show that the recruitment of the yellowfish into populations and the state of the populations are sensitive to and are most likely currently being affected by the source-stressor combinations considered in the study. Furthermore these outcomes show that the Largemouth yellowfish population states and the recruitment of juvenile yellowfish into populations should be selected as indicators of the well being of the populations in the Vaal River and be monitored. Currently the presence/absence and health of individual Largemouth yellowfish alone are being carried out regularly. Findings of this study show that if the e presence/absence and health of individual Largemouth yellowfish monitoring approaches continue, without any considerations of the population state and recruitment. The viability of the Largemouth yellowfish populations in the Vaal River may exceed a critical threshold and not be recoverable by the time negative impacts associated with presence/absence and health of the individuals are observed. Finally, the outcomes show that there are low to moderate risks to the sustainability of the angling industry. Although low a management plan to manage risks to this industry should be established.

Figure 43: Total risk to established endpoints in the study from source-stressor combinations considered in the study.

The relative risks per risk region

Figure 35 presents the relative risks of impacts from the source-stressor combinations in the defined habitats to selected ecological endpoints per RR.

Findings show that the Largemouth yellowfish populations are exposed to a wide range of risks including low to high risks of impacts. In the upper reaches of the catchments (RR1-RR3) current risks to the viability of the populations are low. The level of risk then increased noticeably to the high levels in RR4 and then reduces slightly to moderate levels from RR5 to RR7 and RR9. The levels of risks to the viability of the Largemouth yellowfish populations in RR8 were low. These findings indicate that the state of the yellowfish populations in RR1 to RR3 and RR8 should be in a relatively healthy state with all ecological endpoint requirements being intact. In RR5 to RR7 and in RR9 the state of the yellowfish populations should be moderately impaired, with probable disruptions to the population structures and recruitment of new individuals into areas, in particular. In RR4 where high risks of impacts to the Largemouth yellowfish populations are postulated, the current population state should be impaired. In this RR, noticeable disruptions to the population structures should occur and very little, if any, recruitment of new individuals into the population should occur. Finally, in this region the angling industry and the health of individual yellowfish should also be impaired.

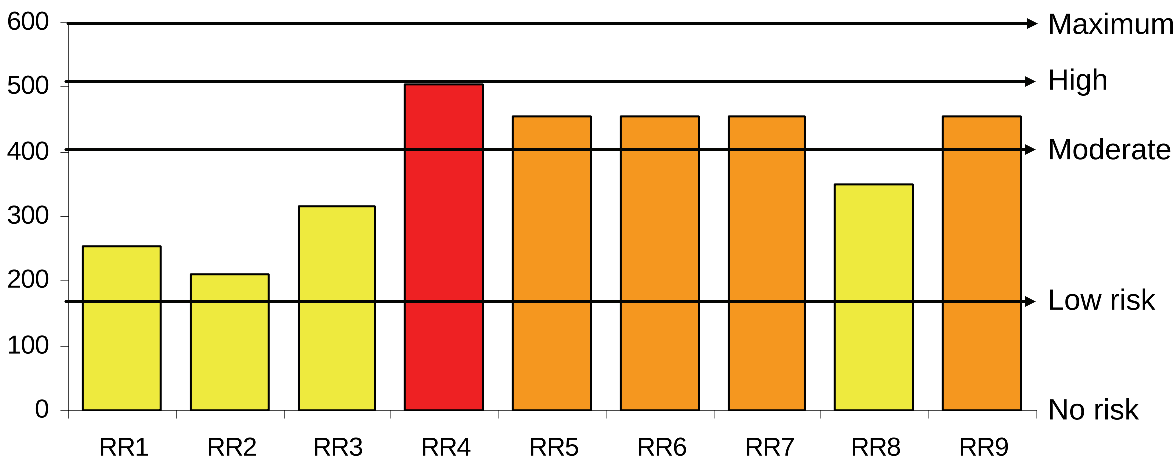

Figure 35: Graphical representation of the current total risks to each risk region considered in the study.

Scenario assessments

Because this relative risk assessment is based on a model of source-stressor combinations in relation to defined habitats and selected ecological endpoints for Largemouth yellowfish population viability in the Vaal River, the mode can be used to evaluate a range of risk scenarios. Risk scenarios are obtained by altering the ranks and filter variables of the model. The ranks and filter relationships are changed to reflect the conditions of the source-stressor combinations and habitat states in the study area for each of the chosen scenarios.   In this study three risk scenarios, in addition to the current risk state assessment have been undertaken. These scenarios include:

- Scenario 1: risks to the endpoints of the study during the early 1900s prior to the development of large dams and interbrain transfer schemes on the Vaal River. In this scenario the severity of the chemical pollution and habitat modifications in RR4 in particular were considered to be lower than current conditions but still important.
- Scenario 2: risk to endpoints of the study if legislated environmental management requirements are implemented in the study area. These requirements include establishment of and implementation of flow, habitat chemical pollution management plans for the Vaal River.
- Scenario 3: risks to endpoints of the study if legislated environmental management requirements are continually not implemented and the use of the resources of the Vaal River continue to increase. In particular, this scenario considers the implications associated with the establishment of open cast coal mines in the upper part of the Vaal River catchment.

Figure 45**Error! Reference source not found.** presents the total relative risks per RR for all of the four scenarios considered in the study including the current risk scenarios (Figure 45A) and risk scenarios 1-3 (Figure 45B, C and D, respectively). The scenario assessment shows that from the early 1900 the viability state of the largemouth yellowfish has reduced considerably, in accordance to other observations resulting in the establishment of the conservation status of the species. Currently, the population is exposed to numerous threats of chemical pollution, flow alterations and habitat alteration stressors in RR 4 in particular and also in RR5 to RR7 and RR8. These findings suggest that the Largemouth yellowfish population in RR4 is not sustainable and that although the population in RR5 to RR7 and in RR8 may be sustainable they are vulnerable to impacts associated with the use of the resources of the Vaal River. In considerations of Scenarios 2 and 3 (C and D), if existing legislated ecosystem management requirements are implemented in the Vaal River catchment water quality, flow and habitat management plans would need to be implemented. Based on this possibility the ranks of stressors would be reduced to low or moderate resulting in a noticeable reduction in the threat to the lower part of the catchment in particular. At this point the sustainability of populations would increase and the threat to the species would reduce possibly allowing for the removal of the conservation status of the species. If however the current *status quo* is maintained and the development of the resource us of the Vaal River is continued the existing risk of threats to the populations would continue to increase. This scenario includes the currently proposed increase in mining activities in the Upper Vaal River catchment which would result in noticeable increases to the ranks of the chemical pollution and habitat stressors in particular of RR1 and RR2. In Figure 45D the modelled changes in final risks of impacts to the Largemouth yellowfish populations to all RRs is presented. These findings show that if the development of the resource use of the system continues without the establishment of management plans the increased levels of risks to the Largemouth yellowfish may render more population unsustainable and warrant an increase in the current conservation status of the species in the Vaal River.

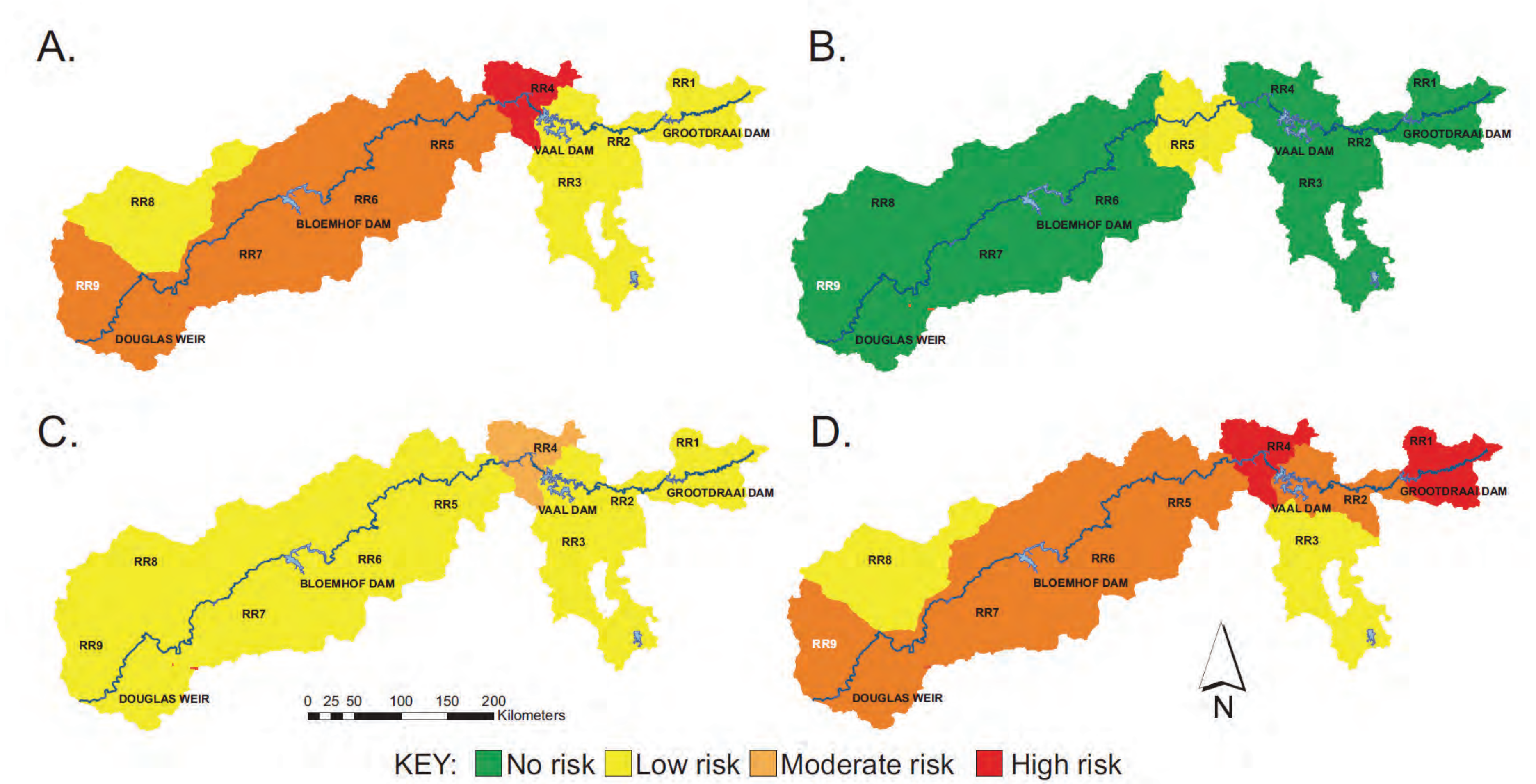

Figure 45: Spatial representation of the total risks to each risk region considered in the study. Maps of current risks (A), historical risks prior to the development of the Vaal River (Scenario 1, B), possible attainable risks if sound management plans are adopted (Scenario 2, C) and realistic future risks (Scenario 3, D) if the development of the system continues without management intervention, to each risk region considered.

7.3.4. Conclusions

This study shows that the value of carrying out relative risk assessments to evaluate the risks of source-stressor combinations to species specific ecological endpoints is high. This approach allowed for evaluation of the nature, magnitude and location of potential threats or impacts to the viability of the Largemouth Yellowfish populations in the Vaal River, according to the known biology and ecology of the species in relation to the dynamics of the ecosystem structure and function.

Outcomes of this study show that the risk of impacts to the viability of the Largemouth yellowfish populations in the Vaal River, below the Vaal Dam, in the vicinity of the Vaal Barrage is high (RR4), and moderate in the rest of the downstream RRs from RR5 to RR8. These outcomes show that excessive use of the Vaal River in the form of sources that result in chemical pollution, flow alteration and habitat alteration stressors, in particular, are high. Furthermore the Largemouth yellowfish population structures and the recruitment of new individuals into the populations are sensitive to these stressors. Habitats associated with these endpoints that are sensitive include spawning areas in particular. The threats to the angling industry were determined to generally be low, suggesting that the industry is still large and has the potential for more growth. In relation to risk outcomes, the impaired state of some Largemouth yellowfish populations may be affecting the angling industry in some areas. After considerations of the total risks to risk regions the study shows that RR1, RR2 and RR8 may be possible refugia areas for Vaal River Largemouth yellowfishes as the outcomes of this study showed that risks to the viability of the species in these areas are still low. Conservation actions for Largemouth yellowfish populations in the Vaal River should be prioritised in these areas. Finally, this study showed that if the management plans, that are required by current legislation, which allow for the establishment of sustainable balances between the use and protection of river ecosystems, are continually not established and the use of the resources of the system continues, the future viability of Largemouth yellowfish in the Vaal River is uncertain. If these management plans are developed and implemented the populations should become sustainable possibly allowing for the reduction in the current protected status of this species.

8. CLOSING REMARKS AND RECOMMENDATIONS

8.1. CLOSING REMARKS

This study presents a broad review of the known biology and ecology of the Vaal yellowfishes, including dedicated sections on species identification, taxonomy and notes on the evolutionary and phylogenetic development of the species, as well as the taxonomic history of the yellowfishes. The study then addresses the approaches adopted and the outcomes of three complementary reproduction, early development and growth studies of the Vaal River yellowfishes. These studies included assessments of the artificial reproduction, early development of and age validation of larval and juvenile Vaal River yellowfish. This includes the first documented findings of any formal early development and growth study of a yellowfish in southern Africa. The early development study has allowed for the characterisation of numerous developmental stages that yellowfish undergo which will contribute towards the life-cycle biology and conservation of these species. The work also presents some evidence of new ecological requirements and previously unknown behavioural features of yellowfish in the Vaal River. Finally, the study shows that distinct morphological features of the larvae and juveniles of each species occur. These features can be used to identify wild larvae and juvenile yellowfish. The age validation study showed that both species deposit daily growth rings that can be counted to accurately determine the age of wild caught yellowfish. This can be used to evaluate the importance of the volume, timing and durations of natural flows and other related ecosystem conditions, to ensure that good recruitment of yellowfish into the Vaal River occurs.

The next section of the report presents the outcomes of the first ecological behavioural assessment, carried out on Vaal River yellowfish using biotelemetry methods. This section details previously unknown behavioural biology and ecology features of the Vaal River yellowfishes. Specific findings include features of the daily, seasonal and annual movements, home ranges, habitat use, migrations and possible territoriality behaviour of Vaal River yellowfishes. In this part of the study, a database of information has been generated that can be used in the future to evaluate the consequences of changing environmental conditions in the Vaal River.

The study is completed with an assessment of components of the conservation and management of Vaal River yellowfishes. This includes a review of a socio-economic value assessment of Yellowfish in the Vaal River, and a study to addresses the possible impacts of angling on yellowfish populations in the Vaal River. This information, along with the historically known biology and ecology of the Vaal River yellowfishes and new information generated in this study was used to carry out a simplified regional scale risk assessment of the threats to Largemouth yellowfish in the Vaal River. This risk assessment shows that the excessive current use of the resources of the Vaal River is threatening the continued viability of these species. In addition, if management plans are not developed and implemented to balance between the use and protection of the resources of the Vaal River, there is a high probability that the conservation status of the Largemouth yellowfish will increase to endangered status.

This study has successfully developed our understanding of these three areas of the biology and ecology of the Vaal River yellowfishes, and demonstrates the value of this information in the conservation and management fishes in southern Africa.

8.2. RECOMMENDATIONS

In consideration of the outcomes of this study the following recommendations are made:

- The reproduction experiments showed that both of the Vaal River yellowfishes can relatively easily be cultured under artificial conditions. Outcomes show however that it is difficult to condition Largemouth Yellowfish in artificial environments. We recommend that a monitoring exercise be carried out in an artificial environment where the conditioning process and behavioural changes of both Largemouth and Smallmouth yellowfishes can be assessed.
- The study shows that distinct morphological features of the larvae and juvenile yellowfish from a set of adult broodstock of each species occur. If consistent, these features can be used to identify wild larvae and juvenile yellowfish. We recommend that an evaluation study be carried out to confirm that these morphological features are consistent and can be used to identify wild yellowfish in the Vaal River.

- The role that that flow plays in the recruitment of *L. aeneus* and *L. kimberleyensis* in the Vaal River is not well understood, but there is evidence that both species depend on optimal flow and temperature conditions for successful reproduction. Following from this study, which is an important preliminary step to aging wild-caught larval *L. aeneus* and *L. kimberleyensis,* a dedicated study that addresses the recruitment of yellowfishes into the Vaal River should be carried out.
- The behavioural monitoring study showed that biotelemetry methods can effectively be implemented to monitor the behaviour of yellowfishes in riverine ecosystems in South Africa. The study produced a range of new behavioural biology and ecology features of both of the Vaal River yellowfishes. Although valuable allot of behavioural events are still unexplainable. We recommend that the biotelemetry monitoring work on yellowfish in the Vaal River be continued, and expanded on into the Orange System and lentic ecosystems in the catchment.
- The outcomes of the simplified regional scale risk assessment show that some of the Largemouth yellowfish populations in the Vaal River may currently be unsustainable. In addition, this assessment suggests that the population structures and recruitment of juveniles into populations can be good indicators of the health of populations. In accordance, we recommend that an assessment of the Largemouth yellowfish population structures and recruitment of juvenile yellowfish into the populations should be carried out.

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10. REFERENCES

ALLANSON BR and JACKSON PBN (1983). Limnology and fisheries potential of Lake le Roux. *South African Scientific Programmes Report No. 77*. CSIR, Pretoria. 182 pp.

BALON EK (1971). The intervals of early fish development and their terminology. *Vestnik Ceskoslovenske Spolecnosti Zoologicke.* **35**, 1-8.

BALON EK (1979). The theory of saltation and its application in the ontogeny of fishes: Steps and thresholds. *Environmental Biology of Fishes.* **4**, 97-101.

BARLOW GW (1993) Fish behavioural ecology: pros, cons and opportunities. In: Behavioural ecology of fishes (eds. FA Huntingford and P Torricelli), Harwood Academic Publ., Reading. pp. 1-5.

BEAMISH RJ and MCFARLANE GA (1983). The forgotten requirement for age validation in fisheries biology. *Trans. Am. Fish. Soc.* **112** (6) 735-743.

BEAMISH FWH (1978) Swimming capacity. In: Fish physiology, Vol 7 (eds. WS Hoar and DJ Randall). Academic press, New York. pp. 101-187.

BERREBI P, KOTTELAT M, SKELTON PH AND RÁB P (1996). Systematics of *Barbus*: State of the art and heuristic comments. *Folia Zoologica,* **45,** 5-12.

BESTGEN KR and BUNDY JM (1998). Environmental factors affect daily increment deposition and otolith growth in young Colorado squawfish. *Trans. Am. Fish. Soc.* **127** (1) 105-117.

BLOOMER P and NARAN D (2007). Identification of conservation units of two yellowfish species: *Labeobarbus kimberleyensis* and *Labeobarbus aeneus. Unpublished report (Pilot Study 2002-2003*).

BLOOMER P, BILLS IR, VAN DER BANK FH, VILLET MH, JONES N and WALSH G (2007). Multidisciplinary investigation of differences and potential hybridization between two yellowfish species *Labeobarbus kimberleyensis* and *L. aeneus* from the Orange-Vaal system. *Follow-up study 2004-2007*. Yellowfish Working Group Report, Federation of Southern African Flyfishers, Johannesburg.

BOK AH (1992). Report: Induced spawning of Clanwilliam yellowfish using Aquaspawn. *Internal Report, Cape Nature conservation*. pp. 5.

BOK AH and IMMELMAN PP (1998) Natural and induced spawning of the whitefish, *Barbus andrewi*. *S. Afr J. Res.* **19**(1):1-3.

BOOTH AJ, MERRON GS and BUXTON CD (1995). The growth of *Oreochromis andersonii* (Pisces: Cichlidae) from the Okavango Delta, Botswana, and a comparison of the scale and otolith methods of ageing. *Environ. Biol. Fishes* **43** (2) 171-178.

BRAND M, MAINA J, MANDER M and O'BRIEN G (2009). Characterisation of the social and economic value of the use and associated conservation of the yellowfishes in the Vaal River. *WRC report KV 226/09*. Water Research Commission. Pretoria.

BRAUNE E and ROGERS KH (1987). The Vaal River catchment: Problems and research needs. A report of the committee for inland water ecosystems national programme for ecosystems research. *South African National Scientific Programmes Report No. 143*.

BRITTON JR, COWX IG, AXFORD SN and FREAR PA (2004). An overview of recruitment patterns of roach *Rutilus rutilus* (L.) between 1969 and 2001 in the rivers of England and their influence on population abundance. *Int. J. Ecohydrology Hydrobiol.* **4** (2) 91-102.

BROWN JL (1964). The evolution of diversity in avian territorial systems. . *Willson Bull*. 76, 160-169.

CAMBRAY JA (1983). Early development and larval behaviour of a minnow, *Barbus anoplus* (Pisces: Cyprinidae). *S. Afr. J. Zool.* **18** (4) 331-336.

CAMBRAY JA (1990). Early ontogeny and notes on breeding behaviour, habitat preference and conservation of the Cape kurper, *Sandelia capensis* (Pisces: Anabantidae). *Annals of the Cape Provincial Museums* **18** (8) 159-182.

CAMBRAY JA and JUBB RA (1977a). Dispersal of fishes via the Orange-Fish tunnel, South Africa. *Journal of the Limnological Society of Southern Africa*, **3,** 33-35.

CAMBRAY JA and JUBB RA (1977b). The Orange-Fish tunnel. *Piscator*, **99**, 4-6

CAMBRAY JA and MEYER K (1988). Early ontogeny of an endangered, relict, cold-water cyprinid from Lesotho, *Oreodaimon quathlambae* (Barnard, 1938). *Revue d'Hydrobiologie Tropicale* (France).

CAMBRAY JA, KING JM and BRUWER C (1997). Spawning behaviour and early development of the Clanwilliam yellowfish (*Barbus capensis*; Cyprinidae), linked to experimental dam releases in the Olifants River, South Africa. *Regul. Rivers: Res. Manage*. **13** (6) 579-602.

CAMBRAY JA, DAVIES BR and ASHTON PJ (1986). The Orange-Vaal River system. In: Davies BR and Walker KF. The Ecology of River Systems. Dr. W. Junk Publishers, Dordrecht. The Netherlands. pp 88-122.

CAMPANA SE (2001). Accuracy, precision and quality control in age determination, including a review of the use and abuse of age validation methods. *J. Fish Biol.* **59** (2) 197-242.

CHILDS AR, COWLEY PD, NÆSJE TF, BOOTH AJ, POTTS WM, THORSTAD EB and ØKLAND F (2008). Estuarine use by spotted grunter *Pomadasys commersonnii* in a South African estuary, as determined by acoustic telemetry. *African Journal of Marine Science*. **30** (1) 123-132.

CHOAT JH, KRITZER JP and ACKERMAN JL (2009). Ageing in Coral Reef Fishes: Do we need to validate the periodicity of increment formation for every species of fish for which we collect age-based demographic data? In: Green BS, Mapstone BD, Carlos G and Begg GA (eds) Tropical Fish Otoliths: Information for Assessment, Management and Ecology. Vol. 11. Springer Netherlands. 23-54.

COWLEY PD, KERWATH SE, CHILDS AR, THORSTAD EB, ØKLAND F and NÆSJE TF (2008). Estuarine habitat use by juvenile dusky kob *Argyrosomus japonicus* (Sciaenidae), with implications for management. *African Journal of Marine Science.* **30** (2) 247-253.

CUSHING DH (1990). Plankton production and year-class strength in fish populations: an update of the match/mismatch hypothesis. *Adv. Mar. Biol.* **26** 249-293.

Davies BR and Day J (1998). Vanishing Waters. University of Cape town Press. University of Cape Town.

DE MOOR IJ and BRUTON MN (1988). Atlas of alien and translocated indigenous aquatic animals in southern Africa. A report of the Committee for Nature Conservation Research National Programme for Ecosystem Research. *South African Scientific Programmes Report No. 144*. Port Elizabeth, South Africa. pp. 310.

DE VILLIERS P and ELLENDER B (2008a). Status of the Orange-Vaal smallmouth yellowfish, *Labeobarbus aeneus* (Burchell, 1822). In: Impson ND, Bills IR, Wolhuter L. Technical Report on the State of Yellowfishes in South Africa. *WRC Technical Report No. KV 212/08*. Water Research Commission. Pretoria. ISBN: 978-1-77005-719-7. pp: 76-91.

DE VILLIERS P and ELLENDER B (2008b). Status of the Orange-Vaal largemouth yellowfish, *Labeobarbus kimberleyensis* (Gilchrist & Thompson, 1913). In: Impson ND, Bills IR, Wolhuter L. Technical Report on the State of Yellowfishes in South Africa. *WRC Technical Report No. KV 212/08*. Water Research Commission. Pretoria. ISBN: 978-1-77005-719-7. pp: 92-102.

DEPARTMENT OF ENVIRONMENTAL AFFAIRS AND TOURISM (DEAT, 2007). National Environmental Managemental Biodiversity Act, 2004 (Act 10 of 2004): Publication of lists of critically endangered, Endangered, Vulnerable and Protected species. *Government Gazette No. 29657 No.R 151.* Republic of South Africa.

DODSON JJ (1997). Fish migration and evolutionary perspective. In: Behavioural Ecology of Teleost Fishes. Godin JJ (ed). Oxford University Press. Oxford. pp 10-32.

DUNN JE and GIPSON PS (1977). Analysis of radio telemetry data in studies of home range. *Biometrics* **33**. 85-101.

DURHAM BW and WILDE GR (2005). Relationship between hatch date and first-summer growth of five species of prairie-stream cyprinids. *Environ. Biol. Fishes* **72** (1) 45-54.

DEPARTMENT OF WATER AFFAIRS (DWA, 2010). River Health Assessment on the Vaal River: Downstream of the Rietspruit and Vaal River confluence to the Erina Spa Bridge and Vaal River Crossing. DWA Project WP9672. Carried out by Jeffares and Green (Pty) Ltd. and the University of Johannesburg on behalf of the Department of Water Affairs, Sasol and Rand Water.

ELLENDER BR (2008). The impact of angling on Smallmouth and Largemouth yellowfish, *Labeobarbus aeneus* and *Labeobarbus kimberleyensis*, in lake Gariep, South Africa. Unpublished Masters of Science Thesis. Rhodes University. Grahamstown.

FAIRWEATHER PG (1991). Implications of `supply-side' ecology for environmental assessment and management. *Trends Ecol. Evol*. **6** (2) 60-63.

FOWLER AJ (1989). Description, interpretation and use of the microstructure of otoliths from juvenile butterflyfishes (family Chaetontidae). *Mar. Biol.* **102** (167-181).

FUIMAN LA (1994). The interplay of ontogeny and scaling in the interactions of fish larvae and their predators. *Journal of Fish Biology* **45** (Supplement A): 55-79

FUIMAN LA, POLING KR and HIGGS DM (1998). Quantifying developmental progress for comparative studies of larval fishes. *Copeia* **3**, 602-611.

GAIGHER IG (1976). The reproduction of *Barbus* cf. *kimberleyensis* (Pisces, Cyprinidae) in the Hardap Dam, South West Africa. *Zoologica Africana*, **11**, 97-110.

GAIGHER IG, HAMMAN KCD and THORNE SC (1980). The distribution, conservation status and factors affecting the survival of indigenous freshwater fishes in the Cape Province. *Koedoe*, **23**, 57-88.

GALINDO-CORTES G, DE ANDA-MONTAÑEZ JA, ARREGUÍN-SÁNCHEZ F, SALAS S and BALART EF (2010). How do environmental factors affect the stock-recruitment relationship? The case of the Pacific sardine (*Sardinops sagax*) of the northeastern Pacific Ocean. *Fisheries Research* **102** (1-2) 173-183.

GEFFEN AJ (1992). Validation of otolith increment deposition rate. In: Stevenson DK and Campana SE (eds) Otolith microstructure examination and analysis. Vol. 117. Canadian Special Publication of Fisheries and Aquatic Science. pp. 101-113.

GERBER R (2009). Physiological response of Vaal-Orange smallmouth yellowfish (*Labeobarbus aeneus*) to catch-and-release angling induced stress in the Vaal river, South Africa. Unpublished Masters of Science thesis. University of Johannesburg. Aucklandpark.

GODIN JJ (ed, 1997) Behavioural Ecology of Teleost Fishes. Oxford University Press. Oxford. pp 2-8.

GOZLAN E (1999). Early development of the sofie, *Chondrostoma toxostoma*. *Environmental Biology of Fishes* **56**, 67-77.

GRAHAM RJ and ORTH DJ (1986). Effects of temperature and streamflow on time and duration of spawning by smallmouth bass. *Trans. Am. Fish. Soc*. **115** (5) 693-702.

GRANT JWA (1997). Territoriality. In: Behavioural Ecology of Teleost Fishes. Godin JJ (ed). Oxford University Press. Oxford. pp 81-98.

GROSS MR (1984). The evolution of behavioural ecology. *Trends Ecol. Evol*., **9**, 358-360.

GROBLER DC, BRAWER CA and HALL GC (1982). A comparison of chemical load estimation algorithms using data obtained by sampling four South African rivers at varying frequencies. *Water SA* **8** (3) 121-129.

GROBLER DC, TOERIEN DF and DE WET JS (1983). Changes in turbidity as a result of mineralisation in the lower Vaal River. *Water SA* **9** (3) 110-116.

GROBLER DC, TOERIEN DP and ROSSOUW JW (1986). Effects of sediment on water quality in the Vaal River system. Symposium on the Vaal River Ecosystem: status and problems. *Occasional Report No 5. FRD*, CSIR, Pretoria, pp 115-148.

GROENEWALD AAvJ (1961). A progress report on the culture of *Barbus holubi*, the Vaal river yellowfish, at the Provincial Fisheries Institute, Lydenburg. Transvaal Provincial Fisheries Research Institute, *Research Report*, 9-20.

HIRSCHOWITZ PM, BIRKHEAD AL and JAMES CS (2007) Hydraulic modelling for ecological studies for South African Rivers. *WRC Report no: K5/105*. Water Research Commission. Pretoria.

HOCUTT CH and SKELTON PH (1983). Fishes of the Sak River, South Africa, with comments on the nomenclature of the smallmouth yellowfish, *Barbus aeneus* (Burchell, 1822). *Special Publications, J L B Smith Institute of Ichthyology, Grahamstown*, **32**, 1-11.

HOUDE ED (1987). Fish early life history dynamics and recruitment variability. *Am. Fish. Soc. Symp*. **2**, 17-29.

HOUDE ED (1989). Comparative growth, mortality, and energetics of marine fish larvae: Temperature and implied latitudinal effects. *Fish. Bull*. **87** (3) 471-495.

HOUDE ED (2009). Fish Larvae. In: Steele JH, Thorpe SA and Turekian KK (eds) *Encyclopaedia of Ocean Sciences (2nd Edition),* Marine Biology. Academic press, London. pp 286-296.

HUMPHRIES P (2005). Spawning time and early life history of Murray cod, Maccullochella peelii (Mitchell) in an Australian river. *Environ. Biol. Fishes* **72** (4) 393-407.

HUMPHRIES P, KING AJ and KOEHN JD (1999). Fish, flows and flood plains: links between freshwater fishes and their environment in the Murray-Darling River system, Australia. *Environ. Biol. Fishes* **56** (1) 129-151.

INTERNATIONAL UNION FOR THE CONSERVATION OF NATURE (IUCN, 2010). IUCN Red List of Threatened Species. Version 2010.4. <www.iucnredlist.org>. Downloaded on 07 March 2011.

JONES C and BROTHERS EB (1987). Validation of the otolith increment aging technique for striped bass, Morone saxatilis, larvae reared under suboptimal feeding conditions. *Fish. Bull.* **85** (2) 171-178.

JUBB RA (1966). Notes on the popular angling yellowfishes and distributions outside their native range. *Piscator*, **68**, 120-125.

JUBB RA (1967). Freshwater fishes of southern Africa. Balkema, Cape Town. pp. 248.

JUBB RA and FARQUHARSON FL (1965). The freshwater fishes of the Orange River drainage basin. *South African Journal of Science*, **61**, 118-124.

KING JM, CAMBRAY JA and IMPSON ND (1998). Linked effects of dam-released floods and water temperature on spawning of the Clanwilliam yellowfish *Barbus capensis*. *Hydrobiologia* **384** (1) 245-265.

KOEHN JD and HARRINGTON DJ (2006). Environmental conditions and timing for the spawning of Murray cod (*Maccullochella peelii peelii*) and the endangered trout cod (*M. macquariensis*) in southeastern Australian rivers. *River Res. Appl.* **22** (3) 327-342.

KRIEL JP (1972). The role of the Hendrik Verwoerd Dam in the Orange River Project. *The Civil Engineer in South Africa*, February 1972.

LANG JB and BUXTON CD (1993). Validation of age estimates in sparid fish using flubrochrome marking. *South African Journal of Marine Science* **13** (1) 195-203.

LANDIS WG (Ed. 2005). Regional Scale Ecological Risk Assessment: Using the Relative Risk Model. CRC Press. Washington, D.C.

LANDIS WG and WIEGERS JK (1997). Design considerations and suggested approach for regional and comparative ecological risk assessment. *Hum. Ecol. Risk Assess.* **3**, 287-297.

LAURENSON LBJ, HOCUTT CH and HECHT T (1989). An evaluation of the success of invasive fish species of the Great Fish River. *Journal of Applied Ichthyology*, **1**, 28-34.

LENHARD G and DU PLOOY A (1965). Studies on bottom deposits of the Vaal River System. *Hydrobiologia* **16**, 271-291.

LE ROUX PJ (1968). Artificial culture of the Vaal River yellowfish, *Barbus holubi*. *Fauna and Flora, Pretoria*. **19**, 34-41.

LUCAN MC and BARAS E (2000) Methods for studying spatial behaviour of freshwater fishes in the natural environment. *Fish and Fisheries*. **1**, 283-316.

LUCAS MC, MERCER T, MCGINTY S and ARMSTRONG JD (1999) Use of a flat-bed passive integrated transponder antenna array to study the migration and behaviour of lowland river fishes at a fish pass. *Fisheries Research* **44**, 183-191.

MIDGLEY DC, PITMAN WV and MIDDLETON BJ (1994). The Surface Water Resources of South Africa 1990 (Vol 1 to 6). Report Numbers 298/1.1/94 to 298/6.1/94 (text) and 298/1.2/94 to 298/6.2/94 (maps), Water Research Commission, Pretoria. Also accompanied by a CD-ROM with selected data sets.

MILLER SJ and STORCK T (1982). Daily Growth Rings in Otoliths of Young-of-the-Year Largemouth Bass. *Trans. Am. Fish. Soc.* **111** (4) 527-530.

MULDER PFS (1973). Aspects on the ecology of *Barbus Kimberleyensis* and *Barbus holubi* in the Vaal River. *Zoologica Africana*, **8** (1): 1-14.

MULDER PFS (1971). ‘n Ekologiese studie van die hengelvis fauna in die Vaalrivier sisteem met spesiale verwysing na *Barbus kimberleyensis*, Gilchrist and Thompson. Unpublished PhD thesis, Rand Afrikaans University, Johannesburg.

MULDER PFS (1973). Aspects on the ecology of *Barbus kimberleyensis* and *Barbus holubi* in the Vaal River. *Zoologica Africana* **8**, 1-14.

MULDER PFS and FRANKE GW (1973). Aspects on the artificial fertilization of the smallmouth yellowfish, *Barbus holubi* (Steindachner, 1894). *Journal of Fisheries Biology*, **5**, 143-145.

MYERS RA (1998). When Do Environment-recruitment Correlations Work? *Rev. Fish Biol. Fish.* **8** (3) 285-305.

NÆSJE TF, CHILDS AR, COWLEY PD, POTTS WM THORSTAD EB and ØKLAND F (2007). Movements of undersized spotted grunter (*Pomadasys commersonnii*) in the Great Fish Estuary, South Africa: implications for fisheries management. *Hydrobiologica* **582**, 25-34.

NAGELKERKE LAJ and SIBBING FA (1997). A revision of the large barbs (*Barbus* spp., Cyprinidae, *Teleostei*) of Lake Tana, Ethiopia, with a description of seven new species. In: Nagelkerke LAJ. *The barbs of Lake Tana, Ethiopia.* 105-170.

NEL J, MAREE G, ROUX D, MOOLMAN J, KLEYNHANS N, SILBERBAUER M and DRIVER A (2004). South African National Spatial Biodiversity Assessment 2004: *Technical Report. Volume 2: River Component.* CSIR Report Number ENV-S-I-2004-063. Stellenbosch: Council for Scientific and Industrial Research.

NEWMAN SJ, CAPPO M and WILLIAMS DMB (2000). Age, growth, mortality rates and corresponding yield estimates using otoliths of the tropical red snappers, *Lutjanus erythropterus*, *L. malabaricus* and *L. sebae*, from the central Great Barrier Reef* 1. *Fisheries Research* **48** (1) 1-14.

NOAKES DLG (1978) Social behaviour as it influences fish production. In: Ecology of freshwater fish production (Ed. By SD Gerking). *Blackwell Scientific Publ.,* Oxford. pp. 360-382.

NOBLE RG and HEMENS J (1978). Inland water ecosystems in South Africa – A Review of Research Needs. *S.Afr. Nat. Sci. Prog. Rept 34*, CSIR, Pretoria, pp 150.

OBERY A and LANDIS WG (2002). Application of the relative risk model for Codorus Creek watershed relative ecological risk assessment: an approach for multiple stressors, *Hum. Ecol. Risk Assess*., **8**, 405-428.

PAXTON BR (2004). Tracking movement of large fish species through a river system: methods development. *WRC Report no. KV 157/04.* Water Research Commission. Pretoria.

PAXTON BR and KING JM (2009). The influence of hydraulics, hydrology and temperature on the distribution, habitat use and recruitment of threatened cyprinids in a Western Cape river, South Africa. *Water Research Commission Report No. 1483/1/09*. pp 170.

PITCHER RC (1988). Validation of a technique for reconstructing daily patterns in the recruitment of coral reef damselfish. *Coral Reefs* **7**, 105-111.

PITCHER TJ and HART PJB (1982). Fisheries Ecology, First Edition. Chapman and Hall, London. pp. 414.

POFF NLR, ALLAN JD, BAIN MB, KARR JR, PRESTEGAARD KL, RICHTER BD, SPARKS RE and STROMBERG JC (1997). The natural flow regime. *Bioscience* **47** (11) 769-784.

PRENTICE EF, FLAGG TA and MCCUTCHEON CS (1990). Feasibility of using implanted passive integrated transponder (PIT) tags in salmonids. *American Fisheries Society Symposium*. **7**, 317-322.

QUICK AJR and BRUTON MN (1984). Age and growth of *Clarias gariepinus* (Pisces: Clariidae) in the PK le Roux Dam, South Africa. *S. Afr. J. Zool.* **19** (1) 37-45.

RIVER HEALTH PROGRAMME (RHP, 2003a). Ecological state of southern Gauteng Rivers. State of the Rivers Reporting System. Department of Water Affairs and Forestry. Pretoria. Download available from: www.csir.co.za/rhp/state_of_rivers

RIVER HEALTH PROGRAMME (RHP, 2003b). State-of-Rivers Report: Free State Region River Systems. Department of Water Affairs and Forestry. Pretoria. ISBN No: 0-620-31794-9. Download available from: www.csir.co.za/rhp/state_of_rivers

ROMBOUGH PJ (1985). Initial egg weight, time to maximum alevin wet weight, and optimal ponding times for chinook salmon (*Oncorhynchus tshawytscha*). *Can. J. Fish. Aquat. Sci.* **42**, 287-291.

ROUX F (2006). Reproduction strategy of the smallscale yellowfish (*Labeobarbus polylepis*) and breeding behaviour in the Blyde and Spekboom rivers. Unpublished Masters of Science dissertation. University of Johannesburg. Aucklandpark.

SCOTT LEP, SKELTON PH, BOOTH AJ, VERHEUST L, HARRIS R and DOOLEY J (2006). *Atlas of Southern African Freshwater Fishes*. Monograph 2, Smithiana, South African Institute for Aquatic Biodiversity, Grahamstown.

SHORTT-SMITH KE (1963). *Freshwater fish and fishing in Africa*. Basutoland. Thomas Nelson & Sons (Africa) (Pty.)Ltd., Johannesburg. pp 55-71.

SKELTON PH (1972). Smallmouth yellowfish (*Barbus holubi*) in Settlers Dam, Grahamstown. *Piscator*, **84**, 27-30.

SKELTON PH (1986). Fish of the Orange-Vaal River system. In: Davies BR and Walker KF .The Ecology of River Systems. Dr. W. Junk Publishers, Dordrecht. The Netherlands.

SKELTON P and BILLS IR (2008). An introduction to African yellowfish and to this report. In: Impson ND, Bills IR and Wolhuter L. Technical report on the state of yellowfishes in South Africa 2007. *WRC Report KV212/08.* Water Research Commission. Pretoria. pp. 1-8.

SKELTON PH (2001). *Freshwater fishes of southern Africa*, *2nd Edition*. Struik Publishers, Cape Town, pp 395.

SKELTON PH (2001). *A Complete Guide to the Freshwater Fishes of Southern Africa.* Southern Publishers (Pty.) Ltd., Halfway House.

SKELTON PS and BILLS R (2008). An introduction to African yellowfish and this report. In: Technical report on the state of yellowfishes in South Africa (eds. ND Impson, IR Bills and L Wolhuter). *WRC Report No. KV 212/08.* Water Research Commission. Pretoria.

STADTLANDER T (2006). Comparative biology of the smallmouth yellowfish *Labeobarbus aeneus* in Glen Melville Reservoir and the Great Fish River, Eastern Cape, South Africa. Unpublished Diploma, University of Bremen, Bremen, Germany.

STASKO AB and PINCOCK DG (1977). Review of underwater biotelemetry with emphasis on ultrasonic techniques. *Journal of the Fisheries Research Board of Canada.* **34**, 1261-1285.

STEYN DJ and TOERIEN DF (1976). Eutrophication levels of some South African impoundments 4. Vaal Dam. *Water SA* **2** (2) 53-57.

STRAUB CC (1971). Aspects of the age determination of the Vaal River yellow fish *Barbus holubi* (Steindachner, 1894) by the scale method. *Final Report Project 7 Progress Reports Series 5.* Department of Zoology University of Potchefstroom for C.H.E., South Africa.

SUTER GW (2001). Applicability of indicator monitoring to ecological risk assessment. *Ecological indicators* **1** (2001) 101-112.

TER BRAAK CJF (1994). Canonical community ordination. Part I: basic theory and linear methods. *Ecoscience* **1**, 127-140.

TER BRAAK CJF (1995). Ordination. In: Data Analysis in Community and Landscape Ecology, Jongman RGH, Ter Braak CJF and Van Tongeren OFR. (Eds), Cambridge University Press, Cambridge, UK, pp 91-173.

TER BRAAK CJ AND SMILAUER F (2004) Canoco for Windows Version 4.53. © 1997-2004 Biometrics – Plant Research International, Wageningen, The Netherlands.

THORSTAD EB, HAY CJ, NÆSJE TF and ØKLAND F (2001). Movements and habitat utilisation of three cichlid species in the Zambezi River, Namibia**.** *Ecology of Freshwater Fish,* **10**, 238-246.

TÓMASSON T, CAMBRAY JA and JACKSON PBN (1984). Reproductive biology of four large riverine fishes (Cyprinidae) in a man-made lake, Orange River, South Africa. *Hydrobiologica,* **112** (3) 179-195.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (USEPA, 1998). Guidelines for ecological risk assessment; notice. Fed Reg 6326846-26924. Environmental Monitoring Systems Laboratory, Office of Research and Development, US Environmental Protection Agency, Cincinnati, Ohio.

VAN DEN BRINK PJ, VAN DEN BRINK NW and TER BRAAK CJF (2003). Multivariate analysis of ecotoxicological data using ordination: demonstration of utility on the basis of various examples. *Australasian Journal of Ecotoxicolog,* **9**, 141-156.

VAN RENSBURG KJ (1966). Die vis van die olifantsrivier (Weskus) met spesiale verwysing na die Geelvis (*Barbus capensis*) en Saagvin (*Barbus serra*). *Investigational Report Cape Department of Nature Conservation 10*. pp 1-14.

VAN WYK F (2001). An Integrated Manual for the Management, Control and Protection of the Vaal River Barrage Reservoir. Unpublished MSc Thesis. Rand Afrikaans University. Aucklandpark.

VENTER JA, FOUCHÉ PSO, VLOK W, MOYO NAG, THERON S and GROBLER P (2009). Background Report: Southern barred minnow (*Opsaridium peringueyi*). *WRC deliverable report*. Water Research Commission. Pretoria.

WELCOMME RL (1985). River Fisheries. *Fisheries Technical Paper No. 262*. Food and Agriculture Organisation of the United Nations (FAO), Rome, Italy.

WIEGERS JK, FEDER HM, MORTENSEN LS, SHAW DG, WILSON VJ and LANDIS WG (1998). A regional multiple stressor rank-based ecological risk assessment for the fjord of Port Valdez, AK, *Hum. Ecol, Risk, Assess*., **4**, 1125-1173.

WILSON GC and SMITH BS (2002). Fish otolith microstructure as a tool for defining environmental flow requirements in freshwater ecosystems. In: Environmental Flows 2002.

WINKER H, ELLENDER BR, WEYL OLF and BOOTH AJ (2010a). Validation of Growth Zone Deposition in Otoliths of Two Large Endemic Cyprinids in Lake Gariep, South Africa. *Afr. Zool.* **45** (1) 133-138.

WINKER H, WEYL OLF, BOOTH AJ and ELLENDER BR (2010b). Validating and corroborating the deposition of two annual growth zones in asteriscus otoliths of common carp Cyprinus carpio from South Africa's largest impoundment. *J. Fish Biol*. **77**, 2210-2228.

WINTER J (1996). Advances in underwater biotelemetry. In: Fisheries Techniques. (eds. BR Murphy and DW Willis), 2nd edition. American Fisheries Society, Bethesda, Maryland. pp 555-590.

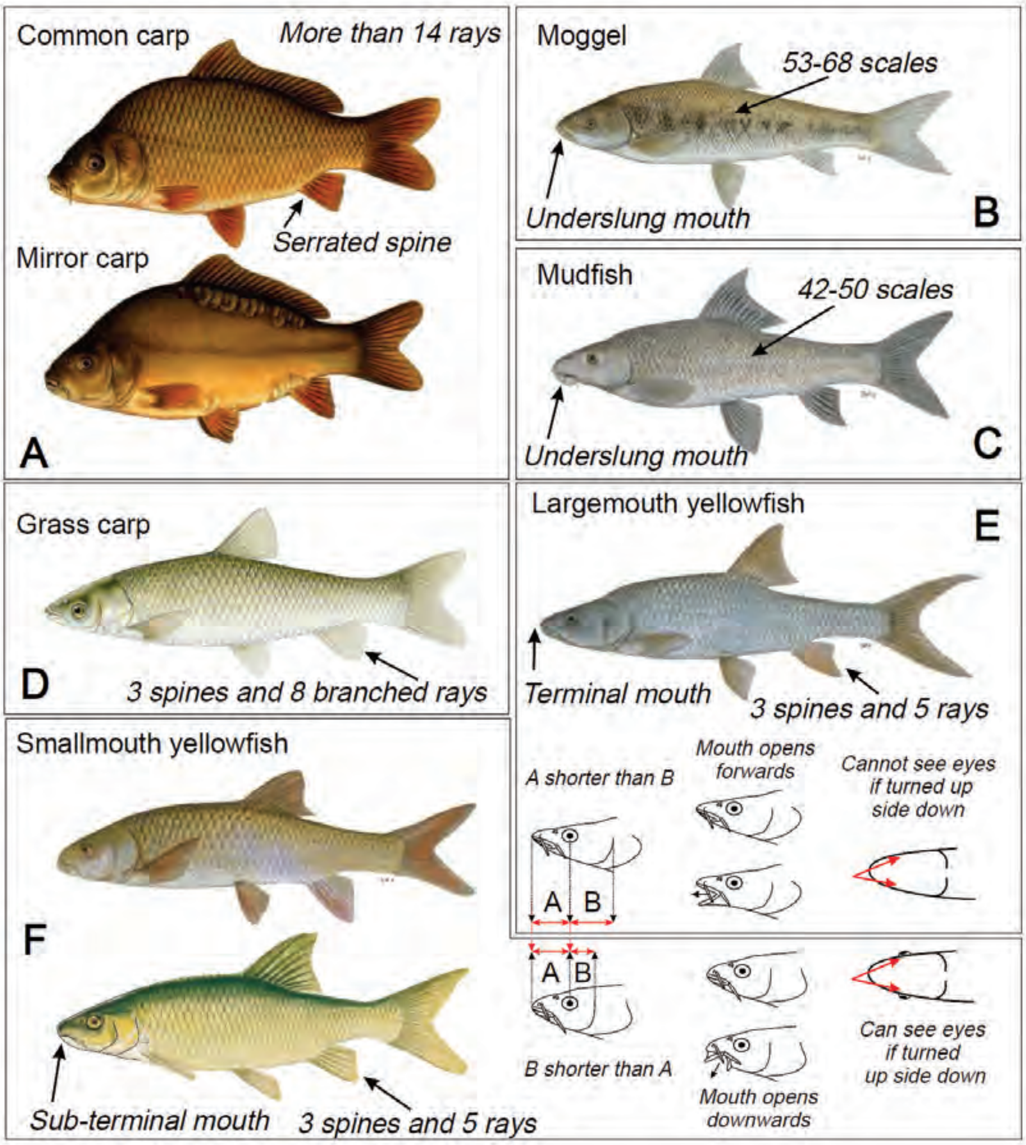
WRIGHT CW and COKE MM (1975a). The artificial propagation of *Barbus natalensis*: Induced spawning and artificial fertilisation. *Lammergeyer No 22*, 37-41.

WRIGHT CW and COKE MM (1975b). The artificial propagation of *Barbus natalensis:* Hatching and early development. *Lammergeyer No 22*, 42-48.

11. APPENDICES

Dummies guide to identifying large cyprinids from the Vaal River

1. Long dorsal fin with more than 14 rays and the anal fin has a serrated spine. .... Carp (PIC A)
   If not go to.. 2
2. Underslung mouth forming a sucker-like disk with 53-68 scales along lateral line... Moggel (PIC B)
   Underslung mouth forming a sucker-like disk with 42-50 scales along lateral line... Mudfish (PIC C)
   No underslung mouth forming a sucker-like disk go to.. 3
3. Anal fin with 3 spines and 8 branched rays mullet resembling fish......................... Grass carp (PIC D)
   Anal fin with 3 spines and 5 rays (yellowfishes) go to.. 4
4. Mouth terminal (opens forward), eyes cannot be seen if fish turned upside-down and distance between snout and eye smaller than eye and 1st operculum groove.. Largemouth (PIC E)
   Mouth sub-terminal (opens downwards), eyes can be seen if fish turned upside-down and distance between snout and eye greater than eye and 1st operculum groove.. Smallmouth (PIC F)



Appendix 1: Dummies guide to identifying large cyprinids from the Vaal River. Pictures of fishes from Skelton (2001) and ().

Appendix 2: Raw data used in the age validation exercise of this study.

Vial	Genus	Species	Tank	Fertilisation Date:Time	Sample Date:Time	FishCode	Otolith	TraySlot	Age	TL 1	Count
A01	*Labeobarbus*	*aeneus*		7-Dec-08	9-Jul-09	A01_1	A	E49	214	33.8	70
A01	*Labeobarbus*	*aeneus*		7-Dec-08	9-Jul-09	A01_1	B	E50	214	33.8	86
A01	*Labeobarbus*	*aeneus*		7-Dec-08	9-Jul-09	A01_1	C	E51	214	33.8	76
A01	*Labeobarbus*	*aeneus*		7-Dec-08	9-Jul-09	A01_1	D	E52	214	33.8	70
A01	*Labeobarbus*	*aeneus*		7-Dec-08	9-Jul-09	A01_2	A	E53	214	35.2	X
A02	*Labeobarbus*	*aeneus*	C3	7-Dec-08	12-Mar-09	A02_1	A	E57	95	33.5	X
A02	*Labeobarbus*	*aeneus*	C3	7-Dec-08	12-Mar-09	A02_1	B	E58	95	33.5	X
A02	*Labeobarbus*	*aeneus*	C3	7-Dec-08	12-Mar-09	A02_2	A	F7	95	28	90
A02	*Labeobarbus*	*aeneus*	C3	7-Dec-08	12-Mar-09	A02_2	B	F8	95	28	52
A03	*Labeobarbus*	*aeneus*	C3	7-Dec-08	30-Apr-09	A03_1	A	E80	144	37.8	80
A03	*Labeobarbus*	*aeneus*	C3	7-Dec-08	30-Apr-09	A03_1	B	E81	144	37.8	81
A03	*Labeobarbus*	*aeneus*	C3	7-Dec-08	30-Apr-09	A03_2	A	F29	144	38.2	80
A03	*Labeobarbus*	*aeneus*	C3	7-Dec-08	30-Apr-09	A03_2	B	F30	144	38.2	82
A03	*Labeobarbus*	*aeneus*	C3	7-Dec-08	30-Apr-09	A03_3	A	F31	144	35.5	57
A03	*Labeobarbus*	*aeneus*	C3	7-Dec-08	30-Apr-09	A03_3	B	F32	144	35.5	80
A04	*Labeobarbus*	*aeneus*	C3	7-Dec-08	19-Feb-09	A04_1	A	E60	74	21.1	64
A04	*Labeobarbus*	*aeneus*	C3	7-Dec-08	19-Feb-09	A04_1	B	E61	74	21.1	50
A04	*Labeobarbus*	*aeneus*	C3	7-Dec-08	19-Feb-09	A04_2	A	E92	74	23.2	56
A04	*Labeobarbus*	*aeneus*	C3	7-Dec-08	19-Feb-09	A04_2	B	E93	74	23.2	X
A04	*Labeobarbus*	*aeneus*	C3	7-Dec-08	19-Feb-09	A04_3	A	E96	74	22	60
A04	*Labeobarbus*	*aeneus*	C3	7-Dec-08	19-Feb-09	A04_3	B	E97	74	22	70
A05	*Labeobarbus*	*aeneus*	C3	7-Dec-08	12-Feb-09	A05_1	A	E62	67	25	60
A05	*Labeobarbus*	*aeneus*	C3	7-Dec-08	12-Feb-09	A05_1	B	E63	67	25	65
A05	*Labeobarbus*	*aeneus*	C3	7-Dec-08	12-Feb-09	A05_2	A	E64	67	26.5	62
A05	*Labeobarbus*	*aeneus*	C3	7-Dec-08	12-Feb-09	A05_2	B	E65	67	26.5	63
A05	*Labeobarbus*	*aeneus*	C3	7-Dec-08	12-Feb-09	A05_3	A	E94	67	23.5	X
A05	*Labeobarbus*	*aeneus*	C3	7-Dec-08	12-Feb-09	A05_3	B	E95	67	23.5	46
A06	*Labeobarbus*	*aeneus*	C3	7-Dec-08	9-Apr-09	A06_1	A	E76	123	31	60
A06	*Labeobarbus*	*aeneus*	C3	7-Dec-08	9-Apr-09	A06_1	B	E77	123	31	70
A06	*Labeobarbus*	*aeneus*	C3	7-Dec-08	9-Apr-09	A06_2	A	F21	123	30.8	81
A06	*Labeobarbus*	*aeneus*	C3	7-Dec-08	9-Apr-09	A06_2	B	F22	123	30.8	68
A06	*Labeobarbus*	*aeneus*	C3	7-Dec-08	9-Apr-09	A06_3	A	F23	123	38	80
A06	*Labeobarbus*	*aeneus*	C3	7-Dec-08	9-Apr-09	A06_3	B	F24	123	38	65
A07	*Labeobarbus*	*aeneus*	B2	7-Dec-08	14-Dec-08	A07_1a	A	E38	7	9.1	7
A07	*Labeobarbus*	*aeneus*	C3	7-Dec-08	18-Dec-08	A07_1b	A	E39	11	11	X
A07	*Labeobarbus*	*aeneus*	C3	7-Dec-08	25-Dec-08	A07_1c	A	E40	18	11	*

Appendix 3: Raw data used in the age validation exercise of this study (continued).

Vial	Genus	Species	Tank	Fertilisation Date:Time	Sample Date:Time	FishCode	Otolith	TraySlot	Age	TL 1	Count
A07	*Labeobarbus*	*aeneus*	C3	7-Dec-08	25-Dec-08	A07_1c	A	G25	18	11	16
A07	*Labeobarbus*	*aeneus*	C3	7-Dec-08	25-Dec-08	A07_1c	B	G19	18	11	18
A07	*Labeobarbus*	*aeneus*	B2	7-Dec-08	1-Jan-09	A07_1d	A	E41	25	15.4	25
A07	*Labeobarbus*	*aeneus*	B2	7-Dec-08	1-Jan-09	A07_1d	B	E42	25	15.4	20
A07	*Labeobarbus*	*aeneus*	C3	7-Dec-08	22-Jan-09	A07_1e	A	E43	46	16.8	35
A07	*Labeobarbus*	*aeneus*	B2	7-Dec-08	14-Dec-08	A07_2a	A	E54	7	9.5	7
A07	*Labeobarbus*	*aeneus*	C3	7-Dec-08	18-Dec-08	A07_2b	A	E55	11	9.9	10
A07	*Labeobarbus*	*aeneus*	C3	7-Dec-08	18-Dec-08	A07_2b	B	G18	11	9.9	9
A07	*Labeobarbus*	*aeneus*	C3	7-Dec-08	25-Dec-08	A07_2b	A	E56	18	10	*
A07	*Labeobarbus*	*aeneus*	C3	7-Dec-08	25-Dec-08	A07_2b	A	G26	18	10	18
A07	*Labeobarbus*	*aeneus*	C3	7-Dec-08	25-Dec-08	A07_2b	B	G20	18	10	16
A07	*Labeobarbus*	*aeneus*	B2	7-Dec-08	1-Jan-09	A07_2c	A	G28	25	15	23
A07	*Labeobarbus*	*aeneus*	B2	7-Dec-08	1-Jan-09	A07_2c	B	G22	25	15	23
A07	*Labeobarbus*	*aeneus*	B2	7-Dec-08	1-Jan-09	A07_2c	A	E59	25	15	*
A07	*Labeobarbus*	*aeneus*	C3	7-Dec-08	22-Jan-09	A07_2d	B	F62	46	17	40
A07	*Labeobarbus*	*aeneus*	C3	7-Dec-08	22-Jan-09	A07_2d	A	F61	46	17	37
A07	*Labeobarbus*	*aeneus*	B2	7-Dec-08	14-Dec-08	A07_3a	A	F54	7	9	6
A07	*Labeobarbus*	*aeneus*	C3	7-Dec-08	25-Dec-08	A07_3b	A	F55	18	9.8	*
A07	*Labeobarbus*	*aeneus*	C3	7-Dec-08	25-Dec-08	A07_3b	A	G27	18	9.8	17
A07	*Labeobarbus*	*aeneus*	C3	7-Dec-08	25-Dec-08	A07_3b	B	G21	18	9.8	16
A07	*Labeobarbus*	*aeneus*	B2	7-Dec-08	1-Jan-09	A07_3c	A	G37	25	14	25
A07	*Labeobarbus*	*aeneus*	B2	7-Dec-08	1-Jan-09	A07_3c	B	G23	25	14	25
A07	*Labeobarbus*	*aeneus*	B2	7-Dec-08	1-Jan-09	A07_3c	A	F56	25	14	*
A07	*Labeobarbus*	*aeneus*	C3	7-Dec-08	22-Jan-09	A07_3d	A	F63	46	14.2	41
A07	*Labeobarbus*	*aeneus*	C3	7-Dec-08	22-Jan-09	A07_3d	B	F64	46	14.2	42
A08	*Labeobarbus*	*aeneus*	C3	7-Dec-08	16-Apr-09	A08_1	A	E78	130	34.5	X
A08	*Labeobarbus*	*aeneus*	C3	7-Dec-08	16-Apr-09	A08_1	B	E79	130	34.5	109
A08	*Labeobarbus*	*aeneus*	C3	7-Dec-08	16-Apr-09	A08_2	A	F25	130	30.8	102
A08	*Labeobarbus*	*aeneus*	C3	7-Dec-08	16-Apr-09	A08_2	B	F26	130	30.8	80
A08	*Labeobarbus*	*aeneus*	C3	7-Dec-08	16-Apr-09	A08_3	A	F27	130	29	82
A08	*Labeobarbus*	*aeneus*	C3	7-Dec-08	16-Apr-09	A08_3	B	F28	130	29	112
A09	*Labeobarbus*	*aeneus*	C3	7-Dec-08	2-Apr-09	A09_1	A	E74	116	31.4	86
A09	*Labeobarbus*	*aeneus*	C3	7-Dec-08	2-Apr-09	A09_1	B	E75	116	31.4	75
A09	*Labeobarbus*	*aeneus*	C3	7-Dec-08	2-Apr-09	A09_2	A	F17	116	33.2	62
A09	*Labeobarbus*	*aeneus*	C3	7-Dec-08	2-Apr-09	A09_2	B	F18	116	33.2	62
A09	*Labeobarbus*	*aeneus*	C3	7-Dec-08	2-Apr-09	A09_3	A	F19	116	31.2	82

Appendix 4: Raw data used in the age validation exercise of this study (continued).

Vial	Genus	Species	Tank	Fertilisation Date:Time	Sample Date:Time	FishCode	Otolith	TraySlot	Age	TL 1	Count
A09	*Labeobarbus*	*aeneus*	C3	7-Dec-08	2-Apr-09	A09_3	B	F20	116	31.2	64
A10	*Labeobarbus*	*aeneus*	C3	7-Dec-08	5-Mar-09	A10_1	A	E68	88	28.9	X
A10	*Labeobarbus*	*aeneus*	C3	7-Dec-08	5-Mar-09	A10_1	B	E69	88	28.9	84
A10	*Labeobarbus*	*aeneus*	C3	7-Dec-08	5-Mar-09	A10_2	A	F3	88	32.2	80
A10	*Labeobarbus*	*aeneus*	C3	7-Dec-08	5-Mar-09	A10_2	B	F4	88	32.2	80
A10	*Labeobarbus*	*aeneus*	C3	7-Dec-08	5-Mar-09	A10_3	A	F5	88	28.5	84
A10	*Labeobarbus*	*aeneus*	C3	7-Dec-08	5-Mar-09	A10_3	B	F6	88	28.5	78
A11	*Labeobarbus*	*aeneus*	C3	7-Dec-08	27-Feb-09	A11_1	A	E66	82	29.8	74
A11	*Labeobarbus*	*aeneus*	C3	7-Dec-08	27-Feb-09	A11_1	B	E67	82	29.8	79
A11	*Labeobarbus*	*aeneus*	C3	7-Dec-08	27-Feb-09	A11_2	A	E98	82	31.8	72
A11	*Labeobarbus*	*aeneus*	C3	7-Dec-08	27-Feb-09	A11_2	B	E99	82	31.8	70
A11	*Labeobarbus*	*aeneus*	C3	7-Dec-08	27-Feb-09	A11_3	A	F1	82	26	80
A11	*Labeobarbus*	*aeneus*	C3	7-Dec-08	27-Feb-09	A11_3	B	F2	82	26	71
A12	*Labeobarbus*	*aeneus*	C3	7-Dec-08	19-Mar-09	A12_1	A	E70	102	31.5	90
A12	*Labeobarbus*	*aeneus*	C3	7-Dec-08	19-Mar-09	A12_1	B	E71	102	31.5	98
A12	*Labeobarbus*	*aeneus*	C3	7-Dec-08	19-Mar-09	A12_2	A	F9	102	26	63
A12	*Labeobarbus*	*aeneus*	C3	7-Dec-08	19-Mar-09	A12_2	B	F10	102	26	60
A12	*Labeobarbus*	*aeneus*	C3	7-Dec-08	19-Mar-09	A12_3	A	F11	102	29.5	90
A12	*Labeobarbus*	*aeneus*	C3	7-Dec-08	19-Mar-09	A12_3	B	F12	102	29.5	80
A13	*Labeobarbus*	*aeneus*	C3	7-Dec-08	8-Jan-09	A13_1	A	E44	32	17.8	*
A13	*Labeobarbus*	*aeneus*	C3	7-Dec-08	8-Jan-09	A13_1a	B	E45	32	17.8	23
A13	*Labeobarbus*	*aeneus*	C3	7-Dec-08	8-Jan-09	A13_1a	C	E46	32	17.8	24
A13	*Labeobarbus*	*aeneus*	C3	7-Dec-08	8-Jan-09	A13_1a	A	G24	32	17.8	23
A13	*Labeobarbus*	*aeneus*	C3	7-Dec-08	15-Jan-09	A13_1b	A	E47	39	19.9	X
A13	*Labeobarbus*	*aeneus*	C3	7-Dec-08	15-Jan-09	A13_1b	B	E48	39	19.9	37
A13	*Labeobarbus*	*aeneus*	C3	7-Dec-08	8-Jan-09	A13_2a	A	F57	32	18.8	X
A13	*Labeobarbus*	*aeneus*	C3	7-Dec-08	8-Jan-09	A13_2a	B	F58	32	18.8	31
A13	*Labeobarbus*	*aeneus*	C3	7-Dec-08	15-Jan-09	A13_2b	A	E90	39	21.2	35
A13	*Labeobarbus*	*aeneus*	C3	7-Dec-08	15-Jan-09	A13_2b	B	E91	39	21.2	X
A13	*Labeobarbus*	*aeneus*	C3	7-Dec-08	8-Jan-09	A13_3	A	F59	32	16	31
A13	*Labeobarbus*	*aeneus*	C3	7-Dec-08	8-Jan-09	A13_3	B	F60	32	16	30
A14	*Labeobarbus*	*aeneus*	C3	7-Dec-08	2-Jul-09	A14_1	A	E82	207	36	72
A14	*Labeobarbus*	*aeneus*	C3	7-Dec-08	2-Jul-09	A14_1	B	E83	207	36	78
A14	*Labeobarbus*	*aeneus*	C3	7-Dec-08	2-Jul-09	A14_2	A	F33	207	33	60
A14	*Labeobarbus*	*aeneus*	C3	7-Dec-08	2-Jul-09	A14_2	B	F34	207	33	60
A15	*Labeobarbus*	*aeneus*	C3	7-Dec-08	21-Mar-09	A15_1	A	E72	104	40.8	30

Appendix 5: Raw data used in the age validation exercise of this study (continued).

Vial	Genus	Species	Tank	Fertilisation Date:Time	Sample Date:Time	FishCode	Otolith	TraySlot	Age	TL 1	Count
A15	*Labeobarbus*	*aeneus*	C3	7-Dec-08	21-Mar-09	A15_1	B	E73	104	40.8	95
A15	*Labeobarbus*	*aeneus*	C3	7-Dec-08	21-Mar-09	A15_2	A	F13	104	38.5	100
A15	*Labeobarbus*	*aeneus*	C3	7-Dec-08	21-Mar-09	A15_2	B	F14	104	38.5	88
A15	*Labeobarbus*	*aeneus*	C3	7-Dec-08	21-Mar-09	A15_3	A	F15	104	40.5	85
A15	*Labeobarbus*	*aeneus*	C3	7-Dec-08	21-Mar-09	A15_3	B	F16	104	40.5	60
A15	*Labeobarbus*	*aeneus*	C3	7-Dec-08	21-Mar-09	A15_4	A	F65	104	36	70
A15	*Labeobarbus*	*aeneus*	C3	7-Dec-08	21-Mar-09	A15_4	B	F66	104	36	no count
K01	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	28-Apr-09	K01_1	A	E20	73	31.1	55
K01	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	28-Apr-09	K01_1	B	E21	73	31.1	58
K01	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	28-Apr-09	K01_1	C	E22	73	31.1	44
K01	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	28-Apr-09	K01_1	D	E23	73	31.1	no count
K01	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	28-Apr-09	K01_2	A	F79	73	32	68
K01	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	28-Apr-09	K01_2	B	F80	73	32	65
K02	*Labeobarbus*	*kimberleyensis*	A7	14-Feb-09	4-Jun-09	K02_1	A	G11	110	33	72
K02	*Labeobarbus*	*kimberleyensis*	A7	14-Feb-09	4-Jun-09	K02_1	B	G12	110	33	65
K02	*Labeobarbus*	*kimberleyensis*	A7	14-Feb-09	4-Jun-09	K02_2	A	G15	110	33.2	55
K02	*Labeobarbus*	*kimberleyensis*	A7	14-Feb-09	4-Jun-09	K02_2	B	G16	110	33.2	74
K03	*Labeobarbus*	*kimberleyensis*	D7	14-Feb-09	16-Apr-09	K03_1	A	E18	61	29.9	53
K03	*Labeobarbus*	*kimberleyensis*	D7	14-Feb-09	16-Apr-09	K03_1	B	E19	61	29.9	55
K03	*Labeobarbus*	*kimberleyensis*	D7	14-Feb-09	16-Apr-09	K03_2	A	F46	61	28.5	53
K03	*Labeobarbus*	*kimberleyensis*	D7	14-Feb-09	16-Apr-09	K03_2	B	F47	61	28.5	52
K03	*Labeobarbus*	*kimberleyensis*	D7	14-Feb-09	16-Apr-09	K03_3	A	F48	61	28	43
K03	*Labeobarbus*	*kimberleyensis*	D7	14-Feb-09	16-Apr-09	K03_3	B	F49	61	28	52
K04	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	25-Jun-09	K04_1	A	E84	131	34.8	65
K04	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	25-Jun-09	K04_1	B	E85	131	34.8	55
K04	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	25-Jun-09	K04_2	A	F93	131	33.2	88
K04	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	25-Jun-09	K04_2	C	F94	131	33.2	45
K04	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	25-Jun-09	K04_3	A	F95	131	34.8	82
K04	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	25-Jun-09	K04_3	B	F96	131	34.8	50
K05	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	19-Feb-09	K05_1a	A	G29	3	8.1	3
K05	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	19-Feb-09	K05_1b	A	E1	5	8.1	*
K05	*Labeobarbus*	*kimberleyensis*	D7	14-Feb-09	27-Feb-09	K05_1c	A	G30	11	10	10
K05	*Labeobarbus*	*kimberleyensis*	D7	14-Feb-09	27-Feb-09	K05_1c	A	E3	13	10	*
K05	*Labeobarbus*	*kimberleyensis*	D1	14-Feb-09	5-Mar-09	K05_1d	A	G32	17	12	17
K05	*Labeobarbus*	*kimberleyensis*	D1	14-Feb-09	5-Mar-09	K05_1d	A	E5	19	12	*
K05	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	12-Mar-09	K05_1e	A	G33	24	16.8	22

Appendix 6: Raw data used in the age validation exercise of this study (continued).

Vial	Genus	Species	Tank	Fertilisation Date:Time	Sample Date:Time	FishCode	Otolith	TraySlot	Age	TL 1	Count
K05	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	12-Mar-09	K05_1e	A	E7	26	16.8	*
K05	*Labeobarbus*	*kimberleyensis*	D7	14-Feb-09	19-Mar-09	K05_1f	A	G34	31	18	31
K05	*Labeobarbus*	*kimberleyensis*	D7	14-Feb-09	19-Mar-09	K05_1f	A	E9	33	18	*
K05	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	19-Feb-09	K05_2a	A	E35	5	8.2	3
K05	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	19-Feb-09	K05_2a	B	E36	5	8.2	3
K05	*Labeobarbus*	*kimberleyensis*	D7	14-Feb-09	27-Feb-09	K05_2b	A	G31	11	10.2	11
K05	*Labeobarbus*	*kimberleyensis*	D7	14-Feb-09	27-Feb-09	K05_2c	A	E37	13	10.2	*
K05	*Labeobarbus*	*kimberleyensis*	D1	14-Feb-09	5-Mar-09	K05_2d	A	F35	17	12	16
K05	*Labeobarbus*	*kimberleyensis*	D1	14-Feb-09	5-Mar-09	K05_2e	B	F36	19	12	14
K05	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	12-Mar-09	K05_2f	A	F41	24	15	22
K05	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	12-Mar-09	K05_2g	B	F42	26	15	23
K05	*Labeobarbus*	*kimberleyensis*	D7	14-Feb-09	19-Mar-09	K05_2h	A	F50	31	19.2	29
K05	*Labeobarbus*	*kimberleyensis*	D7	14-Feb-09	19-Mar-09	K05_2h	B	F51	31	19.2	30
K05	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	19-Feb-09	K05_3	A	F39	5	9	3
K05	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	19-Feb-09	K05_3a	B	F40	5	9	X
K05	*Labeobarbus*	*kimberleyensis*	D1	14-Feb-09	5-Mar-09	K05_3b	A	F37	17	11.5	15
K05	*Labeobarbus*	*kimberleyensis*	D1	14-Feb-09	5-Mar-09	K05_3c	B	F38	19	11.5	14
K05	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	12-Mar-09	K05_3d	A	F43	24	14.5	no count
K05	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	12-Mar-09	K05_3e	B		26	14.5	no count
K05	*Labeobarbus*	*kimberleyensis*	D7	14-Feb-09	19-Mar-09	K05_3	A	F52	31	18	30
K05	*Labeobarbus*	*kimberleyensis*	D7	14-Feb-09	19-Mar-09	K05_3	B	F53	31	18	29
K06	*Labeobarbus*	*kimberleyensis*	C7	14-Feb-09	7-Apr-09	K06_1	A	E15	52	33	49
K06	*Labeobarbus*	*kimberleyensis*	C7	14-Feb-09	7-Apr-09	K06_1	B	E16	52	33	50
K06	*Labeobarbus*	*kimberleyensis*	C7	14-Feb-09	7-Apr-09	K06_2	A	F73	52	34.2	49
K06	*Labeobarbus*	*kimberleyensis*	C7	14-Feb-09	7-Apr-09	K06_2	B	F74	52	34.2	50
K06	*Labeobarbus*	*kimberleyensis*	C7	14-Feb-09	7-Apr-09	K06_3	A	F71	52	33	45
K06	*Labeobarbus*	*kimberleyensis*	C7	14-Feb-09	7-Apr-09	K06_3	B	F72	52	33	46
K07	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	30-Apr-09	K07_1	A	E24	75	30	12
K07	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	30-Apr-09	K07_1	B	E25	75	30	65
K07	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	30-Apr-09	K07_1	C	E26	75	30	55
K07	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	30-Apr-09	K07_2	A	F81	75	30	60
K07	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	30-Apr-09	K07_2	B	F82	75	30	64
K07	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	30-Apr-09	K07_3	A	F83	75	27.2	28
K07	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	30-Apr-09	K07_3	B	F84	75	27.2	68
K08	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	9-Apr-09	K08_1	A	E17	54	26.2	51
K08	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	9-Apr-09	K08_1	B		54		no count

Appendix 7: Raw data used in the age validation exercise of this study (continued).

Vial	Genus	Species	Tank	Fertilisation Date:Time	Sample Date:Time	FishCode	Otolith	TraySlot	Age	TL 1	Count
K08	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	9-Apr-09	K08_2	A	F75	54	24.8	45
K08	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	9-Apr-09	K08_2	B	F76	54	24.8	48
K08	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	9-Apr-09	K08_3	A	F77	54	25	50
K08	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	9-Apr-09	K08_3	B	F78	54	25	50
K09	*Labeobarbus*	*kimberleyensis*	D7	14-Feb-09	21-May-09	K09_1	A	E27	96	33	66
K09	*Labeobarbus*	*kimberleyensis*	D7	14-Feb-09	21-May-09	K09_1	B	E28	96	33	64
K09	*Labeobarbus*	*kimberleyensis*	D7	14-Feb-09	21-May-09	K09_1	C	E29	96	33	88
K09	*Labeobarbus*	*kimberleyensis*	D7	14-Feb-09	21-May-09	K09_1	D	E30	96	33	45
K09	*Labeobarbus*	*kimberleyensis*	D7	14-Feb-09	21-May-09	K09_2	A	F85	96	32.5	76
K09	*Labeobarbus*	*kimberleyensis*	D7	14-Feb-09	21-May-09	K09_2	B	F86	96	32.5	80
K09	*Labeobarbus*	*kimberleyensis*	D7	14-Feb-09	21-May-09	K09_3	A	F87	96	34.8	78
K09	*Labeobarbus*	*kimberleyensis*	D7	14-Feb-09	21-May-09	K09_3	B	F88	96	34.8	78
K10	*Labeobarbus*	*kimberleyensis*	A8	14-Feb-09	11-Jun-09	K10_1	A	G9	117	33.5	58
K10	*Labeobarbus*	*kimberleyensis*	A8	14-Feb-09	11-Jun-09	K10_1	B	G10	117	33.5	50
K10	*Labeobarbus*	*kimberleyensis*	A8	14-Feb-09	11-Jun-09	K10_2	A	G13	117	36	80
K10	*Labeobarbus*	*kimberleyensis*	A8	14-Feb-09	11-Jun-09	K10_2	B	G14	117	36	60
K11	*Labeobarbus*	*kimberleyensis*	A2	14-Feb-09	18-Jun-09	K11_1	A	G5	124	33.5	50
K11	*Labeobarbus*	*kimberleyensis*	A2	14-Feb-09	18-Jun-09	K11_1	B	G6	124	33.5	72
K11	*Labeobarbus*	*kimberleyensis*	A2	14-Feb-09	18-Jun-09	K11_2	A	G7	124	30.8	60
K11	*Labeobarbus*	*kimberleyensis*	A2	14-Feb-09	18-Jun-09	K11_2	B	G8	124	30.8	60
K12	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	25-Mar-09	K12_1a	A	G35	37	22.9	30
K12	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	25-Mar-09	K12_1b	A	E11	39	22.9	*
K12	*Labeobarbus*	*kimberleyensis*	D7	14-Feb-09	2-Apr-09	K12_1c	A	G36	45	24.9	41
K12	*Labeobarbus*	*kimberleyensis*	D7	14-Feb-09	2-Apr-09	K12_1d	A	E13	47	24.9	*
K12	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	25-Mar-09	K12_2a	A	F69	37	21.5	37
K12	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	25-Mar-09	K12_2a	C	F70	37	21.5	35
K12	*Labeobarbus*	*kimberleyensis*	D7	14-Feb-09	2-Apr-09	K12_2b	A	F44	45	23.8	43
K12	*Labeobarbus*	*kimberleyensis*	D7	14-Feb-09	2-Apr-09	K12_2b	B	F45	45	23.8	30
K12	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	25-Mar-09	K12_3c	B	F68	37	22	36
K12	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	25-Mar-09	K12_3d	A	F67	39	22	36
K13	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	2-Jul-09	K13_1	A	E86	138	36	88
K13	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	2-Jul-09	K13_1	B	E87	138	36	70
K13	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	2-Jul-09	K13_2	A	F97	138	35	45
K13	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	2-Jul-09	K13_2	B	F98	138	35	72
K13	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	2-Jul-09	K13_3	A	F99	138	31	53
K13	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	2-Jul-09	K13_3	B	F100	138	31	45

Appendix 8: Raw data used in the age validation exercise of this study (continued).

Vial	Genus	Species	Tank	Fertilisation Date:Time	Sample Date:Time	FishCode	Otolith	TraySlot	Age	TL 1	Count
K14	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	5-Jul-09	K14_1	B	E89	139	39.1	45
K14	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	5-Jul-09	K14_1	A	E88	141	39.1	30
K14	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	5-Jul-09	K14_2	A	G1	141	35.2	35
K14	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	5-Jul-09	K14_2	B	G2	141	35.2	85
K14	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	5-Jul-09	K14_3	A	G3	139	34.8	60
K14	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	5-Jul-09	K14_3	B	G4	141	34.8	70
K15	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	28-May-09	K15_1	A	E31	103	33.1	80
K15	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	28-May-09	K15_1	B	E32	103	33.1	85
K15	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	28-May-09	K15_1	C	E33	103	33.1	55
K15	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	28-May-09	K15_1	D	E34	103	33.1	69
K15	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	28-May-09	K15_2	A	F89	103	33	85
K15	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	28-May-09	K15_2	B	F90	103	33	55
K15	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	28-May-09	K15_3	A	F91	103	32.5	65
K15	*Labeobarbus*	*kimberleyensis*	D8	14-Feb-09	28-May-09	K15_3	B	F92	103	32.5	78

Appendix 9: Raw monitoring data collected from the biotelemetry study from location 1.

FID	DATE	FREQUENCY	Y	X	CUMECS	RAIN	oC	BIOTOPES
1	23-Sep-06	17	-27.150900	26.441300	20.8900	0	28.4	Run
2	27-Sep-06	17	-27.150800	26.440100	20.2300	0	27.8	Riffle
3	28-Sep-06	17	-27.150800	26.440100	19.4300	0	28.8	Riffle
4	29-Sep-06	17	-27.150200	26.431300	19.0100	0	30.3	Glide
5	2-Oct-06	17	-27.150300	26.431400	16.7100	0	25.6	Glide
6	3-Oct-06	17	-27.150600	26.440300	16.2000	0	26.4	Glide
7	4-Oct-06	17	-27.150600	26.440400	15.8500	0	21.4	Glide
8	5-Oct-06	17	-27.150800	26.440400	15.9700	0	24.3	Glide
9	12-Oct-06	17	-27.150700	26.440300	22.6300	0.3	26.8	Glide
10	13-Oct-06	17	-27.150700	26.440100	18.9900	0	29.2	Riffle
11	16-Oct-06	17	-27.150800	26.440100	15.2700	0.3	30.8	Riffle
12	17-Oct-06	17	-27.151100	26.441700	14.8600	3.2	28.8	Run
13	19-Oct-06	17	-27.151100	26.441000	14.3900	0	26.1	Run
14	24-Oct-06	17	-27.150600	26.440500	14.3400	0	36.6	Glide
15	26-Oct-06	17	-27.150700	26.439600	16.2400	0	31.9	Riffle
16	31-Oct-06	17	-27.151000	26.440900	18.8600	0.3	33.3	Run
17	1-Nov-06	17	-27.150800	26.440400	23.4000	2.3	23.8	Glide
18	2-Nov-06	17	-27.150900	26.440300	30.6000	5.4	22.3	Glide
19	7-Nov-06	17	-27.150900	26.439800	40.7900	0	28.1	Riffle
20	8-Nov-06	17	-27.150900	26.439800	34.0400	0	30.6	Riffle
21	14-Nov-06	17	-27.151100	26.441500	18.2000	0	31	Run
22	29-Nov-06	17	-27.150900	26.441600	27.7600	0.3	34.8	Run
23	1-Dec-06	17	-27.150700	26.440600	22.9200	0	30.1	Glide
24	4-Dec-06	17	-27.150800	26.441400	29.6300	0	27.6	Run
25	5-Dec-06	17	-27.150900	26.441500	29.3200	0	30.1	Run
26	6-Dec-06	17	-27.151000	26.441300	26.2900	0	32.6	Run
27	7-Dec-06	17	-27.151000	26.441400	22.6800	0.3	34.6	Run
28	8-Dec-06	17	-27.151000	26.441400	20.2900	0	31.8	Run
29	11-Dec-06	17	-27.150800	26.441300	17.9200	0	28.2	Run
30	13-Dec-06	17	-27.150600	26.441100	19.2900	0	33.2	Run
31	15-Dec-06	17	-27.150600	26.440000	19.3100	0	37	Riffle
32	18-Dec-06	17	-27.151100	26.442400	19.0800	0	36.1	Riffle
33	19-Dec-06	17	-27.151100	26.392400	19.6100	6.8	34.6	Riffle
34	11-Jan-07	17	-27.150800	26.440000	19.6500	0	32.7	Riffle
35	12-Jan-07	17	-27.150600	26.439300	17.8900	0	35.4	Riffle
36	15-Jan-07	17	-27.150800	26.439500	12.7400	5.5	31.2	Riffle
37	16-Jan-07	17	-27.150700	26.439900	12.9800	4.6	31	Riffle
38	17-Jan-07	17	-27.150600	26.439400	14.1000	0	34.4	Riffle
39	18-Jan-07	17	-27.150700	26.439200	17.1300	0	32	Riffle
40	21-Jan-07	17	-27.150700	26.439600	40.5000	0	29.6	Riffle
41	22-Jan-07	17	-27.150700	26.439100	39.8000	0	31.3	Riffle
42	23-Jan-07	17	-27.150700	26.440300	49.4700	0	33.6	Glide
43	31-Jan-07	17	-27.150600	26.439300	13.3300	0	29.9	Riffle
44	2-Feb-07	17	-27.150700	26.439700	13.6600	7.4	32.4	Riffle
45	5-Feb-07	17	-27.150500	26.439100	14.7500	0	34	Riffle
46	6-Feb-07	17	-27.150200	26.439600	15.0700	0	34.3	Glide
47	13-Feb-07	17	-27.150800	26.439800	25.8300	0	26.1	Riffle
48	15-Feb-07	17	-27.150400	26.439100	19.7000	0	32	Riffle
49	16-Feb-07	17	-27.150500	26.439100	19.2900	0	33.5	Riffle
50	2-Apr-07	17	-27.150800	26.439900	21.4800	0	28.5	Riffle
51	15-Apr-07	17	-27.151000	26.439800	20.2700	0.5	26.6	Riffle
52	16-Apr-07	17	-27.150300	26.439100	20.7600	0	28.6	Glide
53	17-Apr-07	17	-27.150300	26.439100	23.2100	0.5	23	Glide
54	20-Apr-07	17	-27.150700	26.440100	25.7600	0	25.4	Riffle
55	22-Apr-07	17	-27.150600	26.439900	42.2500	0	26	Riffle
56	24-Apr-07	17	-27.150800	26.439900	41.9400	0	26.8	Riffle
57	8-May-07	17	-27.150600	26.440300	19.4100	0	26.9	Glide
58	19-May-07	17	-27.150800	26.439800	18.9400	0	26.8	Riffle
59	23-May-07	17	-27.180700	26.439900	19.2900	0	12	Run
60	24-May-07	17	-27.150800	26.439800	19.1800	0	14.1	Riffle

Appendix 10: Continuation of raw data collected from the biotelemetry study from location 1.

61	9-Nov-06	26	-27.153100	26.426200	22.8200	0	30.9	Riffle
62	14-Nov-06	26	-27.159800	26.424900	18.2000	0	31	Pool
63	13-Dec-06	26	-27.160100	26.424300	19.2900	0	33.2	Riffle
64	15-Dec-06	26	-27.163700	26.422200	19.3100	0	37	Glide
65	18-Dec-06	26	-27.160100	26.424400	19.0800	0	36.1	Riffle
66	19-Dec-06	26	-27.161200	26.424200	19.6100	6.8	34.6	Run
67	11-Jan-07	26	-27.159800	26.423800	19.6500	0	32.7	Run
68	15-Jan-07	26	-27.161000	26.424700	12.7400	5.5	31.2	Run
69	17-Jan-07	26	-27.159200	26.424400	14.1000	0	34.4	Pool
70	18-Jan-07	26	-27.160300	26.423900	17.1300	0	32	Riffle
71	22-Jan-07	26	-27.160000	26.424700	39.8000	0	31.3	Pool
72	31-Jan-07	26	-27.160300	26.423900	13.3300	0	29.9	Riffle
73	6-Feb-07	26	-27.160200	26.424300	15.0700	0	34.3	Riffle
74	11-Feb-07	26	-27.162000	26.423600	16.5500	0	22.1	Glide
75	13-Feb-07	26	-27.161200	26.423900	25.8300	0	26.1	Run
76	15-Feb-07	26	-27.161600	26.423600	19.7000	0	32	Run
77	16-Feb-07	26	-27.160100	26.423700	19.2900	0	33.5	Riffle
78	21-Feb-07	26	-27.160300	26.424000	17.1300	0	35.6	Riffle
79	22-Feb-07	26	-27.159500	26.423800	15.0900	0.3	35.7	Run
80	26-Feb-07	26	-27.161100	26.423600	17.4600	0	31.6	Run
81	28-Feb-07	26	-27.161300	26.423300	17.7300	0	33.7	Run
82	2-Apr-07	26	-27.165400	26.422000	21.4800	0	28.5	Glide
83	16-Apr-07	26	-27.161056	26.423833	20.7600	0	28.6	Run
84	17-Apr-07	26	-27.161056	26.423833	23.2100	0.5	23	Run
85	20-Apr-07	26	-27.163700	26.422200	25.7600	0	25.4	Glide
86	24-Apr-07	26	-27.163700	26.422200	41.9400	0	26.8	Glide
87	6-Jun-07	26	-27.161100	26.424100	24.9300	7.6	13.4	Run
88	13-Jun-07	26	-27.159600	26.424500	37.4400	0	23.6	Pool
89	15-Jun-07	26	-27.162900	26.423700	75.5100	0	16.9	Glide
90	18-Jun-07	26	-27.161800	26.424000	34.5700	0	21.5	Glide
91	20-Jun-07	26	-27.161000	26.424300	20.4800	0	19.5	Run
92	29-Jun-07	26	-27.160000	26.424000	17.8800	0	20.5	Riffle
93	9-Nov-06	36	-27.153100	26.426200	22.8200	0	30.9	Riffle
94	21-Nov-06	36	-27.151900	26.427500	54.2400	0	31.3	Riffle
95	22-Nov-06	36	-27.151800	26.427700	67.1600	0	33.8	Riffle
96	29-Nov-06	36	-27.151800	26.427700	27.7600	0.3	34.8	Riffle
97	1-Dec-06	36	-27.151700	26.427800	22.9200	0	30.1	Riffle
98	5-Dec-06	36	-27.151300	26.426800	29.3200	0	30.1	Riffle
99	18-Dec-06	36	-27.151100	26.428400	19.0800	0	36.1	Glide
100	19-Dec-06	36	-27.150600	26.428600	19.6100	6.8	34.6	Glide
101	18-Jan-07	36	-27.150311	26.422756	17.1300	0	32	Glide
102	18-Jan-07	36	-27.150075	26.422747	17.1300	0	32	Glide
103	19-Jan-07	36	-27.150058	26.422578	29.4500	0	33.5	Glide
104	19-Jan-07	36	-27.150308	26.422536	29.4500	0	33.5	Glide
105	21-Jan-07	36	-27.152600	26.426600	40.5000	0	29.6	Riffle
106	22-Jan-07	36	-27.151500	26.427900	39.8000	0	31.3	Riffle
107	23-Jan-07	36	-27.152100	26.427600	49.4700	0	33.6	Glide
108	24-Jan-07	36	-27.152100	26.427600	50.3500	0	32.4	Glide
109	25-Jan-07	36	-27.152100	26.427700	38.6900	0	31.1	Glide
110	31-Jan-07	36	-27.152200	26.427000	13.3300	0	29.9	Run
111	6-Feb-07	36	-27.153800	26.425200	15.0700	0	34.3	Riffle
112	6-Feb-07	36	-27.154700	26.425100	15.0700	0	34.3	Glide
113	9-Feb-07	36	-27.152400	26.426600	14.6000	0	32.2	Riffle
114	13-Feb-07	36	-27.151100	26.428600	25.8300	0	26.1	Glide
115	15-Feb-07	36	-27.151700	26.427800	19.7000	0	32	Riffle
116	16-Feb-07	36	-27.165100	26.422300	19.2900	0	33.5	Glide
117	28-Feb-07	36	-27.150136	26.431642	17.7300	0	33.7	Glide
118	2-Apr-07	36	-27.151000	26.428400	21.4800	0	28.5	Glide
119	5-Apr-07	36	-27.151500	26.428400	19.7800	0	29.3	Glide
120	15-Apr-07	36	-27.150500	26.434400	20.2700	0.5	26.6	Glide
121	15-Apr-07	36	-27.150600	26.428600	20.2700	0.5	26.6	Glide

Appendix 11: Continuation of raw data collected from the biotelemetry study from location 1.

122	17-Apr-07	36	-27.154417	26.425333	23.2100	0.5	23	Glide
123	20-Apr-07	36	-27.151200	26.428400	25.7600	0	25.4	Glide
124	21-Apr-07	36	-27.150203	26.430708	32.7500	2.3	27.7	Riffle
125	24-Apr-07	36	-27.150500	26.427900	41.9400	0	26.8	Glide
126	15-May-07	36	-27.151400	26.428600	19.4500	0	21.2	Glide
127	19-May-07	36	-27.156100	26.425300	18.9400	0	26.8	Pool
128	23-May-07	36	-27.157500	26.424800	19.2900	0	12	Pool
129	6-Jun-07	36	-27.156800	26.424700	24.9300	7.6	13.4	Pool
130	13-Jun-07	36	-27.151200	26.428400	37.4400	0	23.6	Glide
131	18-Jun-07	36	-27.159300	26.424400	34.5700	0	21.5	Pool
132	20-Jun-07	36	-27.159000	26.423900	20.4800	0	19.5	Pool
133	29-Jun-07	36	-27.161400	26.423500	17.8800	0	20.5	Run
134	7-Jul-07	36	-27.158300	26.424400	19.4300	0	18.6	Pool
135	4-Nov-06	45	-27.130800	26.484200	21.9400	0	27.1	Riffle
136	5-Nov-06	45	-27.152100	26.427700	18.1000	0	26.7	Glide
137	6-Nov-06	45	-27.151300	26.428400	17.1000	0	27	Glide
138	7-Nov-06	45	-27.151500	26.427800	40.7900	0	28.1	Riffle
139	8-Nov-06	45	-27.130900	26.483900	34.0400	0	30.6	Run
140	11-Jan-07	45	-27.118200	26.484000	19.6500	0	32.7	Pool
141	5-Nov-06	56	-27.131400	26.484400	18.1000	0	26.7	Riffle
142	6-Nov-06	56	-27.152600	26.426900	17.1000	0	27	Run
143	11-Jan-07	56	-27.131100	26.484700	19.6500	0	32.7	Run
144	12-Jan-07	56	-27.131100	26.484800	17.8900	0	35.4	Run
145	15-Jan-07	56	-27.131100	26.484700	12.7400	5.5	31.2	Run
146	16-Jan-07	56	-27.131200	26.485000	12.9800	4.6	31	Run
147	17-Jan-07	56	-27.131200	26.448400	14.1000	0	34.4	Glide
148	18-Jan-07	56	-27.131100	26.484900	17.1300	0	32	Run
149	20-Jan-07	56	-27.131300	26.484600	39.1200	0	28.7	Glide
150	22-Jan-07	56	-27.131203	26.484886	39.8000	0	31.3	Glide
151	31-Jan-07	56	-27.131278	26.485053	13.3300	0	29.9	Run
152	2-Feb-07	56	-27.131200	26.484500	13.6600	7.4	32.4	Riffle
153	5-Feb-07	56	-27.131300	26.484800	14.7500	0	34	Glide
154	6-Feb-07	56	-27.131100	26.485000	15.0700	0	34.3	Riffle
155	13-Feb-07	56	-27.131400	26.484500	25.8300	0	26.1	Riffle
156	15-Feb-07	56	-27.131300	26.484600	19.7000	0	32	Glide
157	21-Feb-07	56	-27.131100	26.485100	17.1300	0	35.6	Riffle
158	22-Feb-07	56	-27.131200	26.485142	15.0900	0.3	35.7	Run
159	9-Nov-06	64	-27.153100	26.426200	52.1200	0	23.7	Riffle
160	14-Nov-06	64	-27.159900	26.424700	42.1300	4.8	33	Pool
161	21-Nov-06	64	-27.159900	26.424700	22.9200	0	30.1	Pool
162	18-Dec-06	64	-27.159600	26.425000	118.2000	0	30.5	Pool
163	22-Jan-07	64	-27.159400	26.425100	12.5400	2.1	25.5	Pool
164	13-Feb-07	64	-27.152500	26.426600	14.2500	1.5	32.9	Riffle
165	14-Feb-07	64	-27.152300	26.426900	19.8900	0	32.3	Run
166	15-Feb-07	64	-27.152000	26.426900	20.1200	0	32.6	Run
167	16-Feb-07	64	-27.162600	26.423100	17.4600	0	31.6	Glide
168	21-Feb-07	64	-27.162900	26.423300	15.4000	9.2	32.9	Glide
169	28-Feb-07	64	-27.161200	26.424200	8.8400	0	28.9	Run
170	2-Mar-07	64	-27.162600	26.423800	12.2700	0	31.6	Glide
171	5-Mar-07	64	-27.159200	26.424800	10.4100	0	33.6	Pool
172	15-Apr-07	64	-27.155700	26.424900	35.9800	0	28.1	Pool
173	17-Apr-07	64	-27.519100	26.424500	22.9300	0	24.2	Pool
174	24-Apr-07	64	-27.165400	26.422000	20.2300	0	26.7	Glide
175	8-May-07	64	-27.157100	26.424900	19.1300	0	28.1	Pool
176	19-May-07	64	-27.158400	26.424400	20.0100	0	22.4	Pool
177	23-May-07	64	-27.157400	26.424600	20.4900	0	18.6	Pool
178	18-Jun-07	64	-27.159800	26.424500	18.3600	0	16.4	Pool
179	20-Jun-07	64	-27.159800	26.425000	17.8200	0	21.3	Pool
180	21-Jun-07	64	-27.161100	26.423400	17.2200	0	15.8	Run
181	5-Jul-07	64	-27.155900	26.425000	22.2600	0	21.4	Pool
182	7-Jul-07	64	-27.159300	26.424400	20.6200	0	21.7	Pool

Appendix 12: Continuation of raw data collected from the biotelemetry study from location 1.

183	9-Nov-06	74	-27.153189	26.426489	22.8200	0	30.9	Riffle
184	14-Nov-06	74	-27.156700	26.424800	18.2000	0	31	Pool
185	21-Nov-06	74	-27.153900	26.425800	54.2400	0	31.3	Riffle
186	18-Dec-06	74	-27.166000	26.421600	19.0800	0	36.1	Pool
187	19-Dec-06	74	-27.165100	26.422300	19.6100	6.8	34.6	Glide
188	22-Jan-07	74	-27.151900	26.427300	39.8000	0	31.3	Riffle
189	23-Jan-07	74	-27.153800	26.425700	49.4700	0	33.6	Riffle
190	31-Jan-07	74	-27.152000	26.427600	13.3300	0	29.9	Riffle
191	13-Feb-07	74	-27.153400	26.425800	25.8300	0	26.1	Riffle
192	16-Feb-07	74	-27.163200	26.423200	19.2900	0	33.5	Glide
193	21-Feb-07	74	-27.162500	26.422900	17.1300	0	35.6	Glide
194	22-Feb-07	74	-27.164100	26.422300	15.0900	0.3	35.7	Run
195	28-Feb-07	74	-27.154300	26.425600	17.7300	0	33.7	Run
196	2-Mar-07	74	-27.161500	26.423700	20.3900	0	34	Run
197	5-Mar-07	74	-27.162700	26.423400	10.1400	0	23.6	Glide
198	2-Apr-07	74	-27.165100	26.422300	21.4800	0	28.5	Glide
199	17-Apr-07	74	-27.156800	26.424700	23.2100	0.5	23	Pool
200	20-Apr-07	74	-27.164100	26.422300	25.7600	0	25.4	Run
201	24-Apr-07	74	-27.164100	26.422300	41.9400	0	26.8	Run
202	8-May-07	74	-27.155100	26.425100	19.4100	0	26.9	Glide
203	19-May-07	74	-27.158200	26.425000	18.9400	0	26.8	Pool
204	23-May-07	74	-27.158200	26.425000	19.2900	0	12	Pool
205	13-Jun-07	74	-27.158200	26.425000	37.4400	0	23.6	Pool
206	18-Jun-07	74	-27.159200	26.424800	34.5700	0	21.5	Pool
207	20-Jun-07	74	-27.158800	26.424100	20.4800	0	19.5	Pool
208	2-Sep-06	83	-27.151900	26.443400	27.0700	0	22.9	Pool
209	3-Sep-06	83	-27.152600	26.447400	25.8900	0	25.8	Glide
210	5-Sep-06	83	-27.153300	26.448200	24.6600	0	23.1	Run
211	6-Sep-06	83	-27.153200	26.448700	24.6400	0	24.3	Run
212	7-Sep-06	83	-27.152500	26.446500	24.4200	0	24.6	Glide
213	8-Sep-06	83	-27.153100	26.448400	24.2200	0	23.1	Run
214	12-Sep-06	83	-27.152900	26.446800	25.4700	0	28.1	Glide
215	13-Sep-06	83	-27.153000	26.448200	23.5400	0	27.6	Run
216	14-Sep-06	83	-27.153400	26.448500	20.1100	0	29.4	Run
217	15-Sep-06	83	-27.153100	26.447700	17.0700	0	24.9	Run
218	21-Sep-06	83	-27.153300	26.449000	21.7100	0	26.1	Run
219	19-Sep-07	203	-27.151256	26.442314	15.3100	0	31.8	Run
220	25-Sep-07	203	-27.162700	26.423200	11.6800	0	30.4	Glide
221	1-Oct-07	203	-27.160700	26.424400	48.3500	29.2	18.7	Run
222	15-Oct-07	203	-27.152717	26.447639	29.6300	0	31.8	Riffle
223	17-Oct-07	203	-27.152661	26.448044	31.1200	3.3	30.8	Riffle
224	13-May-07	224	-27.150400	26.436500	19.0600	0	26.6	Pool
225	19-May-07	224	-27.157400	26.424600	18.9400	0	26.8	Pool
226	23-May-07	224	-27.158300	26.424400	19.2900	0	12	Pool
227	15-Apr-07	234	-27.152000	26.427600	20.2700	0.5	26.6	Riffle
228	15-Apr-07	234	-27.154100	26.425600	20.7600	0	28.6	Run
229	15-Apr-07	234	-27.162600	26.440800	23.2100	0.5	23	Riffle
230	17-Apr-07	234	-27.162600	26.423100	25.5800	0.3	24	Glide
231	24-Apr-07	234	-27.152000	26.426800	27.3300	0	29	Run
232	8-May-07	234	-27.152000	26.427600	16.9100	0	26.2	Riffle
233	19-May-07	234	-27.150900	26.427700	18.8100	0	8.8	Glide
234	23-May-07	234	-27.154100	26.425600	19.4400	0	16.7	Run
235	18-Jun-07	234	-27.171100	26.420300	20.4800	0	19.5	Pool
236	22-Jun-07	234	-27.163200	26.423200	18.0800	0	19.4	Glide
237	29-Jun-07	234	-27.151200	26.428800	17.2200	0	15.8	Glide
238	19-Jul-07	234	-27.163700	26.422700	19.7800	0	22.5	Glide
239	22-Jul-07	234	-27.169400	26.420500	19.6700	0	24	Pool
240	24-Jul-07	234	-27.168800	26.420400	20.0400	0	16.7	Pool
241	25-Jul-07	234	-27.168200	26.420800	19.0100	20.8	20.8	Pool
242	3-Nov-07	234	-27.308183	26.494369	15.7900	0	26.6	Glide
243	2-Jun-07	262	-27.154800	26.425500	20.4900	0	18.6	Glide

Appendix 13: Continuation of raw data collected from the biotelemetry study from location 1.

244	6-Jun-07	262	-27.158300	26.424400	24.9300	7.6	13.4	Pool
245	13-Jun-07	262	-27.159231	26.424683	37.4400	0	23.6	Pool
246	18-Jun-07	262	-27.167200	26.421300	34.5700	0	21.5	Pool
247	20-Jun-07	262	-27.166500	26.421200	20.4800	0	19.5	Pool
248	18-Jul-07	262	-27.185500	26.427300	21.0600	0	22	Glide
249	19-Jul-07	262	-27.185700	26.427300	20.9100	0	21.2	Glide
250	20-Jul-07	262	-27.186000	26.427300	20.4200	0	21.6	Glide
251	22-Jul-07	262	-27.187694	26.432111	19.2900	0	24.2	Riffle
252	31-Jul-07	262	-27.187889	26.432417	16.7000	0	22.3	Riffle
253	8-Aug-07	262	-27.186917	26.429389	17.5500	0	19.1	Run
254	14-Aug-07	262	-27.188789	26.433117	13.0500	1.1	26.7	Riffle
255	31-Aug-07	262	-27.189206	26.433422	14.5500	0	29.8	Riffle
256	5-Oct-07	262	-27.188250	26.432611	45.5700	9.4	29	Riffle
257	17-Oct-07	262	-27.188528	26.433056	31.1200	3.3	30.8	Riffle
258	19-Oct-07	262	-27.188056	26.432472	34.6600	0.8	28.9	Riffle
259	24-Oct-07	262	-27.188444	26.432917	44.3700	0	24.8	Riffle
260	26-Oct-07	262	-27.188778	26.433333	32.8600	3.4	17.8	Riffle
261	1-Nov-07	262	-27.188528	26.433028	19.7000	3.8	26.6	Riffle
262	2-Nov-07	262	-27.187694	26.431750	19.1200	0	30.6	Riffle
263	3-Nov-07	262	-27.188639	26.433167	18.1700	0	31.9	Riffle
264	30-Dec-07	262	-27.188244	26.432850	19.654	0	30.3	Riffle
265	31-Dec-07	262	-27.188447	26.433192	16.795	0	33.9	Riffle
266	22-Jan-08	262	-27.188181	26.432408	75.524	6.7	26.6	Riffle
267	29-Jan-08	262	-27.187628	26.432417	107.321	0	30.8	Riffle
268	13-Feb-08	262	-27.188797	26.433064	39.569	0	30.6	Riffle
269	20-Feb-08	262	-27.188042	26.432742	42.431	0	31.8	Riffle
270	21-Feb-08	262	-27.188036	26.432125	37.979	0	31.4	Riffle
271	26-Feb-08	262	-27.188336	26.433011		9.9	29.4	Riffle
272	9-Aug-06	322	-27.151600	26.428300	30.5700	0	21.9	Glide
273	17-Aug-06	322	-27.150300	26.429100	36.4100	0	20.9	Glide
274	18-Aug-06	322	-27.151100	26.428400	34.1900	0	20.7	Glide
275	21-Aug-06	322	-27.150300	26.429000	27.1800	0	22.6	Glide
276	22-Aug-06	322	-27.151800	26.427900	26.9300	0	20.8	Riffle
277	23-Aug-06	322	-27.151200	26.429200	27.3500	1.9	20	Pool
278	24-Aug-06	322	-27.150300	26.429100	27.8000	1.6	17.2	Glide
279	25-Aug-06	322	-27.150300	26.429000	30.7100	0	17.8	Glide
280	28-Aug-06	322	-27.150300	26.428900	35.1300	0	23.6	Glide
281	29-Aug-06	322	-27.150300	26.428900	34.5200	0	24.9	Glide
282	31-Aug-06	322	-27.150200	26.428900	33.3900	0	20	Glide
283	1-Sep-06	322	-27.150300	26.428900	31.2100	0	21.1	Glide
284	5-Sep-06	322	-27.152700	26.447400	24.6600	0	23.1	Glide
285	6-Sep-06	322	-27.101200	26.429100	24.6400	0	24.3	Backwater
286	7-Sep-06	322	-27.150200	26.429200	24.4200	0	24.6	Backwater
287	8-Sep-06	322	-27.150200	26.429100	24.2200	0	23.1	Glide
288	12-Sep-06	322	-27.150300	26.429000	25.4700	0	28.1	Glide
289	13-Sep-06	322	-27.150100	26.429200	23.5400	0	27.6	Glide
290	14-Sep-06	322	-27.151300	26.428600	20.1100	0	29.4	Glide
291	15-Sep-06	322	-27.151100	26.428800	17.0700	0	24.9	Glide
292	27-Sep-06	322	-27.150300	26.432100	20.2300	0	27.8	Run
293	28-Sep-06	322	-27.150100	26.432500	19.4300	0	28.8	Run
294	29-Sep-06	322	-27.150100	26.432300	19.0100	0	30.3	Run
295	2-Oct-06	322	-27.150300	26.429000	16.7100	0	25.6	Glide
296	3-Oct-06	322	-27.149800	26.429400	16.2000	0	26.4	Glide
297	4-Oct-06	322	-27.150700	26.429100	15.8500	0	21.4	Glide
298	5-Oct-06	322	-27.150300	26.428800	15.9700	0	24.3	Run
299	9-Oct-06	322	-27.150500	26.428300	16.0300	1.3	25.4	Glide
300	12-Oct-06	322	-27.150400	26.428900	22.6300	0.3	26.8	Glide
301	13-Oct-06	322	-27.150300	26.428900	18.9900	0	29.2	Glide
302	18-Oct-06	322	-27.150300	26.429000	14.9400	0.8	29.4	Glide
303	19-Oct-06	322	-27.150300	26.428600	14.3900	0	26.1	Glide
304	24-Oct-06	322	-27.151300	26.428500	14.3400	0	36.6	Glide

Appendix 14: Continuation of raw data collected from the biotelemetry study from location 1.

305	26-Oct-06	322	-27.150400	26.428800	16.2400	0	31.9	Run
306	31-Oct-06	322	-27.150300	26.428700	18.8600	0.3	33.3	Run
307	1-Nov-06	322	-27.150200	26.428800	23.4000	2.3	23.8	Glide
308	5-Nov-06	322	-27.150900	26.428900	18.1000	0	26.7	Glide
309	6-Nov-06	322	-27.150900	26.429300	17.1000	0	27	Glide
310	7-Nov-06	322	-27.150300	26.428700	40.7900	0	28.1	Run
311	8-Nov-06	322	-27.150700	26.428400	34.0400	0	30.6	Glide
312	14-Nov-06	322	-27.150300	26.428800	18.2000	0	31	Run
313	29-Nov-06	322	-27.151100	26.429200	27.7600	0.3	34.8	Pool
314	1-Dec-06	322	-27.150400	26.428500	22.9200	0	30.1	Glide
315	4-Dec-06	322	-27.150500	26.428500	29.6300	0	27.6	Glide
316	5-Dec-06	322	-27.150400	26.428300	29.3200	0	30.1	Glide
317	6-Dec-06	322	-27.150500	26.428400	26.2900	0	32.6	Glide
318	7-Dec-06	322	-27.150400	26.428500	22.6800	0.3	34.6	Glide
319	8-Dec-06	322	-27.150600	26.428400	20.2900	0	31.8	Glide
320	11-Dec-06	322	-27.150400	26.428400	17.9200	0	28.2	Glide
321	7-Apr-07	333	-27.166100	26.435100	24.3000	0	27.6	Riffle
322	15-Apr-07	333	-27.150600	26.436100	20.2700	0.5	26.6	Glide
323	15-Apr-07	333	-27.150300	26.435700	20.2700	0.5	26.6	Glide
324	16-Apr-07	333	-27.149800	26.434400	20.7600	0	28.6	Glide
325	17-Apr-07	333	-27.149800	26.434400	23.2100	0.5	23	Glide
326	20-Apr-07	333	-27.149800	26.436000	25.7600	0	25.4	Run
327	21-Apr-07	333	-27.149300	26.434800	32.7500	2.3	27.7	Backwater
328	24-Apr-07	333	-27.149400	26.434900	41.9400	0	26.8	Riffle
329	8-May-07	333	-27.150300	26.435700	19.4100	0	26.9	Glide
330	19-May-07	333	-27.150600	26.437300	18.9400	0	26.8	Pool
331	23-May-07	333	-27.150600	26.437300	19.2900	0	12	Pool
332	24-May-07	333	-27.150600	26.437300	19.1800	0	14.1	Pool
333	15-Jun-07	333	-27.159800	26.424900	75.5100	0	16.9	Pool
334	18-Jun-07	333	-27.164000	26.422500	34.5700	0	21.5	Run
335	20-Jun-07	333	-27.162100	26.422800	20.4800	0	19.5	Glide
336	29-Jun-07	333	-27.169400	26.420000	17.8800	0	20.5	Pool
337	4-Jul-07	333	-27.164000	26.422500	21.5000	0	16.1	Run
338	19-Jul-07	333	-27.159500	26.423900	20.9100	0	21.2	Run
339	22-Jul-07	333	-27.171900	26.420314	19.2900	0	24.2	Pool
340	24-Jul-07	333	-27.160200	26.423800	19.6700	0	24	Riffle
341	25-Jul-07	333	-27.161300	26.423300	19.5800	0	20.1	Run
342	8-Aug-07	333	-27.170000	26.419700	17.5500	0	19.1	Pool
343	17-Aug-07	333	-27.162800	26.423000	14.5600	0	18.9	Glide
344	21-Aug-07	333	-27.162400	26.423700	14.3400	0	27.5	Glide
345	23-Aug-07	333	-27.160200	26.423800	14.2000	0	28.6	Riffle
346	31-Aug-07	333	-27.159400	26.424500	14.5500	0	29.8	Pool
347	4-Sep-07	333	-27.157800	26.425200	18.9900	0	32.4	Pool
348	6-Sep-07	333	-27.157600	26.425000	17.7000	0	31.6	Pool
349	10-Sep-07	333	-27.159300	26.424900	11.6900	0	30.2	Pool
350	14-Sep-07	333	-27.161400	26.424200	18.0600	0	31.1	Glide
351	20-Sep-07	333	-27.159800	26.424900	14.0100	0	32.9	Pool
352	25-Sep-07	333	-27.162300	26.422800	11.6800	0	30.4	Glide
353	1-Oct-07	333	-27.161300	26.424300	48.3500	29.2	18.7	Glide
354	2-Oct-07	333	-27.161600	26.424100	54.0900	7.6	25	Glide
355	5-Oct-07	333	-27.161400	26.424200	45.5700	9.4	29	Glide
356	9-Oct-07	333	-27.160000	26.424800	43.9500	0	19.4	Pool
357	15-Oct-07	333	-27.160000	26.424800	29.6300	0	31.8	Pool
358	16-Oct-07	333	-27.159400	26.424500	32.2300	4.6	30.3	Pool
359	17-Oct-07	333	-27.159800	26.424900	31.1200	3.3	30.8	Pool
360	18-Oct-07	333	-27.159600	26.425000	31.0000	0.8	28.7	Pool
361	23-Oct-07	333	-27.159400	26.424200	35.7400	3.4	29.6	Run
362	26-Oct-07	333	-27.162700	26.423400	32.8600	3.4	17.8	Glide
363	14-May-07	351	-27.154800	26.425600	19.4700	0	29	Glide
364	19-May-07	351	-27.154100	26.425700	18.9400	0	26.8	Run
365	20-May-07	351	-27.154100	26.425600	18.4600	0	22.4	Run

Appendix 15: Continuation of raw data collected from the biotelemetry study from location 1.

366	30-Aug-07	363	-27.152600	26.427100	12.8100	0	30	Run
367	31-Aug-07	363	-27.158100	26.424200	14.5500	0	29.8	Pool
368	3-Nov-07	363	-27.287700	26.489100	18.1700	0	31.9	Riffle
369	14-May-07	373	-27.154058	26.426414	19.4700	0	29	Backwater
370	19-May-07	373	-27.157600	26.425000	18.9400	0	26.8	Pool
371	19-Jul-07	373	-27.204708	26.440278	20.9100	0	21.2	Riffle
372	22-Jul-07	373	-27.208078	26.440903	19.2900	0	24.2	Riffle
373	31-Jul-07	373	-27.209903	26.440994	16.7000	0	22.3	Riffle
374	31-Aug-07	373	-27.208786	26.440989	14.5500	0	29.8	Riffle
375	3-Nov-07	373	-27.213361	26.439358	18.1700	0	31.9	Riffle
376	30-Aug-07	383	-27.152631	26.427103	12.8100	0	30	Run
377	31-Aug-07	383	-27.160864	26.424003	14.5500	0	29.8	Run
378	15-Oct-07	383	-27.153911	26.450100	29.6300	0	31.8	Run
379	17-Oct-07	383	-27.153783	26.450642	31.1200	3.3	30.8	Riffle
380	18-Oct-07	383	-27.153739	26.451025	31.0000	0.8	28.7	Run
381	23-Oct-07	383	-27.152656	26.447675	35.7400	3.4	29.6	Riffle
382	3-Nov-07	383	-27.153106	26.153106	18.1700	0	31.9	Run
383	13-Nov-07	383	-27.152806	26.450183	15.195	0	34.9	Glide
384	30-Dec-07	383	-27.153631	26.450939	19.654	0	30.3	Glide
385	30-Jan-08	383	-27.152678	26.449583	78.99	0	31.7	Glide
386	7-Jul-07	402	-27.159467	26.424192	19.4300	0	18.6	Run
387	19-Jul-07	402	-27.162900	26.423300	20.9100	0	21.2	Glide
388	22-Jul-07	402	-27.208786	26.440989	19.2900	0	24.2	Pool
389	25-Jul-07	402	-27.173100	26.422800	19.5800	0	20.1	Pool
390	8-Aug-07	402	-27.176356	26.423806	17.5500	0	19.1	Riffle
391	17-Aug-07	402	-27.162500	26.423000	14.5600	0	18.9	Glide
392	18-Aug-07	402	-27.163000	26.423300	14.1500	0	21.3	Glide
393	21-Aug-07	402	-27.162200	26.423200	14.3400	0	27.5	Glide
394	30-Aug-07	402	-27.169000	26.421300	12.8100	0	30	Pool
395	31-Aug-07	402	-27.167800	26.421200	14.5500	0	29.8	Pool
396	14-May-07	424	-27.151697	26.425950	19.4700	0	29	Backwater
397	19-May-07	424	-27.151500	26.427900	18.9400	0	26.8	Riffle
398	23-May-07	424	-27.150433	26.422208	19.2900	0	12	Glide
399	24-May-07	424	-27.150428	26.422350	19.1800	0	14.1	Glide
400	6-Jun-07	424	-27.168500	26.420200	24.9300	7.6	13.4	Pool
401	22-Jul-07	424	-27.176072	26.423358	19.2900	0	24.2	Riffle
402	24-Jul-07	424	-27.171100	26.420300	19.6700	0	24	Pool
403	25-Jul-07	424	-27.172300	26.420800	19.5800	0	20.1	Pool
404	8-Aug-07	424	-27.170700	26.419900	17.5500	0	19.1	Pool
405	17-Aug-07	424	-27.171400	26.420700	14.5600	0	18.9	Pool
406	21-Aug-07	424	-27.168600	26.421300	14.3400	0	27.5	Pool
407	31-Aug-07	424	-27.168600	26.421300	14.5500	0	29.8	Pool
408	17-Oct-07	424	-27.173100	26.420700	31.1200	3.3	30.8	Pool
409	3-Nov-07	424	-27.177886	26.424622	18.1700	0	31.9	Run
410	12-Sep-07	435	-27.153069	26.426925	11.7400	0	33.6	Run
411	14-Sep-07	435	-27.151900	26.427300	18.0600	0	31.1	Riffle
412	17-Sep-07	435	-27.153400	26.426000	16.2700	0	31.4	Riffle
413	20-Sep-07	435	-27.151600	26.427000	14.0100	0	32.9	Run
414	9-Oct-07	435	-27.162200	26.423200	43.9500	0	19.4	Glide
415	15-Oct-07	435	-27.160700	26.424300	29.6300	0	31.8	Run
416	16-Oct-07	435	-27.160900	26.424400	32.2300	4.6	30.3	Run
417	17-Oct-07	435	-27.161100	26.423600	31.1200	3.3	30.8	Run
418	18-Oct-07	435	-27.161300	26.424300	31.0000	0.8	28.7	Run
419	23-Oct-07	435	-27.161200	26.424100	35.7400	3.4	29.6	Run
420	26-Oct-07	435	-27.168200	26.420400	32.8600	3.4	17.8	Pool
421	3-Nov-07	435	-27.160933	26.424011	18.1700	0	31.9	Run
422	31-Dec-07	435	-27.162900	26.422900	16.795	0	33.9	Glide
423	8-Mar-08	435	-27.188081	26.432744		0.3	29.1	Riffle
424	7-Jul-07	442	-27.158525	26.424725	19.4300	0	18.6	Pool
425	19-Jul-07	442	-27.183500	26.427200	20.9100	0	21.2	Glide
426	20-Jul-07	442	-27.183300	26.426800	20.4200	0	21.6	Glide

Appendix 16: Continuation of raw data collected from the biotelemetry study from location 1.

427	22-Jul-07	442	-27.182944	26.426989	19.2900	0	24.2	Glide
428	31-Jul-07	442	-27.182900	26.426800	16.7000	0	22.3	Glide
429	31-Aug-07	442	-27.182300	26.426000	14.5500	0	29.8	Run
430	5-Oct-07	442	-27.183100	26.426700	45.5700	9.4	29	Glide
431	9-Oct-07	442	-27.183800	26.427600	43.9500	0	19.4	Glide
432	17-Oct-07	442	-27.182800	26.426600	31.1200	3.3	30.8	Glide
433	24-Oct-07	442	-27.182600	26.426300	44.3700	0	24.8	Run
434	3-Nov-07	442	-27.188081	26.432744	18.1700	0	31.9	Riffle
435	14-May-07	456	-27.150500	26.436600	19.4700	0	29	Pool
436	19-May-07	456	-27.150500	26.439300	18.9400	0	26.8	Riffle
437	22-Jun-07	456	-27.301600	26.491000	18.0800	0	19.9	Glide
438	3-Nov-07	456	-27.316000	26.495000	18.1700	0	31.9	Glide
439	2-Sep-07	466	-27.152636	26.427153	16.9600	0	30.9	Run
440	14-Sep-07	466	-27.161700	26.424300	18.0600	0	31.1	Glide
441	17-Sep-07	466	-27.150589	26.439339	16.2700	0	31.4	Riffle
442	20-Sep-07	466	-27.151406	26.426886	14.0100	0	32.9	Riffle
443	25-Sep-07	466	-27.149828	26.436511	11.6800	0	30.4	Run
444	1-Oct-07	466	-27.151200	26.427800	48.3500	29.2	18.7	Glide
445	9-Oct-07	466	-27.151700	26.427800	43.9500	0	19.4	Riffle
446	15-Oct-07	466	-27.151500	26.427800	29.6300	0	31.8	Riffle
447	16-Oct-07	466	-27.150056	26.431228	32.2300	4.6	30.3	Glide
448	17-Oct-07	466	-27.151300	26.426800	31.1200	3.3	30.8	Riffle
449	18-Oct-07	466	-27.150186	26.430864	31.0000	0.8	28.7	Riffle
450	23-Oct-07	466	-27.150500	26.428200	35.7400	3.4	29.6	Glide
451	3-Nov-07	466	-27.151700	26.426800	18.1700	0	31.9	Run
452	31-Dec-07	466	-27.151800	26.427500	16.795	0	33.9	Riffle
453	20-Jan-08	466	-27.151639	26.427658	32.353	2.5	23.3	Riffle

Appendix 17: Raw spatial monitoring data collected from the biotelemetry study of yellowfish at location 2.

FID	TAG OBS	REQUENCYF	SPECIES	FISH NAME	OBSERVER	DATE	YEAR	DAY BETWEEN	TIME	Y	X	METHOD	BIOTOPE	SEASON	CUMECS	MOVEMENT	MAIN_ACTIV	2NDRY_ACTI	OTHER_ACTI	DISTANCE_V	MAIN_SUBST	2NDRY_SUBS	OTHER_SUBS	SURFACE_TY	2NRDY_SURF	MAIN_HABIT	2NDRY_HABI	OTHER_HABI	DEPTH_(MM)	CLARITY_(M	COLOUR	WEATHER
1	0	213	LKIM	Bob	Gordon	27-Jun-09	2009	0	17h15	-26.915190	27.395650	Boat	-	Winter	22.63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	1	213	LKIM	Bob	Gordon	1-Jul-09	2009	4	10h30	-26.915243	27.396066	Boat	Pool	Winter	15.01	10	1	2	6	10	2	6	-	2	3	13	8	3	2500	500	-	-
3	2	213	LKIM	Bob	Gordon	9-Jul-09	2009	8	15h45	-26.915373	27.396194	Boat	Pool	Winter	17.25	10	2	1	6	10	2	6	-	2	3	13	8	3	2000	500	-	-
4	3	213	LKIM	Bob	Gordon	11-Jul-09	2009	2	08h20	-26.915297	27.396406	Boat	Pool	Winter	17.24	10	1	2	6	10	2	6	-	2	-	13	8	3	2000	500	-	-
5	1000	213	LKIM	Bob	Gordon	12-Jul-09	2009	1	18h30	-26.915280	27.396096	Boat	Pool	Winter	17.58	10	1	2	6	10	2	6	-	2	-	13	8	3	3500	500	-	-
6	0	242	LKIM	Steve	Gordon	20-Jul-09	2009	0	9h30	-26.929700	27.411600	Boat	-	Winter	17.98	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	1	242	LKIM	Steve	Gordon	26-Jul-09	2009	6	10h30	-26.924991	27.407023	Boat	Pool	Winter	17.58	10	2	1	-	10	5	6	-	2	-	3	-	-	2000	-	-	-
8	2	242	LKIM	Steve	Gordon	26-Jul-09	2009	0	10h40	-26.924979	27.407167	Boat	Pool	Winter	17.58	10	2	1	-	10	5	6	-	2	-	3	-	-	2500	-	-	-
9	3	242	LKIM	Steve	Gordon	26-Jul-09	2009	0	10h50	-26.925007	27.407086	Boat	Pool	Winter	17.58	10	1	2	-	10	5	6	-	2	-	3	-	-	2000	-	-	-
10	4	242	LKIM	Steve	Gordon	26-Jul-09	2009	0	11h00	-26.925039	27.407257	Boat	Pool	Winter	17.58	10	2	1	-	10	2	5	-	2	-	13	-	-	3500	-	-	-
11	5	242	LKIM	Steve	Gordon	2-Aug-09	2009	7	12h15	-26.929543	27.410672	Boat	Pool	Winter	22.75	10	2	1	-	10	2	5	-	2	-	13	-	-	3500	-	-	-
12	6	242	LKIM	Steve	Gordon	2-Aug-09	2009	0	12h30	-26.929435	27.410840	Boat	Pool	Winter	22.75	50	2	5	-	50	2	5	-	2	-	13	-	-	3500	-	-	-
13	7	242	LKIM	Steve	Gordon	2-Aug-09	2009	0	12h40	-26.929931	27.411782	Boat	Pool	Winter	22.75	10	1	2	-	50	2	5	-	2	-	13	-	-	3000	-	-	-
14	8	242	LKIM	Steve	Gordon	2-Aug-09	2009	0	12h50	-26.929794	27.412108	Boat	Pool	Winter	22.75	10	1	2	-	10	5	6	-	2	-	3	-	-	2000	-	-	-
15	9	242	LKIM	Steve	Gordon	3-Aug-09	2009	1	8h20	-26.929525	27.420008	Boat	Pool	Winter	39.6	50	2	1	-	50	2	5	-	2	-	3	-	-	2500	-	-	-
16	10	242	LKIM	Steve	Gordon	3-Aug-09	2009	0	8h30	-26.929613	27.421161	Boat	Pool	Winter	39.6	10	2	1	-	10	2	5	-	2	-	3	-	-	2500	-	-	-
17	11	242	LKIM	Steve	Gordon	3-Aug-09	2009	0	8h40	-26.929534	27.421220	Boat	Pool	Winter	39.6	10	1	2	-	10	2	5	-	2	-	3	-	-	2500	-	-	-
18	12	242	LKIM	Steve	Gordon	3-Aug-09	2009	0	8h50	-26.929744	27.421073	Boat	Pool	Winter	39.6	10	2	1	-	10	2	5	-	2	-	3	-	-	2500	-	-	-
19	13	242	LKIM	Steve	Gordon	13-Aug-09	2009	10	17h30	-26.919826	27.427379	Boat	Pool	Winter	18.8	50	2	5	-	50	5	6	-	2	-	3	-	-	2500	-	-	-
20	14	242	LKIM	Steve	Gordon	16-Aug-09	2009	3	13h10	-26.921741	27.400429	Boat	Run	Winter	18.84	10	1	2	-	10	5	6	-	4	-	3	-	-	1500	-	-	-
21	15	242	LKIM	Steve	Gordon	16-Aug-09	2009	0	13h20	-26.921895	27.400583	Boat	Run	Winter	18.84	10	1	2	-	10	5	6	-	4	-	3	-	-	2000	-	-	-
22	16	242	LKIM	Steve	Gordon	16-Aug-09	2009	0	13h30	-26.921814	27.400562	Boat	Run	Winter	18.84	10	1	2	-	10	5	6	-	4	-	3	-	-	1500	-	-	-
23	17	242	LKIM	Steve	Gordon	16-Aug-09	2009	0	13h40	-26.921850	27.400460	Boat	Run	Winter	18.84	10	1	2	-	10	5	6	-	4	-	3	-	-	1500	-	-	-
24	18	242	LKIM	Steve	Gordon	7-May-10	2010	264	11h45	-26.926639	27.406878	Air	Pool	Autumn	82.16	10	2	1	-	10	5	6	-	2	-	3	-	-	2500	-	-	-
25	0	253	LKIM	Babe	Gordon	26-Jul-09	2009	90	17h00	-26.915520	27.398330	Boat	-	Winter	17.58	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26	1	253	LKIM	Babe	Francois	24-Oct-09	2009	0	1500	-26.909550	27.392400	Boat	Glide	Spring	19.89	10	1	2	6	10	5	4	3	3	4	1	3	6	2200	330	3	1
27	2	253	LKIM	Babe	Francois	24-Oct-09	2009	0	1510	-26.909583	27.392417	Boat	Glide	Spring	19.89	50	2	1	6	10	5	4	3	3	4	1	3	6	2200	330	3	1
28	3	253	LKIM	Babe	Francois	24-Oct-09	2009	0	1520	-26.909583	27.392433	Boat	Glide	Spring	19.89	10	2	1	6	10	5	4	3	3	4	1	3	6	2200	330	3	1
29	4	253	LKIM	Babe	Francois	24-Oct-09	2009	0	1530	-26.909583	27.392417	Boat	Glide	Spring	19.89	50	2	1	6	10	5	4	3	3	4	1	3	6	2200	330	3	1
30	5	253	LKIM	Babe	Francois	24-Oct-09	2009	0	1540	-26.909600	27.392467	Boat	Glide	Spring	19.89	50	2	1	6	10	5	4	3	3	4	1	3	6	2200	330	3	1
31	6	253	LKIM	Babe	Francois	24-Oct-09	2009	0	1550	-26.909600	27.392450	Boat	Pool	Spring	19.89	50	2	1	6	10	5	4	3	2	4	1	6	11	2200	330	3	1
32	7	253	LKIM	Babe	Francois	24-Oct-09	2009	0	1600	-26.909600	27.392450	Boat	Glide	Spring	19.89	50	2	1	6	10	5	4	3	3	4	6	11	13	2200	330	3	1
33	8	253	LKIM	Babe	Francois	24-Oct-09	2009	0	1610	-26.909617	27.392467	Boat	Pool	Spring	19.89	10	2	1	6	10	5	4	3	2	4	6	11	13	2200	330	3	1
34	9	253	LKIM	Babe	Francois	24-Oct-09	2009	0	1620	-26.909600	27.392433	Boat	Glide	Spring	19.89	50	2	1	6	10	5	4	3	3	2	6	1	11	2200	330	3	1
35	10	253	LKIM	Babe	Francois	24-Oct-09	2009	0	1630	-26.909600	27.392600	Boat	Glide	Spring	19.89	10	2	1	6	10	5	4	3	3	2	6	1	11	2200	330	3	1
36	11	253	LKIM	Babe	Francois	24-Oct-09	2009	0	1640	-26.909600	27.392567	Boat	Glide	Spring	19.89	10	2	1	6	10	5	4	3	3	2	6	1	11	2200	330	3	1
37	12	253	LKIM	Babe	Francois	24-Oct-09	2009	0	1650	-26.909600	27.392567	Boat	Glide	Spring	19.89	10	2	1	6	10	5	4	3	3	2	13	1	11	2200	330	3	1
38	13	253	LKIM	Babe	Francois	24-Oct-09	2009	0	1800	-26.909600	27.392583	Boat	Run	Spring	19.89	10	2	1	6	10	5	4	3	4	2	9	9	3	2200	330	3	1
39	14	253	LKIM	Babe	Francois	24-Oct-09	2009	0	1810	-26.909617	27.392567	Boat	Run	Spring	19.89	50	2	1	6	10	5	4	3	4	3	9	3	13	2200	330	3	1
40	15	253	LKIM	Babe	Francois	24-Oct-09	2009	0	1820	-26.916750	27.393000	Boat	Run	Spring	19.89	50	2	1	6	10	5	4	3	4	3	9	3	13	2200	330	3	1
41	16	253	LKIM	Babe	Francois	24-Oct-09	2009	0	1830	-26.916767	27.393017	Boat	Run	Spring	19.89	50	2	1	6	10	5	4	3	4	3	9	3	13	2200	330	3	1
42	17	253	LKIM	Babe	Francois	24-Oct-09	2009	0	1840	-26.916750	27.392950	Boat	Run	Spring	19.89	50	2	1	6	10	5	4	3	4	3	9	3	3	1000	330	3	1
43	18	253	LKIM	Babe	Francois	24-Oct-09	2009	0	1850	-26.916767	27.392967	Boat	Run	Spring	19.89	50	2	1	6	10	5	4	3	4	3	9	3	3	1500	330	3	1
44	19	253	LKIM	Babe	Francois	24-Oct-09	2009	0	1900	-26.916750	27.393017	Boat	Riffle	Spring	19.89	50	2	1	6	10	5	4	3	5	4	3	5	3	2000	330	3	1
45	20	253	LKIM	Babe	Francois	24-Oct-09	2009	0	1910	-26.916767	27.393017	Boat	Run	Spring	19.89	50	2	1	6	10	5	4	3	4	3	1	9	3	1500	330	3	1
46	21	253	LKIM	Babe	Francois	24-Oct-09	2009	0	1920	-26.916767	27.393017	Boat	Run	Spring	19.89	50	2	1	6	10	5	4	3	4	3	1	9	3	1600	330	3	1
47	22	253	LKIM	Babe	Francois	24-Oct-09	2009	0	1930	-26.916767	27.393033	Boat	Run	Spring	19.89	10	2	1	6	10	5	4	3	4	3	1	9	3	1800	330	3	1
48	23	253	LKIM	Babe	Francois	24-Oct-09	2009	0	1940	-26.916750	27.392950	Boat	Riffle	Spring	19.89	10	2	1	6	10	5	4	3	5	4	3	9	3	1500	330	3	1
49	24	253	LKIM	Babe	Francois	24-Oct-09	2009	0	1950	-26.916733	27.392950	Boat	Riffle	Spring	19.89	50	2	1	6	10	5	4	3	5	4	3	9	3	2000	330	3	1
50	25	253	LKIM	Babe	Francois	24-Oct-09	2009	0	2000	-26.916750	27.392967	Boat	Run	Spring	19.89	50	2	1	6	10	5	4	3	4	3	3	9	3	1500	330	3	1
51	26	253	LKIM	Babe	Francois	24-Oct-09	2009	0	2010	-26.916750	27.392967	Boat	Riffle	Spring	19.89	10	2	1	6	10	5	4	3	5	4	3	9	3	1600	330	3	1
52	27	253	LKIM	Babe	Francois	24-Oct-09	2009	0	2020	-26.916767	27.392967	Boat	Run	Spring	19.89	50	2	1	6	10	5	4	3	4	3	3	9	3	1800	330	3	1

Appendix 18: Continuation of raw spatial monitoring data collected from the biotelemetry study of yellowfish at location 2.

53	28	253	LKIM	Babe	Francois	24-Oct-09	2009	0	2030	-26.916750	27.392950	Boat	Riffle	Spring	19.89	50	2	1	6	10	5	4	3	5	3	3	9	3	2000	330	3	1
54	29	253	LKIM	Babe	Francois	24-Oct-09	2009	0	2040	-26.916750	27.392933	Boat	Riffle	Spring	19.89	10	2	1	6	10	5	4	3	5	4	3	9	3	2300	330	3	1
55	30	253	LKIM	Babe	Francois	24-Oct-09	2009	0	2050	-26.916750	27.392967	Boat	Riffle	Spring	19.89	10	2	1	6	10	5	4	3	5	4	3	9	3	2000	330	3	1
56	31	253	LKIM	Babe	Francois	24-Oct-09	2009	0	2100	-26.916750	27.392983	Boat	Run	Spring	19.89	50	2	1	6	10	5	4	3	4	4	3	9	3	1500	330	3	1
57	32	253	LKIM	Babe	Francois	24-Oct-09	2009	0	2110	-26.916750	27.393017	Boat	Run	Spring	19.89	50	2	1	6	10	5	4	3	4	4	3	9	3	1600	330	3	1
58	33	253	LKIM	Babe	Francois	24-Oct-09	2009	0	2120	-26.916733	27.393017	Boat	Riffle	Spring	19.89	10	2	1	6	10	5	4	3	5	3	3	9	3	2000	330	3	2
59	34	253	LKIM	Babe	Francois	24-Oct-09	2009	0	2130	-26.916717	27.393000	Boat	Riffle	Spring	19.89	50	2	1	6	10	5	4	3	5	4	3	9	3	2300	330	3	2
60	35	253	LKIM	Babe	Francois	24-Oct-09	2009	0	2140	-26.916733	27.393000	Boat	Riffle	Spring	19.89	10	2	1	6	10	5	4	3	5	4	3	9	3	2000	330	3	2
61	36	253	LKIM	Babe	Francois	24-Oct-09	2009	0	2150	-26.916750	27.392983	Boat	Riffle	Spring	19.89	10	2	1	6	10	5	4	3	5	4	3	9	3	1500	330	3	2
62	37	253	LKIM	Babe	Francois	24-Oct-09	2009	0	2200	-26.916750	27.392933	Boat	Riffle	Spring	19.89	10	2	1	6	10	5	4	3	5	4	3	9	3	1600	330	3	2
63	38	253	LKIM	Babe	Francois	24-Oct-09	2009	0	2210	-26.916767	27.392950	Boat	Riffle	Spring	19.89	10	2	1	6	10	5	4	3	5	4	3	9	3	2000	330	3	2
64	39	253	LKIM	Babe	Francois	24-Oct-09	2009	0	2220	-26.916750	27.392967	Boat	Riffle	Spring	19.89	50	2	1	6	10	5	4	3	5	4	3	9	3	2300	330	3	2
65	40	253	LKIM	Babe	Francois	24-Oct-09	2009	0	2230	-26.916750	27.392967	Boat	Riffle	Spring	19.89	50	2	1	6	10	5	4	3	5	4	3	9	3	2000	330	3	2
66	41	253	LKIM	Babe	Francois	25-Oct-09	2009	1	540	-26.916733	27.392983	Boat	Pool	Spring	20.29	10	1	2	6	10	2	3	4	2	3	1	11	12	2000	330	3	1
67	42	253	LKIM	Babe	Francois	25-Oct-09	2009	0	550	-26.916750	27.393067	Boat	Pool	Spring	20.29	50	1	2	6	10	2	3	4	2	3	1	11	12	2300	330	3	1
68	43	253	LKIM	Babe	Francois	25-Oct-09	2009	0	600	-26.916733	27.393017	Boat	Pool	Spring	20.29	10	1	2	6	10	2	3	4	2	3	1	11	12	2000	330	3	1
69	44	253	LKIM	Babe	Francois	25-Oct-09	2009	0	610	-26.909717	27.393117	Boat	Pool	Spring	20.29	50	1	2	6	10	2	3	4	2	3	1	11	12	1500	330	3	1
70	45	253	LKIM	Babe	Francois	25-Oct-09	2009	0	620	-26.909733	27.393150	Boat	Pool	Spring	20.29	10	1	2	6	10	2	3	4	2	3	1	11	12	1600	330	3	1
71	46	253	LKIM	Babe	Francois	25-Oct-09	2009	0	630	-26.909717	27.393133	Boat	Pool	Spring	20.29	10	1	2	6	10	2	3	4	2	3	1	11	12	2000	330	3	1
72	47	253	LKIM	Babe	Francois	25-Oct-09	2009	0	640	-26.909733	27.393133	Boat	Pool	Spring	20.29	50	2	1	6	10	2	3	4	2	3	1	11	12	2300	330	3	1
73	48	253	LKIM	Babe	Francois	25-Oct-09	2009	0	650	-26.909750	27.393150	Boat	Pool	Spring	20.29	50	2	1	6	10	2	3	4	2	3	1	11	12	2000	330	3	1
74	49	253	LKIM	Babe	Francois	25-Oct-09	2009	0	700	-26.909767	27.393150	Boat	Run	Spring	20.29	100	2	1	6	100	5	4	3	4	3	3	9	13	700	330	3	1
75	50	253	LKIM	Babe	Francois	25-Oct-09	2009	0	710	-26.909817	27.393133	Boat	Run	Spring	20.29	10	2	1	6	10	5	4	3	4	3	9	3	13	750	330	3	1
76	51	253	LKIM	Babe	Francois	25-Oct-09	2009	0	720	-26.909917	27.393200	Boat	Run	Spring	20.29	10	2	1	6	20	5	4	3	4	3	3	9	13	500	330	3	1
77	52	253	LKIM	Babe	Francois	25-Oct-09	2009	0	730	-26.916767	27.393050	Boat	Run	Spring	20.29	10	2	1	6	10	5	4	3	4	3	3	9	13	600	330	3	1
78	53	253	LKIM	Babe	Francois	25-Oct-09	2009	0	740	-26.916767	27.393067	Boat	Glide	Spring	20.29	10	2	1	6	10	5	4	3	3	3	9	3	13	800	330	3	1
79	54	253	LKIM	Babe	Francois	25-Oct-09	2009	0	750	-26.916767	27.393050	Boat	Glide	Spring	20.29	50	2	1	6	10	5	4	3	3	3	9	3	13	750	330	3	1
80	55	253	LKIM	Babe	Francois	25-Oct-09	2009	0	800	-26.916767	27.393017	Boat	Glide	Spring	20.29	10	2	1	6	10	5	4	3	3	3	9	3	13	800	330	3	1
81	56	253	LKIM	Babe	Francois	25-Oct-09	2009	0	810	-26.916733	27.393000	Boat	Glide	Spring	20.29	10	2	1	6	10	5	4	3	3	3	9	3	13	1000	330	3	1
82	57	253	LKIM	Babe	Francois	25-Oct-09	2009	0	820	-26.916750	27.392983	Boat	Glide	Spring	20.29	10	2	1	6	10	5	4	3	3	2	9	3	13	1200	330	3	1
83	58	253	LKIM	Babe	Francois	25-Oct-09	2009	0	830	-26.916750	27.393017	Boat	Glide	Spring	20.29	10	2	1	6	10	5	4	3	3	2	9	3	13	1100	330	3	1
84	59	253	LKIM	Babe	Francois	25-Oct-09	2009	0	840	-26.916733	27.393017	Boat	Glide	Spring	20.29	10	2	1	6	10	5	4	3	3	2	9	3	13	700	330	3	1
85	60	253	LKIM	Babe	Francois	25-Oct-09	2009	0	850	-26.916750	27.393050	Boat	Glide	Spring	20.29	10	2	1	6	10	5	4	3	3	2	9	3	13	750	330	3	1
86	61	253	LKIM	Babe	Francois	25-Oct-09	2009	0	900	-26.916750	27.393050	Boat	Run	Spring	20.29	50	2	1	6	10	5	4	3	4	3	13	6	13	500	330	3	1
87	62	253	LKIM	Babe	Francois	25-Oct-09	2009	0	910	-26.916750	27.393017	Boat	Run	Spring	20.29	50	2	1	6	10	5	4	3	4	3	11	6	13	600	330	3	1
88	63	253	LKIM	Babe	Francois	25-Oct-09	2009	0	920	-26.916733	27.393033	Boat	Run	Spring	20.29	10	2	1	6	10	5	4	3	4	3	11	6	13	800	330	3	1
89	64	253	LKIM	Babe	Francois	25-Oct-09	2009	0	930	-26.916750	27.393050	Boat	Glide	Spring	20.29	10	2	1	6	10	5	4	3	3	3	11	6	13	750	330	3	1
90	65	253	LKIM	Babe	Francois	25-Oct-09	2009	0	940	-26.916750	27.393050	Boat	Glide	Spring	20.29	10	2	1	6	10	5	4	3	3	3	11	6	13	800	330	3	1
91	66	253	LKIM	Babe	Francois	25-Oct-09	2009	0	950	-26.909717	27.392733	Boat	Glide	Spring	20.29	50	2	1	6	10	5	4	3	3	3	11	6	13	1000	330	3	1
92	67	253	LKIM	Babe	Francois	25-Oct-09	2009	0	1000	-26.909717	27.392750	Boat	Glide	Spring	20.29	50	2	1	6	10	5	4	3	3	3	11	6	13	1200	330	3	1
93	68	253	LKIM	Babe	Francois	25-Oct-09	2009	0	1010	-26.909717	27.392750	Boat	Glide	Spring	20.29	10	2	1	6	10	5	4	3	3	3	11	6	13	1100	330	3	1
94	69	253	LKIM	Babe	Francois	25-Oct-09	2009	0	1020	-26.909717	27.392750	Boat	Glide	Spring	20.29	10	2	1	6	10	5	4	3	3	3	11	6	13	700	330	3	1
95	70	253	LKIM	Babe	Francois	25-Oct-09	2009	0	1030	-26.923117	27.176183	Boat	Glide	Spring	20.29	10	2	1	6	10	5	4	3	3	2	11	3	13	750	330	3	1
96	71	253	LKIM	Babe	Francois	25-Oct-09	2009	0	1040	-26.923117	27.176200	Boat	Glide	Spring	20.29	50	2	1	6	10	5	4	3	3	2	11	3	13	500	330	3	1
97	72	253	LKIM	Babe	Francois	25-Oct-09	2009	0	1050	-26.923100	27.176183	Boat	Glide	Spring	20.29	50	2	1	6	10	5	4	3	3	2	11	3	13	600	330	3	1
98	73	253	LKIM	Babe	Gordon	2-Feb-10	2010	100	1300	-26.915178	27.397830	Foot	Riffle	Summer	2217	0	1	1	6	0	5	6	6	5	5	13	3	3	6000	5	-	-
99	79	253	LKIM	Babe	Francois	8-May-10	2010	95	1500	-26.909900	27.393167	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
100	80	253	LKIM	Babe	Francois	8-May-10	2010	0	1510	-26.909883	27.393150	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
101	81	253	LKIM	Babe	Francois	8-May-10	2010	0	1520	-26.909867	27.393150	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
102	82	253	LKIM	Babe	Francois	8-May-10	2010	0	1530	-26.909850	27.393150	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
103	83	253	LKIM	Babe	Francois	8-May-10	2010	0	1540	-26.909933	27.393167	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
104	84	253	LKIM	Babe	Francois	8-May-10	2010	0	1550	-26.909850	27.393183	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
105	85	253	LKIM	Babe	Francois	8-May-10	2010	0	1600	-26.909933	27.393200	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
106	86	253	LKIM	Babe	Francois	8-May-10	2010	0	1610	-26.909950	27.393200	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
107	87	253	LKIM	Babe	Francois	8-May-10	2010	0	1620	-26.909967	27.393183	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
108	88	253	LKIM	Babe	Francois	8-May-10	2010	0	1630	-26.909983	27.393183	Boat	Pool	Autumn	72.38	10	2	1	6	10	5	4	3	2	3	1	2	12	1600	500	2	1
109	89	253	LKIM	Babe	Francois	8-May-10	2010	0	1640	-26.909983	27.393200	Boat	Pool	Autumn	72.38	10	2	1	6	10	5	4	3	2	3	1	2	12	1600	500	2	1
110	90	253	LKIM	Babe	Francois	8-May-10	2010	0	1650	-26.900083	27.393117	Boat	Pool	Autumn	72.38	10	2	1	6	10	5	4	3	2	3	1	2	12	1600	500	2	1

Appendix 19: Continuation of raw spatial monitoring data collected from the biotelemetry study of yellowfish at location 2.

111	91	253	LKIM	Babe	Francois	8-May-10	2010	0	1700	-26.900083	27.393083	Boat	Pool	Autumn	72.38	10	2	1	6	10	5	4	3	2	3	1	2	12	1600	500	2	1
112	92	253	LKIM	Babe	Francois	8-May-10	2010	0	1710	-26.900083	27.393100	Boat	Pool	Autumn	72.38	10	2	1	6	10	5	4	3	2	3	1	2	12	1600	500	2	1
113	93	253	LKIM	Babe	Francois	8-May-10	2010	0	1720	-26.900083	27.393117	Boat	Pool	Autumn	72.38	10	2	1	6	10	5	4	3	2	3	1	2	12	1600	500	2	1
114	94	253	LKIM	Babe	Francois	8-May-10	2010	0	1730	-26.900083	27.393133	Boat	Pool	Autumn	72.38	10	2	1	6	10	5	4	3	2	3	1	2	12	1600	500	2	1
115	95	253	LKIM	Babe	Francois	8-May-10	2010	0	1740	-26.909900	27.393167	Boat	Pool	Autumn	72.38	10	2	1	6	10	5	4	3	2	3	1	2	12	1600	500	2	1
116	96	253	LKIM	Babe	Francois	8-May-10	2010	0	1750	-26.909883	27.393150	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
117	97	253	LKIM	Babe	Francois	8-May-10	2010	0	1800	-26.909867	27.393150	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
118	98	253	LKIM	Babe	Francois	8-May-10	2010	0	1810	-26.909850	27.393150	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
119	99	253	LKIM	Babe	Francois	8-May-10	2010	0	1820	-26.909933	27.393167	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
120	100	253	LKIM	Babe	Francois	8-May-10	2010	0	1830	-26.909850	27.393183	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
121	101	253	LKIM	Babe	Francois	8-May-10	2010	0	1840	-26.909933	27.393200	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
122	102	253	LKIM	Babe	Francois	8-May-10	2010	0	1850	-26.909950	27.393200	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
123	103	253	LKIM	Babe	Francois	8-May-10	2010	0	1900	-26.909967	27.393183	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
124	104	253	LKIM	Babe	Francois	8-May-10	2010	0	1910	-26.909983	27.393183	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
125	105	253	LKIM	Babe	Francois	8-May-10	2010	0	1920	-26.909983	27.393200	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
126	106	253	LKIM	Babe	Francois	8-May-10	2010	0	1930	-26.900083	27.393117	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
127	107	253	LKIM	Babe	Francois	8-May-10	2010	0	1940	-26.900083	27.393083	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
128	108	253	LKIM	Babe	Francois	8-May-10	2010	0	1950	-26.900083	27.393100	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
129	109	253	LKIM	Babe	Francois	8-May-10	2010	0	2000	-26.900083	27.393117	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
130	110	253	LKIM	Babe	Francois	8-May-10	2010	0	2010	-26.900083	27.393133	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
131	111	253	LKIM	Babe	Francois	8-May-10	2010	0	2020	-26.909900	27.393167	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
132	112	253	LKIM	Babe	Francois	8-May-10	2010	0	2030	-26.909883	27.393150	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
133	113	253	LKIM	Babe	Francois	8-May-10	2010	0	2040	-26.909867	27.393150	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
134	114	253	LKIM	Babe	Francois	8-May-10	2010	0	2050	-26.909850	27.393150	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
135	115	253	LKIM	Babe	Francois	8-May-10	2010	0	2100	-26.909933	27.393167	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
136	116	253	LKIM	Babe	Francois	8-May-10	2010	0	2110	-26.909850	27.393183	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
137	117	253	LKIM	Babe	Francois	8-May-10	2010	0	2120	-26.909933	27.393200	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
138	118	253	LKIM	Babe	Francois	8-May-10	2010	0	2130	-26.909950	27.393200	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
139	119	253	LKIM	Babe	Francois	8-May-10	2010	0	2140	-26.909967	27.393183	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
140	120	253	LKIM	Babe	Francois	8-May-10	2010	0	2150	-26.909983	27.393183	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
141	121	253	LKIM	Babe	Francois	8-May-10	2010	0	2200	-26.909983	27.393200	Boat	Pool	Autumn	72.38	1	1	2	6	0	5	4	3	2	3	1	2	12	1600	500	2	1
142	122	253	LKIM	Babe	Francois	9-May-10	2010	1	620	-26.900083	27.393117	Boat	Glide	Autumn	57.28	1	2	1	6	0	5	4	3	3	2	3	13	12	1300	500	2	1
143	123	253	LKIM	Babe	Francois	9-May-10	2010	0	630	-26.900083	27.393083	Boat	Glide	Autumn	57.28	10	2	1	6	10	5	4	3	3	2	3	13	12	1300	500	2	1
144	124	253	LKIM	Babe	Francois	9-May-10	2010	0	640	-26.900083	27.393100	Boat	Glide	Autumn	57.28	10	2	1	6	10	5	4	3	3	2	3	13	12	1300	500	2	1
145	125	253	LKIM	Babe	Francois	9-May-10	2010	0	650	-26.900083	27.393117	Boat	Glide	Autumn	57.28	10	2	1	6	10	5	4	3	3	2	3	13	12	1300	500	2	1
146	126	253	LKIM	Babe	Francois	9-May-10	2010	0	700	-26.900083	27.393133	Boat	Glide	Autumn	57.28	10	2	1	6	10	5	4	3	3	2	3	13	12	1300	500	2	1
147	127	253	LKIM	Babe	Francois	9-May-10	2010	0	710	-26.900083	27.393083	Boat	Glide	Autumn	57.28	10	2	1	6	10	5	4	3	3	2	3	13	12	1300	500	2	1
148	128	253	LKIM	Babe	Francois	9-May-10	2010	0	720	-26.900083	27.393100	Boat	Glide	Autumn	57.28	10	2	1	6	10	5	4	3	3	2	3	13	12	1300	500	2	1
149	129	253	LKIM	Babe	Francois	9-May-10	2010	0	730	-26.900083	27.393117	Boat	Glide	Autumn	57.28	10	2	1	6	10	5	4	3	3	2	3	13	12	1300	500	2	1
150	130	253	LKIM	Babe	Francois	9-May-10	2010	0	740	-26.900083	27.393133	Boat	Glide	Autumn	57.28	10	2	1	6	10	5	4	3	3	2	3	13	12	1300	500	2	1
151	131	253	LKIM	Babe	Francois	9-May-10	2010	0	750	-26.900083	27.393083	Boat	Glide	Autumn	57.28	10	2	1	6	10	5	4	3	3	2	3	13	12	1300	500	2	1
152	132	253	LKIM	Babe	Francois	9-May-10	2010	0	800	-26.900083	27.393100	Boat	Glide	Autumn	57.28	10	2	1	6	10	5	4	3	3	2	3	13	12	1300	500	2	1
153	133	253	LKIM	Babe	Francois	9-May-10	2010	0	810	-26.900083	27.393117	Boat	Glide	Autumn	57.28	10	2	1	6	10	5	4	3	3	2	3	13	12	1300	500	2	1
154	134	253	LKIM	Babe	Francois	9-May-10	2010	0	820	-26.900083	27.393133	Boat	Glide	Autumn	57.28	10	2	1	6	10	5	4	3	3	2	3	13	12	1300	500	2	1
155	135	253	LKIM	Babe	Francois	9-May-10	2010	0	830	-26.900083	27.393083	Boat	Glide	Autumn	57.28	10	2	1	6	10	5	4	3	3	2	3	13	12	1300	500	2	1
156	136	253	LKIM	Babe	Francois	9-May-10	2010	0	840	-26.900083	27.393100	Boat	Glide	Autumn	57.28	10	2	1	6	10	5	4	3	3	2	3	13	12	1300	500	2	1
157	137	253	LKIM	Babe	Francois	9-May-10	2010	0	850	-26.900083	27.393117	Boat	Glide	Autumn	57.28	10	2	1	6	10	5	4	3	3	2	3	13	12	1300	500	2	1
158	138	253	LKIM	Babe	Francois	9-May-10	2010	0	900	-26.900083	27.393133	Boat	Glide	Autumn	57.28	10	2	1	6	10	5	4	3	3	2	3	13	12	1300	500	2	1
159	139	253	LKIM	Babe	Hannes	10-Jul-10	2010	61	12:50	-26.916667	27.399717	Boat	Pool	Winter	24.1	1	2	1	6	0	5	6	4	2	3	3	13	6	1600	300	3	1
160	140	253	LKIM	Babe	Hannes	10-Jul-10	2010	0	13:00	-26.916550	27.399700	Boat	Pool	Winter	24.1	10	2	1	6	10	5	6	4	2	3	3	13	6	1600	300	3	1
161	141	253	LKIM	Babe	Hannes	10-Jul-10	2010	0	13:10	-26.916550	27.399700	Boat	Pool	Winter	24.1	10	2	1	6	10	5	6	4	2	3	3	13	6	1600	300	3	1
162	142	253	LKIM	Babe	Hannes	10-Jul-10	2010	0	13:20	-26.916583	27.399633	Boat	Pool	Winter	24.1	10	2	1	6	10	5	6	4	2	3	3	13	6	1600	300	3	1
163	143	253	LKIM	Babe	Hannes	10-Jul-10	2010	0	13:30	-26.916583	27.399633	Boat	Pool	Winter	24.1	10	2	1	6	10	5	6	4	2	3	3	13	6	1600	300	3	1
164	144	253	LKIM	Babe	Hannes	10-Jul-10	2010	0	13:40	-26.916617	27.399500	Boat	Pool	Winter	24.1	10	2	1	6	10	5	6	4	2	3	3	13	6	1600	300	3	1
165	145	253	LKIM	Babe	Hannes	10-Jul-10	2010	0	13:50	-26.916717	27.399500	Boat	Pool	Winter	24.1	10	2	1	6	10	5	6	4	2	3	3	13	6	1600	300	3	1
166	146	253	LKIM	Babe	Hannes	12-Jul-10	2010	2	15:50	-26.916717	27.399583	Boat	Glide	Winter	22.63	1	1	2	6	0	5	6	4	3	2	3	13	6	1500	450	3	1
167	147	253	LKIM	Babe	Hannes	12-Jul-10	2010	0	16:00	-26.916717	27.399633	Boat	Glide	Winter	22.63	10	1	2	6	10	5	6	4	3	2	3	13	6	1600	450	3	1
168	148	253	LKIM	Babe	Hannes	12-Jul-10	2010	0	16:10	-26.916783	27.399667	Boat	Glide	Winter	22.63	1	1	2	6	0	5	6	4	3	2	3	13	6	1500	450	3	1

Appendix 20: Continuation of raw spatial monitoring data collected from the biotelemetry study of yellowfish at location 2.

169	149	253	LKIM	Babe	Hannes	12-Jul-10	2010	0	16:20	-26.916800	27.399700	Boat	Glide	Winter	22.63	1	1	2	6	0	5	6	4	3	2	3	13	6	1600	450	3	1
170	150	253	LKIM	Babe	Hannes	12-Jul-10	2010	0	16:30	-26.916750	27.399750	Boat	Glide	Winter	22.63	1	1	2	6	0	5	6	4	3	2	3	13	6	1500	450	3	1
171	151	253	LKIM	Babe	Hannes	12-Jul-10	2010	0	16:40	-26.916833	27.399717	Boat	Glide	Winter	22.63	1	1	2	6	0	5	6	4	3	2	3	13	6	1500	450	3	1
172	152	253	LKIM	Babe	Hannes	12-Jul-10	2010	0	16:50	-26.916800	27.399700	Boat	Glide	Winter	22.63	1	1	2	6	0	5	6	4	3	2	3	13	6	1500	450	3	1
173	153	253	LKIM	Babe	Hannes	12-Jul-10	2010	0	17:00	-26.916800	27.399700	Boat	Glide	Winter	22.63	1	1	2	6	0	5	6	4	3	2	3	13	6	1500	450	3	1
174	154	253	LKIM	Babe	Hannes	12-Jul-10	2010	0	17:10	-26.916800	27.399700	Boat	Glide	Winter	22.63	1	1	2	6	0	5	6	4	3	2	3	13	6	1500	450	3	1
175	155	253	LKIM	Babe	Hannes	12-Jul-10	2010	0	17:20	-26.916750	27.399750	Boat	Glide	Winter	22.63	1	1	2	6	0	5	6	4	3	2	3	13	6	1500	450	3	1
176	156	253	LKIM	Babe	Hannes	12-Jul-10	2010	0	17:30	-26.916750	27.399750	Boat	Glide	Winter	22.63	1	1	2	6	0	5	6	4	3	2	3	13	6	1500	450	3	1
177	157	253	LKIM	Babe	Hannes	12-Jul-10	2010	0	17:40	-26.916750	27.399750	Boat	Glide	Winter	22.63	1	1	2	6	10	5	6	4	3	2	3	13	6	1500	450	3	1
178	158	253	LKIM	Babe	Hannes	12-Jul-10	2010	0	17:50	-26.916750	27.399750	Boat	Glide	Winter	22.63	1	1	2	6	0	5	6	4	3	2	3	13	6	1500	450	3	1
179	159	253	LKIM	Babe	Hannes	12-Jul-10	2010	0	18:00	-26.916800	27.399700	Boat	Glide	Winter	22.63	1	1	2	6	0	5	6	4	3	2	3	13	6	1500	450	3	1
180	160	253	LKIM	Babe	Hannes	12-Jul-10	2010	0	18:10	-26.916800	27.399700	Boat	Glide	Winter	22.63	1	1	2	6	0	5	6	4	3	2	3	13	6	1500	450	3	1
181	161	253	LKIM	Babe	Hannes	12-Jul-10	2010	0	18:20	-26.916800	27.399700	Boat	Glide	Winter	22.63	1	1	2	6	0	5	6	4	3	2	3	13	6	1500	450	3	1
182	162	253	LKIM	Babe	Hannes	12-Jul-10	2010	0	18:30	-26.916550	27.399800	Boat	Glide	Winter	22.63	1	1	2	6	20	5	6	4	3	2	3	13	2	1200	450	3	1
183	163	253	LKIM	Babe	Hannes	12-Jul-10	2010	0	18:40	-26.916550	27.399800	Boat	Glide	Winter	22.63	1	1	2	6	0	5	6	4	3	2	3	13	2	1200	450	3	1
184	164	253	LKIM	Babe	Hannes	12-Jul-10	2010	0	18:50	-26.916550	27.399800	Boat	Glide	Winter	22.63	1	1	2	6	0	5	6	4	3	2	3	13	2	1200	450	3	1
185	165	253	LKIM	Babe	Hannes	12-Jul-10	2010	0	19:00	-26.916550	27.399800	Boat	Glide	Winter	22.63	1	1	2	6	0	5	6	4	3	2	3	13	2	1200	450	3	1
186	166	253	LKIM	Babe	Hannes	12-Jul-10	2010	0	19:10	-26.916550	27.399800	Boat	Glide	Winter	22.63	1	1	2	6	0	5	6	4	3	2	3	13	2	1200	450	3	1
187	167	253	LKIM	Babe	Hannes	12-Jul-10	2010	0	19:20	-26.916550	27.399800	Boat	Glide	Winter	22.63	1	1	2	6	0	5	6	4	3	2	3	13	2	1200	450	3	1
188	168	253	LKIM	Babe	Hannes	12-Jul-10	2010	0	19:30	-26.916550	27.399800	Boat	Glide	Winter	22.63	1	1	2	6	0	5	6	4	3	2	3	13	2	1200	450	3	1
189	169	253	LKIM	Babe	Hannes	12-Jul-10	2010	0	19:40	-26.916550	27.399800	Boat	Glide	Winter	22.63	1	1	2	6	0	5	6	4	3	2	3	13	2	1200	450	3	1
190	170	253	LKIM	Babe	Hannes	12-Jul-10	2010	0	19:50	-26.916550	27.399800	Boat	Glide	Winter	22.63	1	1	2	6	0	5	6	4	3	2	3	13	2	1200	450	3	1
191	171	253	LKIM	Babe	Hannes	12-Jul-10	2010	0	20:00	-26.916550	27.399800	Boat	Glide	Winter	22.63	1	1	2	6	0	5	6	4	3	2	3	13	2	1200	450	3	1
192	172	253	LKIM	Babe	Hannes	13-Jul-10	2010	1	8:50	-26.916883	27.400033	Boat	Pool	Winter	22.84	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	520	3	1
193	173	253	LKIM	Babe	Hannes	13-Jul-10	2010	0	9:00	-26.916883	27.400033	Boat	Pool	Winter	22.84	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	520	3	1
194	174	253	LKIM	Babe	Hannes	13-Jul-10	2010	0	9:10	-26.916883	27.400033	Boat	Pool	Winter	22.84	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	520	3	1
195	175	253	LKIM	Babe	Hannes	13-Jul-10	2010	0	9:20	-26.916883	27.400033	Boat	Pool	Winter	22.84	1	1	2	6	5	2	3	4	2	3	3	2	13	1200	520	3	1
196	176	253	LKIM	Babe	Hannes	13-Jul-10	2010	0	9:30	-26.916883	27.400017	Boat	Pool	Winter	22.84	1	1	2	6	5	2	3	4	2	3	3	2	13	1200	520	3	1
197	177	253	LKIM	Babe	Hannes	13-Jul-10	2010	0	9:40	-26.916883	27.400017	Boat	Pool	Winter	22.84	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	520	3	1
198	178	253	LKIM	Babe	Hannes	13-Jul-10	2010	0	9:50	-26.916883	27.400017	Boat	Pool	Winter	22.84	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	520	3	1
199	179	253	LKIM	Babe	Hannes	13-Jul-10	2010	0	10:00	-26.916883	27.400017	Boat	Pool	Winter	22.84	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	520	3	1
200	180	253	LKIM	Babe	Hannes	13-Jul-10	2010	0	10:10	-26.916883	27.400017	Boat	Pool	Winter	22.84	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	520	3	1
201	181	253	LKIM	Babe	Hannes	13-Jul-10	2010	0	10:20	-26.916883	27.400017	Boat	Pool	Winter	22.84	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	520	3	1
202	182	253	LKIM	Babe	Hannes	13-Jul-10	2010	0	10:30	-26.916883	27.400017	Boat	Pool	Winter	22.84	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	520	3	1
203	183	253	LKIM	Babe	Hannes	13-Jul-10	2010	0	10:40	-26.916883	27.400017	Boat	Pool	Winter	22.84	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	520	3	1
204	184	253	LKIM	Babe	Hannes	13-Jul-10	2010	0	10:50	-26.916883	27.400017	Boat	Pool	Winter	22.84	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	520	3	1
205	185	253	LKIM	Babe	Hannes	13-Jul-10	2010	0	11:00	-26.916883	27.400017	Boat	Pool	Winter	22.84	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	520	3	1
206	186	253	LKIM	Babe	Hannes	13-Jul-10	2010	0	11:10	-26.916883	27.400017	Boat	Pool	Winter	22.84	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	520	3	1
207	187	253	LKIM	Babe	Hannes	13-Jul-10	2010	0	11:20	-26.916883	27.400017	Boat	Pool	Winter	22.84	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	520	3	1
208	188	253	LKIM	Babe	Hannes	13-Jul-10	2010	0	17:00	-26.916883	27.400017	Boat	Pool	Winter	22.84	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	520	3	1
209	189	253	LKIM	Babe	Hannes	13-Jul-10	2010	0	17:10	-26.916883	27.400017	Boat	Pool	Winter	22.84	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	520	3	1
210	190	253	LKIM	Babe	Hannes	13-Jul-10	2010	0	17:20	-26.916883	27.400017	Boat	Pool	Winter	22.84	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	520	3	1
211	191	253	LKIM	Babe	Hannes	13-Jul-10	2010	0	17:30	-26.916883	27.400017	Boat	Pool	Winter	22.84	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	520	3	1
212	192	253	LKIM	Babe	Hannes	13-Jul-10	2010	0	17:40	-26.916883	27.400017	Boat	Pool	Winter	22.84	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	520	3	1
213	193	253	LKIM	Babe	Hannes	13-Jul-10	2010	0	17:50	-26.916883	27.400017	Boat	Pool	Winter	22.84	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	520	3	1
214	194	253	LKIM	Babe	Hannes	13-Jul-10	2010	0	18:00	-26.916883	27.400017	Boat	Pool	Winter	22.84	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	520	3	1
215	195	253	LKIM	Babe	Hannes	13-Jul-10	2010	0	18:10	-26.916883	27.400017	Boat	Pool	Winter	22.84	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	520	3	1
216	196	253	LKIM	Babe	Hannes	13-Jul-10	2010	0	18:20	-26.916883	27.400017	Boat	Pool	Winter	22.84	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	520	3	1
217	197	253	LKIM	Babe	Hannes	13-Jul-10	2010	0	18:30	-26.916883	27.400017	Boat	Pool	Winter	22.84	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	520	3	1
218	198	253	LKIM	Babe	Hannes	13-Jul-10	2010	0	18:40	-26.916883	27.400017	Boat	Pool	Winter	22.84	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	520	3	1
219	199	253	LKIM	Babe	Hannes	13-Jul-10	2010	0	18:50	-26.916883	27.400017	Boat	Pool	Winter	22.84	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	520	3	1
220	200	253	LKIM	Babe	Hannes	13-Jul-10	2010	0	19:00	-26.916883	27.400017	Boat	Pool	Winter	22.84	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	520	3	1
221	201	253	LKIM	Babe	Hannes	13-Jul-10	2010	0	19:10	-26.916883	27.400017	Boat	Pool	Winter	22.84	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	520	3	1
222	202	253	LKIM	Babe	Hannes	13-Jul-10	2010	0	19:20	-26.916883	27.400017	Boat	Pool	Winter	22.84	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	520	3	1
223	203	253	LKIM	Babe	Hannes	13-Jul-10	2010	0	19:30	-26.916883	27.400017	Boat	Pool	Winter	22.84	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	520	3	1
224	204	253	LKIM	Babe	Hannes	14-Jul-10	2010	1	10:00	-26.916883	27.400017	Boat	Pool	Winter	23.07	1	1	2	6	0	2	3	4	2	1	3	2	13	1200	520	3	1
225	205	253	LKIM	Babe	Hannes	14-Jul-10	2010	0	10:10	-26.916883	27.400017	Boat	Pool	Winter	23.07	1	1	2	6	0	2	3	4	2	1	3	2	13	1200	520	3	1
226	206	253	LKIM	Babe	Hannes	14-Jul-10	2010	0	10:20	-26.916883	27.400017	Boat	Pool	Winter	23.07	1	1	2	6	0	2	3	4	2	1	3	2	13	1200	520	3	1

Appendix 21: Continuation of raw spatial monitoring data collected from the biotelemetry study of yellowfish at location 2.

227	207	253	LKIM	Babe	Hannes	14-Jul-10	2010	0	10:30	-26.916883	27.400033	Boat	Pool	Winter	23.07	1	1	2	6	5	2	3	4	2	1	3	2	13	1200	520	3	1
228	208	253	LKIM	Babe	Hannes	14-Jul-10	2010	0	10:40	-26.916883	27.400033	Boat	Pool	Winter	23.07	1	1	2	6	0	2	3	4	2	1	3	2	13	1200	520	3	1
229	209	253	LKIM	Babe	Hannes	14-Jul-10	2010	0	10:50	-26.916883	27.400017	Boat	Pool	Winter	23.07	1	1	2	6	5	2	3	4	2	1	3	2	13	1200	520	3	1
230	210	253	LKIM	Babe	Hannes	14-Jul-10	2010	0	11:00	-26.916883	27.400017	Boat	Pool	Winter	23.07	1	1	2	6	0	2	3	4	2	1	3	2	13	1200	520	3	1
231	211	253	LKIM	Babe	Hannes	14-Jul-10	2010	0	11:10	-26.916883	27.400017	Boat	Pool	Winter	23.07	1	1	2	6	0	2	3	4	2	1	3	2	13	1200	520	3	1
232	212	253	LKIM	Babe	Hannes	24-Jul-10	2010	10	13:10	-26.916633	27.399483	Boat	Glide	Winter	24.18	1	2	1	6	0	5	4	3	3	2	3	13	13	1200	720	3	3
233	213	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	13:20	-26.916633	27.399483	Boat	Glide	Winter	24.18	1	2	1	6	0	5	4	3	3	2	3	13	13	1200	720	3	3
234	214	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	13:30	-26.916633	27.399483	Boat	Glide	Winter	24.18	1	2	1	6	0	5	4	3	3	2	3	13	13	1200	720	3	3
235	215	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	13:40	-26.916633	27.399483	Boat	Glide	Winter	24.18	1	2	1	6	0	5	4	3	3	2	3	13	13	1200	720	3	3
236	216	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	13:50	-26.916817	27.399717	Boat	Pool	Winter	24.18	1	1	2	6	20	2	3	4	2	3	3	2	13	1200	720	3	3
237	217	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	14:00	-26.916817	27.399717	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
238	218	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	14:10	-26.916817	27.399717	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
239	219	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	14:20	-26.916817	27.399717	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
240	220	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	14:30	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	20	2	3	4	2	3	3	2	13	1200	720	3	3
241	221	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	14:40	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
242	222	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	14:50	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
243	223	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	15:00	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
244	224	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	15:10	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
245	225	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	15:20	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
246	226	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	15:30	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
247	227	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	15:40	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
248	228	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	15:50	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
249	229	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	16:00	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
250	230	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	16:10	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
251	231	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	16:20	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
252	232	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	16:30	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
253	233	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	16:40	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
254	234	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	16:50	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
255	235	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	17:00	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
256	236	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	17:10	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
257	237	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	17:20	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
258	238	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	17:30	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
259	239	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	17:40	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
260	240	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	17:50	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
261	241	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	18:00	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
262	242	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	18:10	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
263	243	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	18:20	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
264	244	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	18:30	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
265	245	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	18:40	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
266	246	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	18:50	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
267	247	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	19:00	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
268	248	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	19:10	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
269	249	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	19:20	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
270	250	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	19:30	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
271	251	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	19:40	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
272	252	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	19:50	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
273	253	253	LKIM	Babe	Hannes	24-Jul-10	2010	0	20:00	-26.916817	27.400017	Boat	Pool	Winter	24.18	1	1	2	6	0	2	3	4	2	3	3	2	13	1200	720	3	3
274	254	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	22	1530	-26.909550	27.392400	Boat	Glide	Winter	25.11	1	2	1	6	0	5	6	3	3	2	11	1	12	2000	600	2	1
275	255	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	1540	-26.909517	27.392367	Boat	Glide	Winter	25.11	10	2	1	6	10	5	6	3	3	2	11	1	12	2000	600	2	1
276	256	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	1550	-26.909500	27.392350	Boat	Glide	Winter	25.11	10	2	1	6	10	5	6	3	3	2	11	1	12	2000	600	2	1
277	257	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	1600	-26.909533	27.392367	Boat	Glide	Winter	25.11	10	2	1	6	10	5	6	3	3	2	11	1	12	2000	600	2	1
278	258	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	1610	-26.909483	27.392317	Boat	Glide	Winter	25.11	1	2	1	6	0	5	6	3	3	2	11	1	12	2000	600	2	1
279	259	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	1620	-26.909467	27.392300	Boat	Glide	Winter	25.11	10	2	1	6	10	5	6	3	3	2	11	1	12	2000	600	2	1
280	260	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	1630	-26.909450	27.392267	Boat	Glide	Winter	25.11	10	2	1	6	10	5	6	3	3	2	11	1	12	2000	600	2	1
281	261	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	1640	-26.909433	27.392283	Boat	Glide	Winter	25.11	10	2	1	6	10	5	6	3	3	2	11	1	12	2000	600	2	1
282	262	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	1650	-26.909417	27.392300	Boat	Glide	Winter	25.11	1	2	1	6	0	5	6	3	3	2	11	1	12	2000	600	2	1
283	263	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	1700	-26.909417	27.392317	Boat	Glide	Winter	25.11	10	2	1	6	10	5	6	3	3	2	11	1	12	2000	600	2	1
284	264	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	1710	-26.909417	27.392333	Boat	Glide	Winter	25.11	10	2	1	6	10	5	6	3	3	2	11	1	12	2000	600	2	1

Appendix 22: Continuation of raw spatial monitoring data collected from the biotelemetry study of yellowfish at location 2.

285	265	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	1720	-26.909550	27.392400	Boat	Glide	Winter	25.11	10	2	1	6	10	5	6	3	3	2	11	1	12	2000	600	2	1
286	266	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	1730	-26.909517	27.392367	Boat	Glide	Winter	25.11	1	2	1	6	0	5	6	3	3	2	11	1	12	2000	600	2	1
287	267	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	1740	-26.909500	27.392350	Boat	Glide	Winter	25.11	10	2	1	6	10	5	6	3	3	2	11	1	12	2000	600	2	1
288	268	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	1750	-26.909533	27.392367	Boat	Glide	Winter	25.11	10	2	1	6	10	5	6	3	3	2	11	1	12	2000	600	2	1
289	269	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	1800	-26.909483	27.392317	Boat	Glide	Winter	25.11	10	2	1	6	10	5	6	3	3	2	11	1	12	2000	600	2	1
290	270	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	1810	-26.909467	27.392300	Boat	Glide	Winter	25.11	1	2	1	6	0	5	6	3	3	2	11	1	12	2000	600	2	1
291	271	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	1820	-26.909450	27.392267	Boat	Glide	Winter	25.11	10	2	1	6	10	5	6	3	3	2	11	1	12	2000	600	2	1
292	272	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	1830	-26.909433	27.392283	Boat	Glide	Winter	25.11	10	2	1	6	10	5	6	3	3	2	11	1	12	2000	600	2	1
293	273	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	1840	-26.909417	27.392300	Boat	Glide	Winter	25.11	10	2	1	6	10	5	6	3	3	2	11	1	12	2000	600	2	1
294	274	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	1850	-26.909417	27.392317	Boat	Glide	Winter	25.11	1	2	1	6	0	5	6	3	3	2	11	1	12	2000	600	2	1
295	275	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	1900	-26.909417	27.392333	Boat	Glide	Winter	25.11	10	2	1	6	10	5	6	3	3	2	11	1	12	2000	600	2	1
296	276	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	1910	-26.909550	27.392400	Boat	Glide	Winter	25.11	10	2	1	6	10	5	6	3	3	2	11	1	12	2000	600	2	1
297	277	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	1920	-26.909517	27.392367	Boat	Glide	Winter	25.11	10	2	1	6	10	5	6	3	3	2	11	1	12	2000	600	2	1
298	278	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	1930	-26.909500	27.392350	Boat	Glide	Winter	25.11	1	2	1	6	0	5	6	3	3	2	11	1	12	2000	600	2	1
299	279	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	1940	-26.909533	27.392367	Boat	Glide	Winter	25.11	10	2	1	6	10	5	6	3	3	2	11	1	12	2000	600	2	1
300	280	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	1950	-26.909483	27.392317	Boat	Glide	Winter	25.11	10	2	1	6	10	5	6	3	3	2	11	1	12	2000	600	2	1
301	281	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	2000	-26.909467	27.392300	Boat	Glide	Winter	25.11	10	2	1	6	10	5	6	3	3	2	11	1	12	2000	600	2	1
302	282	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	2010	-26.909450	27.392267	Boat	Glide	Winter	25.11	1	2	1	6	0	5	6	3	3	2	11	1	12	2000	600	2	1
303	283	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	2020	-26.909433	27.392283	Boat	Glide	Winter	25.11	10	2	1	6	10	5	6	3	3	2	11	1	12	2000	600	2	1
304	284	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	2030	-26.909417	27.392300	Boat	Glide	Winter	25.11	10	2	1	6	10	5	6	3	3	2	11	1	12	2000	600	2	1
305	285	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	2040	-26.909417	27.392317	Boat	Glide	Winter	25.11	10	2	1	6	10	5	6	3	3	2	11	1	12	2000	600	2	1
306	286	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	2050	-26.909417	27.392333	Boat	Glide	Winter	25.11	1	2	1	6	0	5	6	3	3	2	11	1	12	2000	600	2	1
307	287	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	2100	-26.909550	27.392400	Boat	Glide	Winter	25.11	10	2	1	6	10	5	6	3	3	2	11	1	12	2000	600	2	1
308	288	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	2110	-26.909517	27.392367	Boat	Glide	Winter	25.11	10	2	1	6	10	5	6	3	3	2	11	1	12	2000	600	2	1
309	289	253	LKIM	Babe	Fran. + Renate	15-Aug-10	2010	0	2120	-26.909500	27.392350	Boat	Glide	Winter	25.11	10	2	1	6	10	5	6	3	3	2	11	1	12	2000	600	2	1
310	290	253	LKIM	Babe	Fran. + Renate	16-Aug-10	2010	1	620	-26.909533	27.392367	Boat	Backwater	Winter	24.99	1	2	1	6	0	2	1	3	1	2	1	2	12	1700	610	2	1
311	291	253	LKIM	Babe	Fran. + Renate	16-Aug-10	2010	0	630	-26.909483	27.392317	Boat	Backwater	Winter	24.99	10	2	1	6	10	2	1	3	1	2	1	2	12	1700	610	2	1
312	292	253	LKIM	Babe	Fran. + Renate	16-Aug-10	2010	0	640	-26.909467	27.392300	Boat	Backwater	Winter	24.99	1	2	1	6	0	2	1	3	1	2	1	2	12	1700	610	2	1
313	293	253	LKIM	Babe	Fran. + Renate	16-Aug-10	2010	0	650	-26.909450	27.392267	Boat	Backwater	Winter	24.99	10	2	1	6	10	2	1	3	1	2	1	2	12	1700	610	2	1
314	294	253	LKIM	Babe	Fran. + Renate	16-Aug-10	2010	0	700	-26.909433	27.392283	Boat	Backwater	Winter	24.99	1	2	1	6	0	2	1	3	1	2	1	2	12	1700	610	2	1
315	295	253	LKIM	Babe	Fran. + Renate	16-Aug-10	2010	0	710	-26.909417	27.392300	Boat	Backwater	Winter	24.99	10	2	1	6	10	2	1	3	1	2	1	2	12	1700	610	2	1
316	296	253	LKIM	Babe	Fran. + Renate	16-Aug-10	2010	0	720	-26.909417	27.392317	Boat	Backwater	Winter	24.99	1	2	1	6	0	2	1	3	1	2	1	2	12	1700	610	2	1
317	297	253	LKIM	Babe	Fran. + Renate	16-Aug-10	2010	0	730	-26.909417	27.392333	Boat	Backwater	Winter	24.99	10	2	1	6	10	2	1	3	1	2	1	2	12	1700	610	2	1
318	298	253	LKIM	Babe	Fran. + Renate	16-Aug-10	2010	0	740	-26.909550	27.392400	Boat	Glide	Winter	24.99	10	2	1	6	10	4	3	5	3	4	3	13	12	1000	610	2	1
319	299	253	LKIM	Babe	Fran. + Renate	16-Aug-10	2010	0	750	-26.909517	27.392367	Boat	Glide	Winter	24.99	10	2	1	6	10	4	3	5	3	4	3	13	12	1000	610	2	1
320	300	253	LKIM	Babe	Fran. + Renate	16-Aug-10	2010	0	800	-26.909500	27.392350	Boat	Glide	Winter	24.99	10	2	1	6	10	4	3	5	3	4	3	13	12	1000	610	2	1
321	301	253	LKIM	Babe	Fran. + Renate	16-Aug-10	2010	0	810	-26.909533	27.392367	Boat	Glide	Winter	24.99	10	2	1	6	10	4	3	5	3	4	3	13	12	1000	610	2	1
322	302	253	LKIM	Babe	Fran. + Renate	16-Aug-10	2010	0	820	-26.909483	27.392317	Boat	Glide	Winter	24.99	10	2	1	6	10	4	3	5	3	4	3	13	12	1000	610	2	1
323	303	253	LKIM	Babe	Fran. + Renate	16-Aug-10	2010	0	830	-26.909467	27.392300	Boat	Glide	Winter	24.99	10	2	1	6	10	4	3	5	3	4	3	13	12	1000	610	2	1
324	304	253	LKIM	Babe	Fran. + Renate	16-Aug-10	2010	0	840	-26.909450	27.392267	Boat	Glide	Winter	24.99	10	2	1	6	10	4	3	5	3	4	3	13	12	1000	610	2	1
325	305	253	LKIM	Babe	Fran. + Renate	16-Aug-10	2010	0	850	-26.909433	27.392283	Boat	Glide	Winter	24.99	10	2	1	6	10	4	3	5	3	4	3	13	12	1000	610	2	1
326	306	253	LKIM	Babe	Fran. + Renate	16-Aug-10	2010	0	900	-26.909417	27.392300	Boat	Glide	Winter	24.99	10	2	1	6	10	4	3	5	3	4	3	13	12	1000	610	2	1
327	307	253	LKIM	Babe	Fran. + Renate	16-Aug-10	2010	0	910	-26.909417	27.392317	Boat	Glide	Winter	24.99	10	2	1	6	10	4	3	5	3	4	3	13	12	1000	610	2	1
328	308	253	LKIM	Babe	Fran. + Renate	16-Aug-10	2010	0	920	-26.909417	27.392333	Boat	Glide	Winter	24.99	10	2	1	6	10	4	3	5	3	4	3	13	12	1000	610	2	1
329	309	253	LKIM	Babe	Fran. + Renate	16-Aug-10	2010	0	930	-26.909417	27.392333	Boat	Glide	Winter	24.99	10	2	1	6	10	4	3	5	3	4	3	13	12	1000	610	2	1
330	310	253	LKIM	Babe	Fran. + Renate	17-Aug-10	2010	1	1440	-26.909750	27.393100	Boat	Glide	Winter	24.92	1	2	1	6	0	5	4	3	3	2	2	3	12	1300	500	2	1
331	311	253	LKIM	Babe	Fran. + Renate	17-Aug-10	2010	0	1450	-26.909750	27.393117	Boat	Glide	Winter	24.92	10	2	1	6	10	5	4	3	3	2	2	3	12	1300	500	2	1
332	312	253	LKIM	Babe	Fran. + Renate	17-Aug-10	2010	0	1500	-26.909767	27.393083	Boat	Glide	Winter	24.92	10	2	1	6	10	5	4	3	3	2	2	3	12	1300	500	2	1
333	313	253	LKIM	Babe	Fran. + Renate	17-Aug-10	2010	0	1510	-26.909733	27.393083	Boat	Glide	Winter	24.92	10	2	1	6	10	5	4	3	3	2	2	3	12	1300	500	2	1
334	314	253	LKIM	Babe	Fran. + Renate	17-Aug-10	2010	0	1520	-26.909700	27.393083	Boat	Glide	Winter	24.92	10	2	1	6	10	5	4	3	3	2	2	3	12	1300	500	2	1
335	315	253	LKIM	Babe	Fran. + Renate	17-Aug-10	2010	0	1530	-26.909700	27.393083	Boat	Glide	Winter	24.92	10	2	1	6	10	5	4	3	3	2	2	3	12	1300	500	2	1
336	316	253	LKIM	Babe	Fran. + Renate	17-Aug-10	2010	0	1540	-26.916683	27.393117	Boat	Glide	Winter	24.92	10	2	1	6	10	5	4	3	3	2	2	3	12	1300	500	2	1
337	317	253	LKIM	Babe	Fran. + Renate	17-Aug-10	2010	0	1550	-26.916683	27.393100	Boat	Glide	Winter	24.92	10	2	1	6	10	5	4	3	3	2	2	3	12	1300	500	2	1
338	318	253	LKIM	Babe	Fran. + Renate	17-Aug-10	2010	0	1600	-26.916700	27.393117	Boat	Glide	Winter	24.92	10	2	1	6	10	5	4	3	3	2	2	3	12	1300	500	2	1
339	319	253	LKIM	Babe	Fran. + Renate	17-Aug-10	2010	0	1610	-26.916717	27.393100	Boat	Glide	Winter	24.92	10	2	1	6	10	5	4	3	3	2	2	3	12	1300	500	2	1
340	320	253	LKIM	Babe	Fran. + Renate	17-Aug-10	2010	0	1620	-26.916733	27.393050	Boat	Glide	Winter	24.92	10	2	1	6	10	5	4	3	3	2	2	3	12	1300	500	2	1
341	321	253	LKIM	Babe	Fran. + Renate	17-Aug-10	2010	0	1630	-26.916733	27.393067	Boat	Glide	Winter	24.92	10	2	1	6	10	5	4	3	3	2	2	3	12	1300	500	2	1
342	322	253	LKIM	Babe	Fran. + Renate	17-Aug-10	2010	0	1640	-26.916733	27.393083	Boat	Glide	Winter	24.92	10	2	1	6	10	5	4	3	3	2	2	3	12	1300	500	2	1

Appendix 23: Continuation of raw spatial monitoring data collected from the biotelemetry study of yellowfish at location 2.

343	323	253	LKIM	Babe	Fran. + Renate	17-Aug-10	2010	0	1650	-26.916733	27.393100	Boat	Glide	Winter	24.92	10	2	1	6	10	5	4	3	3	2	2	3	12	1300	500	2	1
344	324	253	LKIM	Babe	Fran. + Renate	17-Aug-10	2010	0	1700	-26.916733	27.393117	Boat	Glide	Winter	24.92	10	2	1	6	10	5	4	3	3	2	2	3	12	1300	500	2	1
345	325	253	LKIM	Babe	Fran. + Renate	17-Aug-10	2010	0	1710	-26.916733	27.393133	Boat	Glide	Winter	24.92	10	2	1	6	10	5	4	3	3	2	2	3	12	1300	500	2	1
346	326	253	LKIM	Babe	Francois	25-Aug-10	2010	8	1500	-26.909533	27.392883	Boat	Backwater	Winter	20.51	1	2	1	6	0	2	1	6	1	2	6	11	12	1700	600	2	1
347	327	253	LKIM	Babe	Francois	25-Aug-10	2010	0	1510	-26.909533	27.392900	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
348	328	253	LKIM	Babe	Francois	25-Aug-10	2010	0	1520	-26.909533	27.392883	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
349	329	253	LKIM	Babe	Francois	25-Aug-10	2010	0	1530	-26.909517	27.392850	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
350	330	253	LKIM	Babe	Francois	25-Aug-10	2010	0	1540	-26.909550	27.392917	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
351	331	253	LKIM	Babe	Francois	25-Aug-10	2010	0	1550	-26.909567	27.392933	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
352	332	253	LKIM	Babe	Francois	25-Aug-10	2010	0	1600	-26.909567	27.392950	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
353	333	253	LKIM	Babe	Francois	25-Aug-10	2010	0	1610	-26.909533	27.392900	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
354	334	253	LKIM	Babe	Francois	25-Aug-10	2010	0	1620	-26.909533	27.392917	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
355	335	253	LKIM	Babe	Francois	25-Aug-10	2010	0	1630	-26.909533	27.392933	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
356	336	253	LKIM	Babe	Francois	25-Aug-10	2010	0	1640	-26.909533	27.392950	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
357	337	253	LKIM	Babe	Francois	25-Aug-10	2010	0	1650	-26.909533	27.392967	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
358	338	253	LKIM	Babe	Francois	25-Aug-10	2010	0	1700	-26.909533	27.392883	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
359	339	253	LKIM	Babe	Francois	25-Aug-10	2010	0	1710	-26.909533	27.392900	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
360	340	253	LKIM	Babe	Francois	25-Aug-10	2010	0	1720	-26.909533	27.392883	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
361	341	253	LKIM	Babe	Francois	25-Aug-10	2010	0	1730	-26.909517	27.392850	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
362	342	253	LKIM	Babe	Francois	25-Aug-10	2010	0	1740	-26.909550	27.392917	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
363	343	253	LKIM	Babe	Francois	25-Aug-10	2010	0	1750	-26.909567	27.392933	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
364	344	253	LKIM	Babe	Francois	25-Aug-10	2010	0	1800	-26.909567	27.392950	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
365	345	253	LKIM	Babe	Francois	25-Aug-10	2010	0	1810	-26.909533	27.392900	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
366	346	253	LKIM	Babe	Francois	25-Aug-10	2010	0	1820	-26.909533	27.392917	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
367	347	253	LKIM	Babe	Francois	25-Aug-10	2010	0	1830	-26.909533	27.392933	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
368	348	253	LKIM	Babe	Francois	25-Aug-10	2010	0	1840	-26.909533	27.392950	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
369	349	253	LKIM	Babe	Francois	25-Aug-10	2010	0	1850	-26.909533	27.392967	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
370	350	253	LKIM	Babe	Francois	25-Aug-10	2010	0	1900	-26.909533	27.392883	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
371	351	253	LKIM	Babe	Francois	25-Aug-10	2010	0	1910	-26.909533	27.392900	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
372	352	253	LKIM	Babe	Francois	25-Aug-10	2010	0	1920	-26.909533	27.392883	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
373	353	253	LKIM	Babe	Francois	25-Aug-10	2010	0	1930	-26.909517	27.392850	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
374	354	253	LKIM	Babe	Francois	25-Aug-10	2010	0	1940	-26.909550	27.392917	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
375	355	253	LKIM	Babe	Francois	25-Aug-10	2010	0	1950	-26.909567	27.392933	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
376	356	253	LKIM	Babe	Francois	25-Aug-10	2010	0	2000	-26.909567	27.392950	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
377	357	253	LKIM	Babe	Francois	25-Aug-10	2010	0	2010	-26.909533	27.392900	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
378	358	253	LKIM	Babe	Francois	25-Aug-10	2010	0	2020	-26.909533	27.392917	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
379	359	253	LKIM	Babe	Francois	25-Aug-10	2010	0	2030	-26.909533	27.392933	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
380	360	253	LKIM	Babe	Francois	25-Aug-10	2010	0	2040	-26.909533	27.392950	Boat	Backwater	Winter	20.51	10	2	1	6	10	2	1	6	1	2	6	11	12	1700	600	2	1
381	74	253	LKIM	Babe	Gordon	2-Feb-10	2010	0	1310	-26.915178	27.397830	Foot	Riffle	Summer	2217	1	1	1	6	0	5	6	6	5	5	13	3	3	6000	5	-	-
382	75	253	LKIM	Babe	Gordon	2-Feb-10	2010	0	1320	-26.915178	27.397830	Foot	Riffle	Summer	2217	1	1	1	6	0	5	6	6	5	5	13	3	3	6000	5	-	-
383	76	253	LKIM	Babe	Gordon	2-Feb-10	2010	0	1330	-26.915178	27.397830	Foot	Riffle	Summer	2217	1	1	1	6	0	5	6	6	5	5	13	3	3	6000	5	-	-
384	77	253	LKIM	Babe	Gordon	2-Feb-10	2010	0	1340	-26.915178	27.397830	Foot	Riffle	Summer	2217	1	1	1	6	0	5	6	6	5	5	13	3	3	6000	5	-	-
385	78	253	LKIM	Babe	Gordon	2-Feb-10	2010	0	1400	-26.915178	27.397830	Foot	Riffle	Summer	2217	1	1	1	6	0	5	6	6	5	5	13	3	3	6000	5	-	-
386	0	261	LKIM	Vetkoek	Hannes	21-Aug-10	2010	0	17:15	-26.916072	27.395910	Boat	-	Winter	25.21	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
387	1	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	3	11:00	-26.915133	27.395833	Boat	Pool	Winter	22.2	1	1	2	6	0	5	4	6	2	3	3	2	13	3500	450	3	1
388	2	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	0	11:10	-26.915133	27.395833	Boat	Pool	Winter	22.2	1	1	2	6	0	5	4	6	2	3	3	2	13	3500	450	3	1
389	3	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	0	11:20	-26.915133	27.395833	Boat	Pool	Winter	22.2	1	1	2	6	0	5	4	6	2	3	3	2	13	3500	450	3	1
390	4	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	0	11:30	-26.915133	27.395833	Boat	Pool	Winter	22.2	1	1	2	6	0	5	4	6	2	3	3	2	13	3500	450	3	1
391	5	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	0	11:40	-26.915167	27.395917	Boat	Pool	Winter	22.2	1	1	2	6	5	5	4	6	2	3	3	2	13	3500	450	3	1
392	6	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	0	11:50	-26.915167	27.395917	Boat	Pool	Winter	22.2	1	1	2	6	0	5	4	6	2	3	3	2	13	3500	450	3	1
393	7	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	0	12:00	-26.915167	27.395917	Boat	Pool	Winter	22.2	1	1	2	6	0	5	4	6	2	3	3	2	13	3500	450	3	1
394	8	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	0	12:10	-26.915167	27.395917	Boat	Pool	Winter	22.2	1	1	2	6	0	5	4	6	2	3	3	2	13	3500	450	3	1
395	9	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	0	12:20	-26.915167	27.395917	Boat	Pool	Winter	22.2	1	1	2	6	0	5	4	6	2	3	3	2	13	3500	450	3	1
396	10	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	0	12:30	-26.915133	27.396033	Boat	Pool	Winter	22.2	1	1	2	6	5	5	4	6	2	3	3	2	13	3500	450	3	1
397	11	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	0	12:40	-26.915133	27.396033	Boat	Pool	Winter	22.2	1	1	2	6	0	5	4	6	2	3	3	2	13	3500	450	3	1
398	12	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	0	12:50	-26.915350	27.395883	Boat	Pool	Winter	22.2	1	1	2	6	15	5	4	6	2	3	3	2	13	3500	450	3	1
399	13	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	0	13:00	-26.915267	27.395967	Boat	Pool	Winter	22.2	1	1	2	6	10	5	4	6	2	3	3	2	13	4500	450	3	1
400	14	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	0	13:10	-26.915267	27.395967	Boat	Pool	Winter	22.2	1	1	2	6	0	5	4	6	2	3	3	2	13	4500	450	3	1

Appendix 24: Continuation of raw spatial monitoring data collected from the biotelemetry study of yellowfish at location 2.

401	15	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	0	13:20	-26.915150	27.395850	Boat	Pool	Winter	22.2	1	1	2	6	5	5	4	6	2	3	3	2	13	3500	450	3	1
402	16	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	0	13:30	-26.915150	27.395850	Boat	Pool	Winter	22.2	1	1	2	6	0	5	4	6	2	3	3	2	13	3500	450	3	1
403	17	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	0	14:30	-26.915150	27.395850	Boat	Pool	Winter	22.2	1	1	2	6	0	5	4	6	2	3	3	2	13	3500	450	3	1
404	18	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	0	14:40	-26.915150	27.395850	Boat	Pool	Winter	22.2	1	1	2	6	0	5	4	6	2	3	3	2	13	3500	450	3	1
405	19	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	0	14:50	-26.915150	27.395850	Boat	Pool	Winter	22.2	1	1	2	6	0	5	4	6	2	3	3	2	13	3500	450	3	1
406	20	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	0	15:00	-26.915150	27.395850	Boat	Pool	Winter	22.2	1	1	2	6	0	5	4	6	2	3	3	2	13	3500	450	3	1
407	21	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	0	15:10	-26.915150	27.395850	Boat	Pool	Winter	22.2	1	1	2	6	0	5	4	6	2	3	3	2	13	3500	450	3	1
408	22	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	0	15:20	-26.915150	27.395850	Boat	Pool	Winter	22.2	1	1	2	6	0	5	4	6	2	3	3	2	13	3500	450	3	1
409	23	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	0	15:30	-26.915150	27.395850	Boat	Pool	Winter	22.2	1	1	2	6	0	5	4	6	2	3	3	2	13	3500	450	3	1
410	24	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	0	15:40	-26.915150	27.395850	Boat	Pool	Winter	22.2	1	1	2	6	0	5	4	6	2	3	3	2	13	3500	450	3	1
411	25	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	0	15:50	-26.915150	27.395850	Boat	Pool	Winter	22.2	1	1	2	6	0	5	4	6	2	3	3	2	13	3500	450	3	1
412	26	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	0	16:00	-26.915150	27.395850	Boat	Pool	Winter	22.2	1	1	2	6	0	5	4	6	2	3	3	2	13	3500	450	3	1
413	27	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	0	16:10	-26.915150	27.395850	Boat	Pool	Winter	22.2	1	1	2	6	0	5	4	6	2	3	3	2	13	3500	450	3	1
414	28	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	0	16:20	-26.915150	27.395850	Boat	Pool	Winter	22.2	1	1	2	6	0	5	4	6	2	3	3	2	13	3500	450	3	1
415	29	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	0	16:30	-26.915150	27.395850	Boat	Pool	Winter	22.2	1	1	2	6	0	5	4	6	2	3	3	2	13	3500	450	3	1
416	30	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	0	16:40	-26.915150	27.395850	Boat	Pool	Winter	22.2	1	1	2	6	0	5	4	6	2	3	3	2	13	3500	450	3	1
417	31	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	0	16:50	-26.915150	27.395850	Boat	Pool	Winter	22.2	1	1	2	6	0	5	4	6	2	3	3	2	13	3500	450	3	1
418	32	261	LKIM	Vetkoek	Hannes	24-Aug-10	2010	0	17:00	-26.915150	27.395850	Boat	Pool	Winter	22.2	1	1	2	6	0	5	4	6	2	3	3	2	13	3500	450	3	1
419	0	272	LKIM	Alley Cat	Gordon	22-Jul-09	2009	0	10h15	-26.938840	27.151650	Boat	Pool	Winter	17.89	1	1	2	-	0	5	6	-	2	-	13	3	-	2500	500	-	-
420	1	272	LKIM	Alley Cat	Gordon	9-Nov-09	2009	110	16h00	-26.930510	27.095624	Boat	Pool	Spring	46.76	50	4	6	-	0	3	5	-	2	-	13	3	-	2000	300	-	-
421	2	272	LKIM	Alley Cat	Gordon	7-May-10	2010	179	11h50	-26.942176	27.142489	Air	Pool	Autumn	82.16	1	2	2	-	0	5	6	-	2	-	13	3	-	3000	300	-	-
422	0	281	LKIM	Skaars	Gordon	22-Jul-09	2009	0	10h00	-26.938840	27.151650	Boat	-	Winter	17.89	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
423	1	281	LKIM	Skaars	Rindert	17-Aug-09	2009	26	1210	-26.941570	27.141060	Boat	Pool	Winter	18.72	1	1	2	0	0	2	5	3	2	0	3	13	15	2500	800	2	1
424	2	281	LKIM	Skaars	Rindert	17-Aug-09	2009	0	1115	-26.941570	27.141060	Boat	Pool	Winter	18.72	10	2	1	0	0	2	5	3	2	0	3	13	15	2500	800	2	1
425	3	281	LKIM	Skaars	Rindert	17-Aug-09	2009	0	1200	-26.941570	27.141060	Boat	Pool	Winter	18.72	10	2	1	0	10	2	5	3	2	0	3	13	15	2500	800	2	1
426	4	281	LKIM	Skaars	Rindert	17-Aug-09	2009	0	1220	-26.941570	27.141060	Boat	Pool	Winter	18.72	10	2	1	0	20	2	5	3	2	0	3	13	15	2500	800	2	1
427	5	281	-	Skaars	Fran. & Gordon	26-Aug-09	2009	-	1420	-26.942100	27.143000	-	Pool	Winter	-	1	1	2	-	0	5	4	2	2	-	13	5	-	2000	150	3	1
428	6	281	-	Skaars	Fran. & Gordon	26-Aug-09	2009	-	1430	-26.942000	27.142800	-	Pool	Winter	-	10	1	2	-	10	5	4	2	2	-	13	5	-	2000	150	3	1
429	7	281	-	Skaars	Fran. & Gordon	26-Aug-09	2009	-	1440	-26.942000	27.142800	-	Pool	Winter	-	20	1	5	-	10	5	4	2	2	-	13	5	-	2000	150	3	1
430	8	281	-	Skaars	Fran. & Gordon	26-Aug-09	2009	-	1500	-26.942100	27.142700	-	Pool	Winter	-	50	1	2	-	10	5	4	2	2	-	13	5	-	2000	150	3	1
431	9	281	LKIM	Skaars	Rindert	4-Sep-09	2009	18	1120	-26.941860	27.141310	Boat	Pool	Spring	14.98	10	2	1	0	10	2	5	3	2	9	13	3	15	1600	250	2	1
432	10	281	LKIM	Skaars	Rindert	4-Sep-09	2009	0	1100	-26.941860	27.141310	Boat	Pool	Spring	14.98	10	2	1	0	0	2	5	3	2	9	13	3	15	1600	250	2	1
433	11	281	LKIM	Skaars	Rindert	4-Sep-09	2009	0	1110	-26.941860	27.141310	Boat	Pool	Spring	14.98	1	1	2	0	10	2	5	3	2	9	13	3	15	1600	250	2	1
434	12	281	LKIM	Skaars	Rindert	4-Sep-09	2009	0	1130	-26.941860	27.141310	Boat	Pool	Spring	14.98	10	2	1	0	20	2	5	3	2	9	13	3	15	1600	250	2	1
435	13	281	LKIM	Skaars	Rindert	8-Sep-09	2009	4	1140	-26.941620	27.141130	Boat	Pool	Spring	16.7	10	2	1	0	60	2	5	0	2	9	3	13	15	2000	250	2	1
436	14	281	LKIM	Skaars	Rindert	8-Sep-09	2009	0	1120	-26.941470	27.141170	Boat	Pool	Spring	16.7	50	2	1	0	0	2	5	0	2	9	3	13	15	2000	250	2	1
437	15	281	LKIM	Skaars	Rindert	8-Sep-09	2009	0	1130	-26.941470	27.141170	Boat	Pool	Spring	16.7	50	2	1	0	50	2	5	0	2	9	3	13	15	2000	250	2	1
438	16	281	LKIM	Skaars	Rindert	8-Sep-09	2009	0	1150	-26.941620	27.141130	Boat	Pool	Spring	16.7	10	1	1	0	70	2	5	0	2	9	3	13	15	2000	250	2	1
439	17	281	LKIM	Skaars	Rindert & Fran.	9-Sep-09	2009	1	1145	-26.941820	27.141300	Boat	Pool	Spring	14.22	100	2	0	0	150	3	5	2	2	0	3	13	15	2000	300	2	1
440	18	281	LKIM	Skaars	Rindert & Fran.	9-Sep-09	2009	0	1125	-26.941820	27.141300	Boat	Pool	Spring	14.22	50	2	0	0	0	3	5	2	2	0	3	13	15	2000	300	2	1
441	19	281	LKIM	Skaars	Rindert & Fran.	9-Sep-09	2009	0	1135	-26.941820	27.141300	Boat	Pool	Spring	14.22	50	2	0	0	50	3	5	2	2	0	3	13	15	2000	300	2	1
442	20	281	LKIM	Skaars	Rindert & Fran.	9-Sep-09	2009	0	1155	-26.941820	27.141300	Boat	Pool	Spring	14.22	50	2	5	0	200	3	5	2	2	0	3	13	15	2000	300	2	1
443	21	281	LKIM	Skaars	Rindert	30-Sep-09	2009	21	930	-26.941910	27.141100	Boat	Pool	Spring	13.6	10	1	2	0	60	5	2	0	2	9	3	13	15	2800	460	2	3
444	22	281	LKIM	Skaars	Rindert	30-Sep-09	2009	0	910	-26.942000	27.141070	Boat	Pool	Spring	13.6	50	2	1	0	0	5	2	0	2	9	3	13	15	2800	460	2	3
445	23	281	LKIM	Skaars	Rindert	30-Sep-09	2009	0	920	-26.941920	27.141090	Boat	Pool	Spring	13.6	10	1	2	0	50	5	2	0	2	9	3	13	15	2800	460	2	3
446	24	281	LKIM	Skaars	Rindert	30-Sep-09	2009	0	940	-26.941950	27.141080	Boat	Pool	Spring	13.6	10	1	2	0	70	5	2	0	2	9	3	13	15	2800	460	2	3
447	25	281	LKIM	Skaars	Rindert	8-Dec-09	2009	69	1415	-26.941220	27.142810	Boat	Pool	Summer	27.74	50	5	2	0	0	5	2	3	2	9	3	13	15	2000	800	2	1
448	26	281	LKIM	Skaars	Rindert	8-Dec-09	2009	0	1430	-26.942230	27.141740	Boat	Pool	Summer	27.74	10	1	2	0	10	5	2	3	2	9	3	13	15	2000	800	2	1
449	0	283	LKIM	Wit brood	Gordon	21-May-09	2009	0	7:00am	-26.925400	27.179500	Boat	-	Autumn	18.59	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
450	1	283	LKIM	Wit brood	Rindert	14-Sep-09	2009	116	1340	-26.942950	27.180920	Boat	Pool	Spring	10	1	1	2	0	0	5	2	0	2	0	13	9	16	2000	370	2	1
451	2	283	LKIM	Wit brood	Rindert	14-Sep-09	2009	0	1320	-26.942950	27.180920	Boat	Pool	Spring	10	10	2	1	0	0	5	2	0	2	0	13	9	16	2000	370	2	1
452	3	283	LKIM	Wit brood	Rindert	14-Sep-09	2009	0	1330	-26.942950	27.180920	Boat	Pool	Spring	10	10	2	1	0	10	5	2	0	2	0	13	9	16	2000	370	2	1
453	4	283	LKIM	Wit brood	Rindert	14-Sep-09	2009	0	1350	-26.942950	27.180920	Boat	Pool	Spring	10	10	2	1	0	20	5	2	0	2	0	13	9	16	2000	370	2	1
454	5	283	LKIM	Wit brood	Rindert	22-Sep-09	2009	8	1230	-26.942970	27.180940	Boat	Pool	Spring	16.84	1	1	0	0	0	5	2	0	2	0	3	13	1	2000	450	2	1
455	6	283	LKIM	Wit brood	Rindert	22-Sep-09	2009	0	1210	-26.942950	27.180920	Boat	Pool	Spring	16.84	1	1	0	0	0	5	2	0	2	0	3	13	1	2000	450	2	1
456	7	283	LKIM	Wit brood	Rindert	22-Sep-09	2009	0	1220	-26.942960	27.180930	Boat	Pool	Spring	16.84	1	1	0	0	0	5	2	0	2	0	3	13	1	2000	450	2	1
457	8	283	LKIM	Wit brood	Rindert	22-Sep-09	2009	0	1240	-26.942980	27.180950	Boat	Pool	Spring	16.84	1	1	0	0	0	5	2	0	2	0	3	13	1	2000	450	2	1
458	0	292	LKIM	Tsotsie	Gordon	27-Jun-09	2009	0	12h30	-26.916520	27.391890	Boat	-	Winter	22.63	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Appendix 25: Continuation of raw spatial monitoring data collected from the biotelemetry study of yellowfish at location 2.

459	0	302	LKIM	M. Robertson	Gordon	22-May-09	2009	0	14:15	-26.977790	27.189870	Boat	-	Autumn	17.18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
460	1	302	LKIM	M. Robertson	Gordon	7-May-10	2010	350	12h15	-26.929990	27.233845	Air	Pool	Autumn	82.16	10	1	2	-	0	2	5	-	2	-	13	8	6	5000	500	-	-
461	0	322	LKIM	Lu	Gordon	26-May-09	2009	0	14h00	-26.938670	27.137040	Boat	-	Autumn	15.8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
462	1	322	LKIM	Lu	Rindert	4-Sep-09	2009	101	1430	-26.936590	27.132210	Boat	Pool	Spring	14.98	50	2	1	0	50	2	5	0	2	9	3	9	16	700	250	3	1
463	2	322	LKIM	Lu	Rindert	4-Sep-09	2009	0	1410	-26.936760	27.131840	Boat	Backwater	Spring	14.98	10	2	1	0	0	2	5	0	1	0	3	9	14	700	150	3	1
464	3	322	LKIM	Lu	Rindert	4-Sep-09	2009	0	1420	-26.936570	27.132050	Boat	Pool	Spring	14.98	10	2	1	0	10	2	5	0	2	0	3	9	16	800	250	3	1
465	4	322	LKIM	Lu	Rindert	4-Sep-09	2009	0	1440	-26.936590	27.132210	Boat	Pool	Spring	14.98	10	2	1	0	60	2	5	0	2	9	3	9	16	700	250	3	1
466	5	322	LKIM	Lu	Rindert	8-Sep-09	2009	4	1300	-26.937770	27.132560	Boat	Pool	Spring	16.7	10	1	2	0	20	2	5	4	2	0	9	14	16	1500	100	3	1
467	6	322	LKIM	Lu	Rindert	8-Sep-09	2009	0	1240	-26.937770	27.132560	Boat	Pool	Spring	16.7	10	1	2	0	0	2	5	4	2	0	9	14	16	1500	100	3	1
468	7	322	LKIM	Lu	Rindert	8-Sep-09	2009	0	1250	-26.937770	27.132560	Boat	Pool	Spring	16.7	10	1	2	0	10	2	5	4	2	0	9	14	16	1500	100	3	1
469	8	322	LKIM	Lu	Rindert	8-Sep-09	2009	0	1310	-26.937770	27.132560	Boat	Pool	Spring	16.7	10	1	2	0	30	2	5	4	2	0	9	14	16	1500	100	3	1
470	9	322	LKIM	Lu	Francois	9-Sep-09	2009	1	1530	-27.562800	27.221233	Boat	Glide	Spring	14.22	1	1	2	6	0	2	5	4	3	2	6	3	12	1700	300	3	1
471	10	322	LKIM	Lu	Rindert & Fran.	9-Sep-09	2009	0	1250	-26.937700	27.132630	Boat	Pool	Spring	14.22	50	2	1	0	100	2	0	0	2	0	13	9	16	2000	200	2	1
472	11	322	LKIM	Lu	Rindert & Fran.	9-Sep-09	2009	0	1230	-26.937700	27.132630	Boat	Pool	Spring	14.22	50	2	1	0	0	2	0	0	2	0	9	13	14	2000	200	2	1
473	12	322	LKIM	Lu	Rindert & Fran.	9-Sep-09	2009	0	1240	-26.937700	27.132630	Boat	Pool	Spring	14.22	50	2	1	0	50	2	0	0	2	0	13	17	16	2000	200	2	1
474	13	322	LKIM	Lu	Rindert & Fran.	9-Sep-09	2009	0	1300	-26.937700	27.132630	Boat	Pool	Spring	14.22	10	1	2	0	110	2	0	0	2	0	13	12	16	2000	200	2	1
475	14	322	LKIM	Lu	Rindert & Fran.	9-Nov-09	2009	61	1600	-26.937630	27.132680	Boat	Pool	Spring	46.76	1	1	2	0	0	2	5	0	2	0	13	17	16	1700	200	2	1
476	15	322	LKIM	Lu	Rindert & Fran.	9-Nov-09	2009	0	1830	-26.937650	27.132770	Boat	Pool	Spring	46.76	1	1	2	0	0	2	5	0	2	0	13	17	16	1700	300	2	1
477	16	322	LKIM	Lu	Rindert & Fran.	9-Nov-09	2009	0	2020	-26.937680	27.132740	Boat	Pool	Spring	46.76	1	1	0	0	0	2	5	0	2	0	13	17	16	1700	350	2	1
478	17	322	LKIM	Lu	Rindert & Fran.	9-Nov-09	2009	0	1540	-26.937630	27.132680	Boat	Pool	Spring	46.76	1	1	2	0	0	2	5	0	2	0	13	17	16	1700	200	2	1
479	18	322	LKIM	Lu	Rindert & Fran.	9-Nov-09	2009	0	1550	-26.937630	27.132680	Boat	Pool	Spring	46.76	1	1	2	0	0	2	5	0	2	0	13	17	16	1700	200	2	1
480	19	322	LKIM	Lu	Rindert & Fran.	9-Nov-09	2009	0	1610	-26.937630	27.132680	Boat	Pool	Spring	46.76	1	1	2	0	10	2	5	0	2	0	13	17	16	1700	200	2	1
481	20	322	LKIM	Lu	Rindert & Fran.	9-Nov-09	2009	0	1810	-26.937650	27.132770	Boat	Pool	Spring	46.76	1	1	2	0	0	2	5	0	2	0	13	17	16	1700	300	2	1
482	21	322	LKIM	Lu	Rindert & Fran.	9-Nov-09	2009	0	1820	-26.937650	27.132770	Boat	Pool	Spring	46.76	1	1	2	0	0	2	5	0	2	0	13	17	16	1700	300	2	1
483	22	322	LKIM	Lu	Rindert & Fran.	9-Nov-09	2009	0	1840	-26.937650	27.132770	Boat	Pool	Spring	46.76	1	1	2	0	10	2	5	0	2	0	13	17	16	1700	300	2	1
484	23	322	LKIM	Lu	Rindert & Fran.	9-Nov-09	2009	0	2000	-26.937680	27.132740	Boat	Pool	Spring	46.76	1	1	0	0	0	2	5	0	2	0	13	17	16	1700	350	2	1
485	24	322	LKIM	Lu	Rindert & Fran.	9-Nov-09	2009	0	2010	-26.937680	27.132740	Boat	Pool	Spring	46.76	1	1	0	0	0	2	5	0	2	0	13	17	16	1700	350	2	1
486	25	322	LKIM	Lu	Rindert & Fran.	9-Nov-09	2009	0	2030	-26.937680	27.132740	Boat	Pool	Spring	46.76	1	1	0	0	0	2	5	0	2	0	13	17	16	1700	350	2	1
487	1000	322	LKIM	Lu	Rindert & Fran.	16-Nov-09	2009	7	16h00	-26.937680	27.132740	Boat	-	Spring	58.44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
488	0	331	LKIM	Zoolander	Gordon	26-Jul-09	2009	0	7h45	-26.914180	27.390550	Boat	-	Winter	17.58	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
489	1	331	LKIM	Zoolander	Gordon	26-Jul-09	2009	0	9h30	-26.915434	27.391114	Boat	Pool	Winter	17.58	50	5	6	-	100	5	6	-	2	-	3	14	-	1200	-	-	-
490	2	331	LKIM	Zoolander	Gordon	26-Jul-09	2009	0	11h20	-26.917291	27.393158	Boat	Run	Winter	17.58	50	5	6	-	100	5	2	-	4	-	3	14	-	1500	-	-	-
491	3	331	LKIM	Zoolander	Gordon	26-Jul-09	2009	0	11h50	-26.917087	27.393473	Boat	Run	Winter	17.58	50	5	6	-	50	5	4	-	4	-	13	3	-	1500	-	-	-
492	4	331	LKIM	Zoolander	Gordon	2-Aug-09	2009	7	11h00	-26.915275	27.391403	Boat	Pool	Winter	22.75	10	1	2	-	0	5	6	-	2	-	13	3	-	2000	-	-	-
493	5	331	LKIM	Zoolander	Gordon	14-Aug-09	2009	12	9h15	-26.917291	27.393158	Boat	Pool	Winter	18.61	10	2	1	-	0	5	4	-	2	-	13	3	-	2500	-	-	-
494	6	331	LKIM	Zoolander	Gordon	14-Aug-09	2009	0	9h30	-26.914322	27.390883	Boat	Pool	Winter	18.61	10	1	2	-	10	5	2	-	2	-	13	3	-	3000	-	-	-
495	7	331	LKIM	Zoolander	Gordon	14-Aug-09	2009	0	9h40	-26.914351	27.390949	Boat	Pool	Winter	18.61	10	2	1	-	10	5	4	-	2	-	13	3	-	2000	-	-	-
496	8	331	LKIM	Zoolander	Gordon	14-Aug-09	2009	0	9h50	-26.914381	27.390901	Boat	Pool	Winter	18.61	10	1	2	-	10	5	2	-	2	-	13	3	-	2500	-	-	-
497	9	331	LKIM	Zoolander	Gordon	18-Aug-09	2009	4	15h50	-26.916075	27.391880	Boat	Pool	Winter	17.59	10	1	2	-	0	5	6	-	2	-	13	3	-	2500	-	-	-
498	10	331	LKIM	Zoolander	Gordon	18-Aug-09	2009	0	17h10	-26.914523	27.391371	Boat	Pool	Winter	17.59	10	2	1	-	0	5	4	-	2	-	13	3	-	2000	-	-	-
499	11	331	LKIM	Zoolander	Gordon	18-Aug-09	2009	0	17h20	-26.914438	27.391120	Boat	Pool	Winter	17.59	10	2	1	-	50	5	2	-	2	-	13	3	-	2000	-	-	-
500	12	331	LKIM	Zoolander	Gordon	18-Aug-09	2009	0	17h30	-26.914510	27.390837	Boat	Pool	Winter	17.59	10	2	1	-	10	5	6	-	2	-	13	8	-	2500	-	-	-
501	13	331	LKIM	Zoolander	Gordon	18-Aug-09	2009	0	17h40	-26.914892	27.391228	Boat	Run	Winter	17.59	10	2	1	-	50	5	4	-	4	-	13	8	-	2500	-	-	-
502	14	331	LKIM	Zoolander	Gordon	21-Sep-09	2009	34	16h20	-26.915777	27.391003	Boat	Pool	Spring	18.09	10	1	2	-	50	5	2	-	2	-	13	3	-	3500	-	-	-
503	15	331	LKIM	Zoolander	Gordon	21-Sep-09	2009	0	16h40	-26.916210	27.392020	Boat	Run	Spring	18.09	10	1	2	-	0	5	6	-	4	-	13	3	-	3500	-	-	-
504	16	331	LKIM	Zoolander	Gordon	21-Sep-09	2009	0	16h50	-26.916282	27.392058	Boat	Backwater	Spring	18.09	10	2	1	-	10	5	4	-	1	-	13	3	-	2500	-	-	-
505	17	331	LKIM	Zoolander	Gordon	21-Sep-09	2009	0	17h00	-26.916245	27.392093	Boat	Pool	Spring	18.09	10	2	1	-	10	5	2	-	2	-	13	3	-	3000	-	-	-
506	18	331	LKIM	Zoolander	Gordon	7-May-10	2010	228	11h30	-26.874582	27.345252	Air	Backwater	Autumn	82.16	10	1	2	-	10	5	6	-	1	-	13	3	-	5000	-	-	-
507	0	351	LKIM	Fourie	Gordon	29-Jun-09	2009	0	15h10	-26.955430	27.182570	Boat	-	Winter	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
508	1000	351	LKIM	Fourie	Gordon	2-Aug-09	2009	34	11h00	-26.955041	27.183184	Boat	-	Winter	22.75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
509	0	371	LKIM	Luck Strike	Gordon	20-Jul-09	2009	0	11h15	-26.923300	27.422500	Boat	-	Winter	17.98	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
510	0	402	LKIM	Johnny	Gordon	3-Apr-09	2009	0	15:30	-26.927210	27.182440	Boat	-	Autumn	22.94	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
511	1	402	LAEN	Johnny	Rindert	17-Aug-09	2009	136	940	-26.923660	27.171800	Boat	Glide	Winter	18.72	10	2	1	0	20	5	3	0	3	0	3	9	16	1500	400	2	1
512	2	402	LAEN	Johnny	Rindert	17-Aug-09	2009	0	915	-26.923390	27.172410	Boat	Glide	Winter	18.72	10	2	1	0	0	5	3	0	3	0	3	4	0	1300	400	2	1
513	3	402	LAEN	Johnny	Rindert	17-Aug-09	2009	0	930	-26.923500	27.171940	Boat	Glide	Winter	18.72	10	2	1	0	10	5	3	0	3	0	3	0	16	1300	400	2	1
514	4	402	LAEN	Johnny	Rindert	17-Aug-09	2009	0	950	-26.923780	27.171890	Boat	Glide	Winter	18.72	10	2	1	0	30	5	3	0	3	0	3	9	16	1000	400	2	1
515	5	402	LAEN	Johnny	Rindert	18-Aug-09	2009	1	940	-26.923730	27.171810	Boat	Pool	Winter	17.59	1	1	2	0	0	2	5	3	2	9	3	13	16	1500	300	2	1
516	6	402	LAEN	Johnny	Rindert	18-Aug-09	2009	0	915	-26.923430	27.171670	Boat	Glide	Winter	17.59	10	5	2	0	0	2	5	3	3	0	4	13	16	2000	350	2	1

Appendix 26: Continuation of raw spatial monitoring data collected from the biotelemetry study of yellowfish at location 2.

517	7	402	LAEN	Johnny	Rindert	18-Aug-09	2009	0	930	-26.923730	27.171810	Boat	Pool	Winter	17.59	10	2	1	0	10	2	5	3	2	9	3	13	16	1500	300	2	1
518	8	402	LAEN	Johnny	Rindert	18-Aug-09	2009	0	950	-26.923730	27.171810	Boat	Pool	Winter	17.59	10	2	1	0	20	2	5	3	2	9	3	13	16	1500	300	2	1
519	9	402	LAEN	Johnny	Rindert & Fran.	19-Aug-09	2009	1	930	-26.923730	27.172170	Boat	Pool	Winter	16.16	10	2	1	0	0	3	5	2	2	9	4	9	16	1000	250	2	2
520	10	402	LAEN	Johnny	Rindert & Fran.	19-Aug-09	2009	0	940	-26.923730	27.172170	Boat	Pool	Winter	16.16	50	2	1	0	10	3	5	2	2	9	4	9	16	1000	250	2	2
521	11	402	LAEN	Johnny	Fran. & Gordon	26-Aug-09	2009	7	1130	-26.924400	27.174900	Boat	Glide	Winter	16.25	1	5	2	0	0	2	4	1	3	-	3	6	13	800	150	3	1
522	12	402	LAEN	Johnny	Fran. & Gordon	26-Aug-09	2009	0	1155	-26.924300	27.174200	Boat	Glide	Winter	16.25	50	2	0	0	50	2	4	1	3	-	3	6	13	800	150	3	1
523	13	402	LAEN	Johnny	Fran. & Gordon	26-Aug-09	2009	0	1205	-26.924500	27.174400	Boat	Glide	Winter	16.25	50	2	0	0	50	2	4	1	3	-	3	6	13	800	150	3	1
524	14	402	LAEN	Johnny	Fran. & Gordon	26-Aug-09	2009	0	1220	-26.924700	27.175000	Boat	Glide	Winter	16.25	100	2	0	0	100	2	4	1	3	-	3	6	13	800	150	3	1
525	15	402	LAEN	Johnny	Rindert	4-Sep-09	2009	9	910	-26.923500	27.172840	Boat	Glide	Spring	14.98	10	2	1	0	0	2	5	3	3	0	3	9	16	800	100	3	1
526	16	402	LAEN	Johnny	Rindert	4-Sep-09	2009	0	845	-26.923500	27.172840	Boat	Glide	Spring	14.98	10	2	1	0	0	2	5	3	3	0	3	9	16	800	100	3	1
527	17	402	LAEN	Johnny	Rindert	4-Sep-09	2009	0	900	-26.923500	27.172840	Boat	Glide	Spring	14.98	1	1	2	0	10	2	5	3	3	0	3	9	16	800	100	3	1
528	18	402	LAEN	Johnny	Rindert	4-Sep-09	2009	0	920	-26.923500	27.172840	Boat	Glide	Spring	14.98	1	1	2	0	20	2	5	3	3	0	3	9	16	800	100	3	1
529	19	402	LAEN	Johnny	Rindert	8-Sep-09	2009	4	930	-26.926370	27.180780	Boat	Pool	Spring	16.7	10	1	2	0	20	2	5	0	2	0	3	9	16	1000	150	3	1
530	20	402	LAEN	Johnny	Rindert	8-Sep-09	2009	0	910	-26.926370	27.180780	Boat	Pool	Spring	16.7	10	1	2	0	0	2	5	0	2	0	3	9	16	1000	150	3	1
531	21	402	LAEN	Johnny	Rindert	8-Sep-09	2009	0	920	-26.926370	27.180780	Boat	Pool	Spring	16.7	10	1	2	0	10	2	5	0	2	0	3	9	16	1000	150	3	1
532	22	402	LAEN	Johnny	Rindert	8-Sep-09	2009	0	940	-26.926370	27.180780	Boat	Pool	Spring	16.7	10	1	2	0	30	2	5	0	2	0	3	9	16	1000	150	3	1
533	23	402	LAEN	Johnny	Rindert & Fran.	9-Sep-09	2009	1	920	-26.926470	27.180890	Boat	Glide	Spring	14.22	10	1	2	0	20	3	5	2	3	4	9	3	16	1500	250	3	1
534	24	402	LAEN	Johnny	Rindert & Fran.	9-Sep-09	2009	0	900	-26.926470	27.180890	Boat	Glide	Spring	14.22	10	1	2	0	0	3	5	2	3	4	9	3	16	1500	250	3	1
535	25	402	LAEN	Johnny	Rindert & Fran.	9-Sep-09	2009	0	910	-26.926470	27.180890	Boat	Glide	Spring	14.22	10	1	2	0	10	3	5	2	3	4	9	3	16	1500	250	3	1
536	26	402	LAEN	Johnny	Rindert & Fran.	9-Sep-09	2009	0	930	-26.926470	27.180890	Boat	Glide	Spring	14.22	10	1	2	0	30	3	5	2	3	4	9	3	16	1500	250	3	1
537	27	402	LAEN	Johnny	Francious	13-Sep-09	2009	4	1650	-26.926600	27.181200	Boat	Glide	Spring	10.45	10	2	-	-	0	4	5	-	3	-	9	-	-	1000	150	3	1
538	28	402	LAEN	Johnny	Francious	13-Sep-09	2009	0	1700	-26.926800	27.181000	Boat	Glide	Spring	10.45	50	2	-	-	10	4	5	-	3	-	3	-	-	1000	150	3	1
539	29	402	LAEN	Johnny	Francious	13-Sep-09	2009	0	1710	-26.927100	27.181700	Boat	Run	Spring	10.45	50	2	-	-	20	4	5	-	4	-	3	-	-	800	150	3	1
540	30	402	LAEN	Johnny	Francious	13-Sep-09	2009	0	1720	-26.926800	27.181400	Boat	Glide	Spring	10.45	10	2	-	-	20	4	5	-	3	-	13	-	-	1000	150	3	1
541	31	402	LAEN	Johnny	Rindert & Fran.	19-Sep-09	2009	6	1040	-26.926020	27.180180	Boat	Pool	Spring	18.16	10	1	2	0	20	5	3	2	2	0	3	9	1	1500	430	2	1
542	32	402	LAEN	Johnny	Rindert & Fran.	19-Sep-09	2009	0	1250	-26.926040	27.180150	Boat	Pool	Spring	18.16	10	1	2	0	20	5	3	2	2	0	3	9	1	1500	430	2	1
543	33	402	LAEN	Johnny	Rindert & Fran.	19-Sep-09	2009	0	1520	-26.926200	27.181050	Boat	Pool	Spring	18.16	10	1	2	0	60	5	4	0	2	0	9	13	16	1700	470	2	1
544	34	402	LAEN	Johnny	Rindert & Fran.	19-Sep-09	2009	0	1820	-26.926400	27.180750	Boat	Pool	Spring	18.16	10	1	2	0	20	5	4	0	2	0	9	13	16	1700	470	2	1
545	35	402	LAEN	Johnny	Rindert & Fran.	19-Sep-09	2009	0	2050	-26.926400	27.180750	Boat	Pool	Spring	18.16	10	1	2	0	20	5	4	0	2	0	9	13	16	1700	470	2	1
546	36	402	LAEN	Johnny	Rindert & Fran.	19-Sep-09	2009	0	2320	-26.926400	27.180750	Boat	Pool	Spring	18.16	1	1	0	0	0	5	4	0	2	0	3	13	16	1700	470	2	1
547	37	402	LAEN	Johnny	Rindert & Fran.	19-Sep-09	2009	0	1020	-26.926050	27.180160	Boat	Pool	Spring	18.16	10	1	2	0	0	5	3	2	2	0	3	9	1	1500	430	2	1
548	38	402	LAEN	Johnny	Rindert & Fran.	19-Sep-09	2009	0	1030	-26.926040	27.180170	Boat	Pool	Spring	18.16	10	1	2	0	10	5	3	2	2	0	3	9	1	1500	430	2	1
549	39	402	LAEN	Johnny	Rindert & Fran.	19-Sep-09	2009	0	1050	-26.926070	27.180150	Boat	Pool	Spring	18.16	10	1	2	0	30	5	3	2	2	0	3	9	1	1500	430	2	1
550	40	402	LAEN	Johnny	Rindert & Fran.	19-Sep-09	2009	0	1230	-26.926050	27.180160	Boat	Pool	Spring	18.16	10	1	2	0	0	5	3	2	2	0	3	9	1	1500	430	2	1
551	41	402	LAEN	Johnny	Rindert & Fran.	19-Sep-09	2009	0	1240	-26.926070	27.180170	Boat	Pool	Spring	18.16	10	1	2	0	10	5	3	2	2	0	3	9	1	1500	430	2	1
552	42	402	LAEN	Johnny	Rindert & Fran.	19-Sep-09	2009	0	1300	-26.926060	27.180180	Boat	Pool	Spring	18.16	10	1	2	0	30	5	3	2	2	0	3	9	1	1500	430	2	1
553	43	402	LAEN	Johnny	Rindert & Fran.	19-Sep-09	2009	0	1500	-26.926170	27.181010	Boat	Pool	Spring	18.16	10	1	2	0	0	5	4	0	2	0	9	13	16	1700	470	2	1
554	44	402	LAEN	Johnny	Rindert & Fran.	19-Sep-09	2009	0	1510	-26.926190	27.180830	Boat	Pool	Spring	18.16	50	2	1	0	50	5	4	0	2	0	9	13	16	1700	470	2	1
555	45	402	LAEN	Johnny	Rindert & Fran.	19-Sep-09	2009	0	1530	-26.926210	27.181060	Boat	Pool	Spring	18.16	10	1	2	0	70	5	4	0	2	0	9	13	16	1700	470	2	1
556	46	402	LAEN	Johnny	Rindert & Fran.	19-Sep-09	2009	0	1800	-26.926380	27.180770	Boat	Pool	Spring	18.16	10	1	2	0	0	5	4	0	2	0	9	13	16	1700	470	2	1
557	47	402	LAEN	Johnny	Rindert & Fran.	19-Sep-09	2009	0	1810	-26.926390	27.180760	Boat	Pool	Spring	18.16	10	1	2	0	10	5	4	0	2	0	9	13	16	1700	470	2	1
558	48	402	LAEN	Johnny	Rindert & Fran.	19-Sep-09	2009	0	1830	-26.926410	27.180740	Boat	Pool	Spring	18.16	10	1	2	0	30	5	4	0	2	0	9	13	16	1700	470	2	1
559	49	402	LAEN	Johnny	Rindert & Fran.	19-Sep-09	2009	0	2030	-26.926380	27.180770	Boat	Pool	Spring	18.16	10	1	2	0	0	5	4	0	2	0	9	13	16	1700	470	2	1
560	50	402	LAEN	Johnny	Rindert & Fran.	19-Sep-09	2009	0	2040	-26.926390	27.180760	Boat	Pool	Spring	18.16	10	1	2	0	10	5	4	0	2	0	9	13	16	1700	470	2	1
561	51	402	LAEN	Johnny	Rindert & Fran.	19-Sep-09	2009	0	2100	-26.926410	27.180740	Boat	Pool	Spring	18.16	10	1	2	0	30	5	4	0	2	0	9	13	16	1700	470	2	1
562	52	402	LAEN	Johnny	Rindert & Fran.	19-Sep-09	2009	0	2300	-26.926380	27.180770	Boat	Pool	Spring	18.16	1	1	0	0	0	5	4	0	2	0	3	13	16	1700	470	2	1
563	53	402	LAEN	Johnny	Rindert & Fran.	19-Sep-09	2009	0	2310	-26.926390	27.180760	Boat	Pool	Spring	18.16	1	1	0	0	0	5	4	0	2	0	3	13	16	1700	470	2	1
564	54	402	LAEN	Johnny	Rindert & Fran.	19-Sep-09	2009	0	2330	-26.926410	27.180740	Boat	Pool	Spring	18.16	1	1	0	0	0	5	4	0	2	0	3	13	16	1700	470	2	1
565	55	402	LAEN	Johnny	Rindert & Fran.	20-Sep-09	2009	1	220	-26.926400	27.180750	Boat	Pool	Spring	18.56	1	1	0	0	0	5	4	0	2	0	3	13	16	1700	470	2	1
566	56	402	LAEN	Johnny	Rindert & Fran.	20-Sep-09	2009	0	520	-26.926400	27.180750	Boat	Pool	Spring	18.56	1	1	0	0	0	5	4	0	2	0	3	13	16	1700	470	2	1
567	57	402	LAEN	Johnny	Rindert & Fran.	20-Sep-09	2009	0	820	-26.926020	27.180180	Boat	Pool	Spring	18.56	10	1	2	0	60	5	2	0	2	0	3	13	1	1800	470	2	1
568	58	402	LAEN	Johnny	Rindert & Fran.	20-Sep-09	2009	0	200	-26.926380	27.180770	Boat	Pool	Spring	18.56	1	1	0	0	0	5	4	0	2	0	3	13	16	1700	470	2	1
569	59	402	LAEN	Johnny	Rindert & Fran.	20-Sep-09	2009	0	210	-26.926390	27.180760	Boat	Pool	Spring	18.56	1	1	0	0	0	5	4	0	2	0	3	13	16	1700	470	2	1
570	60	402	LAEN	Johnny	Rindert & Fran.	20-Sep-09	2009	0	230	-26.926410	27.180740	Boat	Pool	Spring	18.56	1	1	0	0	0	5	4	0	2	0	3	13	16	1700	470	2	1
571	61	402	LAEN	Johnny	Rindert & Fran.	20-Sep-09	2009	0	500	-26.926380	27.180770	Boat	Pool	Spring	18.56	1	1	0	0	0	5	4	0	2	0	3	13	16	1700	470	2	1
572	62	402	LAEN	Johnny	Rindert & Fran.	20-Sep-09	2009	0	510	-26.926390	27.180760	Boat	Pool	Spring	18.56	1	1	0	0	0	5	4	0	2	0	3	13	16	1700	470	2	1
573	63	402	LAEN	Johnny	Rindert & Fran.	20-Sep-09	2009	0	530	-26.926410	27.180740	Boat	Pool	Spring	18.56	1	1	0	0	0	5	4	0	2	0	3	13	16	1700	470	2	1
574	64	402	LAEN	Johnny	Rindert & Fran.	20-Sep-09	2009	0	800	-26.926050	27.180160	Boat	Pool	Spring	18.56	50	2	1	0	0	5	2	0	2	0	3	13	1	1800	470	2	1

Appendix 27: Continuation of raw spatial monitoring data collected from the biotelemetry study of yellowfish at location 2.

575	65	402	LAEN	Johnny	Rindert & Fran.	20-Sep-09	2009	0	810	-26.926040	27.180170	Boat	Pool	Spring	18.56	10	1	2	0	50	5	2	0	2	0	3	13	1	1800	470	2	1
576	66	402	LAEN	Johnny	Rindert & Fran.	20-Sep-09	2009	0	830	-26.926070	27.180150	Boat	Pool	Spring	18.56	10	1	2	0	70	5	2	0	2	0	3	13	1	1800	470	2	1
577	67	402	LAEN	Johnny	Rindert	23-Sep-09	2009	3	1050	-26.926020	27.180180	Boat	Pool	Spring	15.46	10	1	2	0	20	5	3	2	2	9	3	9	1	1500	450	2	1
578	68	402	LAEN	Johnny	Rindert	23-Sep-09	2009	0	1030	-26.926050	27.180160	Boat	Pool	Spring	15.46	10	1	2	0	0	5	3	2	2	9	3	9	1	1500	450	2	1
579	69	402	LAEN	Johnny	Rindert	23-Sep-09	2009	0	1040	-26.926040	27.180170	Boat	Pool	Spring	15.46	10	1	2	0	10	5	3	2	2	9	3	9	1	1500	450	2	1
580	70	402	LAEN	Johnny	Rindert	23-Sep-09	2009	0	1100	-26.926070	27.180150	Boat	Pool	Spring	15.46	10	1	2	0	30	5	3	2	2	9	3	9	1	1500	450	2	1
581	71	402	LAEN	Johnny	Rindert	1-Oct-09	2009	8	810	-26.926020	27.180150	Boat	Pool	Spring	12.56	10	1	2	0	20	5	3	2	2	0	3	13	6	1600	480	2	3
582	72	402	LAEN	Johnny	Rindert	1-Oct-09	2009	0	750	-26.926050	27.180160	Boat	Pool	Spring	12.56	10	1	2	0	0	5	3	2	2	0	3	13	6	1600	480	2	3
583	73	402	LAEN	Johnny	Rindert	1-Oct-09	2009	0	800	-26.926040	27.180190	Boat	Pool	Spring	12.56	10	1	2	0	10	5	3	2	2	0	3	13	6	1600	480	2	3
584	74	402	LAEN	Johnny	Rindert	1-Oct-09	2009	0	820	-26.926060	27.180170	Boat	Pool	Spring	12.56	10	1	2	0	30	5	3	2	2	0	3	13	6	1600	480	2	3
585	75	402	LAEN	Johnny	Francois	9-Feb-10	2010	131	18:40	-26.502500	27.650667	Boat	Run	Summer	187.6	1	1	2	6	0	3	4	5	4	3	6	1	2	1100	100	3	1
586	76	402	LAEN	Johnny	Francois	9-Feb-10	2010	0	18:50	-26.502000	27.051317	Boat	Run	Summer	187.6	10	2	1	6	10	3	4	5	4	3	6	1	2	1100	100	3	1
587	77	402	LAEN	Johnny	Francois	9-Feb-10	2010	0	19:00	-26.499333	27.644833	Boat	Glide	Summer	187.6	10	2	1	6	10	2	3	4	3	2	6	1	2	1100	100	3	1
588	78	402	LAEN	Johnny	Francois	9-Feb-10	2010	0	19:10	-26.497833	27.640667	Boat	Glide	Summer	187.6	10	2	1	6	10	2	3	4	3	2	6	1	2	1100	100	3	1
589	79	402	LAEN	Johnny	Francois	9-Feb-10	2010	0	19:20	-26.476000	27.653000	Boat	Glide	Summer	187.6	1	2	1	6	0	2	3	4	3	2	6	1	2	1100	100	3	1
590	80	402	LAEN	Johnny	Francois	9-Feb-10	2010	0	19:30	-26.476000	27.656333	Boat	Pool	Summer	187.6	50	2	1	6	50	2	3	4	2	3	12	3	1	1100	100	3	1
591	81	402	LAEN	Johnny	Francois	9-Feb-10	2010	0	19:40	-26.475833	27.653667	Boat	Pool	Summer	187.6	10	2	1	6	10	2	3	4	2	3	12	3	1	1000	100	3	1
592	82	402	LAEN	Johnny	Francois	9-Feb-10	2010	0	19:50	-26.475833	27.655167	Boat	Run	Summer	187.6	10	2	1	6	10	3	4	5	4	3	12	3	1	1000	100	3	1
593	83	402	LAEN	Johnny	Francois	9-Feb-10	2010	0	20:00	-26.476000	27.659667	Boat	Run	Summer	187.6	1	2	1	6	0	4	5	3	4	3	12	3	1	1000	100	3	1
594	84	402	LAEN	Johnny	Francois	9-Feb-10	2010	0	20:10	-26.475833	27.662167	Boat	Run	Summer	187.6	10	2	1	6	10	4	5	3	4	3	12	3	1	1000	100	3	1
595	85	402	LAEN	Johnny	Francois	9-Feb-10	2010	0	20:20	-26.475000	27.657500	Boat	Pool	Summer	187.6	10	2	1	6	10	2	3	4	2	3	12	1	2	1000	100	3	1
596	86	402	LAEN	Johnny	Francois	9-Feb-10	2010	0	20:30	-26.476500	27.656000	Boat	Pool	Summer	187.6	10	2	1	6	10	2	3	4	2	3	12	1	2	1000	100	3	1
597	87	402	LAEN	Johnny	Francois	9-Feb-10	2010	0	20:40	-26.475833	27.653667	Boat	Pool	Summer	187.6	1	2	1	6	0	2	3	4	2	3	12	1	2	1000	100	3	1
598	88	402	LAEN	Johnny	Francois	9-Feb-10	2010	0	20:50	-26.476333	27.651167	Boat	Pool	Summer	187.6	10	2	1	6	10	2	3	4	2	3	12	1	2	1000	100	3	1
599	89	402	LAEN	Johnny	Francois	9-Feb-10	2010	0	21:00	-26.475500	27.653667	Boat	Pool	Summer	187.6	10	2	1	6	10	2	3	4	2	3	12	1	2	1000	100	3	1
600	90	402	LAEN	Johnny	Francois	9-Feb-10	2010	0	21:10	-26.475333	27.653667	Boat	Pool	Summer	187.6	10	2	1	6	10	2	3	4	2	3	12	1	2	1000	100	3	1
601	91	402	LAEN	Johnny	Francois	10-Feb-10	2010	1	5:40	-26.459667	27.540500	Boat	Glide	Summer	164	1	1	2	6	0	4	5	4	3	2	3	12	2	1100	100	3	1
602	92	402	LAEN	Johnny	Francois	10-Feb-10	2010	0	5:50	-26.462333	27.539333	Boat	Glide	Summer	164	1	1	2	6	0	4	5	4	3	2	3	12	2	1100	100	3	1
603	93	402	LAEN	Johnny	Francois	10-Feb-10	2010	0	6:00	-26.460167	27.539667	Boat	Glide	Summer	164	10	2	1	6	10	4	5	4	3	2	3	12	2	1100	100	3	1
604	94	402	LAEN	Johnny	Francois	10-Feb-10	2010	0	6:10	-26.462167	27.540167	Boat	Glide	Summer	164	10	2	1	6	10	4	5	4	3	2	3	12	2	1100	100	3	1
605	95	402	LAEN	Johnny	Francois	10-Feb-10	2010	0	6:20	-26.453000	27.535500	Boat	Glide	Summer	164	1	2	1	6	0	4	5	4	3	2	3	12	2	1100	100	3	1
606	96	402	LAEN	Johnny	Francois	10-Feb-10	2010	0	6:30	-26.466000	27.533333	Boat	Glide	Summer	164	10	2	1	6	10	4	5	4	3	2	3	12	2	1100	100	3	1
607	97	402	LAEN	Johnny	Francois	10-Feb-10	2010	0	6:40	-26.445833	27.532500	Boat	Glide	Summer	164	10	2	1	6	10	4	5	4	3	2	3	12	2	1100	100	3	1
608	98	402	LAEN	Johnny	Francois	10-Feb-10	2010	0	6:50	-26.443667	27.532000	Boat	Glide	Summer	164	50	2	1	6	10	2	3	4	3	2	3	12	2	1000	100	3	1
609	99	402	LAEN	Johnny	Francois	10-Feb-10	2010	0	7:00	-26.441000	27.531000	Boat	Glide	Summer	164	1	2	1	6	0	2	3	4	3	2	1	2	3	1000	100	3	1
610	100	402	LAEN	Johnny	Francois	10-Feb-10	2010	0	7:10	-26.442167	27.534333	Boat	Glide	Summer	164	10	2	1	6	10	2	3	4	3	2	1	2	3	1000	100	3	1
611	101	402	LAEN	Johnny	Francois	10-Feb-10	2010	0	7:20	-26.443000	27.537333	Boat	Glide	Summer	164	10	2	1	6	10	2	3	4	3	2	1	2	3	1000	100	3	1
612	102	402	LAEN	Johnny	Francois	10-Feb-10	2010	0	7:30	-26.443667	27.539500	Boat	Run	Summer	164	10	2	1	6	10	4	5	4	4	3	12	3	3	1000	100	3	1
613	103	402	LAEN	Johnny	Francois	10-Feb-10	2010	0	7:40	-26.443000	27.535667	Boat	Run	Summer	164	1	2	1	6	0	4	5	4	4	3	12	3	3	1000	100	3	1
614	104	402	LAEN	Johnny	Francois	10-Feb-10	2010	0	7:50	-26.441333	27.533167	Boat	Run	Summer	164	10	2	1	6	0	4	5	4	4	3	12	3	3	1000	100	3	1
615	105	402	LAEN	Johnny	Francois	10-Feb-10	2010	0	8:00	-26.442667	27.536000	Boat	Run	Summer	164	10	2	1	6	10	4	5	4	4	3	12	3	3	1000	100	3	1
616	106	402	LAEN	Johnny	Francois	10-Feb-10	2010	0	8:10	-26.444000	27.540333	Boat	Run	Summer	164	10	2	1	6	10	4	5	4	4	3	2	3	3	1000	100	3	1
617	107	402	LAEN	Johnny	Francois & Hanne	18-Feb-10	2010	8	16:50	-26.621333	27.950667	Boat	Glide	Summer	312.8	10	2	1	6	0	5	4	4	3	2	3	12	12	1800	150	3	1
618	108	402	LAEN	Johnny	Francois & Hanne	18-Feb-10	2010	0	17:00	-26.622500	27.952167	Boat	Pool	Summer	312.8	50	2	1	6	50	2	3	4	2	1	1	2	12	1800	150	3	1
619	109	402	LAEN	Johnny	Francois & Hanne	18-Feb-10	2010	0	17:10	-26.622000	27.950500	Boat	Pool	Summer	312.8	10	2	1	6	10	2	3	4	2	1	1	2	12	1800	150	3	1
620	110	402	LAEN	Johnny	Francois & Hanne	18-Feb-10	2010	0	17:20	-26.623000	27.954333	Boat	Pool	Summer	312.8	10	2	1	6	10	2	3	4	2	1	1	2	12	1800	150	3	1
621	111	402	LAEN	Johnny	Francois & Hanne	18-Feb-10	2010	0	17:30	-26.621833	27.947333	Boat	Pool	Summer	312.8	10	2	1	6	10	2	3	4	2	3	3	11	12	1500	150	3	1
622	112	402	LAEN	Johnny	Francois & Hanne	18-Feb-10	2010	0	17:40	-26.622000	27.944000	Boat	Pool	Summer	312.8	10	2	1	6	10	2	3	4	2	3	3	11	12	1500	150	3	1
623	113	402	LAEN	Johnny	Francois & Hanne	18-Feb-10	2010	0	18:00	-26.621833	27.947167	Boat	Glide	Summer	312.8	50	2	1	6	50	4	3	2	3	2	3	12	12	1400	150	3	1
624	114	402	LAEN	Johnny	Francois & Hanne	18-Feb-10	2010	0	18:10	-26.622500	27.963833	Boat	Run	Summer	312.8	10	2	1	6	10	5	4	3	4	3	3	12	12	1400	150	3	1
625	115	402	LAEN	Johnny	Francois & Hanne	18-Feb-10	2010	0	18:20	-26.624167	27.956000	Boat	Run	Summer	312.8	10	2	1	6	10	5	4	3	4	3	3	12	12	1400	150	3	1
626	116	402	LAEN	Johnny	Francois & Hanne	18-Feb-10	2010	0	18:30	-26.625000	27.956000	Boat	Run	Summer	312.8	10	2	1	6	10	5	4	3	4	3	3	12	12	1400	150	3	1
627	117	402	LAEN	Johnny	Francois & Hanne	18-Feb-10	2010	0	18:40	-26.647833	27.965167	Boat	Run	Summer	312.8	50	2	1	6	50	5	4	3	4	3	3	12	12	1400	150	3	1
628	118	402	LAEN	Johnny	Francois & Hanne	18-Feb-10	2010	0	17:50	-26.621833	27.942333	Boat	Pool	Summer	312.8	10	2	1	6	10	2	3	4	2	3	3	11	12	1500	150	3	1
629	119	402	LAEN	Johnny	Francois & Hanne	18-Feb-10	2010	0	18:50	-26.649000	27.951333	Boat	Run	Summer	312.8	50	2	1	6	50	5	4	3	4	3	3	12	12	1400	150	3	1
630	120	402	LAEN	Johnny	Francois & Hanne	18-Feb-10	2010	0	19:00	-26.648000	27.966000	Boat	Pool	Summer	312.8	10	2	1	6	10	2	3	4	2	1	1	12	1	1400	150	3	1
631	121	402	LAEN	Johnny	Francois & Hanne	18-Feb-10	2010	0	19:10	-26.649333	27.969833	Boat	Pool	Summer	312.8	10	2	1	6	10	2	3	4	2	3	1	3	12	1400	150	3	1
632	122	402	LAEN	Johnny	Francois & Hanne	18-Feb-10	2010	0	19:20	-26.630667	27.961333	Boat	Glide	Summer	312.8	10	2	1	6	10	2	5	4	3	2	1	12	12	1400	150	3	1

Appendix 28: Continuation of raw spatial monitoring data collected from the biotelemetry study of yellowfish at location 2.

633	123	402	LAEN	Johnny	Francois	9-Mar-10	2010	19	18:40	-26.924050	27.175083	Boat	Run	Autumn	124.8	1	1	2	6	0	3	4	5	4	3	6	1	2	1100	100	3	1
634	124	402	LAEN	Johnny	Francois	9-Mar-10	2010	0	18:50	-26.924017	27.175100	Boat	Run	Autumn	124.8	10	2	1	6	10	3	4	5	4	3	6	1	2	1100	100	3	1
635	125	402	LAEN	Johnny	Francois	9-Mar-10	2010	0	19:00	-26.924067	27.175100	Boat	Glide	Autumn	124.8	10	2	1	6	10	2	3	4	3	2	6	1	2	1100	100	3	1
636	126	402	LAEN	Johnny	Francois	9-Mar-10	2010	0	19:10	-26.924067	27.175150	Boat	Glide	Autumn	124.8	10	2	1	6	10	2	3	4	3	2	6	1	2	1100	100	3	1
637	127	402	LAEN	Johnny	Francois	9-Mar-10	2010	0	19:20	-26.924050	27.175117	Boat	Glide	Autumn	124.8	1	2	1	6	0	2	3	4	3	2	6	1	2	1100	100	3	1
638	128	402	LAEN	Johnny	Francois	9-Mar-10	2010	0	19:30	-26.924033	27.174967	Boat	Pool	Autumn	124.8	50	2	1	6	50	2	3	4	2	3	12	3	1	1100	100	3	1
639	129	402	LAEN	Johnny	Francois	9-Mar-10	2010	0	19:40	-26.924017	27.175000	Boat	Pool	Autumn	124.8	10	2	1	6	10	2	3	4	2	3	12	3	1	1000	100	3	1
640	130	402	LAEN	Johnny	Francois	9-Mar-10	2010	0	19:50	-26.924083	27.175033	Boat	Run	Autumn	124.8	10	2	1	6	10	3	4	5	4	3	12	3	1	1000	100	3	1
641	131	402	LAEN	Johnny	Francois	9-Mar-10	2010	0	20:00	-26.924050	27.175050	Boat	Run	Autumn	124.8	1	2	1	6	0	4	5	3	4	3	12	3	1	1000	100	3	1
642	132	402	LAEN	Johnny	Francois	9-Mar-10	2010	0	20:10	-26.924017	27.175017	Boat	Run	Autumn	124.8	10	2	1	6	10	4	5	3	4	3	12	3	1	1000	100	3	1
643	133	402	LAEN	Johnny	Francois	9-Mar-10	2010	0	20:20	-26.924017	27.175083	Boat	Pool	Autumn	124.8	10	2	1	6	10	2	3	4	2	3	12	1	2	1000	100	3	1
644	134	402	LAEN	Johnny	Francois	9-Mar-10	2010	0	20:30	-26.924050	27.175033	Boat	Pool	Autumn	124.8	10	2	1	6	10	2	3	4	2	3	12	1	2	1000	100	3	1
645	135	402	LAEN	Johnny	Francois	9-Mar-10	2010	0	20:40	-26.924000	27.175067	Boat	Pool	Autumn	124.8	1	2	1	6	0	2	3	4	2	3	12	1	2	1000	100	3	1
646	136	402	LAEN	Johnny	Francois	9-Mar-10	2010	0	20:50	-26.924017	27.174983	Boat	Pool	Autumn	124.8	10	2	1	6	10	2	3	4	2	3	12	1	2	1000	100	3	1
647	137	402	LAEN	Johnny	Francois	9-Mar-10	2010	0	21:00	-26.923983	27.175050	Boat	Pool	Autumn	124.8	10	2	1	6	10	2	3	4	2	3	12	1	2	1000	100	3	1
648	138	402	LAEN	Johnny	Francois	10-Mar-10	2010	1	21:10	-26.924000	27.175083	Boat	Pool	Autumn	110.4	10	2	1	6	10	2	3	4	2	3	12	1	2	1000	100	3	1
649	139	402	LAEN	Johnny	Francois	10-Mar-10	2010	0	5:40	-26.924100	27.175883	Boat	Glide	Autumn	110.4	1	1	2	6	0	4	5	4	3	2	3	12	2	1100	100	3	1
650	140	402	LAEN	Johnny	Francois	10-Mar-10	2010	0	5:50	-26.924100	27.175883	Boat	Glide	Autumn	110.4	1	1	2	6	0	4	5	4	3	2	3	12	2	1100	100	3	1
651	141	402	LAEN	Johnny	Francois	10-Mar-10	2010	0	6:00	-26.924067	27.175867	Boat	Glide	Autumn	110.4	10	2	1	6	10	4	5	4	3	2	3	12	2	1100	100	3	1
652	142	402	LAEN	Johnny	Francois	10-Mar-10	2010	0	6:10	-26.924117	27.175917	Boat	Glide	Autumn	110.4	10	2	1	6	10	4	5	4	3	2	3	12	2	1100	100	3	1
653	143	402	LAEN	Johnny	Francois	10-Mar-10	2010	0	6:20	-26.924117	27.175917	Boat	Glide	Autumn	110.4	1	2	1	6	0	4	5	4	3	2	3	12	2	1100	100	3	1
654	144	402	LAEN	Johnny	Francois	10-Mar-10	2010	0	6:30	-26.924150	27.175900	Boat	Glide	Autumn	110.4	10	2	1	6	10	4	5	4	3	2	3	12	2	1100	100	3	1
655	145	402	LAEN	Johnny	Francois	10-Mar-10	2010	0	6:40	-26.924150	27.175983	Boat	Glide	Autumn	110.4	10	2	1	6	10	4	5	4	3	2	3	12	2	1100	100	3	1
656	146	402	LAEN	Johnny	Francois	10-Mar-10	2010	0	6:50	-26.924200	27.175933	Boat	Glide	Autumn	110.4	50	2	1	6	10	2	3	4	3	2	3	12	2	1000	100	3	1
657	147	402	LAEN	Johnny	Francois	10-Mar-10	2010	0	7:00	-26.924200	27.175933	Boat	Glide	Autumn	110.4	1	2	1	6	0	2	3	4	3	2	1	2	3	1000	100	3	1
658	148	402	LAEN	Johnny	Francois	10-Mar-10	2010	0	7:10	-26.924167	27.175950	Boat	Glide	Autumn	110.4	10	2	1	6	10	2	3	4	3	2	1	2	3	1000	100	3	1
659	149	402	LAEN	Johnny	Francois	10-Mar-10	2010	0	7:20	-26.924133	27.175967	Boat	Glide	Autumn	110.4	10	2	1	6	10	2	3	4	3	2	1	2	3	1000	100	3	1
660	150	402	LAEN	Johnny	Francois	10-Mar-10	2010	0	7:30	-26.924167	27.175917	Boat	Run	Autumn	110.4	10	2	1	6	10	4	5	4	4	3	12	3	3	1000	100	3	1
661	151	402	LAEN	Johnny	Francois	10-Mar-10	2010	0	7:40	-26.924167	27.175917	Boat	Run	Autumn	110.4	1	2	1	6	0	4	5	4	4	3	12	3	3	1000	100	3	1
662	152	402	LAEN	Johnny	Francois	10-Mar-10	2010	0	7:50	-26.924167	27.175917	Boat	Run	Autumn	110.4	10	2	1	6	0	4	5	4	4	3	12	3	3	1000	100	3	1
663	153	402	LAEN	Johnny	Francois	10-Mar-10	2010	0	8:00	-26.924117	27.175900	Boat	Run	Autumn	110.4	10	2	1	6	10	4	5	4	4	3	12	3	3	1000	100	3	1
664	154	402	LAEN	Johnny	Francois	18-Mar-10	2010	8	8:10	-26.924117	27.175867	Boat	Run	Autumn	31.06	10	2	1	6	10	4	5	4	4	3	2	3	3	1000	100	3	1
665	155	402	LAEN	Johnny	Francois & Hanne	18-Mar-10	2010	0	16:50	-26.927717	27.182950	Boat	Glide	Autumn	31.06	10	2	1	6	0	5	4	4	3	2	3	12	12	1800	150	3	1
666	156	402	LAEN	Johnny	Francois & Hanne	18-Mar-10	2010	0	17:00	-26.928000	27.182850	Boat	Pool	Autumn	31.06	50	2	1	6	50	2	3	4	2	1	1	2	12	1800	150	3	1
667	157	402	LAEN	Johnny	Francois & Hanne	18-Mar-10	2010	0	17:10	-26.927933	27.182850	Boat	Pool	Autumn	31.06	10	2	1	6	10	2	3	4	2	1	1	2	12	1800	150	3	1
668	158	402	LAEN	Johnny	Francois & Hanne	18-Mar-10	2010	0	17:20	-26.927867	27.182867	Boat	Pool	Autumn	31.06	10	2	1	6	10	2	3	4	2	1	1	2	12	1800	150	3	1
669	159	402	LAEN	Johnny	Francois & Hanne	18-Mar-10	2010	0	17:30	-26.927867	27.182800	Boat	Pool	Autumn	31.06	10	2	1	6	10	2	3	4	2	3	3	11	12	1500	150	3	1
670	160	402	LAEN	Johnny	Francois & Hanne	18-Mar-10	2010	0	17:40	-26.927817	27.182917	Boat	Pool	Autumn	31.06	10	2	1	6	10	2	3	4	2	3	3	11	12	1500	150	3	1
671	161	402	LAEN	Johnny	Francois & Hanne	18-Mar-10	2010	0	18:00	-26.927967	27.182917	Boat	Glide	Autumn	31.06	50	2	1	6	50	4	3	2	3	2	3	12	12	1400	150	3	1
672	162	402	LAEN	Johnny	Francois & Hanne	18-Mar-10	2010	0	18:10	-26.927917	27.182883	Boat	Run	Autumn	31.06	10	2	1	6	10	5	4	3	4	3	3	12	12	1400	150	3	1
673	163	402	LAEN	Johnny	Francois & Hanne	18-Mar-10	2010	0	18:20	-26.927933	27.182850	Boat	Run	Autumn	31.06	10	2	1	6	10	5	4	3	4	3	3	12	12	1400	150	3	1
674	164	402	LAEN	Johnny	Francois & Hanne	18-Mar-10	2010	0	18:30	-26.928000	27.182850	Boat	Run	Autumn	31.06	10	2	1	6	10	5	4	3	4	3	3	12	12	1400	150	3	1
675	165	402	LAEN	Johnny	Francois & Hanne	18-Mar-10	2010	0	18:40	-26.927733	27.182933	Boat	Run	Autumn	31.06	50	2	1	6	50	5	4	3	4	3	3	12	12	1400	150	3	1
676	166	402	LAEN	Johnny	Francois & Hanne	18-Mar-10	2010	0	17:50	-26.927733	27.182933	Boat	Pool	Autumn	31.06	10	2	1	6	10	2	3	4	2	3	3	11	12	1500	150	3	1
677	167	402	LAEN	Johnny	Francois & Hanne	18-Mar-10	2010	0	18:50	-26.927983	27.182883	Boat	Run	Autumn	31.06	50	2	1	6	50	5	4	3	4	3	3	12	12	1400	150	3	1
678	168	402	LAEN	Johnny	Francois & Hanne	18-Mar-10	2010	0	19:00	-26.927917	27.182883	Boat	Pool	Autumn	31.06	10	2	1	6	10	2	3	4	2	1	1	12	1	1400	150	3	1
679	169	402	LAEN	Johnny	Francois & Hanne	18-Mar-10	2010	0	19:10	-26.927867	27.182800	Boat	Pool	Autumn	31.06	10	2	1	6	10	2	3	4	2	3	1	3	12	1400	150	3	1
680	170	402	LAEN	Johnny	Francois	8-Apr-10	2010	21	1500	-26.922333	27.175150	Boat	Glide	Autumn	374.9	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
681	171	402	LAEN	Johnny	Francois	8-Apr-10	2010	0	1510	-26.922333	27.175133	Boat	Glide	Autumn	374.9	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
682	172	402	LAEN	Johnny	Francois	8-Apr-10	2010	0	1520	-26.922350	27.175133	Boat	Glide	Autumn	374.9	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
683	173	402	LAEN	Johnny	Francois	8-Apr-10	2010	0	1530	-26.922350	27.175133	Boat	Glide	Autumn	374.9	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
684	174	402	LAEN	Johnny	Francois	8-Apr-10	2010	0	1540	-26.922350	27.175133	Boat	Glide	Autumn	374.9	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
685	175	402	LAEN	Johnny	Francois	8-Apr-10	2010	0	1550	-26.922350	27.175133	Boat	Glide	Autumn	374.9	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
686	176	402	LAEN	Johnny	Francois	8-Apr-10	2010	0	1600	-26.922333	27.175117	Boat	Glide	Autumn	374.9	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
687	177	402	LAEN	Johnny	Francois	8-Apr-10	2010	0	1610	-26.922333	27.175133	Boat	Glide	Autumn	374.9	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
688	178	402	LAEN	Johnny	Francois	8-Apr-10	2010	0	1620	-26.922333	27.175133	Boat	Glide	Autumn	374.9	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
689	179	402	LAEN	Johnny	Francois	8-Apr-10	2010	0	1630	-26.922350	27.175133	Boat	Glide	Autumn	374.9	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
690	180	402	LAEN	Johnny	Francois	8-Apr-10	2010	0	1640	-26.922350	27.175133	Boat	Glide	Autumn	374.9	10	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1

Appendix 29: Continuation of raw spatial monitoring data collected from the biotelemetry study of yellowfish at location 2.

691	181	402	LAEN	Johnny	Francois	8-Apr-10	2010	0	1650	-26.922333	27.175150	Boat	Glide	Autumn	374.9	10	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
692	182	402	LAEN	Johnny	Francois	8-Apr-10	2010	0	1700	-26.922333	27.175133	Boat	Glide	Autumn	374.9	10	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
693	183	402	LAEN	Johnny	Francois	8-Apr-10	2010	0	1710	-26.922350	27.175133	Boat	Glide	Autumn	374.9	10	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
694	184	402	LAEN	Johnny	Francois	8-Apr-10	2010	0	1720	-26.922350	27.175133	Boat	Glide	Autumn	374.9	10	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
695	185	402	LAEN	Johnny	Francois	8-Apr-10	2010	0	1730	-26.922350	27.175133	Boat	Glide	Autumn	374.9	10	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
696	186	402	LAEN	Johnny	Francois	8-Apr-10	2010	0	1740	-26.922350	27.175133	Boat	Glide	Autumn	374.9	10	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
697	187	402	LAEN	Johnny	Francois	8-Apr-10	2010	0	1750	-26.922333	27.175117	Boat	Glide	Autumn	374.9	10	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
698	188	402	LAEN	Johnny	Francois	8-Apr-10	2010	0	1800	-26.922333	27.175133	Boat	Glide	Autumn	374.9	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
699	189	402	LAEN	Johnny	Francois	8-Apr-10	2010	0	1810	-26.922333	27.175133	Boat	Glide	Autumn	374.9	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
700	190	402	LAEN	Johnny	Francois	8-Apr-10	2010	0	1820	-26.922350	27.175133	Boat	Glide	Autumn	374.9	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
701	191	402	LAEN	Johnny	Francois	8-Apr-10	2010	0	1830	-26.922350	27.175133	Boat	Glide	Autumn	374.9	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
702	192	402	LAEN	Johnny	Francois	8-Apr-10	2010	0	1840	-26.922333	27.175150	Boat	Glide	Autumn	374.9	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
703	193	402	LAEN	Johnny	Francois	8-Apr-10	2010	0	1850	-26.922350	27.175133	Boat	Glide	Autumn	374.9	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
704	194	402	LAEN	Johnny	Francois	8-Apr-10	2010	0	1900	-26.922350	27.175133	Boat	Glide	Autumn	374.9	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
705	195	402	LAEN	Johnny	Francois	8-Apr-10	2010	0	1910	-26.922350	27.175133	Boat	Glide	Autumn	374.9	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
706	196	402	LAEN	Johnny	Francois	8-Apr-10	2010	0	1920	-26.922333	27.175117	Boat	Glide	Autumn	374.9	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
707	197	402	LAEN	Johnny	Francois	8-Apr-10	2010	0	1930	-26.922333	27.175133	Boat	Glide	Autumn	374.9	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
708	198	402	LAEN	Johnny	Francois	8-Apr-10	2010	0	1940	-26.922333	27.175133	Boat	Glide	Autumn	374.9	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
709	199	402	LAEN	Johnny	Francois	8-Apr-10	2010	0	1950	-26.922350	27.175133	Boat	Glide	Autumn	374.9	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
710	200	402	LAEN	Johnny	Francois	8-Apr-10	2010	0	2000	-26.922350	27.175133	Boat	Glide	Autumn	374.9	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
711	201	402	LAEN	Johnny	Francois	8-Apr-10	2010	0	2010	-26.922350	27.175133	Boat	Glide	Autumn	374.9	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
712	202	402	LAEN	Johnny	Francois	9-Apr-10	2010	1	1540	-26.922350	27.175133	Boat	Glide	Autumn	366.6	1	1	2	6	0	2	4	5	3	4	1	2	12	3000	50	4	1
713	203	402	LAEN	Johnny	Francois	9-Apr-10	2010	0	1550	-26.922350	27.175133	Boat	Glide	Autumn	366.6	1	1	2	6	0	2	4	5	3	4	1	2	12	3000	50	4	1
714	204	402	LAEN	Johnny	Francois	9-Apr-10	2010	0	1600	-26.922350	27.175133	Boat	Glide	Autumn	366.6	1	1	2	6	10	2	4	5	3	4	1	2	12	2500	50	4	1
715	205	402	LAEN	Johnny	Francois	9-Apr-10	2010	0	1610	-26.922350	27.175133	Boat	Glide	Autumn	366.6	1	1	2	6	10	2	4	5	3	4	1	2	12	2300	50	4	1
716	206	402	LAEN	Johnny	Francois	9-Apr-10	2010	0	1620	-26.922333	27.175117	Boat	Glide	Autumn	366.6	10	1	2	6	10	2	4	5	3	4	1	2	12	2400	50	4	1
717	207	402	LAEN	Johnny	Francois	9-Apr-10	2010	0	1630	-26.922333	27.175133	Boat	Glide	Autumn	366.6	10	1	2	6	10	2	4	5	3	4	1	2	12	3000	50	4	1
718	208	402	LAEN	Johnny	Francois	9-Apr-10	2010	0	1640	-26.922333	27.175133	Boat	Glide	Autumn	366.6	10	1	2	6	10	2	4	5	3	4	1	2	12	2500	50	4	1
719	209	402	LAEN	Johnny	Francois	9-Apr-10	2010	0	1650	-26.922350	27.175133	Boat	Glide	Autumn	366.6	10	1	2	6	10	2	4	5	3	4	1	2	12	1700	50	4	1
720	210	402	LAEN	Johnny	Francois	9-Apr-10	2010	0	1700	-26.922350	27.175133	Boat	Glide	Autumn	366.6	10	2	1	6	10	2	4	5	3	4	1	2	12	1600	50	4	1
721	211	402	LAEN	Johnny	Francois	9-Apr-10	2010	0	1710	-26.922333	27.175150	Boat	Glide	Autumn	366.6	10	2	1	6	10	2	4	5	3	4	1	2	12	1500	50	4	1
722	212	402	LAEN	Johnny	Francois	9-Apr-10	2010	0	1720	-26.922333	27.175133	Boat	Glide	Autumn	366.6	10	2	1	6	10	2	4	5	3	4	1	2	12	2500	50	4	1
723	213	402	LAEN	Johnny	Francois	9-Apr-10	2010	0	1730	-26.922350	27.175133	Boat	Glide	Autumn	366.6	10	2	1	6	10	2	4	5	3	4	1	2	12	2300	50	4	1
724	214	402	LAEN	Johnny	Francois	9-Apr-10	2010	0	1740	-26.922350	27.175133	Boat	Glide	Autumn	366.6	10	2	1	6	10	2	4	5	3	4	1	2	12	2400	50	4	1
725	215	402	LAEN	Johnny	Francois	9-Apr-10	2010	0	1750	-26.922350	27.175133	Boat	Glide	Autumn	366.6	10	2	1	6	10	2	4	5	3	4	1	2	12	3000	50	4	1
726	216	402	LAEN	Johnny	Francois	9-Apr-10	2010	0	1800	-26.922350	27.175133	Boat	Glide	Autumn	366.6	10	2	1	6	10	2	4	5	3	4	1	2	12	2500	50	4	1
727	217	402	LAEN	Johnny	Francois	9-Apr-10	2010	0	1810	-26.922333	27.175117	Boat	Glide	Autumn	366.6	10	2	1	6	10	2	4	5	3	4	2	2	12	1700	50	4	1
728	218	402	LAEN	Johnny	Francois	9-Apr-10	2010	0	1820	-26.922333	27.175133	Boat	Glide	Autumn	366.6	1	2	1	6	10	2	4	5	3	2	2	1	12	1600	50	4	1
729	219	402	LAEN	Johnny	Francois	9-Apr-10	2010	0	1830	-26.922333	27.175133	Boat	Glide	Autumn	366.6	10	2	1	6	10	2	4	5	3	2	2	1	12	2500	50	4	1
730	220	402	LAEN	Johnny	Francois	9-Apr-10	2010	0	1840	-26.922350	27.175133	Boat	Glide	Autumn	366.6	10	2	1	6	10	2	4	5	3	2	2	1	12	2300	50	4	1
731	221	402	LAEN	Johnny	Francois	9-Apr-10	2010	0	1850	-26.922350	27.175133	Boat	Glide	Autumn	366.6	10	2	1	6	10	2	4	5	3	2	2	1	12	2400	50	4	1
732	222	402	LAEN	Johnny	Francois	9-Apr-10	2010	0	1900	-26.922333	27.175150	Boat	Glide	Autumn	366.6	10	2	1	6	10	2	4	5	3	2	2	1	12	3000	50	4	1
733	223	402	LAEN	Johnny	Francois	9-Apr-10	2010	0	1910	-26.922333	27.175133	Boat	Glide	Autumn	366.6	1	2	1	6	10	2	4	5	3	2	2	1	12	2500	50	4	1
734	224	402	LAEN	Johnny	Francois	9-Apr-10	2010	0	1920	-26.922350	27.175133	Boat	Glide	Autumn	366.6	1	2	1	6	10	2	4	5	3	2	2	1	12	1700	50	4	1
735	225	402	LAEN	Johnny	Francois	9-Apr-10	2010	0	1930	-26.922350	27.175133	Boat	Glide	Autumn	366.6	1	2	1	6	10	2	4	5	3	2	2	1	12	1600	50	4	1
736	226	402	LAEN	Johnny	Francois	9-Apr-10	2010	0	1940	-26.922350	27.175133	Boat	Glide	Autumn	366.6	1	1	2	6	10	2	4	5	3	2	2	1	12	2500	50	4	1
737	227	402	LAEN	Johnny	Francois	9-Apr-10	2010	0	1950	-26.922350	27.175133	Boat	Glide	Autumn	366.6	1	1	2	6	10	2	4	5	3	2	2	1	12	2300	50	4	1
738	228	402	LAEN	Johnny	Francois	9-Apr-10	2010	0	2000	-26.922333	27.175117	Boat	Glide	Autumn	366.6	10	1	2	6	10	2	4	5	3	2	2	1	12	2400	50	4	1
739	229	402	LAEN	Johnny	Francois	9-Apr-10	2010	0	2010	-26.922333	27.175133	Boat	Glide	Autumn	366.6	10	1	2	6	10	2	4	5	3	2	2	1	12	3000	50	4	1
740	230	402	LAEN	Johnny	Francois	9-Apr-10	2010	0	2020	-26.922333	27.175133	Boat	Glide	Autumn	366.6	10	1	2	6	10	2	4	5	3	2	2	1	12	2500	50	4	1
741	231	402	LAEN	Johnny	Francois	9-Apr-10	2010	0	2030	-26.922350	27.175133	Boat	Glide	Autumn	366.6	10	1	2	6	10	2	4	5	3	2	2	1	12	1700	50	4	1
742	232	402	LAEN	Johnny	Francois	9-Apr-10	2010	0	2040	-26.922350	27.175133	Boat	Glide	Autumn	366.6	1	1	2	6	10	2	4	5	3	2	2	1	12	1600	50	4	1
743	233	402	LAEN	Johnny	Francois	9-Apr-10	2010	0	2050	-26.922333	27.175150	Boat	Glide	Autumn	366.6	1	1	2	6	10	2	4	5	3	2	2	1	12	3000	50	4	1
744	234	402	LAEN	Johnny	Francois	10-Apr-10	2010	1	610	-26.922333	27.175133	Boat	Glide	Autumn	340.4	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
745	235	402	LAEN	Johnny	Francois	10-Apr-10	2010	0	620	-26.922350	27.175133	Boat	Glide	Autumn	340.4	10	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
746	236	402	LAEN	Johnny	Francois	10-Apr-10	2010	0	630	-26.922350	27.175133	Boat	Glide	Autumn	340.4	10	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
747	237	402	LAEN	Johnny	Francois	10-Apr-10	2010	0	640	-26.922350	27.175133	Boat	Glide	Autumn	340.4	10	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
748	238	402	LAEN	Johnny	Francois	10-Apr-10	2010	0	650	-26.922350	27.175133	Boat	Glide	Autumn	340.4	10	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1

Appendix 30: Continuation of raw spatial monitoring data collected from the biotelemetry study of yellowfish at location 2.

749	239	402	LAEN	Johnny	Francois	10-Apr-10	2010	0	700	-26.922333	27.175117	Boat	Glide	Autumn	340.4	10	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
750	240	402	LAEN	Johnny	Francois	10-Apr-10	2010	0	710	-26.922333	27.175133	Boat	Glide	Autumn	340.4	10	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
751	241	402	LAEN	Johnny	Francois	10-Apr-10	2010	0	720	-26.922333	27.175133	Boat	Glide	Autumn	340.4	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
752	242	402	LAEN	Johnny	Francois	10-Apr-10	2010	0	730	-26.922350	27.175133	Boat	Glide	Autumn	340.4	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
753	243	402	LAEN	Johnny	Francois	10-Apr-10	2010	0	740	-26.922350	27.175133	Boat	Glide	Autumn	340.4	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
754	244	402	LAEN	Johnny	Francois	10-Apr-10	2010	0	750	-26.922333	27.175150	Boat	Glide	Autumn	340.4	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
755	245	402	LAEN	Johnny	Francois	10-Apr-10	2010	0	800	-26.922333	27.175133	Boat	Glide	Autumn	340.4	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
756	246	402	LAEN	Johnny	Francois	10-Apr-10	2010	0	810	-26.922350	27.175133	Boat	Glide	Autumn	340.4	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
757	247	402	LAEN	Johnny	Francois	10-Apr-10	2010	0	820	-26.922350	27.175133	Boat	Glide	Autumn	340.4	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
758	248	402	LAEN	Johnny	Francois	10-Apr-10	2010	0	830	-26.922350	27.175133	Boat	Glide	Autumn	340.4	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
759	249	402	LAEN	Johnny	Francois	10-Apr-10	2010	0	840	-26.922350	27.175133	Boat	Glide	Autumn	340.4	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
760	250	402	LAEN	Johnny	Francois	10-Apr-10	2010	0	850	-26.922333	27.175117	Boat	Glide	Autumn	340.4	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
761	251	402	LAEN	Johnny	Francois	10-Apr-10	2010	0	900	-26.922333	27.175133	Boat	Glide	Autumn	340.4	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
762	252	402	LAEN	Johnny	Francois	10-Apr-10	2010	0	910	-26.922333	27.175133	Boat	Glide	Autumn	340.4	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
763	253	402	LAEN	Johnny	Francois	10-Apr-10	2010	0	920	-26.922350	27.175133	Boat	Glide	Autumn	340.4	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
764	254	402	LAEN	Johnny	Francois	10-Apr-10	2010	0	930	-26.922350	27.175133	Boat	Glide	Autumn	340.4	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
765	255	402	LAEN	Johnny	Francois	10-Apr-10	2010	0	940	-26.922333	27.175150	Boat	Glide	Autumn	340.4	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
766	256	402	LAEN	Johnny	Francois	10-Apr-10	2010	0	950	-26.922333	27.175133	Boat	Glide	Autumn	340.4	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
767	257	402	LAEN	Johnny	Francois	10-Apr-10	2010	0	1000	-26.922350	27.175133	Boat	Glide	Autumn	340.4	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
768	258	402	LAEN	Johnny	Francois	10-Apr-10	2010	0	1010	-26.922350	27.175133	Boat	Glide	Autumn	340.4	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
769	259	402	LAEN	Johnny	Francois	10-Apr-10	2010	0	1020	-26.922350	27.175133	Boat	Glide	Autumn	340.4	10	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
770	260	402	LAEN	Johnny	Francois	10-Apr-10	2010	0	1030	-26.922350	27.175133	Boat	Glide	Autumn	340.4	10	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
771	261	402	LAEN	Johnny	Francois	10-Apr-10	2010	0	1040	-26.922350	27.175117	Boat	Glide	Autumn	340.4	10	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
772	262	402	LAEN	Johnny	Francois	10-Apr-10	2010	0	1050	-26.922333	27.175133	Boat	Glide	Autumn	340.4	10	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
773	263	402	LAEN	Johnny	Francois	10-Apr-10	2010	0	1100	-26.922333	27.175133	Boat	Glide	Autumn	340.4	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
774	264	402	LAEN	Johnny	Francois	10-Apr-10	2010	0	1110	-26.922350	27.175133	Boat	Glide	Autumn	340.4	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
775	265	402	LAEN	Johnny	Francois	10-Apr-10	2010	0	1120	-26.922350	27.175133	Boat	Glide	Autumn	340.4	1	1	2	6	0	2	4	5	3	2	1	2	12	3000	50	4	1
776	266	402	LAEN	Johnny	Francois	11-Apr-10	2010	1	600	-26.922333	27.175133	Boat	Glide	Autumn	280.6	1	1	2	6	10	2	4	5	3	2	2	1	12	3000	50	4	1
777	267	402	LAEN	Johnny	Francois	11-Apr-10	2010	0	610	-26.922333	27.175117	Boat	Glide	Autumn	280.6	1	1	2	6	0	2	4	5	3	2	2	1	12	3000	50	4	1
778	268	402	LAEN	Johnny	Francois	11-Apr-10	2010	0	620	-26.922333	27.175117	Boat	Glide	Autumn	280.6	1	1	2	6	10	2	4	5	3	2	2	1	12	2500	50	4	1
779	269	402	LAEN	Johnny	Francois	11-Apr-10	2010	0	630	-26.922333	27.175133	Boat	Glide	Autumn	280.6	10	2	1	6	10	2	4	5	3	2	2	1	12	2500	50	4	1
780	270	402	LAEN	Johnny	Francois	11-Apr-10	2010	0	640	-26.922333	27.175133	Boat	Glide	Autumn	280.6	10	2	1	6	10	2	4	5	3	2	2	1	12	3000	50	4	1
781	271	402	LAEN	Johnny	Francois	11-Apr-10	2010	0	650	-26.922350	27.175133	Boat	Glide	Autumn	280.6	1	2	1	6	0	2	4	5	3	2	2	1	12	2600	50	4	1
782	272	402	LAEN	Johnny	Francois	11-Apr-10	2010	0	700	-26.922350	27.175133	Boat	Glide	Autumn	280.6	1	1	2	6	10	2	4	5	3	2	2	1	12	2300	50	4	1
783	273	402	LAEN	Johnny	Francois	11-Apr-10	2010	0	710	-26.922350	27.175133	Boat	Glide	Autumn	280.6	10	1	2	6	10	2	4	5	3	2	2	1	12	2500	50	4	1
784	274	402	LAEN	Johnny	Francois	11-Apr-10	2010	0	720	-26.922350	27.175133	Boat	Glide	Autumn	280.6	10	1	2	6	10	2	4	5	3	2	2	1	12	2500	50	4	1
785	275	402	LAEN	Johnny	Francois	11-Apr-10	2010	0	730	-26.922333	27.175117	Boat	Glide	Autumn	280.6	10	1	2	6	10	2	4	5	3	2	2	1	12	3000	50	4	1
786	276	402	LAEN	Johnny	Francois	11-Apr-10	2010	0	740	-26.922333	27.175133	Boat	Glide	Autumn	280.6	10	1	2	6	0	2	4	5	3	2	2	1	12	2600	50	4	1
787	277	402	LAEN	Johnny	Francois	11-Apr-10	2010	0	750	-26.922333	27.175133	Boat	Glide	Autumn	280.6	1	1	2	6	10	2	4	5	3	2	2	1	12	2300	50	4	1
788	278	402	LAEN	Johnny	Francois	11-Apr-10	2010	0	800	-26.922350	27.175133	Boat	Glide	Autumn	280.6	1	1	2	6	10	2	4	5	3	2	2	1	12	2500	50	4	1
789	279	402	LAEN	Johnny	Francois	11-Apr-10	2010	0	810	-26.922350	27.175133	Boat	Glide	Autumn	280.6	1	1	2	6	10	2	4	5	3	2	2	1	12	2500	50	4	1
790	280	402	LAEN	Johnny	Francois	11-Apr-10	2010	0	820	-26.922333	27.175150	Boat	Glide	Autumn	280.6	1	1	2	6	0	2	4	5	3	2	2	1	12	3000	50	4	1
791	281	402	LAEN	Johnny	Francois	11-Apr-10	2010	0	830	-26.922333	27.175133	Boat	Glide	Autumn	280.6	1	1	2	6	10	2	4	5	3	2	2	1	12	2600	50	4	1
792	282	402	LAEN	Johnny	Francois	19-Apr-10	2010	8	1530	-26.923100	27.176217	Boat	Run	Autumn	41.11	1	1	2	6	0	4	5	6	4	3	3	2	12	1550	150	3	4
793	283	402	LAEN	Johnny	Francois	19-Apr-10	2010	0	1540	-26.923100	27.176183	Boat	Run	Autumn	41.11	10	2	1	6	10	4	5	6	4	3	3	2	12	1500	150	3	4
794	284	402	LAEN	Johnny	Francois	19-Apr-10	2010	0	1550	-26.923100	27.176217	Boat	Run	Autumn	41.11	10	2	1	6	10	4	5	6	4	3	3	2	12	1300	150	3	4
795	285	402	LAEN	Johnny	Francois	19-Apr-10	2010	0	1600	-26.923083	27.176200	Boat	Run	Autumn	41.11	1	2	1	6	10	4	5	6	4	3	3	2	12	1500	150	3	4
796	286	402	LAEN	Johnny	Francois	19-Apr-10	2010	0	1610	-26.923117	27.176217	Boat	Run	Autumn	41.11	1	2	1	6	0	4	5	6	4	3	3	2	12	1550	150	3	4
797	287	402	LAEN	Johnny	Francois	19-Apr-10	2010	0	1620	-26.923150	27.176183	Boat	Run	Autumn	41.11	10	2	1	6	10	4	5	6	4	3	3	2	12	1500	150	3	4
798	288	402	LAEN	Johnny	Francois	19-Apr-10	2010	0	1630	-26.923133	27.176167	Boat	Run	Autumn	41.11	10	2	1	6	10	4	5	6	4	3	3	2	12	1300	150	3	4
799	289	402	LAEN	Johnny	Francois	19-Apr-10	2010	0	1640	-26.923083	27.176200	Boat	Run	Autumn	41.11	10	2	1	6	10	4	5	6	4	3	3	2	12	1500	150	3	4
800	290	402	LAEN	Johnny	Francois	19-Apr-10	2010	0	1650	-26.923100	27.176233	Boat	Run	Autumn	41.11	50	2	1	6	0	4	5	6	4	3	3	12	12	1550	150	3	4
801	291	402	LAEN	Johnny	Francois	19-Apr-10	2010	0	1700	-26.923083	27.176217	Boat	Run	Autumn	41.11	10	2	1	6	10	4	5	6	4	3	3	12	12	1500	150	3	4
802	292	402	LAEN	Johnny	Francois	19-Apr-10	2010	0	1710	-26.923100	27.176233	Boat	Run	Autumn	41.11	10	2	1	6	10	4	5	6	4	3	3	12	12	1300	150	3	4
803	293	402	LAEN	Johnny	Francois	19-Apr-10	2010	0	1720	-26.923117	27.176217	Boat	Run	Autumn	41.11	10	2	1	6	10	4	5	6	4	3	3	12	12	1500	150	3	4
804	294	402	LAEN	Johnny	Francois	19-Apr-10	2010	0	1730	-26.923117	27.176233	Boat	Run	Autumn	41.11	1	2	1	6	0	4	5	6	4	3	3	12	12	1550	150	3	4
805	295	402	LAEN	Johnny	Francois	19-Apr-10	2010	0	1740	-26.923200	27.176133	Boat	Run	Autumn	41.11	10	2	1	6	10	4	5	6	4	3	3	12	12	1500	150	3	4
806	296	402	LAEN	Johnny	Francois	19-Apr-10	2010	0	1750	-26.923200	27.176000	Boat	Run	Autumn	41.11	10	2	1	6	10	4	5	6	4	3	3	12	12	1300	150	3	4

Appendix 31: Continuation of raw spatial monitoring data collected from the biotelemetry study of yellowfish at location 2.

807	297	402	LAEN	Johnny	Francois	19-Apr-10	2010	0	1800	-26.923217	27.176150	Boat	Run	Autumn	41.11	10	2	1	6	10	4	5	6	4	3	3	12	12	1500	150	3	4
808	298	402	LAEN	Johnny	Francois	19-Apr-10	2010	0	1810	-26.923217	27.176183	Boat	Run	Autumn	41.11	1	2	1	6	0	5	4	6	4	3	3	12	12	1550	150	3	4
809	299	402	LAEN	Johnny	Francois	19-Apr-10	2010	0	1820	-26.923317	27.176133	Boat	Run	Autumn	41.11	10	2	1	6	10	5	4	6	4	3	3	12	12	1500	150	3	4
810	300	402	LAEN	Johnny	Francois	19-Apr-10	2010	0	1830	-26.923350	27.176133	Boat	Run	Autumn	41.11	10	2	1	6	10	5	4	6	4	3	3	12	12	1300	150	3	4
811	301	402	LAEN	Johnny	Francois	19-Apr-10	2010	0	1840	-26.923350	27.176150	Boat	Run	Autumn	41.11	50	2	1	6	10	5	4	6	4	3	3	12	12	1500	150	3	4
812	302	402	LAEN	Johnny	Francois	19-Apr-10	2010	0	1850	-26.923367	27.176000	Boat	Run	Autumn	41.11	10	2	1	6	0	5	4	6	4	3	3	12	12	1550	150	3	4
813	303	402	LAEN	Johnny	Francois	19-Apr-10	2010	0	1900	-26.923383	27.176167	Boat	Run	Autumn	41.11	10	2	1	6	10	5	4	6	4	3	3	12	12	1500	150	3	4
814	304	402	LAEN	Johnny	Francois	19-Apr-10	2010	0	1910	-26.923367	27.176200	Boat	Run	Autumn	41.11	10	2	1	6	10	5	4	6	4	3	3	12	12	1300	150	3	4
815	305	402	LAEN	Johnny	Francois	19-Apr-10	2010	0	1920	-26.923350	27.176250	Boat	Run	Autumn	41.11	10	2	1	6	10	5	4	6	4	3	3	12	12	1500	150	3	4
816	306	402	LAEN	Johnny	Francois	19-Apr-10	2010	0	1930	-26.923400	27.176217	Boat	Run	Autumn	41.11	1	2	1	6	0	5	4	6	4	3	3	12	12	1550	150	3	4
817	307	402	LAEN	Johnny	Francois	19-Apr-10	2010	0	1940	-26.923417	27.176183	Boat	Run	Autumn	41.11	10	2	1	6	10	5	4	6	4	3	3	12	12	1500	150	3	4
818	308	402	LAEN	Johnny	Francois	19-Apr-10	2010	0	1950	-26.923417	27.176233	Boat	Run	Autumn	41.11	10	2	1	6	10	5	4	6	4	3	3	12	12	1300	150	3	4
819	309	402	LAEN	Johnny	Francois	19-Apr-10	2010	0	2000	-26.923400	27.176250	Boat	Run	Autumn	41.11	10	2	1	6	10	5	4	6	4	3	3	12	12	1500	150	3	4
820	310	402	LAEN	Johnny	Francois	19-Apr-10	2010	0	2010	-26.922333	27.175117	Boat	Run	Autumn	41.11	1	2	1	6	0	5	4	6	4	3	3	12	12	1550	150	3	4
821	311	402	LAEN	Johnny	Francois	19-Apr-10	2010	0	2020	-26.922350	27.175117	Boat	Run	Autumn	41.11	10	2	1	6	10	5	4	6	4	3	3	3	12	1500	150	3	4
822	312	402	LAEN	Johnny	Francois	19-Apr-10	2010	0	2030	-26.922350	27.175133	Boat	Run	Autumn	41.11	10	2	1	6	10	5	4	6	4	3	3	3	12	1300	150	3	4
823	313	402	LAEN	Johnny	Francois	19-Apr-10	2010	0	2040	-26.922333	27.175117	Boat	Run	Autumn	41.11	10	2	1	6	10	5	4	6	4	3	3	3	12	1500	150	3	4
824	314	402	LAEN	Johnny	Francois	20-Apr-10	2010	0	540	-26.922983	27.175983	Boat	Run	Autumn	39.02	1	1	2	6	0	5	4	3	4	3	3	12	-	1500	50	4	1
825	315	402	LAEN	Johnny	Francois	20-Apr-10	2010	0	550	-26.923000	27.175967	Boat	Run	Autumn	39.02	10	2	1	6	10	5	4	3	4	3	3	12	-	1500	50	4	1
826	316	402	LAEN	Johnny	Francois	20-Apr-10	2010	0	600	-26.923000	27.175983	Boat	Run	Autumn	39.02	10	2	1	6	10	5	4	3	4	3	3	12	-	1500	50	4	1
827	317	402	LAEN	Johnny	Francois	20-Apr-10	2010	0	610	-26.922983	27.175967	Boat	Run	Autumn	39.02	10	2	1	6	10	5	4	3	4	3	3	12	-	1500	50	4	1
828	318	402	LAEN	Johnny	Francois	20-Apr-10	2010	0	620	-26.923000	27.175967	Boat	Run	Autumn	39.02	1	2	1	6	0	5	4	3	4	3	3	12	-	1500	50	4	1
829	319	402	LAEN	Johnny	Francois	20-Apr-10	2010	0	630	-26.923167	27.176167	Boat	Run	Autumn	39.02	50	2	1	6	50	5	4	3	4	3	3	12	-	1500	50	4	1
830	320	402	LAEN	Johnny	Francois	20-Apr-10	2010	1	640	-26.923183	27.176167	Boat	Glide	Autumn	39.02	10	2	1	6	10	5	4	3	3	4	3	12	2	1200	50	4	1
831	321	402	LAEN	Johnny	Francois	20-Apr-10	2010	0	650	-26.923200	27.176183	Boat	Glide	Autumn	39.02	10	2	1	6	10	5	4	3	3	4	3	12	2	1200	50	4	1
832	322	402	LAEN	Johnny	Francois	20-Apr-10	2010	0	700	-26.923200	27.176183	Boat	Glide	Autumn	39.02	1	2	1	6	0	5	4	3	3	4	3	12	2	1200	50	4	1
833	323	402	LAEN	Johnny	Francois	20-Apr-10	2010	0	710	-26.923200	27.176167	Boat	Glide	Autumn	39.02	10	2	1	6	10	5	4	3	3	4	3	12	2	1200	50	4	1
834	324	402	LAEN	Johnny	Francois	20-Apr-10	2010	0	720	-26.923217	27.176200	Boat	Glide	Autumn	39.02	10	2	1	6	10	5	4	3	3	4	3	12	2	1200	50	4	1
835	325	402	LAEN	Johnny	Francois	20-Apr-10	2010	0	730	-26.923200	27.176183	Boat	Glide	Autumn	39.02	10	2	1	6	10	5	4	3	3	4	3	12	2	1200	50	4	1
836	326	402	LAEN	Johnny	Francois	20-Apr-10	2010	0	740	-26.923233	27.176217	Boat	Glide	Autumn	39.02	1	2	1	6	0	5	4	3	3	4	3	12	2	1200	50	4	1
837	327	402	LAEN	Johnny	Francois	20-Apr-10	2010	0	750	-26.923217	27.176200	Boat	Glide	Autumn	39.02	10	2	1	6	10	5	4	3	3	4	3	12	2	1200	50	4	1
838	328	402	LAEN	Johnny	Francois	20-Apr-10	2010	0	800	-26.923233	27.176217	Boat	Glide	Autumn	39.02	10	2	1	6	10	5	4	3	3	4	3	12	2	1200	50	4	1
839	329	402	LAEN	Johnny	Francois	20-Apr-10	2010	0	810	-26.923233	27.176217	Boat	Glide	Autumn	39.02	10	2	1	6	10	5	4	3	3	4	3	12	2	1200	50	4	1
840	330	402	LAEN	Johnny	Francois	21-Apr-10	2010	1	1510	-26.923183	27.176367	Boat	Run	Autumn	38.09	1	1	2	6	0	4	5	3	4	3	3	12	-	1400	100	3	3
841	331	402	LAEN	Johnny	Francois	21-Apr-10	2010	0	1520	-26.923183	27.176350	Boat	Run	Autumn	38.09	10	2	6	1	10	4	5	3	4	3	3	12	-	1400	100	3	3
842	332	402	LAEN	Johnny	Francois	21-Apr-10	2010	0	1530	-26.923183	27.176367	Boat	Run	Autumn	38.09	10	2	1	6	10	4	5	3	4	3	3	12	-	1400	100	3	3
843	333	402	LAEN	Johnny	Francois	21-Apr-10	2010	0	1540	-26.923183	27.176333	Boat	Run	Autumn	38.09	10	2	1	6	10	4	5	3	4	3	3	12	-	1400	100	3	3
844	334	402	LAEN	Johnny	Francois	21-Apr-10	2010	0	1550	-26.923167	27.176300	Boat	Run	Autumn	38.09	1	2	1	6	0	4	5	3	4	3	3	12	-	1500	100	3	3
845	335	402	LAEN	Johnny	Francois	21-Apr-10	2010	0	1600	-26.923167	27.176300	Boat	Run	Autumn	38.09	10	2	1	6	10	4	5	3	4	3	3	12	-	1600	100	3	3
846	336	402	LAEN	Johnny	Francois	21-Apr-10	2010	0	1610	-26.923150	27.176300	Boat	Run	Autumn	38.09	10	2	1	6	10	4	5	3	4	3	3	12	-	1400	100	3	3
847	337	402	LAEN	Johnny	Francois	21-Apr-10	2010	0	1620	-26.923133	27.176300	Boat	Run	Autumn	38.09	10	2	1	6	10	4	5	3	4	3	3	12	-	1400	100	3	3
848	338	402	LAEN	Johnny	Francois	21-Apr-10	2010	0	1630	-26.923150	27.176283	Boat	Run	Autumn	38.09	1	2	1	6	0	4	5	3	4	3	3	12	-	1400	100	3	3
849	339	402	LAEN	Johnny	Francois	21-Apr-10	2010	0	1640	-26.923000	27.176300	Boat	Run	Autumn	38.09	10	2	1	6	10	4	5	3	4	3	3	12	-	1400	100	3	3
850	340	402	LAEN	Johnny	Francois	21-Apr-10	2010	0	1650	-26.923133	27.176267	Boat	Run	Autumn	38.09	10	2	1	6	10	4	5	3	4	3	3	12	-	1500	100	3	3
851	341	402	LAEN	Johnny	Francois	21-Apr-10	2010	0	1700	-26.923133	27.176283	Boat	Run	Autumn	38.09	10	2	1	6	10	4	5	3	4	3	3	12	-	1500	100	3	3
852	342	402	LAEN	Johnny	Francois	21-Apr-10	2010	0	1710	-26.923117	27.176267	Boat	Run	Autumn	38.09	1	2	1	6	0	5	4	3	4	3	1	3	12	1300	100	3	3
853	343	402	LAEN	Johnny	Francois	21-Apr-10	2010	0	1720	-26.923117	27.176250	Boat	Run	Autumn	38.09	50	2	1	6	20	5	4	3	4	3	1	3	12	1400	100	3	3
854	344	402	LAEN	Johnny	Francois	21-Apr-10	2010	0	1730	-26.923117	27.176267	Boat	Run	Autumn	38.09	10	2	1	6	10	5	4	3	4	3	3	12	1	1400	100	3	3
855	345	402	LAEN	Johnny	Francois	21-Apr-10	2010	0	1740	-26.923117	27.176267	Boat	Run	Autumn	38.09	10	2	1	6	10	5	4	3	4	3	3	12	1	1500	100	3	3
856	346	402	LAEN	Johnny	Francois	21-Apr-10	2010	0	1750	-26.923117	27.176267	Boat	Run	Autumn	38.09	50	2	1	6	0	5	4	3	4	3	2	3	12	1400	100	3	3
857	347	402	LAEN	Johnny	Francois	21-Apr-10	2010	0	1800	-26.923117	27.176267	Boat	Run	Autumn	38.09	10	2	1	6	10	5	4	3	4	3	2	3	12	1400	100	3	3
858	348	402	LAEN	Johnny	Francois	21-Apr-10	2010	0	1810	-26.923133	27.176283	Boat	Run	Autumn	38.09	10	2	1	6	10	5	4	3	4	3	2	3	12	1400	100	3	3
859	349	402	LAEN	Johnny	Francois	21-Apr-10	2010	0	1820	-26.923133	27.176300	Boat	Run	Autumn	38.09	10	2	1	6	10	5	4	3	4	3	2	3	12	1400	100	3	3
860	350	402	LAEN	Johnny	Francois	21-Apr-10	2010	0	1830	-26.923000	27.176300	Boat	Run	Autumn	38.09	1	2	1	6	0	5	4	3	4	3	2	3	12	1400	100	3	3
861	351	402	LAEN	Johnny	Francois	21-Apr-10	2010	0	1840	-26.923133	27.176283	Boat	Run	Autumn	38.09	10	2	1	6	10	5	4	3	4	3	2	3	12	1300	100	3	3
862	352	402	LAEN	Johnny	Francois	21-Apr-10	2010	0	1850	-26.923117	27.176267	Boat	Run	Autumn	38.09	10	2	1	6	10	5	4	3	4	3	2	3	12	1500	100	3	3
863	353	402	LAEN	Johnny	Francois	21-Apr-10	2010	0	1900	-26.923000	27.176300	Boat	Run	Autumn	38.09	10	2	1	6	10	5	4	3	4	3	2	3	12	1400	100	3	3
864	354	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	3	1510	-26.923450	27.176417	Boat	Run	Autumn	40.09	1	2	1	6	0	5	4	3	4	3	6	3	12	1300	150	3	3

Appendix 32: Continuation of raw spatial monitoring data collected from the biotelemetry study of yellowfish at location 2.

865	355	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	0	1520	-26.923467	27.176433	Boat	Run	Autumn	40.09	10	2	1	6	10	5	4	3	4	3	6	3	12	1300	150	3	3
866	356	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	0	1530	-26.923500	27.176450	Boat	Run	Autumn	40.09	10	2	1	6	10	5	4	3	4	3	6	3	12	1300	150	3	3
867	357	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	0	1540	-26.923517	27.176467	Boat	Run	Autumn	40.09	10	2	1	6	10	5	4	3	4	3	6	3	12	1300	150	3	3
868	358	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	0	1550	-26.923550	27.176483	Boat	Run	Autumn	40.09	1	2	1	6	0	5	4	3	4	3	6	3	12	1300	150	3	3
869	359	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	0	1600	-26.923550	27.176500	Boat	Run	Autumn	40.09	10	2	1	6	10	5	4	3	4	3	6	3	12	1300	150	3	3
870	360	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	0	1610	-26.923567	27.176517	Boat	Run	Autumn	40.09	10	2	1	6	10	5	4	3	4	3	6	3	12	1300	150	3	3
871	361	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	0	1620	-26.923617	27.176533	Boat	Run	Autumn	40.09	10	2	1	6	10	5	4	3	4	3	6	3	12	1300	150	3	3
872	362	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	0	1630	-26.923650	27.176550	Boat	Run	Autumn	40.09	10	2	1	6	10	5	4	3	4	3	6	3	12	1300	150	3	3
873	363	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	0	1640	-26.923667	27.176583	Boat	Run	Autumn	40.09	10	2	1	6	10	5	4	3	4	3	6	3	12	1300	150	3	3
874	364	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	0	1650	-26.923667	27.176583	Boat	Run	Autumn	40.09	10	2	1	6	10	5	4	3	4	3	6	3	12	1300	150	3	3
875	365	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	0	1700	-26.923667	27.176567	Boat	Run	Autumn	40.09	10	2	1	6	10	5	4	3	4	3	6	3	12	1300	150	3	3
876	366	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	0	1710	-26.923683	27.176583	Boat	Run	Autumn	40.09	10	2	1	6	10	5	4	3	4	3	6	3	12	1300	150	3	3
877	367	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	0	1720	-26.923667	27.176567	Boat	Run	Autumn	40.09	10	2	1	6	10	5	4	3	4	3	6	3	12	1300	150	3	3
878	368	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	0	1730	-26.923683	27.176583	Boat	Run	Autumn	40.09	10	2	1	6	10	6	5	4	4	3	3	12	-	1200	150	3	4
879	369	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	0	1740	-26.923667	27.176567	Boat	Run	Autumn	40.09	10	2	1	6	10	6	5	4	4	3	3	12	-	1200	150	3	4
880	370	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	0	1750	-26.923667	27.176567	Boat	Run	Autumn	40.09	1	2	1	6	0	6	5	4	4	3	3	12	-	1200	150	3	4
881	371	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	0	1800	-26.923683	27.176567	Boat	Run	Autumn	40.09	10	2	1	6	10	6	5	4	4	3	3	12	-	1200	150	3	4
882	372	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	0	1810	-26.923700	27.176583	Boat	Run	Autumn	40.09	10	2	1	6	10	6	5	4	4	3	3	12	-	1200	150	3	4
883	373	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	0	1820	-26.923700	27.176583	Boat	Run	Autumn	40.09	10	2	1	6	10	6	5	4	4	3	3	12	-	1200	150	3	4
884	374	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	0	1830	-26.923700	27.176567	Boat	Run	Autumn	40.09	50	2	1	6	50	5	4	3	4	3	3	12	-	1300	150	3	4
885	375	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	0	1840	-26.923733	27.176600	Boat	Run	Autumn	40.09	10	2	1	6	10	5	4	3	4	3	3	12	-	1300	150	3	4
886	376	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	0	1850	-26.923717	27.176583	Boat	Run	Autumn	40.09	10	2	1	6	10	5	4	3	4	3	3	12	-	1300	150	3	3
887	377	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	0	1900	-26.923717	27.176583	Boat	Run	Autumn	40.09	10	2	1	6	10	5	4	3	4	3	3	12	-	1300	150	3	3
888	378	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	0	1910	-26.923700	27.176583	Boat	Run	Autumn	40.09	1	2	1	6	0	5	4	3	4	3	3	12	-	1300	150	3	3
889	379	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	0	1920	-26.923667	27.176550	Boat	Run	Autumn	40.09	10	2	1	6	10	5	4	3	4	3	3	12	-	1300	150	3	3
890	380	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	0	1930	-26.923683	27.176567	Boat	Run	Autumn	40.09	10	2	1	6	10	5	4	3	4	3	3	12	-	1300	150	3	3
891	381	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	0	1940	-26.923700	27.176583	Boat	Run	Autumn	40.09	10	2	1	6	10	5	4	3	4	3	3	12	-	1300	150	3	3
892	382	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	0	1950	-26.923733	27.176583	Boat	Run	Autumn	40.09	10	2	1	6	10	5	4	3	4	3	3	12	-	1300	150	3	3
893	383	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	0	2000	-26.923750	27.176600	Boat	Run	Autumn	40.09	10	2	1	6	10	5	4	3	4	3	3	12	-	1300	150	3	3
894	384	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	0	2010	-26.923717	27.176600	Boat	Run	Autumn	40.09	10	2	1	6	10	5	4	3	4	3	3	12	-	1300	150	3	3
895	385	402	LAEN	Johnny	Francois and Ola	24-Apr-10	2010	0	2020	-26.923717	27.176567	Boat	Run	Autumn	40.09	10	2	1	6	10	5	4	3	4	3	3	12	-	1300	150	3	3
896	386	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	1	610	-26.923217	27.176217	Boat	Run	Autumn	40.59	1	2	1	6	0	5	4	3	4	3	6	3	12	1200	150	3	3
897	387	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	620	-26.923233	27.176217	Boat	Run	Autumn	40.59	10	2	1	6	10	5	4	3	4	3	6	3	12	1200	150	3	3
898	388	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	630	-26.923233	27.176217	Boat	Run	Autumn	40.59	10	2	1	6	10	5	4	3	4	3	6	3	12	1200	150	3	3
899	389	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	640	-26.923250	27.176200	Boat	Run	Autumn	40.59	10	2	1	6	10	5	4	3	4	3	6	3	12	1200	150	3	3
900	390	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	650	-26.923267	27.176217	Boat	Run	Autumn	40.59	1	2	1	6	0	5	4	3	4	3	6	3	12	1300	150	3	3
901	391	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	700	-26.923233	27.176183	Boat	Run	Autumn	40.59	10	2	1	6	10	5	4	3	4	3	6	3	12	1300	150	3	3
902	392	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	710	-26.923233	27.176217	Boat	Run	Autumn	40.59	10	2	1	6	10	5	4	3	4	3	6	3	12	1300	150	3	3
903	393	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	720	-26.923250	27.176217	Boat	Run	Autumn	40.59	10	2	1	6	10	5	4	3	4	3	6	3	12	1200	150	3	3
904	394	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	730	-26.923233	27.176183	Boat	Run	Autumn	40.59	1	2	1	6	0	5	4	3	4	3	6	3	12	1200	150	3	3
905	395	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	740	-26.923217	27.176183	Boat	Run	Autumn	40.59	10	2	1	6	10	5	4	3	4	3	6	3	12	1200	150	3	3
906	396	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	750	-26.923300	27.176367	Boat	Run	Autumn	40.59	50	2	1	6	50	5	4	3	4	3	3	12	-	1200	150	3	3
907	397	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	800	-26.923300	27.176400	Boat	Run	Autumn	40.59	10	2	1	6	10	5	4	3	4	3	3	12	-	1200	150	3	3
908	398	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	810	-26.923317	27.176400	Boat	Run	Autumn	40.59	1	2	1	6	0	5	4	3	4	3	3	12	-	1400	150	3	3
909	399	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	820	-26.923300	27.176400	Boat	Run	Autumn	40.59	10	2	1	6	10	5	4	3	4	3	3	12	-	1300	150	3	3
910	400	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	830	-26.923300	27.176367	Boat	Run	Autumn	40.59	10	2	1	6	10	5	4	3	4	3	3	12	-	1300	150	3	3
911	401	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	840	-26.923317	27.176383	Boat	Run	Autumn	40.59	10	2	1	6	10	5	4	3	4	3	3	12	-	1300	150	3	3
912	402	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	850	-26.923300	27.176400	Boat	Run	Autumn	40.59	1	2	1	6	0	5	4	3	4	3	3	12	-	1200	150	3	3
913	403	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	900	-26.923317	27.176400	Boat	Run	Autumn	40.59	10	2	1	6	10	5	4	3	4	3	3	12	-	1200	150	3	3
914	404	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	910	-26.923317	27.176383	Boat	Run	Autumn	40.59	10	2	1	6	10	5	4	3	4	3	3	12	-	1200	150	3	3
915	405	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	920	-26.923317	27.176400	Boat	Run	Autumn	40.59	10	2	1	6	10	5	4	3	4	3	3	12	-	1200	150	3	3
916	406	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	930	-26.923300	27.176400	Boat	Run	Autumn	40.59	1	2	1	6	0	5	4	3	4	3	3	12	-	1200	150	3	3
917	407	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	940	-26.923300	27.176400	Boat	Run	Autumn	40.59	10	2	1	6	10	5	4	3	4	3	3	12	-	1200	150	3	3
918	408	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	950	-26.923300	27.176383	Boat	Run	Autumn	40.59	10	2	1	6	10	5	4	3	4	3	3	12	-	1200	150	3	3
919	409	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1000	-26.923317	27.176400	Boat	Run	Autumn	40.59	10	2	1	6	10	5	4	3	4	3	3	12	-	1200	150	3	3
920	410	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1010	-26.923317	27.176383	Boat	Run	Autumn	40.59	1	2	1	6	0	5	4	3	4	3	3	12	-	1200	150	3	3
921	411	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1020	-26.923300	27.176400	Boat	Run	Autumn	40.59	1	1	2	6	0	5	4	3	4	3	3	12	-	1200	150	3	3
922	412	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1030	-26.923317	27.176400	Boat	Run	Autumn	40.59	10	1	2	6	10	5	4	3	4	3	3	12	-	1200	150	3	3

Appendix 33: Continuation of raw spatial monitoring data collected from the biotelemetry study of yellowfish at location 2.

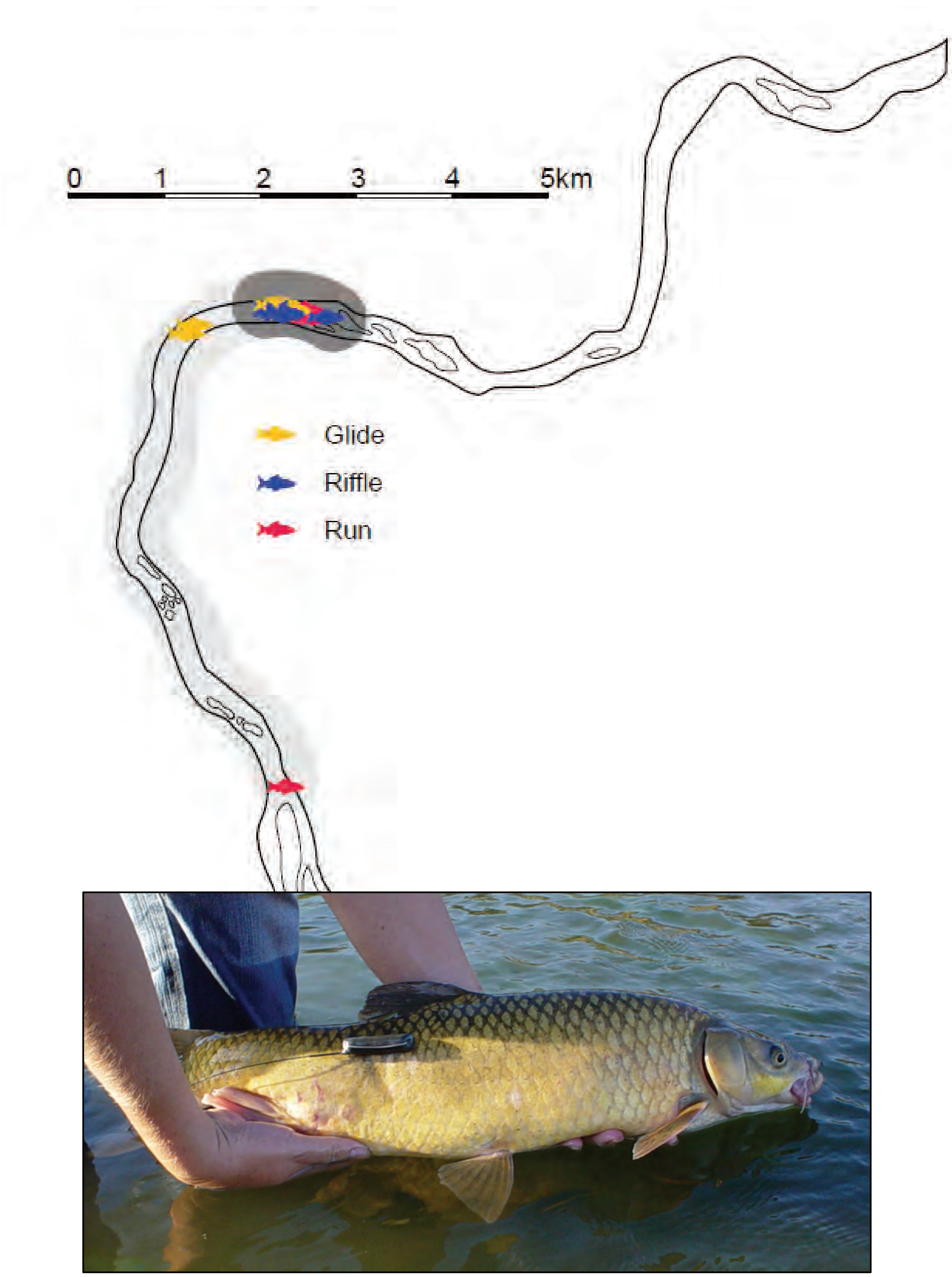
923	413	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1040	-26.923317	27.176400	Boat	Run	Autumn	40.59	1	1	2	6	0	5	4	3	4	3	3	12	-	1200	150	3	3
924	414	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1050	-26.923300	27.176400	Boat	Run	Autumn	40.59	1	1	2	6	0	5	4	3	4	3	3	12	-	1200	150	3	3
925	415	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1100	-26.923317	27.176400	Boat	Run	Autumn	40.59	10	1	2	6	0	5	4	3	4	3	3	12	-	1200	150	3	3
926	416	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1110	-26.923317	27.176400	Boat	Run	Autumn	40.59	1	1	2	6	0	5	4	3	4	3	3	12	-	1200	150	3	3
927	417	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1120	-26.922917	27.176033	Boat	Run	Autumn	40.59	1	1	2	6	0	5	4	3	4	3	3	12	-	1200	150	3	3
928	418	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1500	-26.922933	27.176033	Boat	Run	Autumn	40.59	1	1	2	6	0	5	4	3	4	3	6	3	12	1400	150	3	3
929	419	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1510	-26.922933	27.176050	Boat	Run	Autumn	40.59	10	1	2	6	10	5	4	3	4	3	6	3	12	1400	150	3	3
930	420	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1520	-26.922933	27.176033	Boat	Run	Autumn	40.59	10	1	2	6	10	5	4	3	4	3	6	3	12	1400	150	3	3
931	421	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1530	-26.922933	27.176050	Boat	Run	Autumn	40.59	10	1	2	6	10	5	4	3	4	3	6	3	12	1400	150	3	3
932	422	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1540	-26.922933	27.176067	Boat	Run	Autumn	40.59	1	1	2	6	0	5	4	3	4	3	6	3	12	1400	150	3	3
933	423	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1550	-26.922933	27.176083	Boat	Run	Autumn	40.59	10	1	2	6	10	5	4	3	4	3	6	3	12	1400	150	3	3
934	424	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1600	-26.922917	27.176083	Boat	Run	Autumn	40.59	10	1	2	6	10	5	4	3	4	3	6	3	12	1400	150	3	3
935	425	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1610	-26.922917	27.176083	Boat	Run	Autumn	40.59	10	2	1	6	10	5	4	3	4	3	6	3	12	1200	150	3	3
936	426	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1620	-26.922933	27.176083	Boat	Run	Autumn	40.59	1	2	1	6	0	5	4	3	4	3	3	12	-	1200	150	3	3
937	427	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1630	-26.922933	27.176083	Boat	Run	Autumn	40.59	10	2	1	6	10	5	4	3	4	3	3	12	-	1200	150	3	3
938	428	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1640	-26.922917	27.176083	Boat	Run	Autumn	40.59	10	2	1	6	10	5	4	3	4	3	3	12	-	1200	150	3	3
939	429	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1650	-26.922917	27.176100	Boat	Run	Autumn	40.59	10	2	1	6	10	5	4	3	4	3	3	12	-	1200	150	3	3
940	430	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1700	-26.922933	27.176100	Boat	Run	Autumn	40.59	1	2	1	6	0	5	4	3	4	3	3	12	-	1200	150	3	3
941	431	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1710	-26.922950	27.176117	Boat	Run	Autumn	40.59	10	2	1	6	10	5	4	3	4	3	3	12	-	1200	150	3	3
942	432	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1720	-26.922933	27.176117	Boat	Run	Autumn	40.59	10	2	1	6	10	5	4	3	4	3	3	12	-	1200	150	3	3
943	433	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1730	-26.923317	27.176383	Boat	Run	Autumn	40.59	10	2	1	6	10	5	4	3	4	3	3	12	-	1200	150	3	3
944	434	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1740	-26.923317	27.176383	Boat	Run	Autumn	40.59	1	2	1	6	10	5	4	3	4	3	3	12	-	1200	150	3	3
945	435	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1750	-26.923317	27.176383	Boat	Run	Autumn	40.59	10	2	1	6	10	5	4	3	4	3	3	12	-	1200	150	3	3
946	436	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1800	-26.923317	27.176383	Boat	Run	Autumn	40.59	10	2	1	6	10	5	4	3	4	3	3	12	-	1200	150	3	3
947	437	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1810	-26.923167	27.176150	Boat	Run	Autumn	40.59	10	2	1	6	10	5	4	3	4	3	3	12	-	1200	150	3	3
948	438	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1820	-26.923167	27.176150	Boat	Run	Autumn	40.59	50	2	1	6	50	5	4	3	4	3	3	12	-	1200	150	3	3
949	439	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1830	-26.923167	27.176150	Boat	Run	Autumn	40.59	10	2	1	6	10	5	4	3	4	3	3	12	-	1200	150	3	3
950	440	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1840	-26.923183	27.176150	Boat	Run	Autumn	40.59	10	2	1	6	10	5	4	3	4	3	3	12	-	1200	150	3	3
951	441	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1850	-26.923150	27.176150	Boat	Run	Autumn	40.59	10	2	1	6	10	5	4	3	4	3	3	12	-	1200	150	3	3
952	442	402	LAEN	Johnny	Francois and Ola	25-Apr-10	2010	0	1900	-26.923100	27.176267	Boat	Run	Autumn	40.59	10	2	1	6	10	5	4	3	4	3	3	12	-	1200	150	3	3
953	443	402	LAEN	Johnny	Francois and Ren	27-Apr-10	2010	2	1500	-26.923100	27.176250	Boat	Glide	Autumn	61.95	1	1	2	6	0	5	4	3	3	2	3	12	-	1400	150	3	3
954	444	402	LAEN	Johnny	Francois and Ren	27-Apr-10	2010	0	1510	-26.923100	27.176250	Boat	Glide	Autumn	61.95	1	1	2	6	0	5	4	3	3	2	3	12	-	1400	150	3	3
955	445	402	LAEN	Johnny	Francois and Ren	27-Apr-10	2010	0	1520	-26.923117	27.176267	Boat	Glide	Autumn	61.95	10	2	1	6	10	5	4	3	3	2	3	12	-	1300	150	3	3
956	446	402	LAEN	Johnny	Francois and Ren	27-Apr-10	2010	0	1530	-26.923100	27.176233	Boat	Glide	Autumn	61.95	10	2	1	6	10	5	4	3	3	2	3	12	-	1300	150	3	3
957	447	402	LAEN	Johnny	Francois and Ren	27-Apr-10	2010	0	1540	-26.923100	27.176217	Boat	Glide	Autumn	61.95	1	2	1	6	0	5	4	3	3	2	3	12	-	1200	150	3	3
958	448	402	LAEN	Johnny	Francois and Ren	27-Apr-10	2010	0	1550	-26.923083	27.176250	Boat	Glide	Autumn	61.95	10	2	1	6	0	5	4	3	3	2	3	12	-	1200	150	3	3
959	449	402	LAEN	Johnny	Francois and Ren	27-Apr-10	2010	0	1600	-26.923050	27.176233	Boat	Glide	Autumn	61.95	10	2	1	6	10	5	4	3	3	2	3	12	-	1200	150	3	3
960	450	402	LAEN	Johnny	Francois and Ren	27-Apr-10	2010	0	1610	-26.923050	27.176217	Boat	Glide	Autumn	61.95	10	2	1	6	10	5	4	3	3	2	3	12	-	1200	150	3	3
961	451	402	LAEN	Johnny	Francois and Ren	27-Apr-10	2010	0	1620	-26.923083	27.176233	Boat	Glide	Autumn	61.95	1	2	1	6	0	5	4	3	3	2	3	12	-	1200	150	3	3
962	452	402	LAEN	Johnny	Francois and Ren	27-Apr-10	2010	0	1630	-26.923100	27.176250	Boat	Glide	Autumn	61.95	10	2	1	6	10	5	4	3	3	2	3	12	-	1200	150	3	3
963	453	402	LAEN	Johnny	Francois and Ren	27-Apr-10	2010	0	1640	-26.923117	27.176267	Boat	Glide	Autumn	61.95	10	2	1	6	10	5	4	3	3	2	3	12	-	1200	150	3	3
964	454	402	LAEN	Johnny	Francois and Ren	27-Apr-10	2010	0	1650	-26.923100	27.176267	Boat	Glide	Autumn	61.95	10	2	1	6	10	5	4	3	3	2	3	12	-	1200	150	3	3
965	455	402	LAEN	Johnny	Francois and Ren	27-Apr-10	2010	0	1700	-26.923100	27.176250	Boat	Glide	Autumn	61.95	1	2	1	6	0	5	4	3	3	2	3	12	-	1200	150	3	3
966	456	402	LAEN	Johnny	Francois and Ren	27-Apr-10	2010	0	1710	-26.923083	27.176233	Boat	Glide	Autumn	61.95	10	2	1	6	10	5	4	3	3	2	2	3	12	1200	150	3	3
967	457	402	LAEN	Johnny	Francois and Ren	27-Apr-10	2010	0	1720	-26.923000	27.175967	Boat	Glide	Autumn	61.95	10	2	1	6	10	5	4	3	3	2	2	3	12	1200	150	3	3
968	458	402	LAEN	Johnny	Francois and Ren	27-Apr-10	2010	0	1730	-26.922967	27.175983	Boat	Glide	Autumn	61.95	10	2	1	6	10	5	4	3	3	2	2	3	12	1200	150	3	3
969	459	402	LAEN	Johnny	Francois and Ren	27-Apr-10	2010	0	1740	-26.922967	27.175983	Boat	Run	Autumn	61.95	1	2	1	6	0	4	5	3	4	3	3	12	-	1200	150	3	3
970	460	402	LAEN	Johnny	Francois and Ren	27-Apr-10	2010	0	1750	-26.922967	27.176133	Boat	Run	Autumn	61.95	10	2	1	6	10	4	5	3	4	3	3	12	-	1200	150	3	3
971	461	402	LAEN	Johnny	Francois and Ren	27-Apr-10	2010	0	1800	-26.923033	27.176033	Boat	Run	Autumn	61.95	10	2	1	6	10	4	5	3	4	3	3	12	-	1200	150	3	3
972	462	402	LAEN	Johnny	Francois and Ren	27-Apr-10	2010	0	1810	-26.923033	27.176017	Boat	Run	Autumn	61.95	10	2	1	6	10	4	5	3	4	3	3	12	-	1200	150	3	3
973	463	402	LAEN	Johnny	Francois and Ren	27-Apr-10	2010	0	1820	-26.923033	27.176033	Boat	Run	Autumn	61.95	1	1	2	6	10	4	5	3	4	3	3	3	12	1200	150	3	3
974	464	402	LAEN	Johnny	Francois and Ren	27-Apr-10	2010	0	1830	-26.923050	27.176033	Boat	Run	Autumn	61.95	10	2	1	6	10	4	5	3	4	3	3	3	12	1200	150	3	3
975	465	402	LAEN	Johnny	Francois and Ren	27-Apr-10	2010	0	1840	-26.923067	27.176033	Boat	Run	Autumn	61.95	10	2	1	6	10	4	5	3	4	3	3	3	12	1200	150	3	3
976	466	402	LAEN	Johnny	Francois and Ren	27-Apr-10	2010	0	1850	-26.923050	27.176067	Boat	Run	Autumn	61.95	10	2	1	6	10	4	5	3	4	3	3	3	12	1200	150	3	3
977	467	402	LAEN	Johnny	Francois and Ren	27-Apr-10	2010	0	1900	-26.923250	27.176367	Boat	Run	Autumn	61.95	10	2	1	6	10	4	5	3	4	3	3	3	12	1200	150	3	3
978	468	402	LAEN	Johnny	Francois and Ren	27-Apr-10	2010	0	1910	-26.923267	27.176367	Boat	Run	Autumn	61.95	10	2	1	6	10	4	5	3	4	3	3	3	12	1200	150	3	3
979	469	402	LAEN	Johnny	Francois and Han	15-May-10	2010	18	1630	-26.923283	27.176367	Boat	Run	Autumn	40.49	1	2	1	6	0	5	4	3	4	3	3	12	6	1000	-	3	3
980	470	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	1640	-26.923283	27.176383	Boat	Run	Autumn	40.49	10	2	1	6	10	5	4	3	4	3	3	12	6	1000	-	3	3

Appendix 34: Continuation of raw spatial monitoring data collected from the biotelemetry study of yellowfish at location 2.

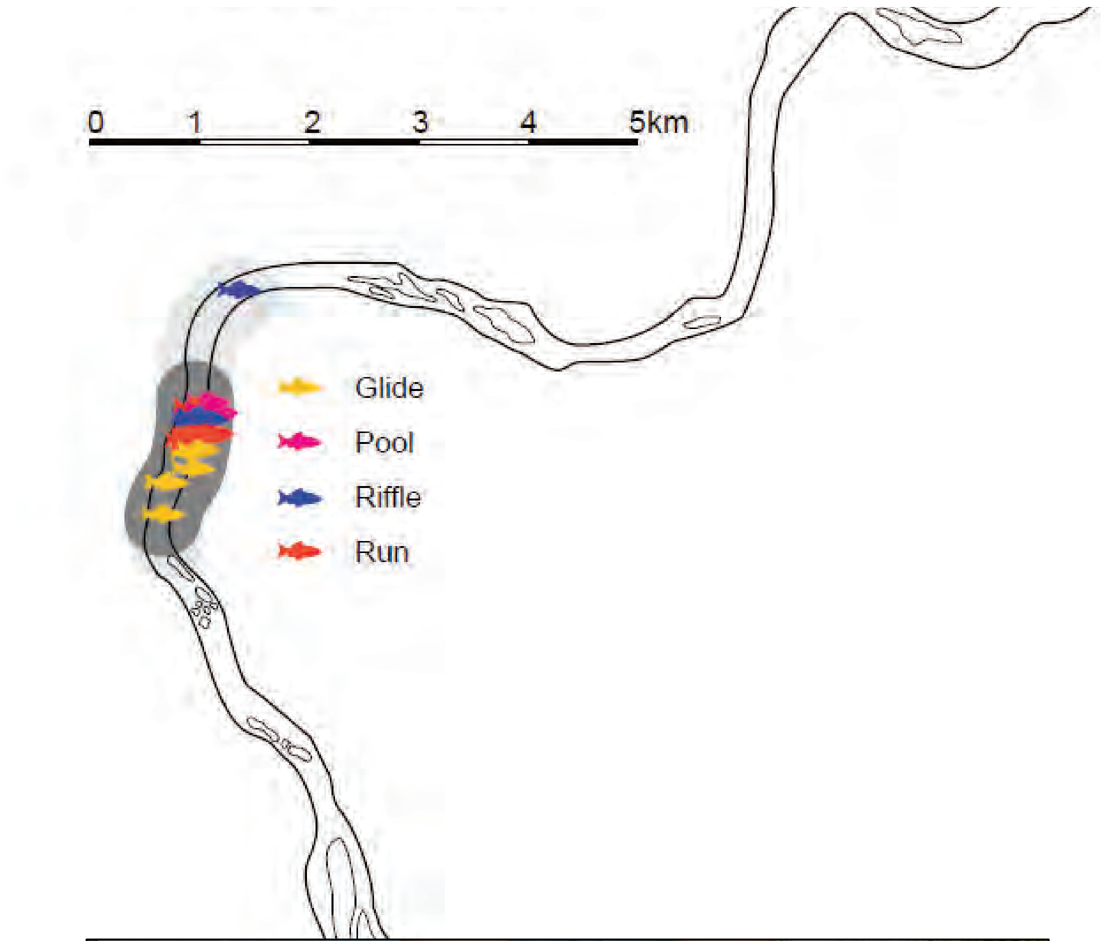
981	471	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	1650	-26.923300	27.176400	Boat	Run	Autumn	40.49	10	2	1	6	10	5	4	3	4	3	3	12	6	1000	-	3	3
982	472	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	1700	-26.923283	27.176417	Boat	Run	Autumn	40.49	10	2	1	6	10	5	4	3	4	3	3	12	6	1000	-	3	3
983	473	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	1710	-26.923283	27.176400	Boat	Run	Autumn	40.49	1	2	1	6	10	5	4	3	4	3	3	12	6	1000	-	3	3
984	474	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	1720	-26.923283	27.176417	Boat	Run	Autumn	40.49	10	2	1	6	10	5	4	3	4	3	3	12	6	1000	-	3	3
985	475	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	1730	-26.923283	27.176383	Boat	Run	Autumn	40.49	10	2	1	6	10	5	4	3	4	3	3	12	6	1000	-	3	3
986	476	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	1740	-26.923283	27.176367	Boat	Run	Autumn	40.49	10	2	1	6	10	5	4	3	4	3	3	12	6	1000	-	3	3
987	477	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	1750	-26.923283	27.176400	Boat	Run	Autumn	40.49	1	2	1	6	10	5	4	3	4	3	3	12	6	1000	-	3	3
988	478	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	1800	-26.923317	27.176400	Boat	Run	Autumn	40.49	10	2	1	6	10	5	4	3	4	3	3	12	6	1000	-	3	3
989	479	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	1810	-26.923300	27.176367	Boat	Run	Autumn	40.49	10	2	1	6	10	5	4	3	4	3	3	12	6	1000	-	3	3
990	480	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	1820	-26.923300	27.176400	Boat	Run	Autumn	40.49	10	2	1	6	10	5	4	3	4	3	3	12	6	1000	-	3	3
991	481	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	19:20	-26.927833	27.182900	Boat	Glide	Autumn	40.49	10	2	1	6	10	2	5	4	3	2	1	12	12	1400	150	3	1
992	482	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	1830	-26.923300	27.176400	Boat	Run	Autumn	40.49	1	2	1	6	0	5	4	3	4	3	3	12	6	1000	-	3	3
993	483	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	1840	-26.923283	27.176417	Boat	Run	Autumn	40.49	10	2	1	6	10	5	4	3	4	3	3	12	6	1000	-	3	3
994	484	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	1850	-26.923283	27.176417	Boat	Run	Autumn	40.49	10	2	1	6	10	5	4	3	4	3	3	12	6	1000	-	3	3
995	485	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	1900	-26.923283	27.176417	Boat	Run	Autumn	40.49	10	2	1	6	10	5	4	3	4	3	3	12	6	1000	-	3	3
996	486	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	1910	-26.923283	27.176417	Boat	Run	Autumn	40.49	1	2	1	6	0	5	4	3	4	3	3	12	6	1000	-	3	3
997	487	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	1920	-26.923283	27.176417	Boat	Run	Autumn	40.49	10	2	1	6	10	5	4	3	4	3	3	12	6	1000	-	3	3
998	488	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	1930	-26.923283	27.176417	Boat	Run	Autumn	40.49	10	2	1	6	10	5	4	3	4	3	3	12	6	1000	-	3	3
999	489	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	1940	-26.923283	27.176417	Boat	Run	Autumn	40.49	10	2	1	6	10	5	4	3	4	3	3	12	6	1000	-	3	3
1000	490	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	1950	-26.923283	27.176417	Boat	Run	Autumn	40.49	1	2	1	6	0	5	4	3	4	3	3	12	6	1000	-	3	3
1001	491	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	2000	-26.923283	27.176417	Boat	Run	Autumn	40.49	10	2	1	6	10	5	4	3	4	3	3	12	6	1000	-	3	3
1002	492	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	2010	-26.923283	27.176417	Boat	Run	Autumn	40.49	10	2	1	6	10	5	4	3	4	3	3	12	6	1000	-	3	3
1003	493	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	2020	-26.923283	27.176417	Boat	Run	Autumn	40.49	10	2	1	6	10	5	4	3	4	3	3	12	6	1000	-	3	3
1004	494	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	2030	-26.923283	27.176417	Boat	Run	Autumn	40.49	10	2	1	6	10	5	4	3	4	3	3	12	6	1000	-	3	3
1005	495	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	2040	-26.923283	27.176417	Boat	Run	Autumn	40.49	10	2	1	6	10	5	4	3	4	3	3	12	6	1000	-	3	3
1006	496	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	2050	-26.923283	27.176417	Boat	Run	Autumn	40.49	10	2	1	6	10	5	4	3	4	3	3	12	6	1000	-	3	3
1007	497	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	2100	-26.923283	27.176417	Boat	Run	Autumn	40.49	10	2	1	6	10	5	4	3	4	3	3	12	6	1000	-	3	3
1008	498	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	2110	-26.923283	27.176417	Boat	Run	Autumn	40.49	10	2	1	6	10	5	4	3	4	3	3	12	6	1000	-	3	3
1009	499	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	2120	-26.923283	27.176417	Boat	Run	Autumn	40.49	10	2	1	6	10	5	4	3	4	3	3	12	6	1000	-	3	3
1010	500	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	2130	-26.922883	27.176067	Boat	Run	Autumn	40.49	10	2	1	6	10	5	4	3	4	3	3	12	6	1000	-	3	3
1011	501	402	LAEN	Johnny	Francois and Han	15-May-10	2010	0	2140	-26.922900	27.176067	Boat	Run	Autumn	40.49	10	2	1	6	10	5	4	3	4	3	3	12	6	1000	-	3	3
1012	502	402	LAEN	Johnny	Francois and Han	16-May-10	2010	1	650	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	2	1	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1013	503	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	700	-26.922900	27.176067	Boat	Glide	Autumn	40.71	10	2	1	6	10	5	4	3	3	2	3	12	-	1000	-	3	1
1014	504	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	710	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	2	1	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1015	505	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	720	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1016	506	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	730	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1017	507	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	740	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1018	508	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	750	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1019	509	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	800	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1020	510	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	810	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1021	511	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	820	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1022	512	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	830	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1023	513	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	840	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1024	514	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	850	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1025	515	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	900	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1026	516	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	910	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1027	517	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	920	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1028	518	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	930	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1029	519	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	940	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1030	520	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	950	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1031	521	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	1000	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1032	522	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	1700	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1033	523	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	1710	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1034	524	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	1720	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1035	525	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	1730	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1036	526	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	1740	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1037	527	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	1750	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1038	528	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	1800	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1

Appendix 35: Continuation of raw spatial monitoring data collected from the biotelemetry study of yellowfish at location 2.

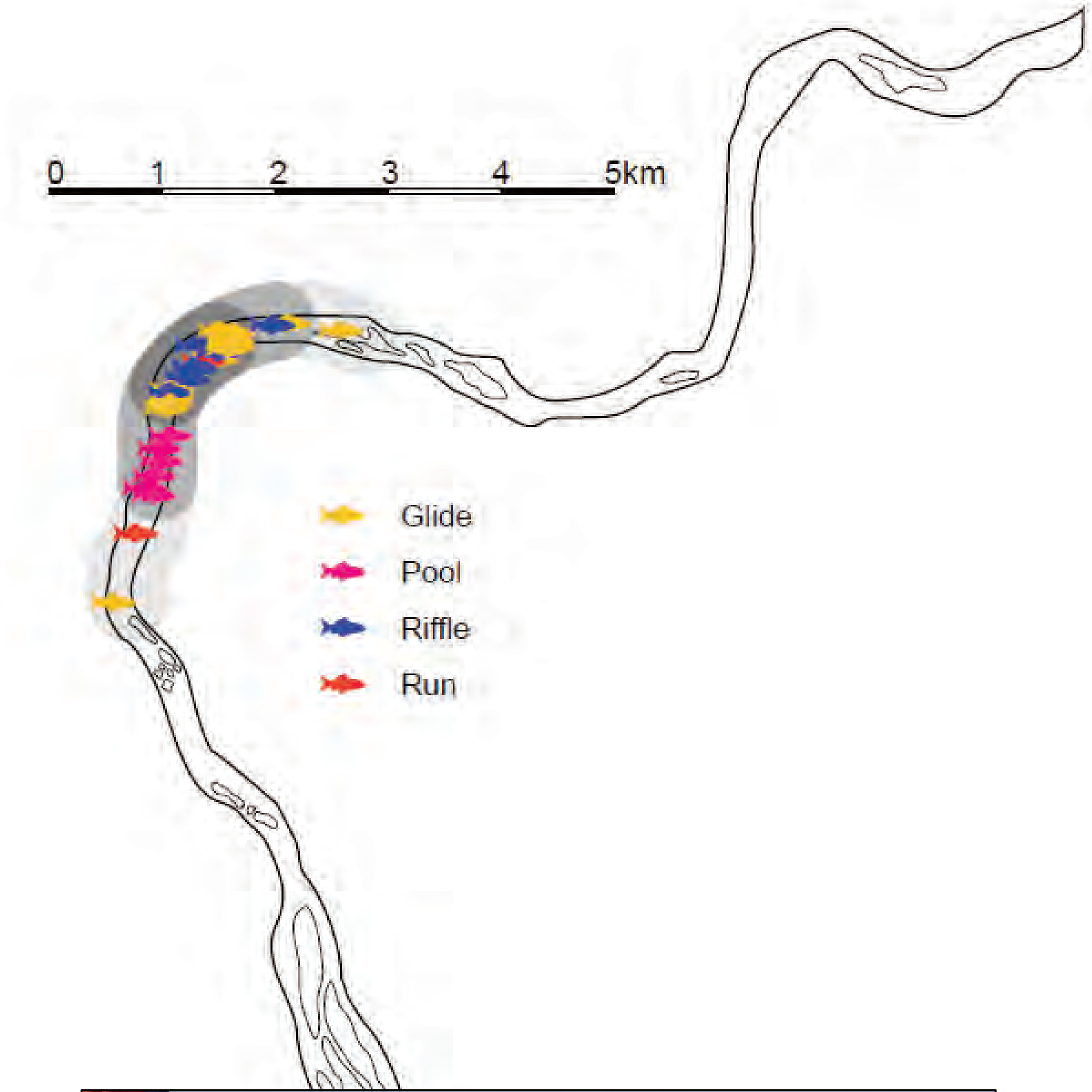
1039	529	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	1810	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1040	530	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	1820	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1041	531	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	1830	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1042	532	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	1840	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1043	533	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	1850	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1044	534	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	1900	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1045	535	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	1910	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1046	536	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	1920	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1047	537	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	1930	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1048	538	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	1940	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1049	539	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	1950	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1050	540	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	2000	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1051	541	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	2010	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1052	542	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	2020	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1053	543	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	2030	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1054	544	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	2040	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1055	545	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	2050	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1056	546	402	LAEN	Johnny	Francois and Han	16-May-10	2010	0	2100	-26.922900	27.176067	Boat	Glide	Autumn	40.71	1	1	2	6	0	5	4	3	3	2	3	12	-	1000	-	3	1
1057	0	422	LKIM	Liefling	Gordon	29-Jun-09	2009	0	14h30	-26.958660	27.181350	Boat	-	Winter	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1058	1	422	LKIM	Liefling	Rindert	14-Sep-09	2009	77	1220	-26.954950	27.183200	Boat	Pool	Spring	10	1	1	0	0	0	2	3	0	2	0	3	9	14	1000	360	2	1
1059	2	422	LKIM	Liefling	Rindert	14-Sep-09	2009	0	1200	-26.954950	27.183200	Boat	Pool	Spring	10	1	1	0	0	0	2	3	0	2	0	3	9	14	1000	360	2	1
1060	3	422	LKIM	Liefling	Rindert	14-Sep-09	2009	0	1210	-26.954950	27.183200	Boat	Pool	Spring	10	1	1	0	0	0	2	3	0	2	0	3	9	14	1000	360	2	1
1061	4	422	LKIM	Liefling	Rindert	14-Sep-09	2009	0	1230	-26.954950	27.183200	Boat	Pool	Spring	10	1	1	0	0	0	2	3	0	2	0	3	9	14	1000	360	2	1
1062	5	422	LKIM	Liefling	Rindert	22-Sep-09	2009	8	1120	-26.954970	27.183400	Boat	Pool	Spring	16.84	1	1	0	0	0	3	2	0	2	0	3	9	14	1000	400	2	1
1063	6	422	LKIM	Liefling	Rindert	22-Sep-09	2009	0	1100	-26.954950	27.183200	Boat	Pool	Spring	16.84	1	1	0	0	0	3	2	0	2	0	3	9	14	1000	400	2	1
1064	7	422	LKIM	Liefling	Rindert	22-Sep-09	2009	0	1110	-26.954960	27.183300	Boat	Pool	Spring	16.84	1	1	0	0	0	3	2	0	2	0	3	9	14	1000	400	2	1
1065	8	422	LKIM	Liefling	Rindert	22-Sep-09	2009	0	1130	-26.954980	27.183500	Boat	Pool	Spring	16.84	1	1	0	0	0	3	2	0	2	0	3	9	14	1000	400	2	1



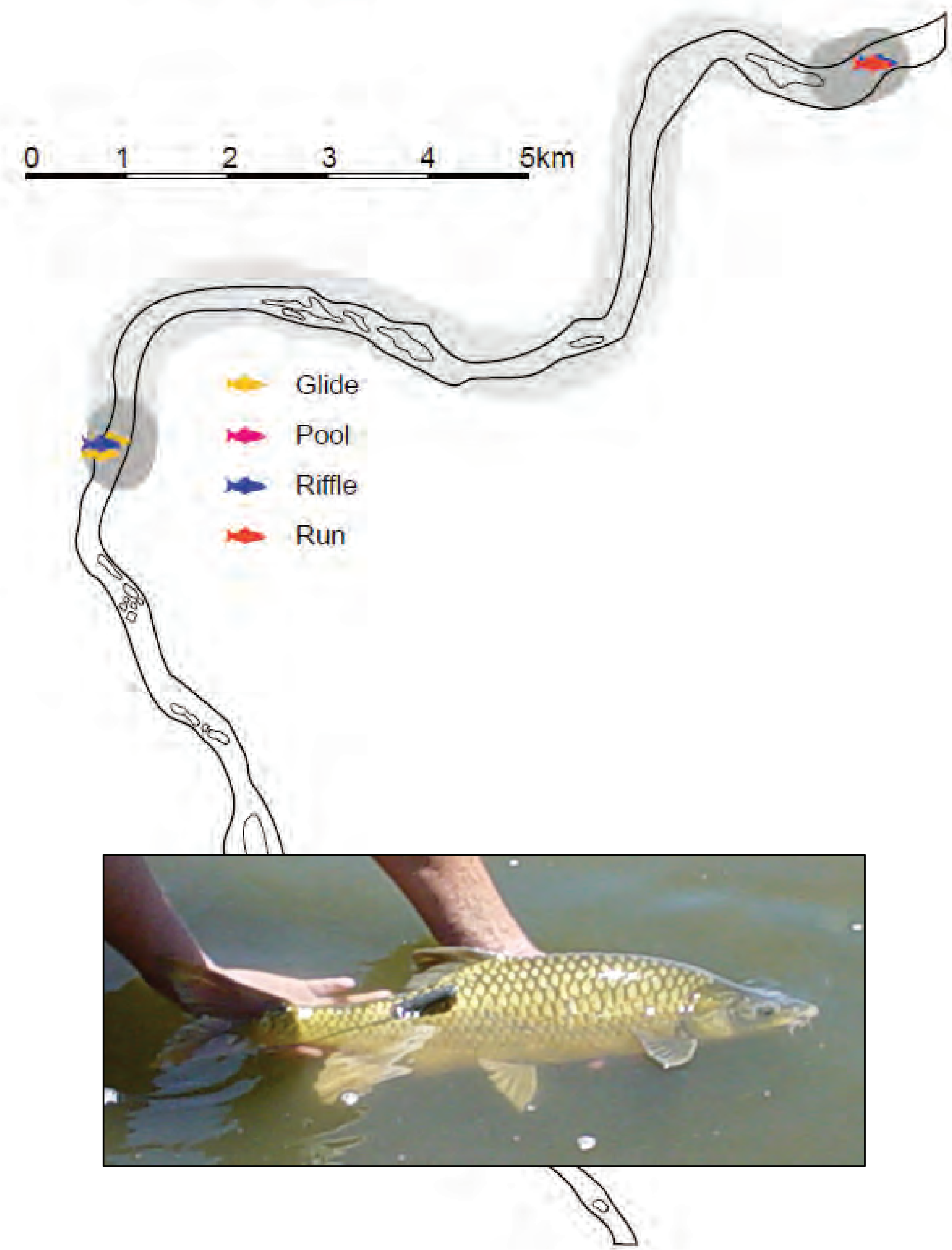
Appendix 36: Graphical representation of the home range of the 3.2 kg, Smallmouth yellowfish (*L. aeneus*) tagged with transmitter 142.017 at locality 1 in the study. This individual was monitored on 60 occasions from 23rd of September 2006 to the 24th of May 2007.



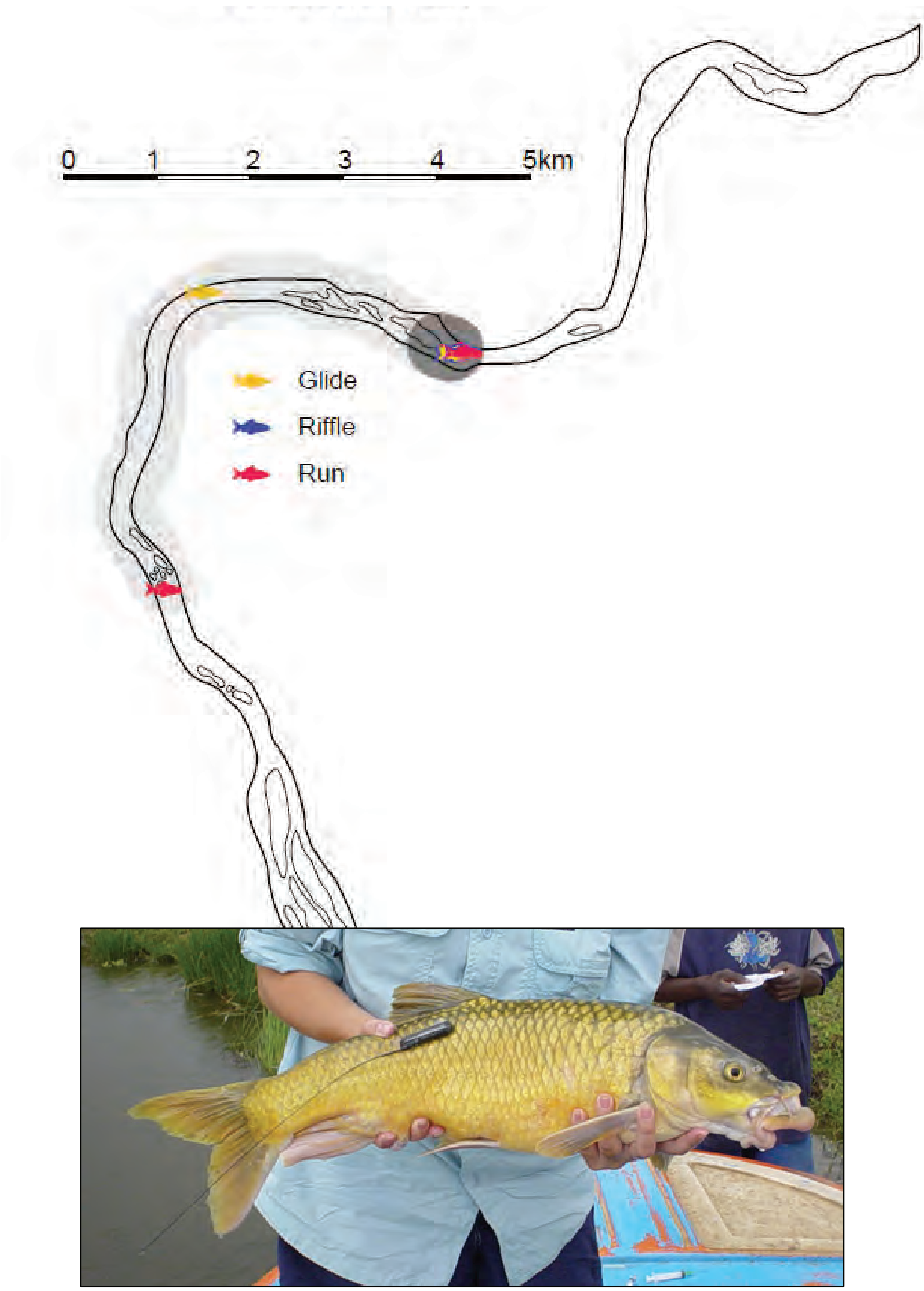
Appendix 37: Graphical representation of the home range of the 3.8 kg, Smallmouth yellowfish (*L. aeneus*) tagged with transmitter 142.026 at locality 1 in the study. This individual was monitored on 32 occasions from 9th of November 2006 to the 29th of June 2007.



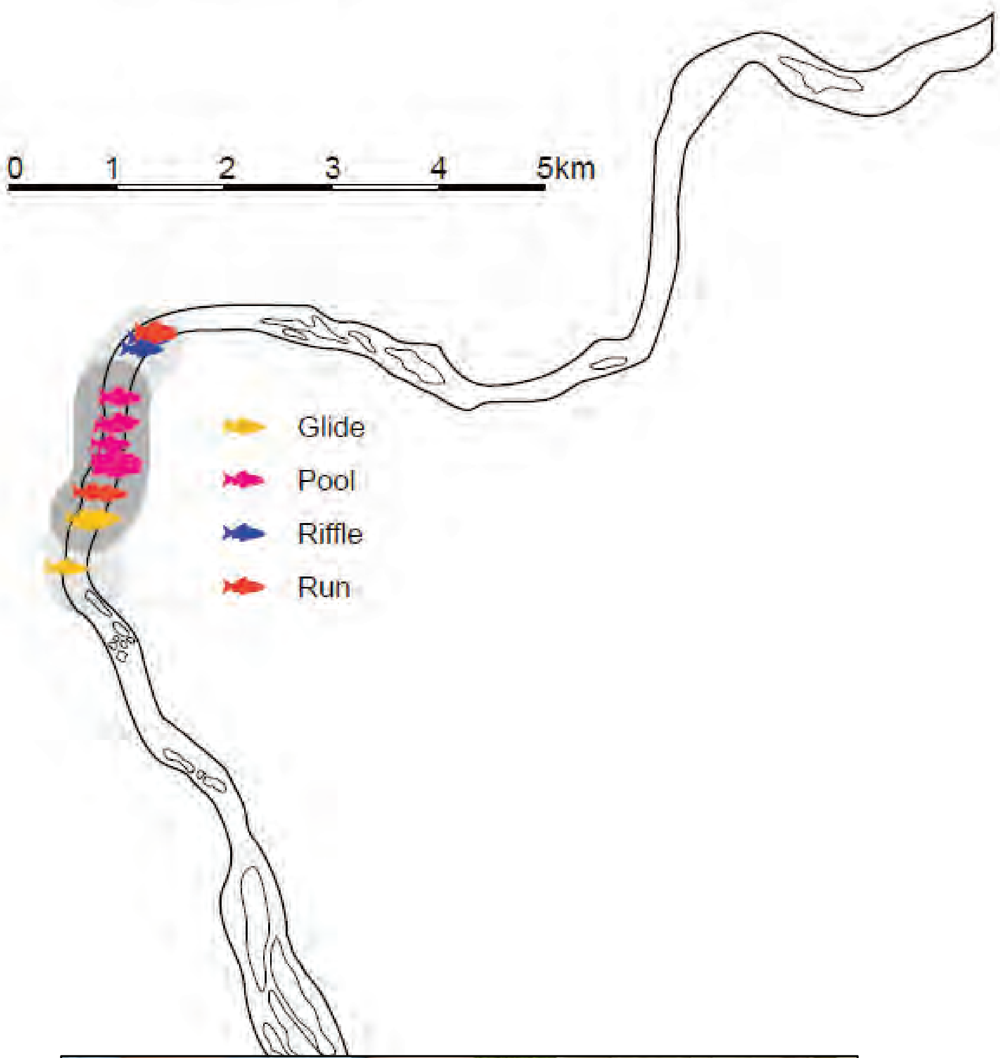
Appendix 38: Graphical representation of the home range of the 4.4 kg, Largemouth yellowfish (*L. kimberleyensis*) tagged with transmitter 142.036 at locality 1 in the study. This individual was monitored on 42 occasions from 9th of November 2006 to the 7th of July 2007.



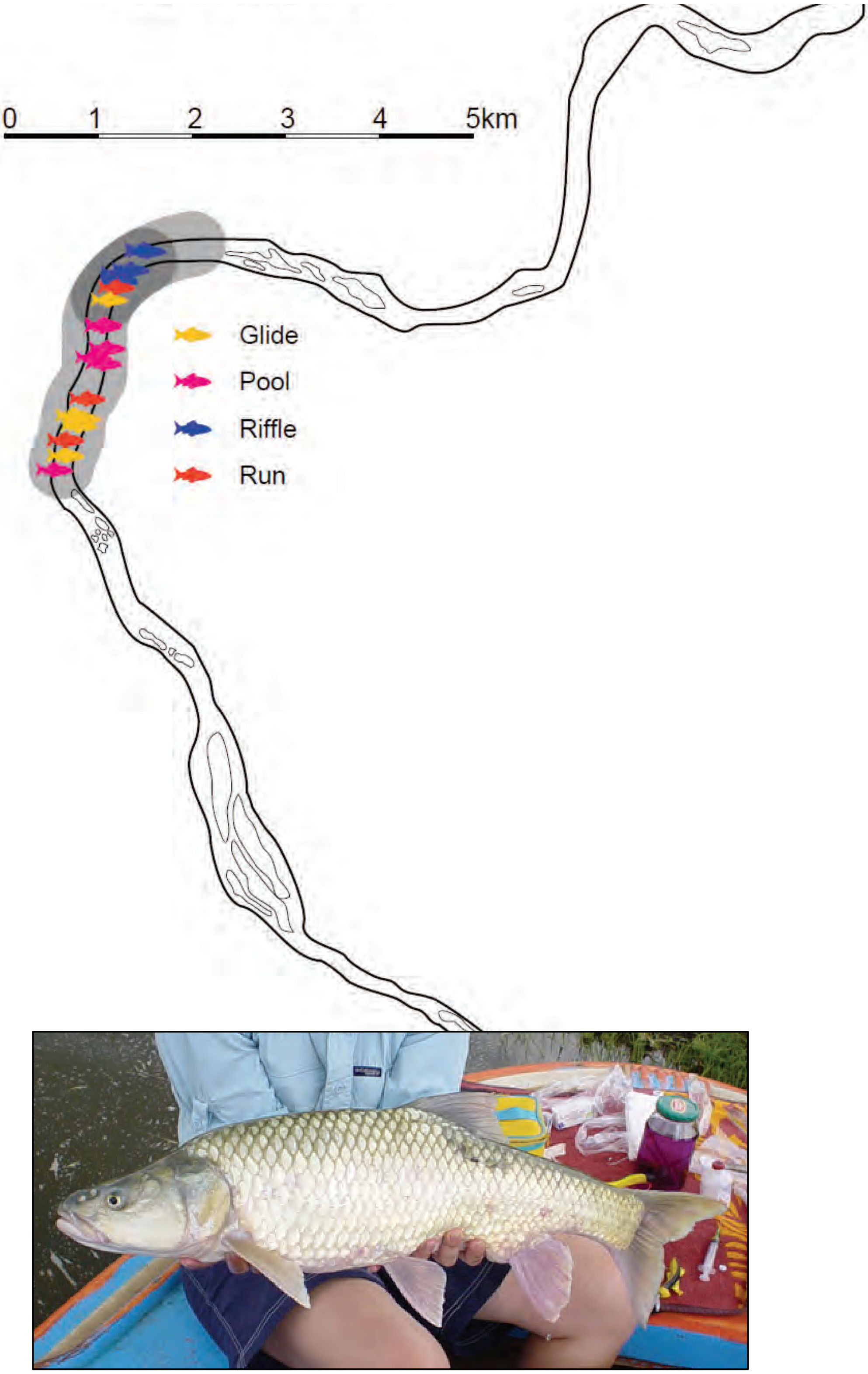
Appendix 39: Graphical representation of the home range of the 1.7 kg, Smallmouth yellowfish (*L. aeneus*) tagged with transmitter 142.045 at locality 1 in the study. This individual was monitored on 5 occasions from 4th of November 2006 to the 11th of January 2007.



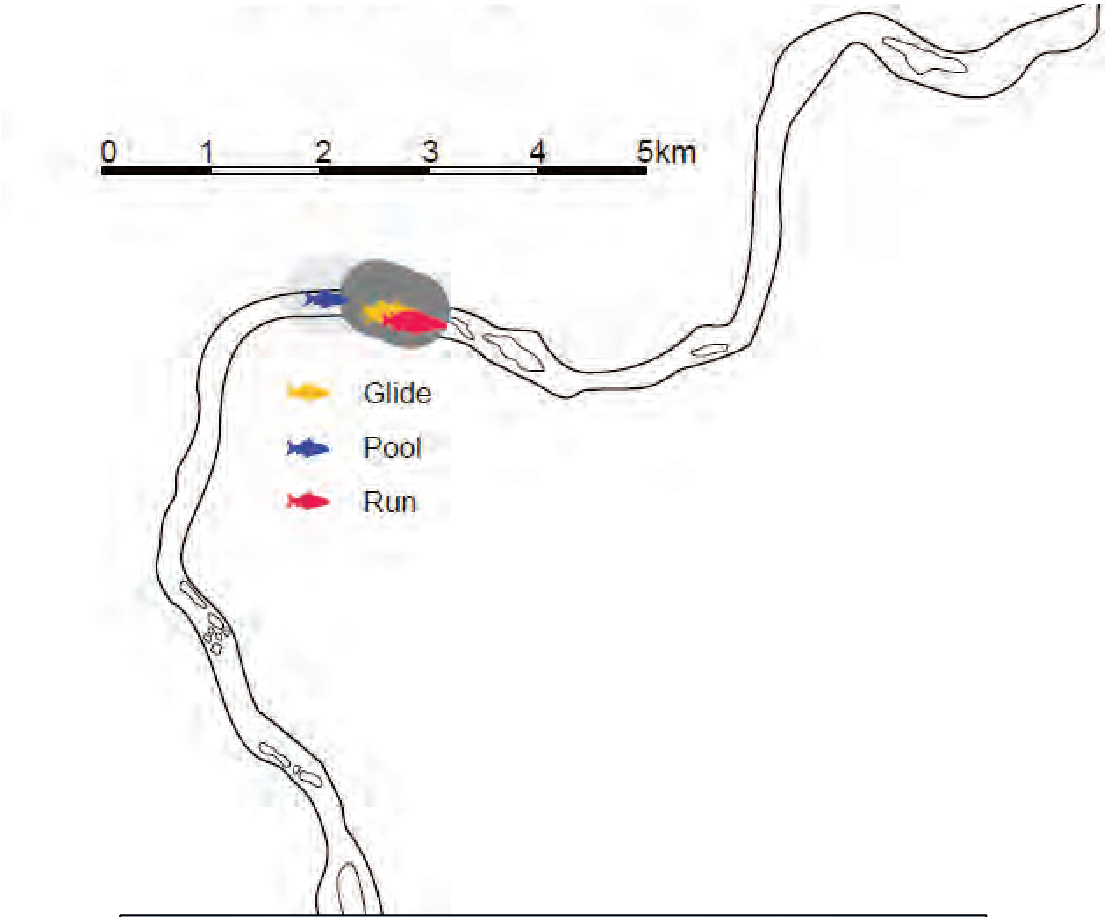
Appendix 40: Graphical representation of the home range of the 1.1 kg, Smallmouth yellowfish (*L. aeneus*) tagged with transmitter 142.056 at locality 1 in the study. This individual was monitored on 18 occasions from 5th of November 2006 to the 22nd of February 2007.



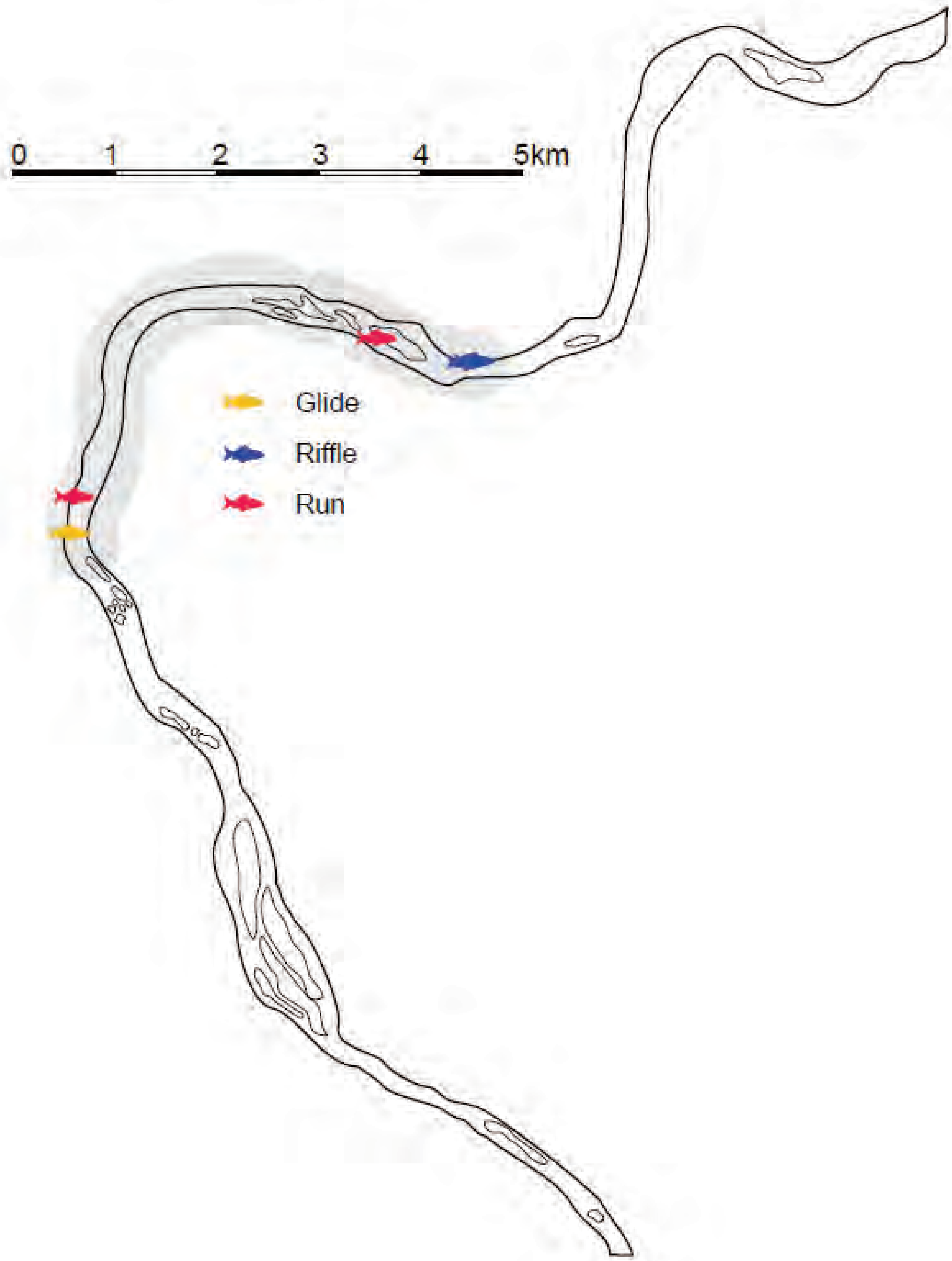
Appendix 41: Graphical representation of the home range of the 2.2 kg, Largemouth yellowfish (*L. kimberleyensis*) tagged with transmitter 142.064 at locality 1 in the study. This individual was monitored on 24 occasions from 9th of November 2006 to the 7th of July 2007.



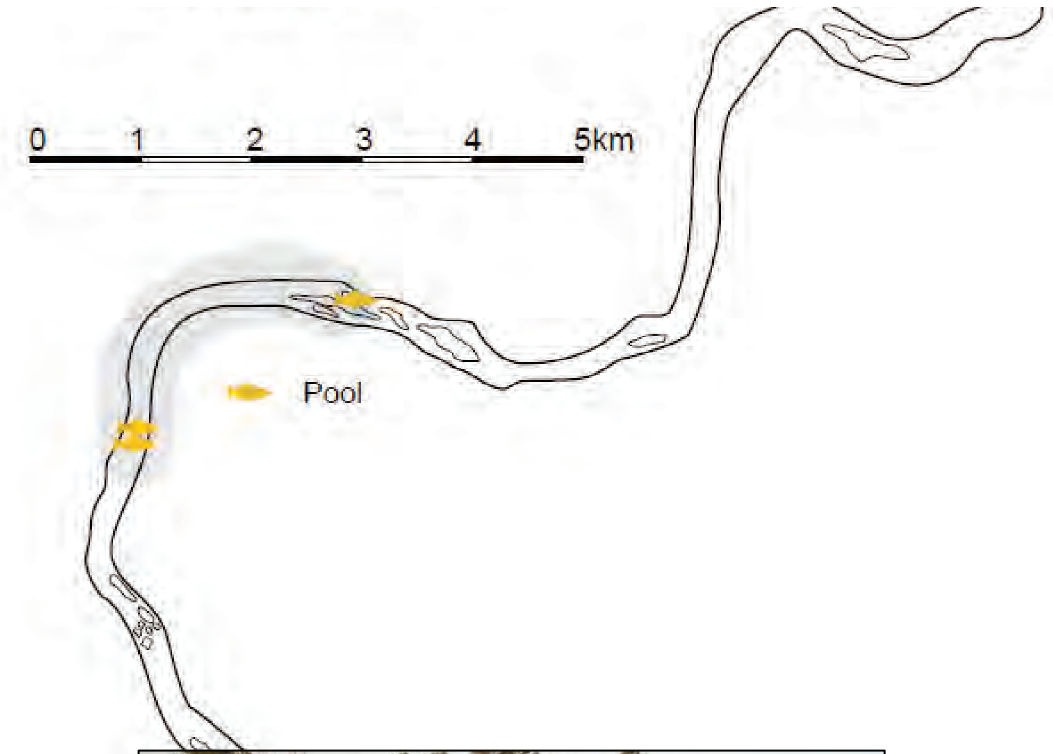
Appendix 42: Graphical representation of the home range of the 5 kg, Largemouth yellowfish (*L. kimberleyensis*) tagged with transmitter 142.074 at locality 1 in the study. This individual was monitored on 42 occasions from 9th of November 2006 to the 20th of June 2007.



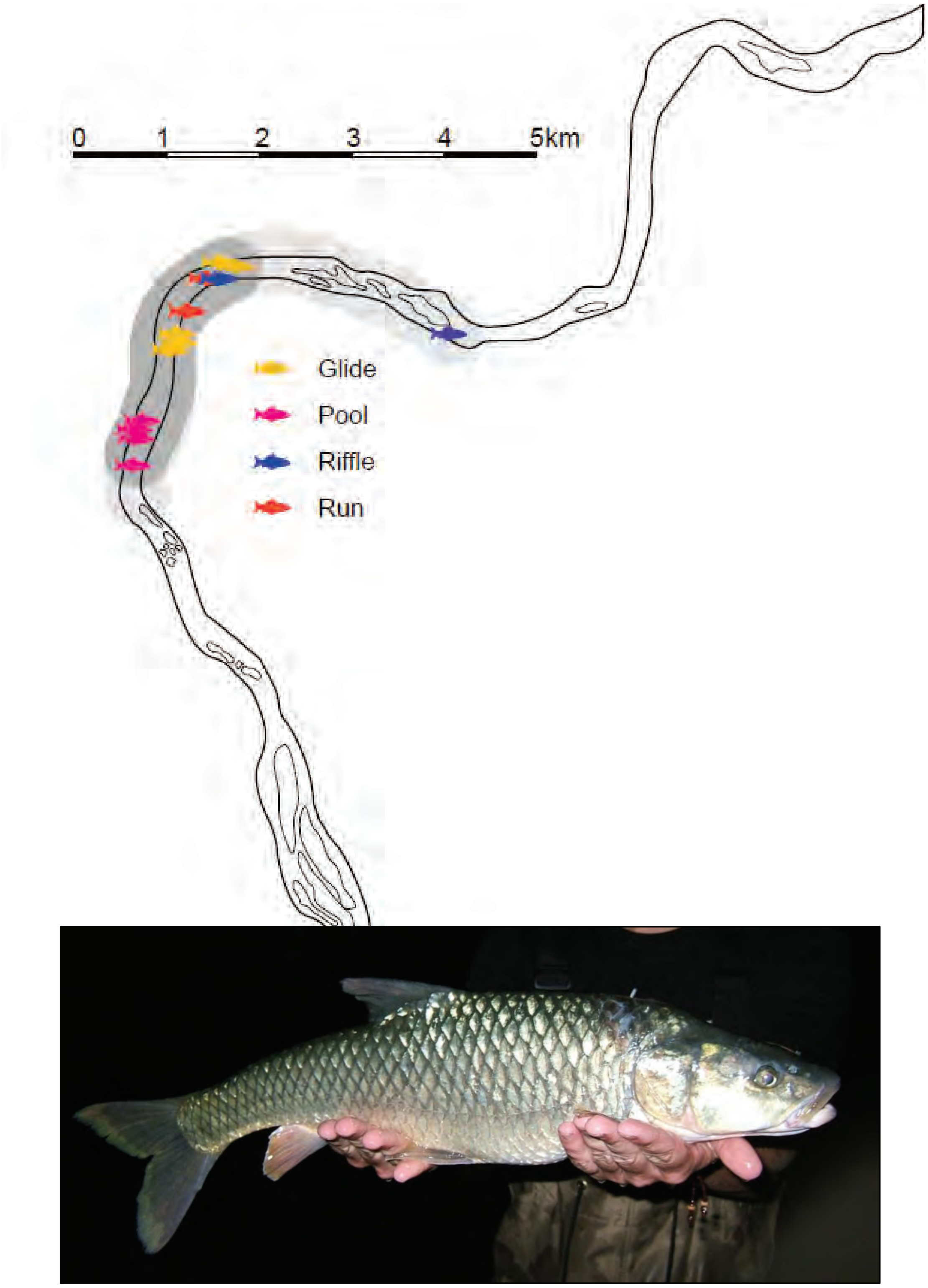
Appendix 43: Graphical representation of the home range of the 3.3 kg, Smallmouth yellowfish (*L. aeneus*) tagged with transmitter 142.083 at locality 1 in the study. This individual was monitored on 11 occasions from 2nd of September 2006 to the 21st of September 2006.



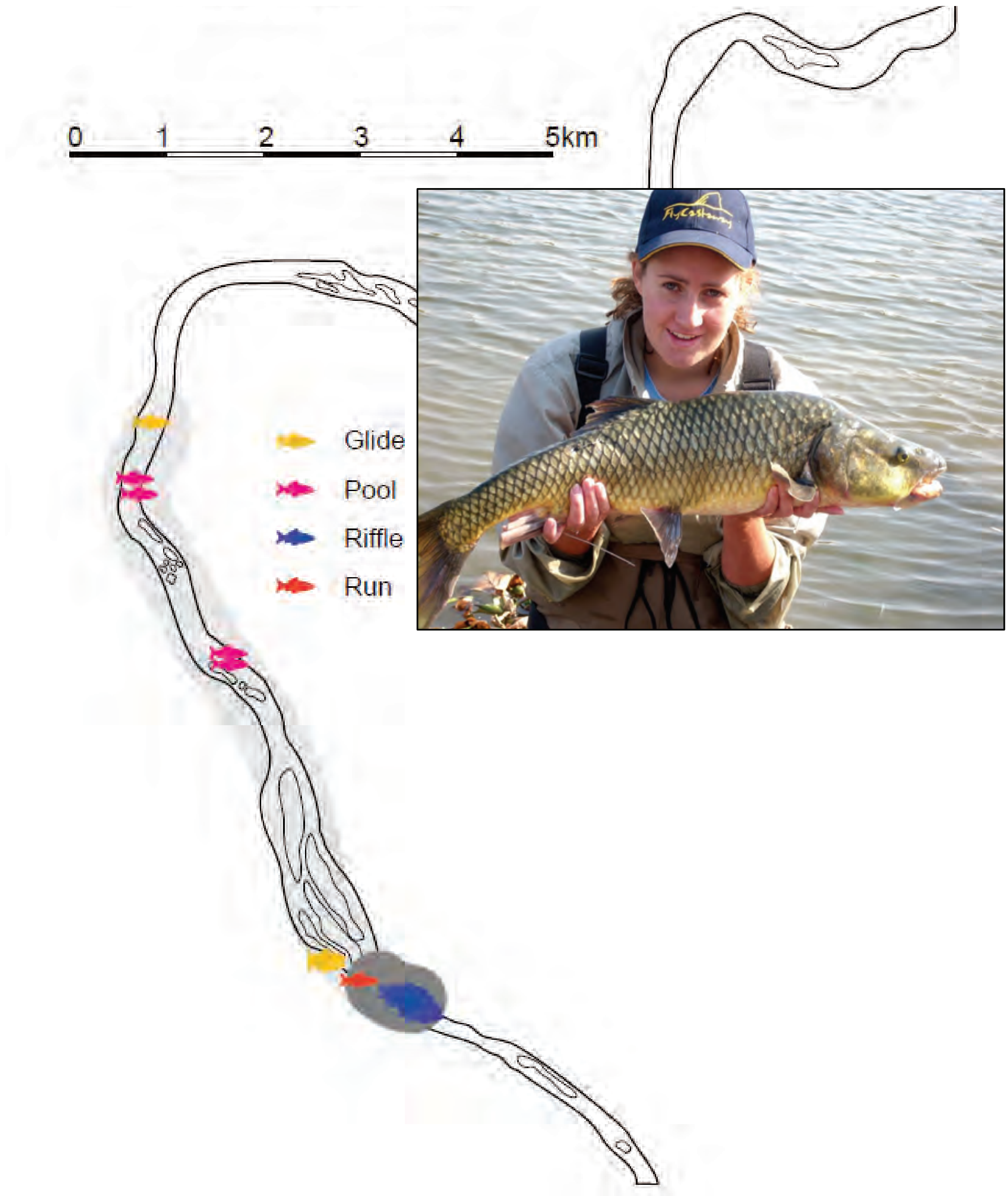
Appendix 44: Graphical representation of the home range of the 2.1 kg, Smallmouth yellowfish (*L. aeneus*) tagged with transmitter 142.203 at locality 1 in the study. This individual was monitored on 5 occasions from 19th of September 2007 to the 17th of October 2007.



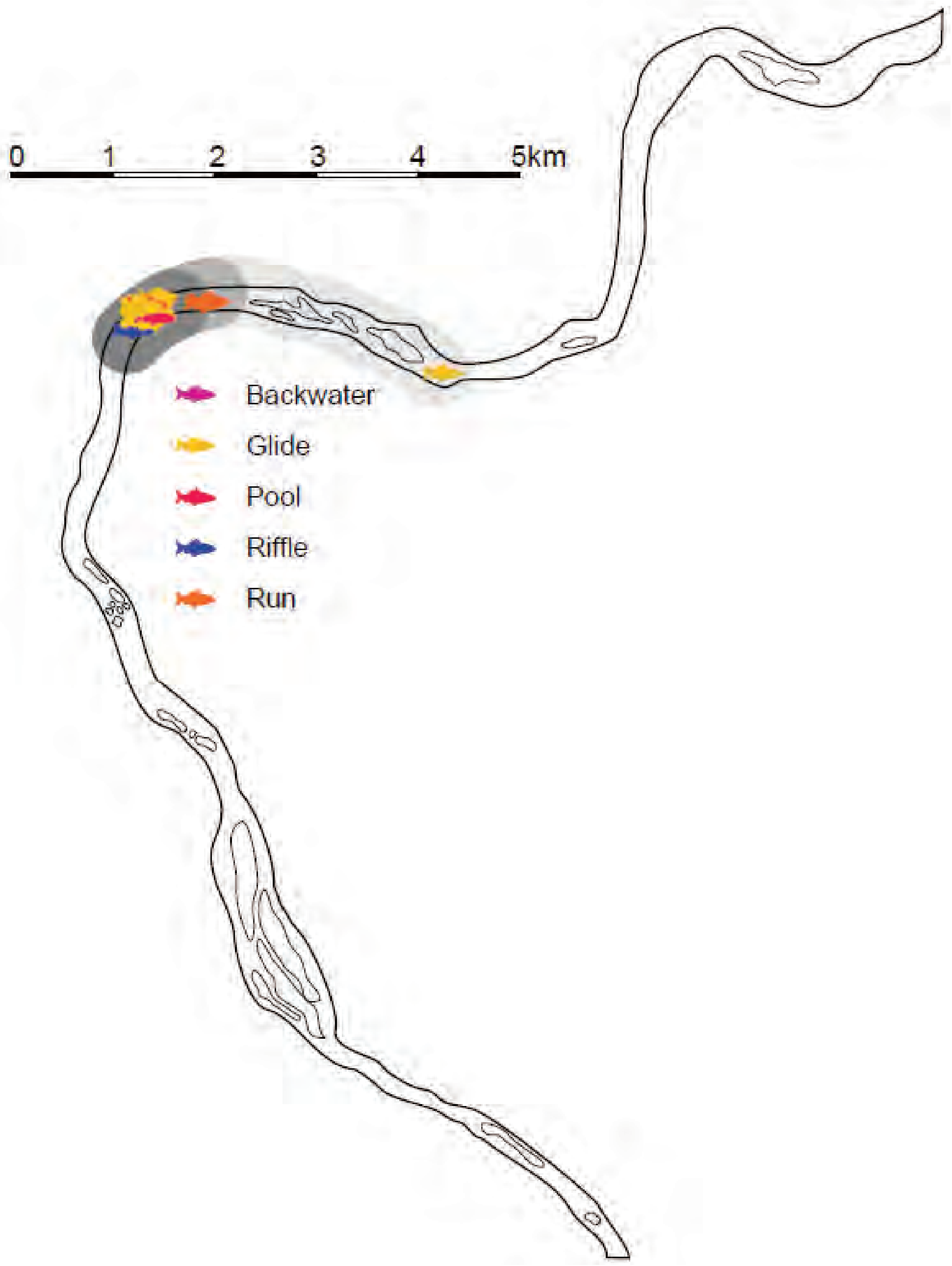
Appendix 45: Graphical representation of the home range of the 1.9 kg, Largemouth yellowfish (*L. kimberleyensis*) tagged with transmitter 142.224 at locality 1 in the study. This individual was monitored on 1 occasion after capture on the 13th of May 2007 on the 23rd of May 2007.



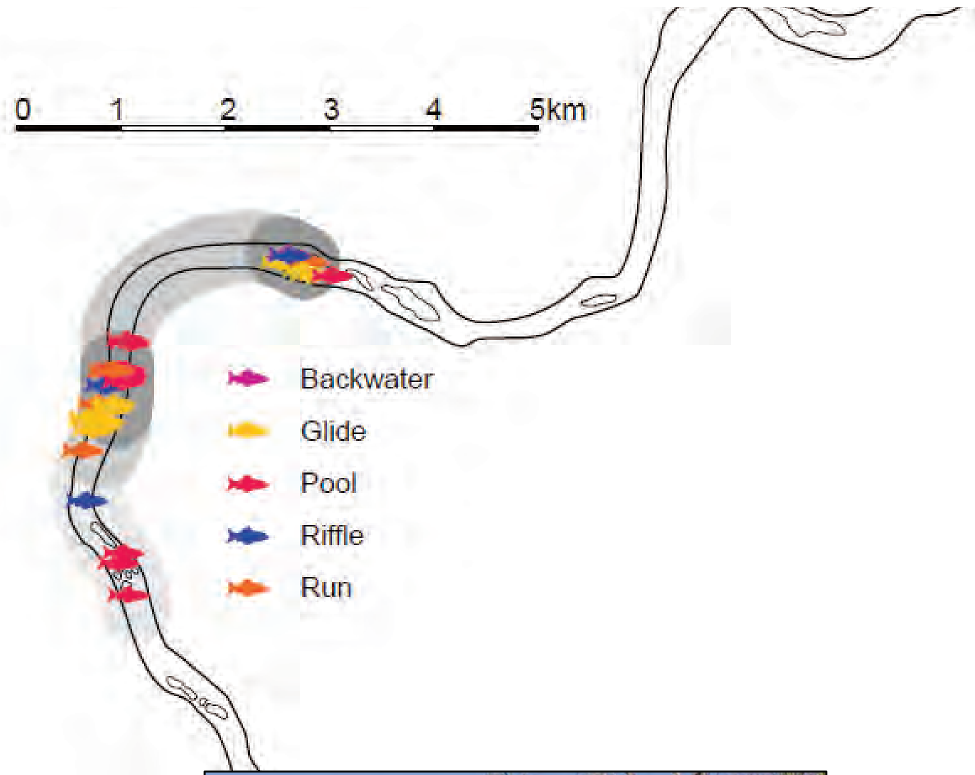
Appendix 46: Graphical representation of the home range of the 1.7 kg, Largemouth yellowfish (*L. kimberleyensis*) tagged with transmitter 142.234 at locality 1 in the study. This individual was monitored on 19 occasions from 15th of November 2006 to the 3rd of November 2007.



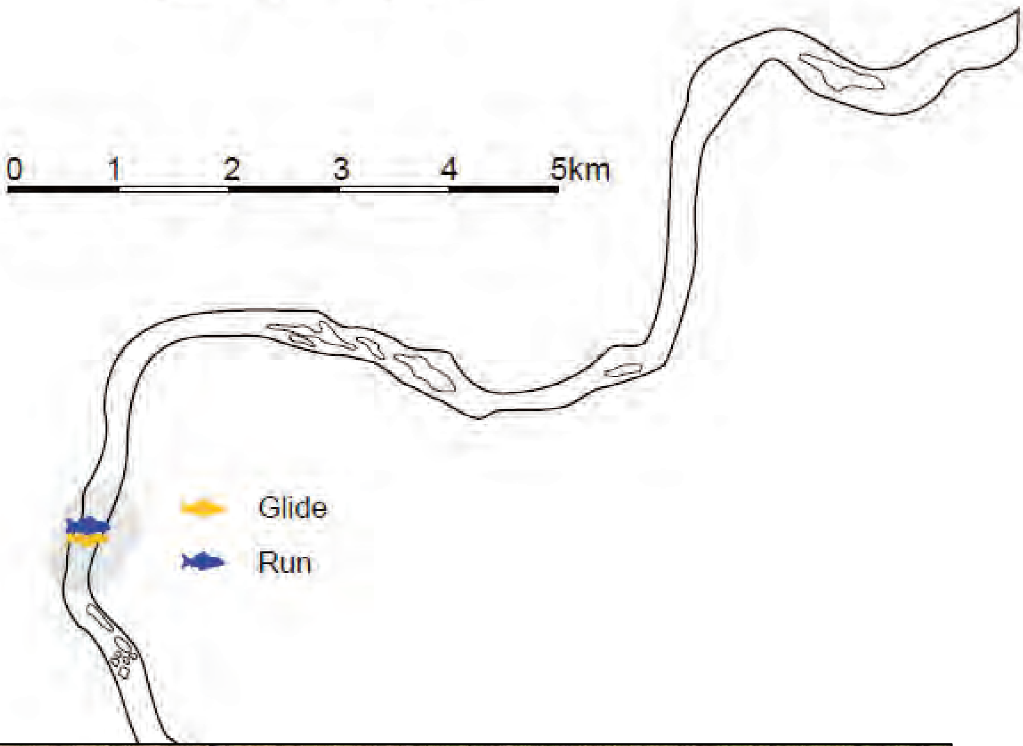
Appendix 47: Graphical representation of the home range of the 6.2 kg, Largemouth yellowfish (*L. kimberleyensis*) tagged with transmitter 142.262 at locality 1 in the study. This individual was monitored on 29 occasions from 2nd of June 2006 to the 26th of February 2008.



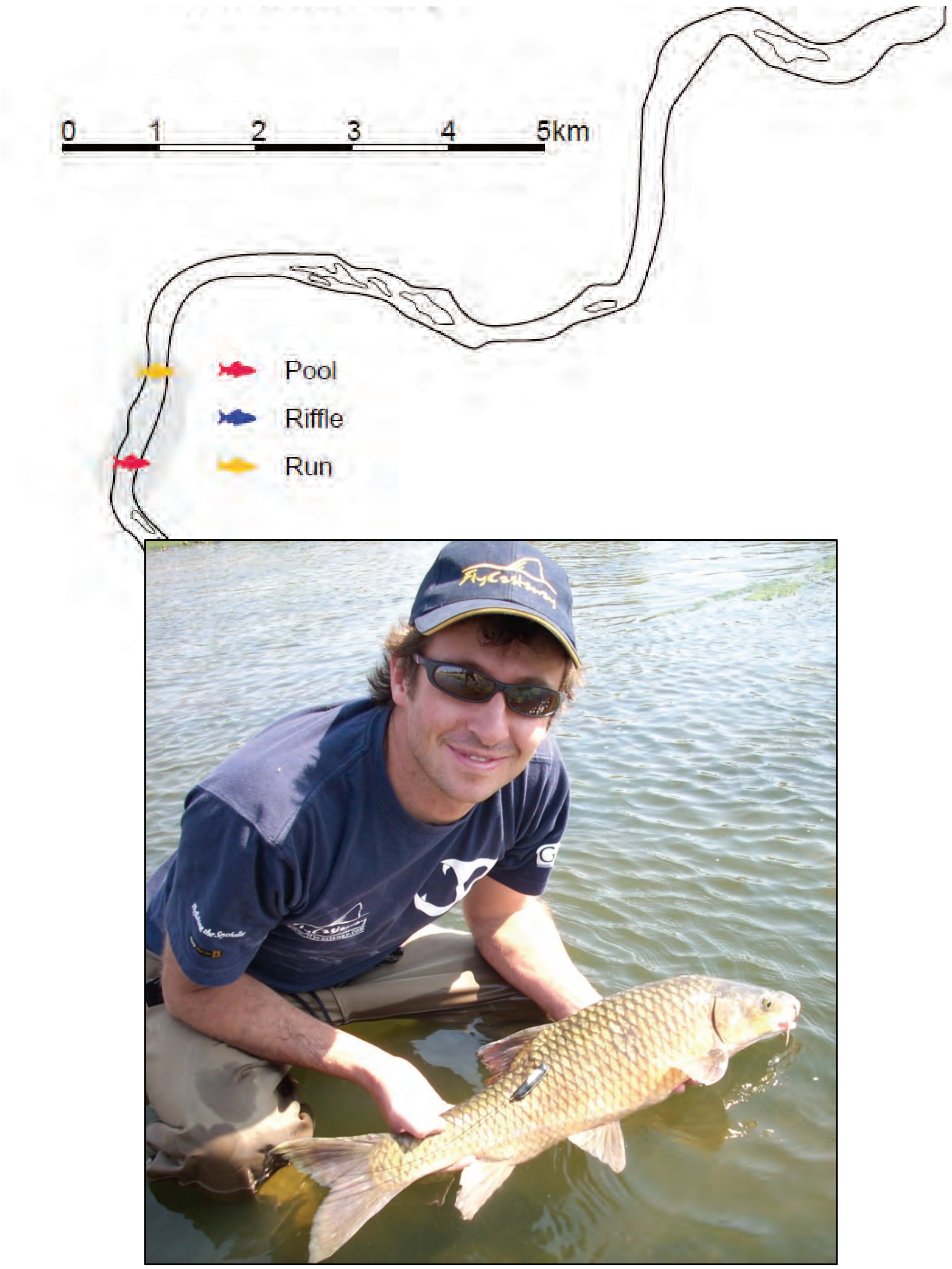
Appendix 48: Graphical representation of the home range of the 3.4 kg, Smallmouth yellowfish (*L. aeneus*) tagged with transmitter 142.322 at locality 1 in the study. This individual was monitored on 49 occasions from 9th of August 2006 to the 11th of December 2006.



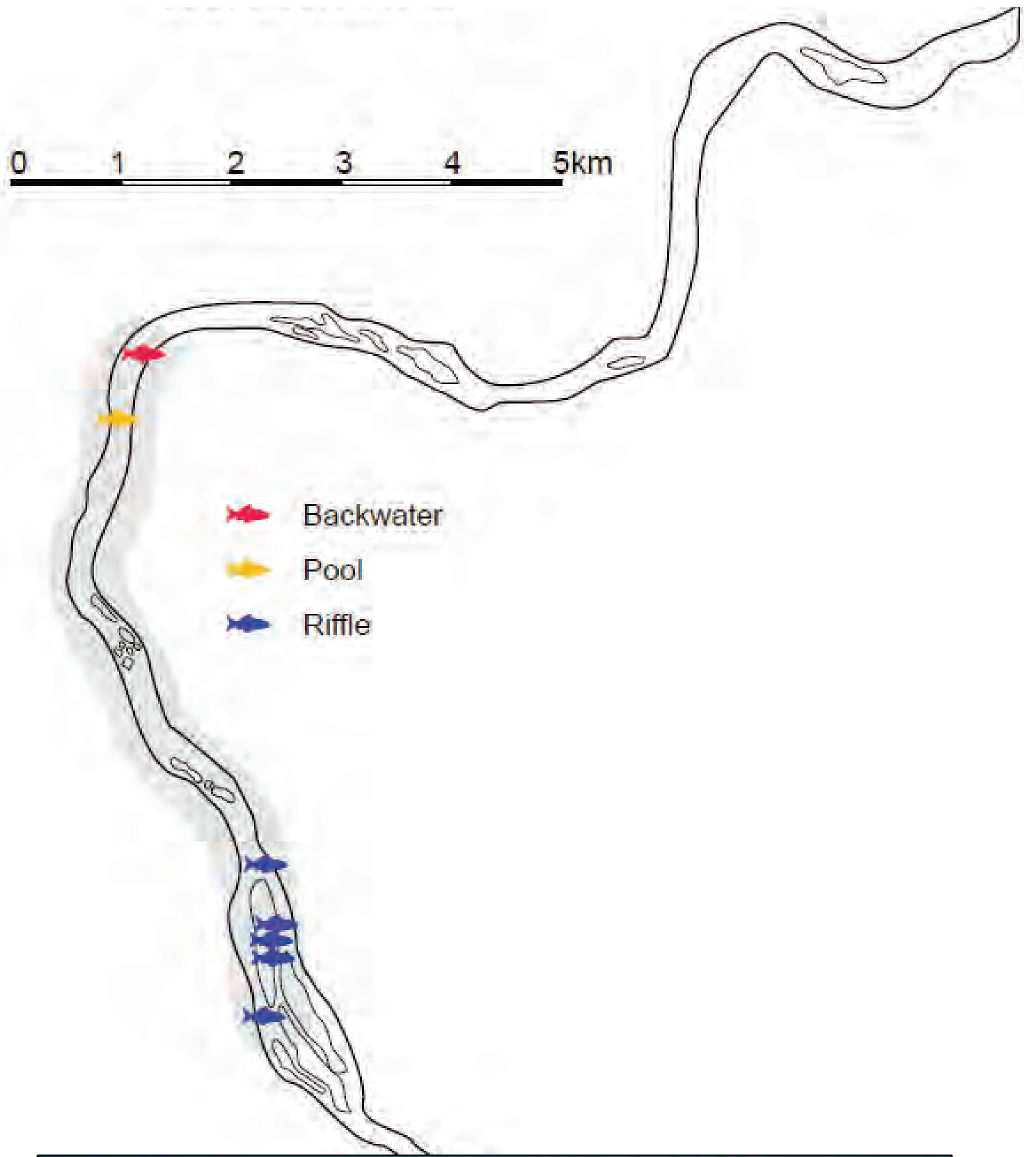
Appendix 49: Graphical representation of the home range of the 2.2 kg, Smallmouth yellowfish (*L. aeneus*) tagged with transmitter 142.333 at locality 1 in the study. This individual was monitored on 42 occasions from 7th of April 2006 to the 26th of October 2007.



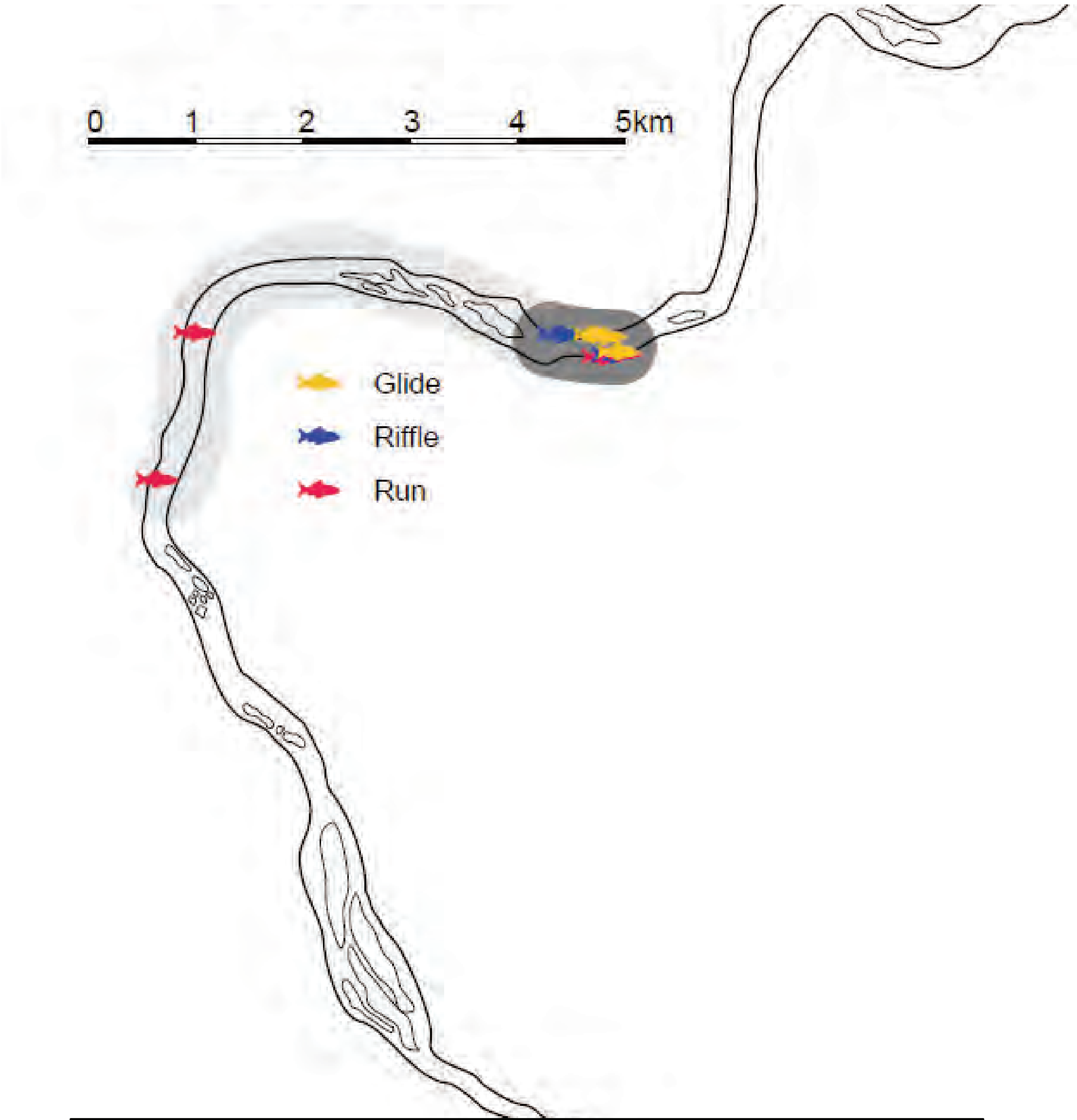
Appendix 50: Graphical representation of the home range of the 3.4 kg, Largemouth yellowfish (*L. kimberleyensis*) tagged with transmitter 142.351 at locality 1 in the study. This individual was monitored on 3 occasions from 14th of May 2007 to the 20th of May 2007.



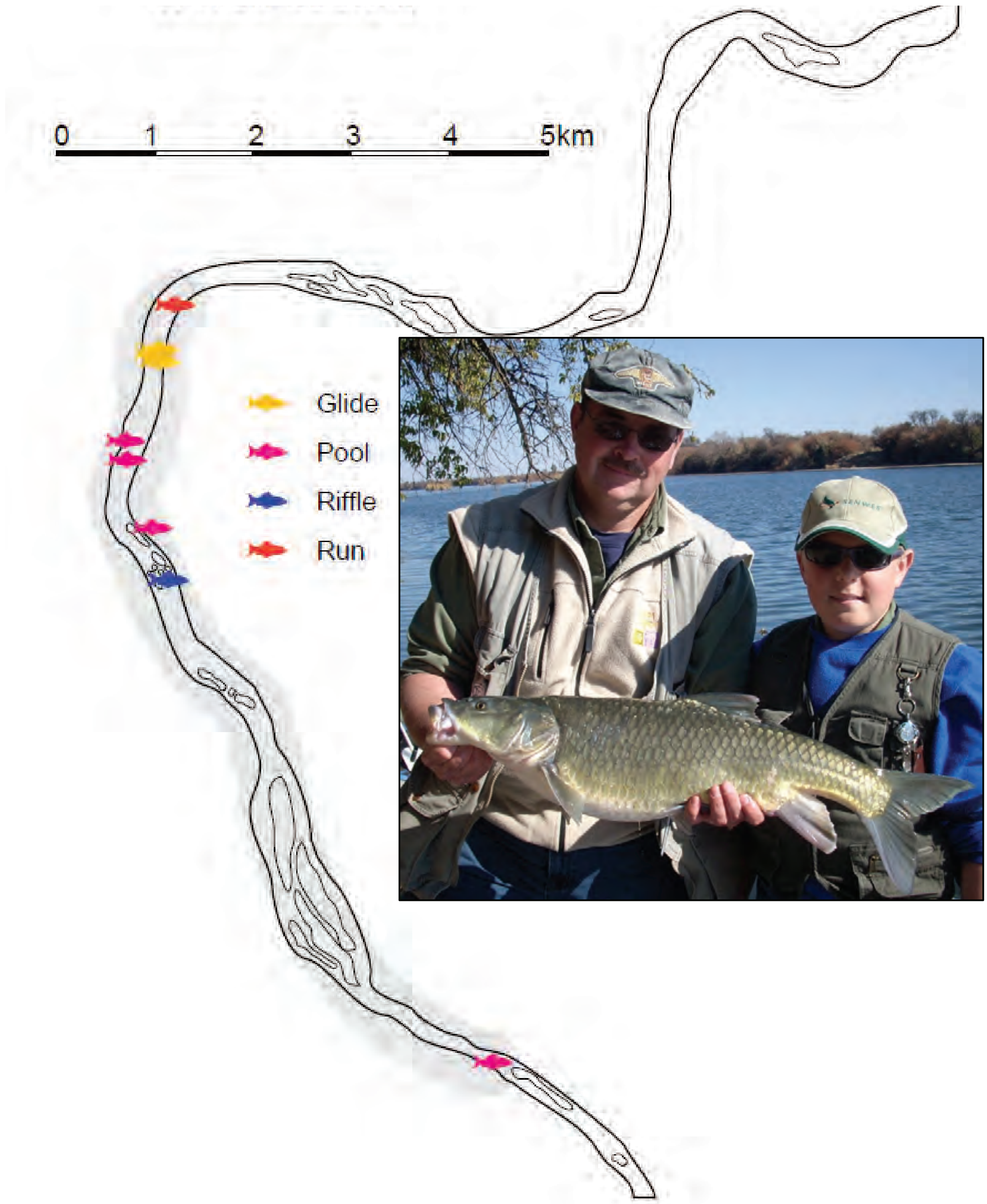
Appendix 51: Graphical representation of the home range of the 3 kg, Smallmouth yellowfish (*L. aeneus*) tagged with transmitter 142.363 at locality 1 in the study. This individual was monitored on 3 occasions from 30th of August 2007 to the 3rd of November 2007.



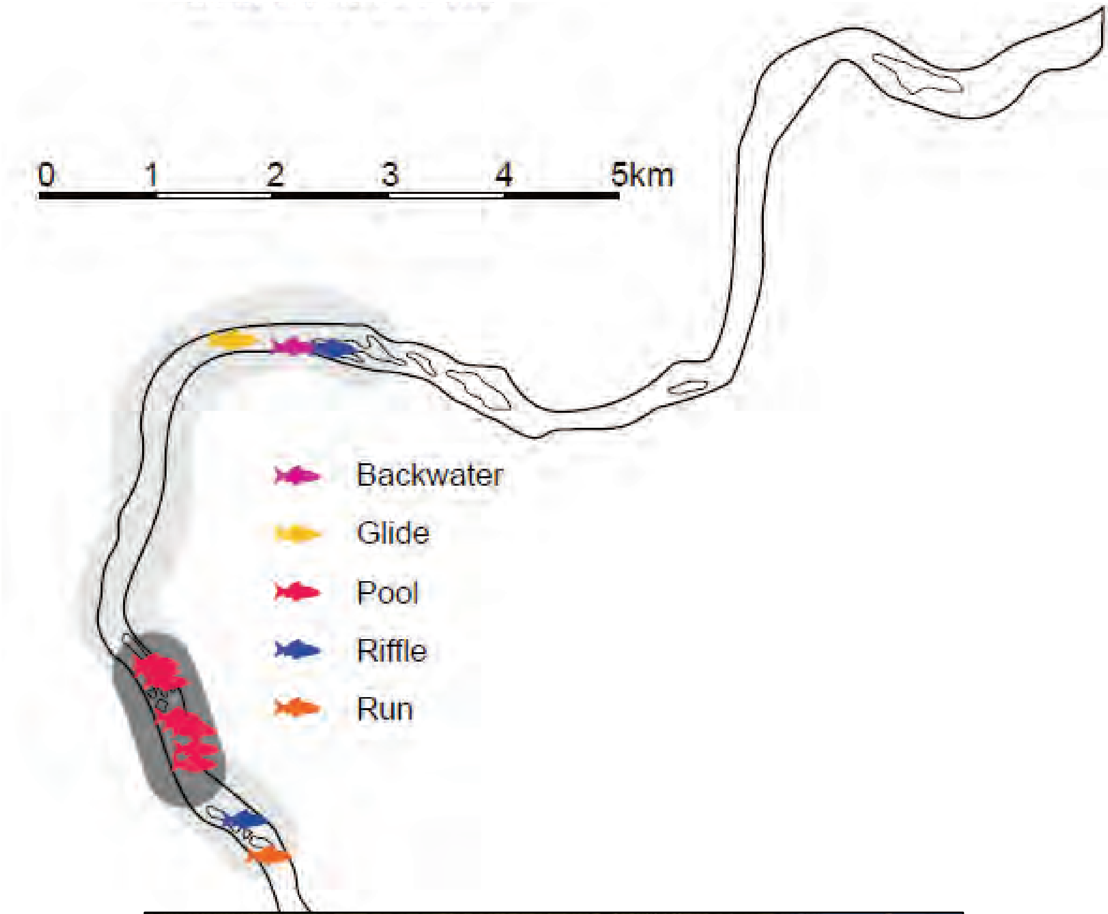
Appendix 52: Graphical representation of the home range of the 1.7 kg, Largemouth yellowfish (*L. kimberleyensis*) tagged with transmitter 142.373 at locality 1 in the study. This individual was monitored on 7 occasions from 14th of May 2007 to the 3rd of November 2007.



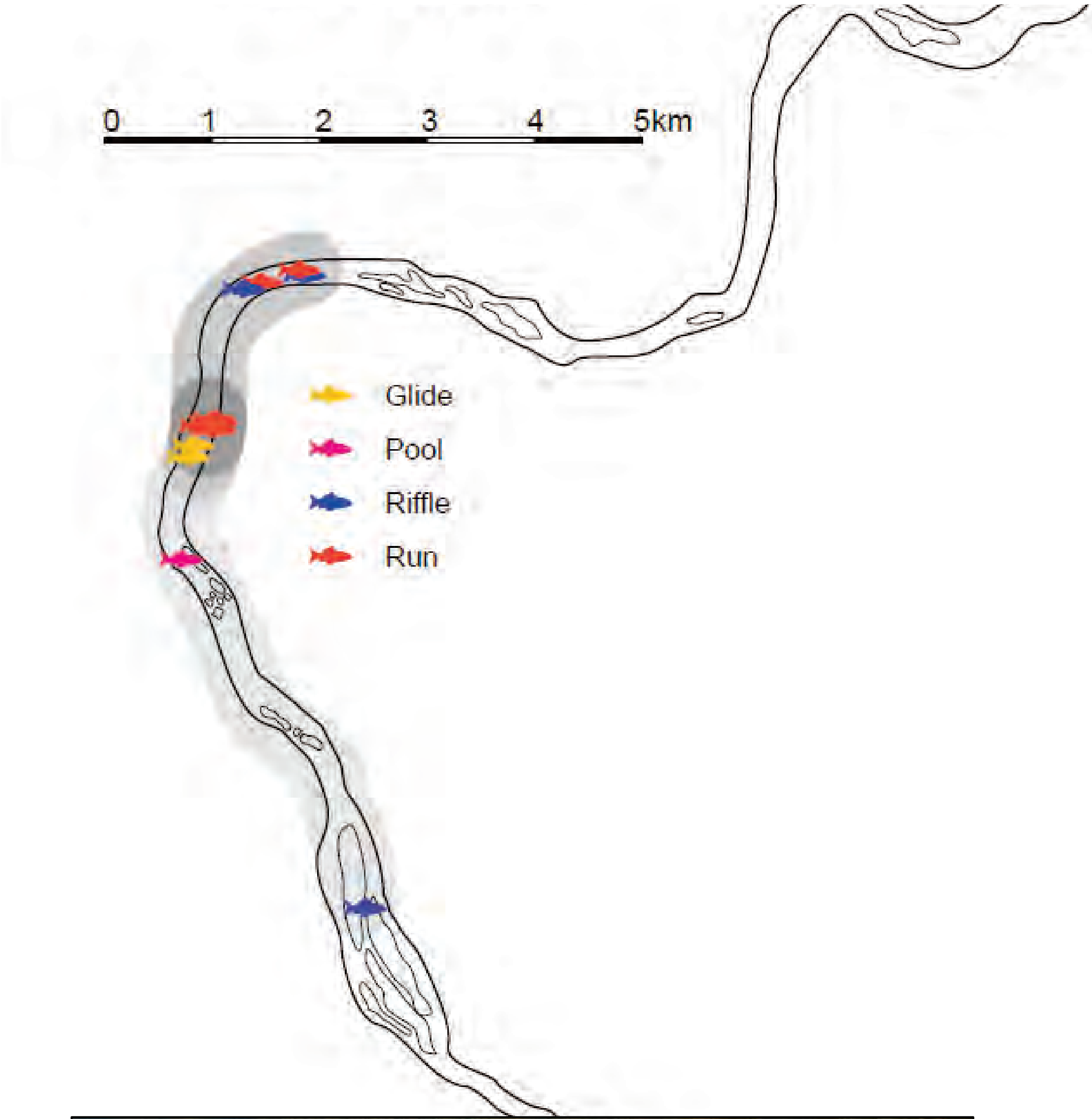
Appendix 53: Graphical representation of the home range of the 5 kg, Largemouth yellowfish (*L. kimberleyensis*) tagged with transmitter 142.383 at locality 1 in the study. This individual was monitored on 10 occasions from 30th of August 2006 to the 30th of January 2008.



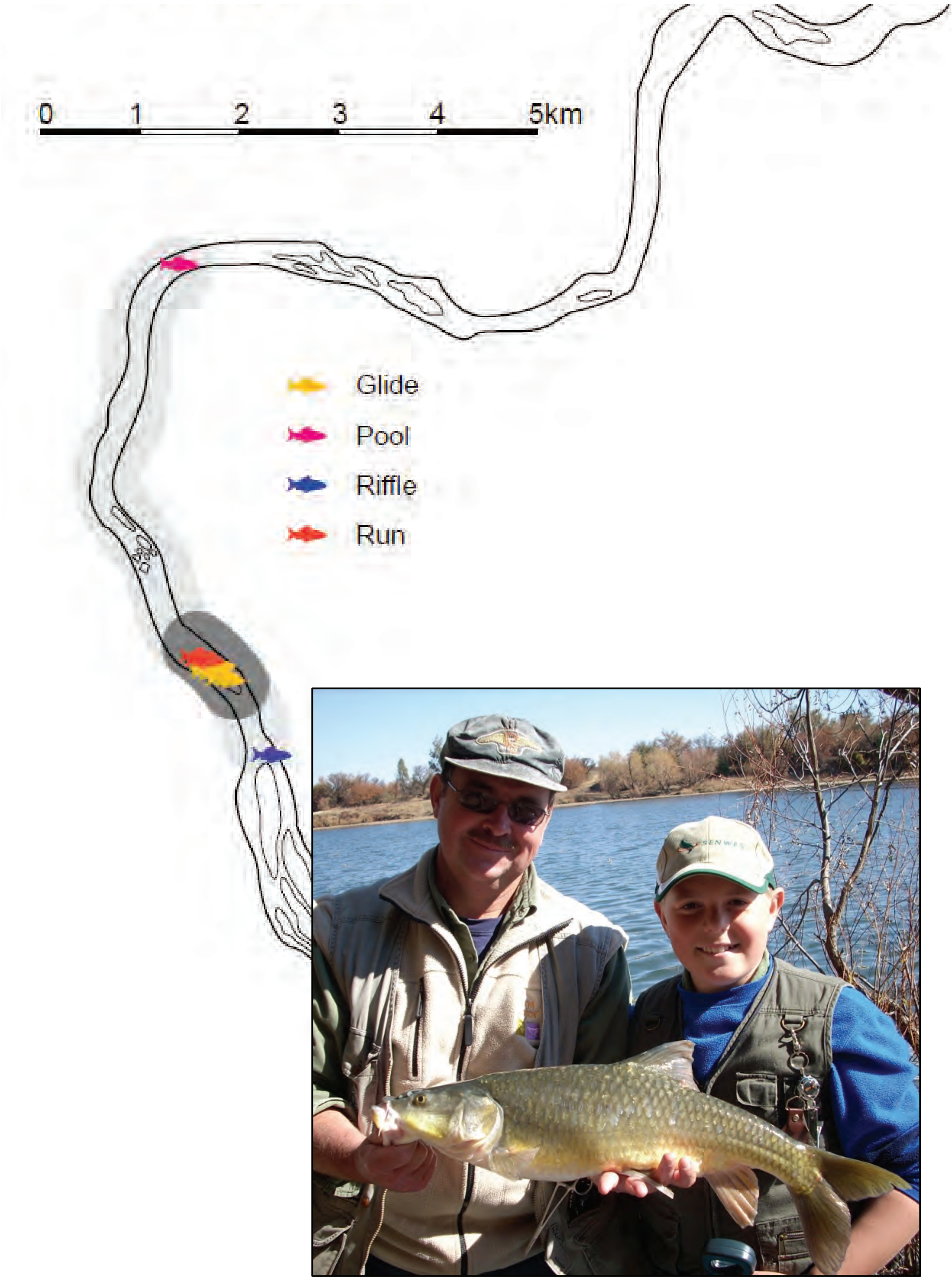
Appendix 54: Graphical representation of the home range of the 4.9 kg, Largemouth yellowfish (*L. kimberleyensis*) tagged with transmitter 142.402 at locality 1 in the study. This individual was monitored on 10 occasions from 7th of July 2007 to the 31st of August 2007.



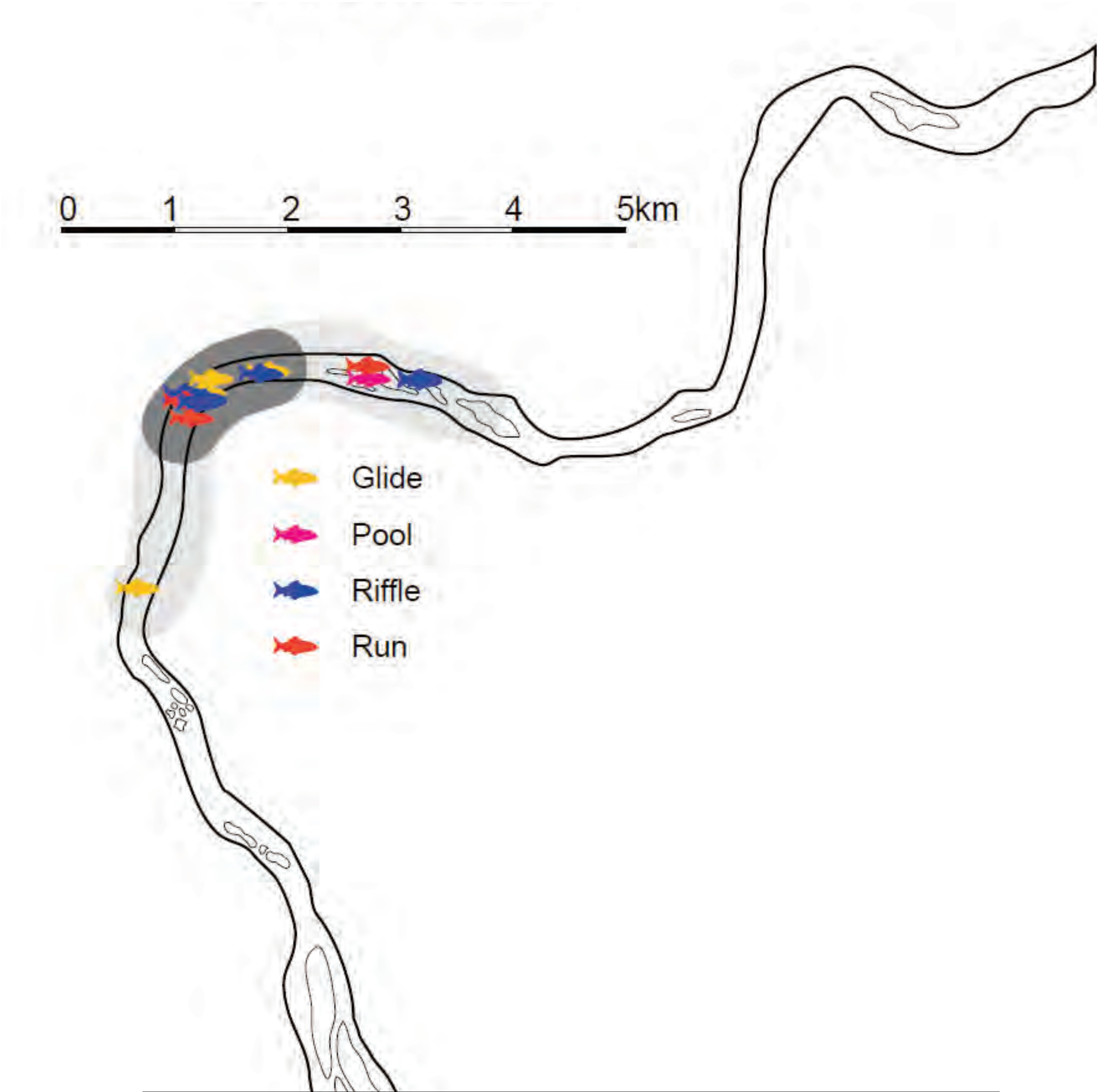
Appendix 55: Graphical representation of the home range of the 3 kg, Largemouth yellowfish (*L. kimberleyensis*) tagged with transmitter 142.424 at locality 1 in the study. This individual was monitored on 14 occasions from 14th of May 2007 to the 3rd of November 2007.



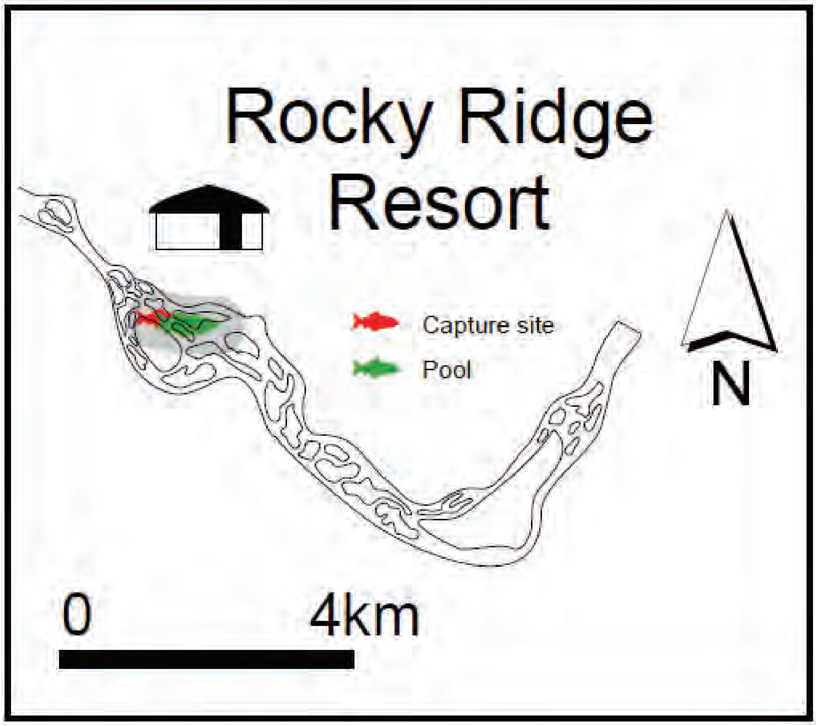
Appendix 56: Graphical representation of the home range of the 2 kg, Smallmouth yellowfish (*L. aeneus*) tagged with transmitter 142.435 at locality 1 in the study. This individual was monitored on 14 occasions from 12th of September 2007 to the 8th of March 2008.



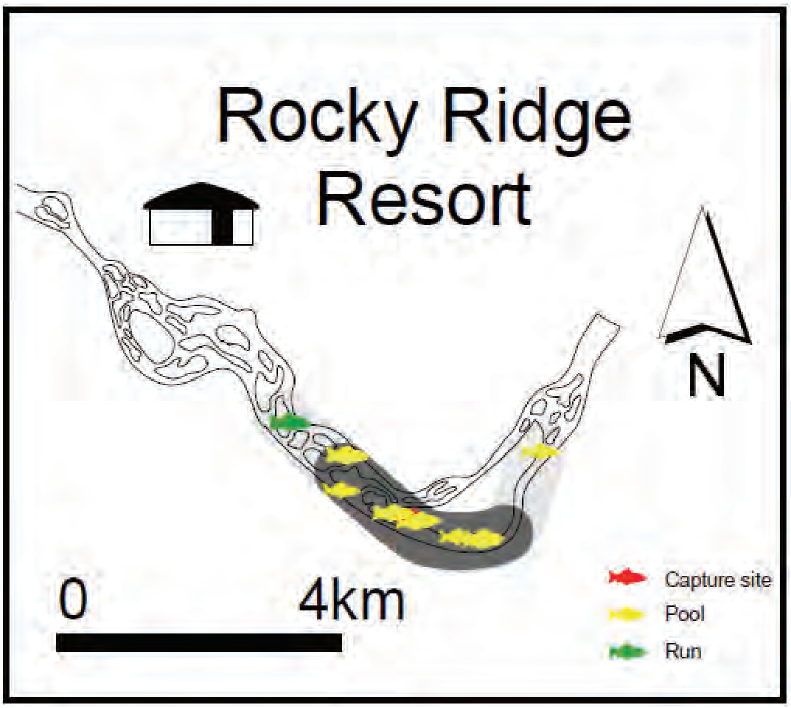
Appendix 57: Graphical representation of the home range of the 2.9 kg, Largemouth yellowfish (*L. kimberleyensis*) tagged with transmitter 142.442 at locality 1 in the study. This individual was monitored on 11 occasions from 7th of July 2007 to the 3rd of November 2007.



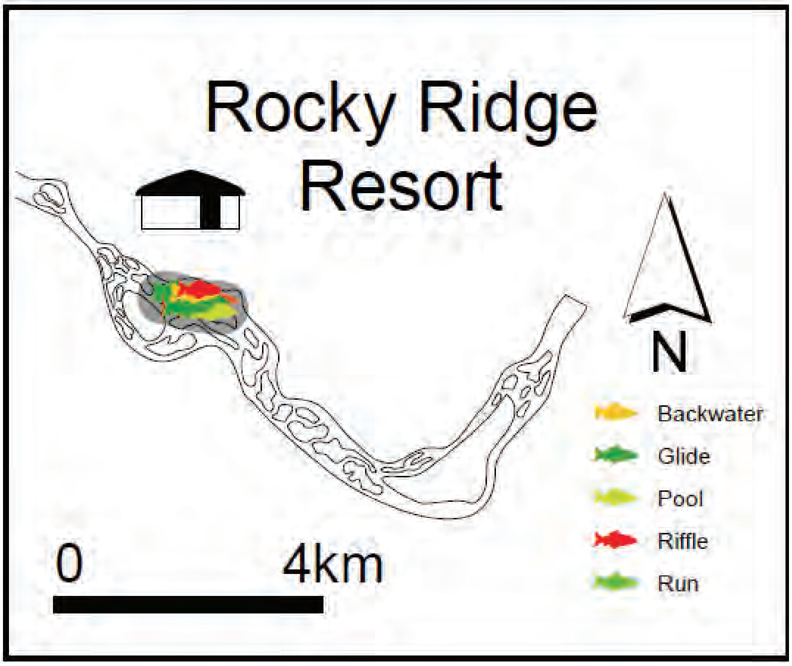
Appendix 58: Graphical representation of the home range of the 1.6 kg, Smallmouth yellowfish (*L. aeneus*) tagged with transmitter 142.466 at locality 1 in the study. This individual was monitored on 15 occasions from 2nd of September 2007 to the 20th of January 2008.



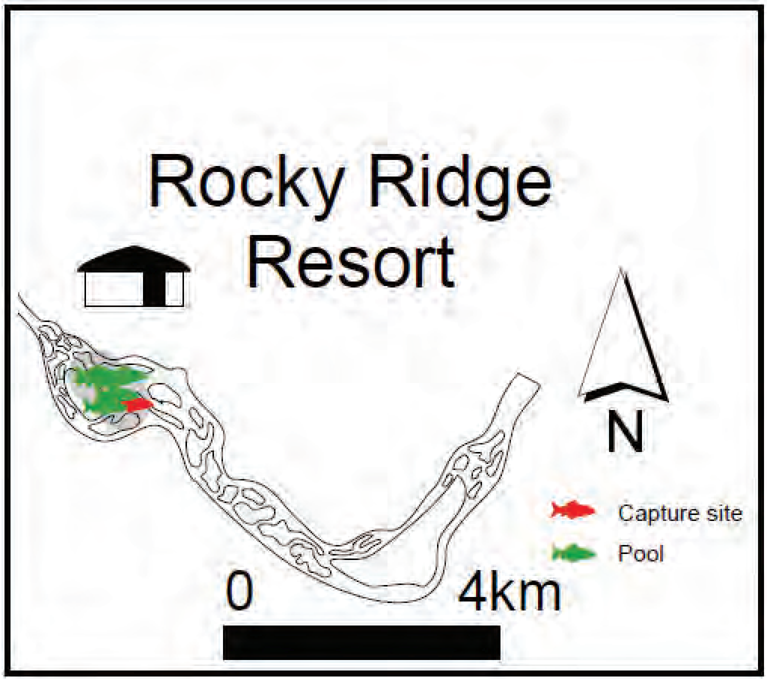
Appendix 59: Graphical representation of the home range of the 3.3 kg, Largemouth yellowfish (*L. kimberleyensis*) tagged with transmitter 142.213 at locality 2 in the study. This individual was monitored on 4 occasions from 27th of June 2009 to the 12th of July 2009.



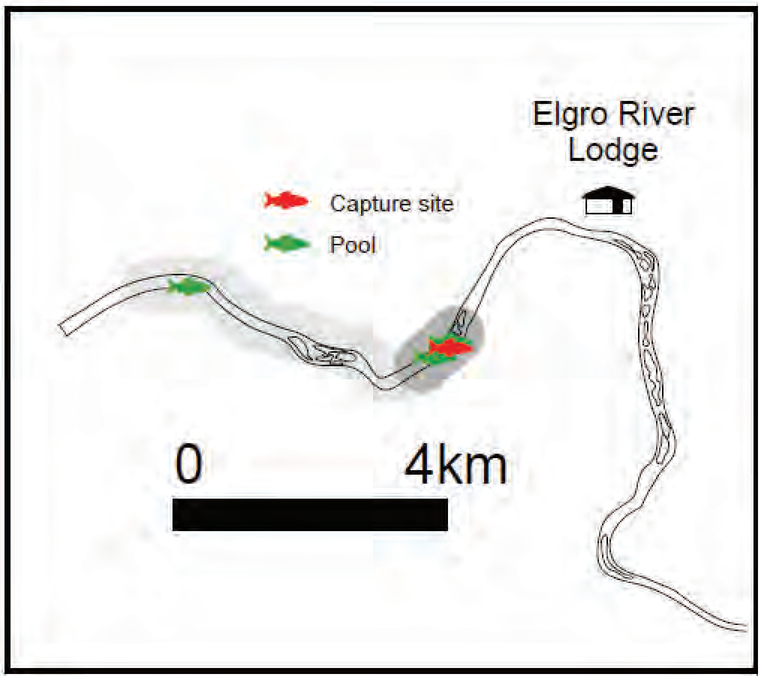
Appendix 60: Graphical representation of the home range of the 3.5 kg, Largemouth yellowfish (*L. kimberleyensis*) tagged with transmitter 142.242 at locality 2 in the study. This individual was monitored on 18 occasions from 20th of July 2009 to the 7th of May 2010.



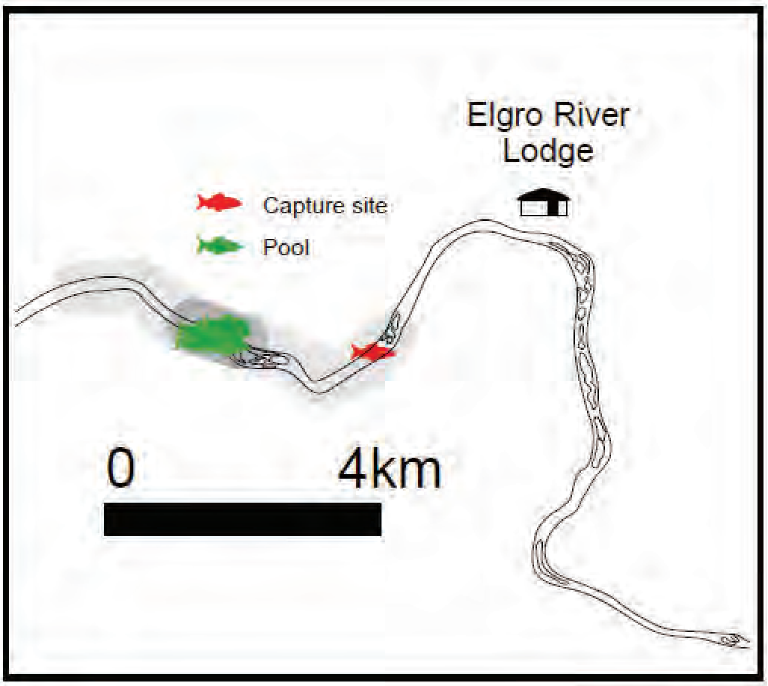
Appendix 61: Graphical representation of the home range of the 3 kg, Largemouth yellowfish (*L. kimberleyensis*) tagged with transmitter 142.253 at locality 2 in the study. This individual was monitored on 78 occasions from 26th of July 2009 to the 2nd of February 2010.



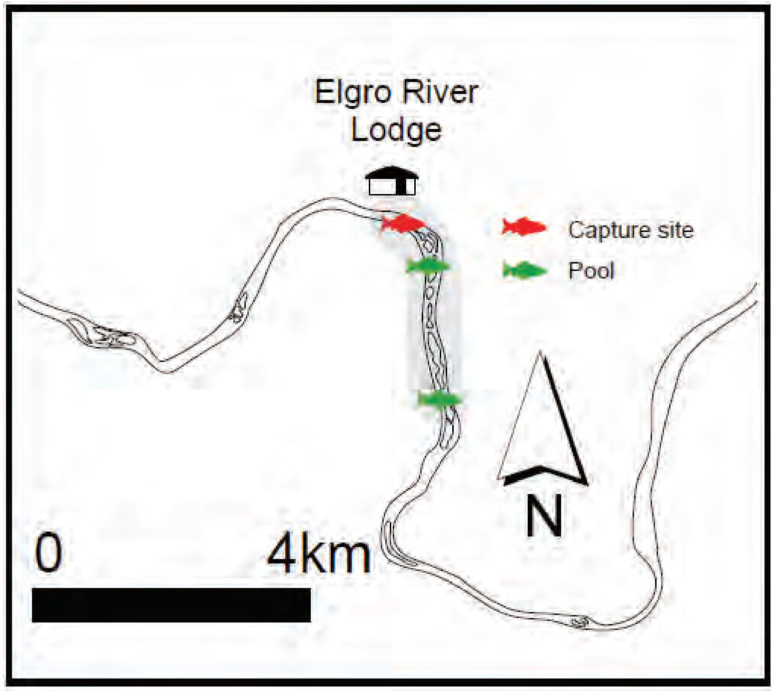
Appendix 62: Graphical representation of the home range of the 3 kg, Largemouth yellowfish (*L. kimberleyensis*) tagged with transmitter 142.261 at locality 2 in the study. This individual was monitored on 4 occasions from 7th of October 2010 to the 24th of August 2010.



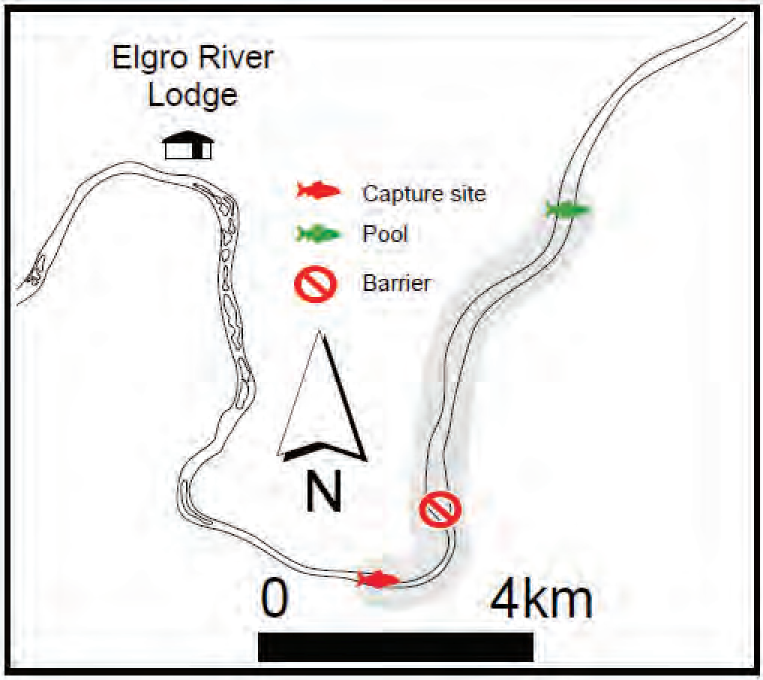
Appendix 63: Graphical representation of the home range of the 3.5 kg, Largemouth yellowfish (*L. kimberleyensis*) tagged with transmitter 142.272 at locality 2 in the study. This individual was monitored on 2 occasions from 22nd of July 2009 to the 7th of May 2010.



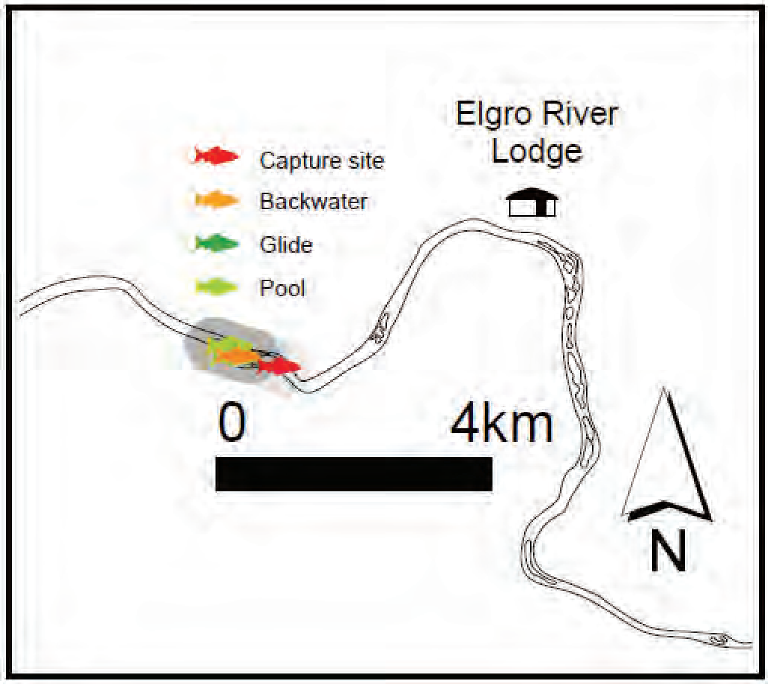
Appendix 64: Graphical representation of the home range of the 3.7 kg, Largemouth yellowfish (*L. kimberleyensis*) tagged with transmitter 142.281 at locality 2 in the study. This individual was monitored on 26 occasions from 22nd of July 2009 to the 8th of December 2009.



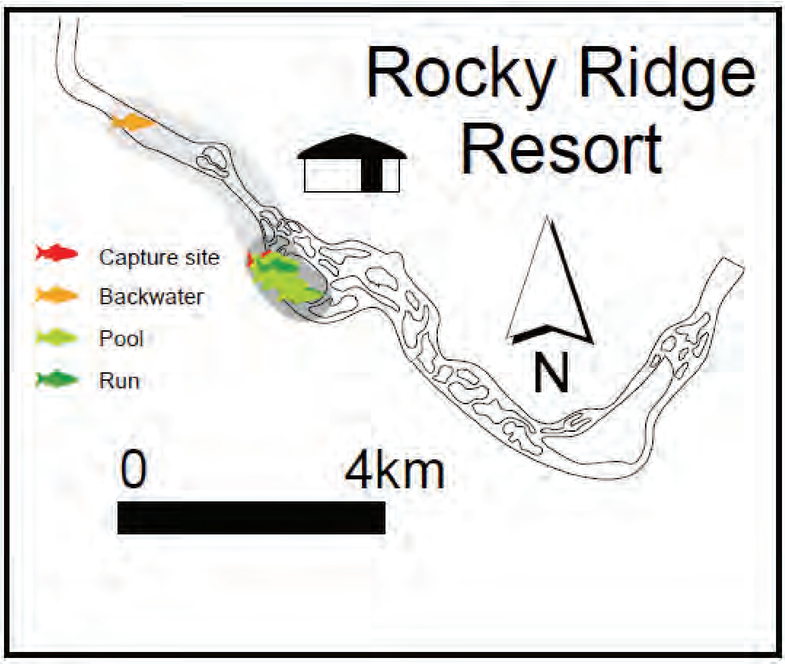
Appendix 65: Graphical representation of the home range of the 2 kg, Largemouth yellowfish (*L. kimberleyensis*) tagged with transmitter 142.283 at locality 2 in the study. This individual was monitored on 8 occasions from 21st of May 2009 to the 22nd of September 2009.



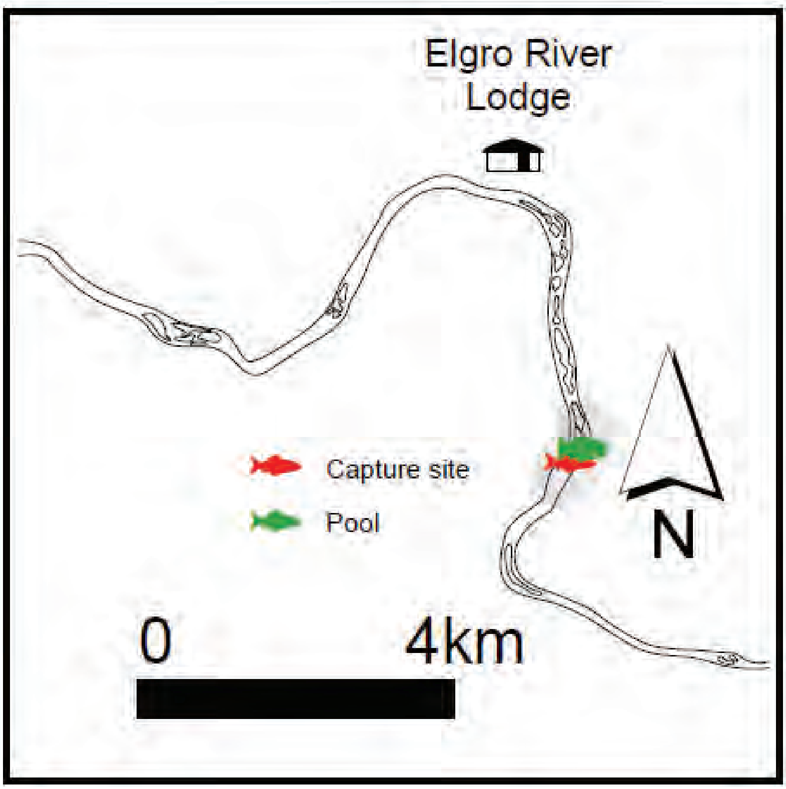
Appendix 66: Graphical representation of the home range of the 4.2 kg, Largemouth yellowfish (*L. kimberleyensis*) tagged with transmitter 142.302 at locality 2 in the study. This individual was monitored on 2 occasions from 22nd of May 2009 to the 7th of May 2010.



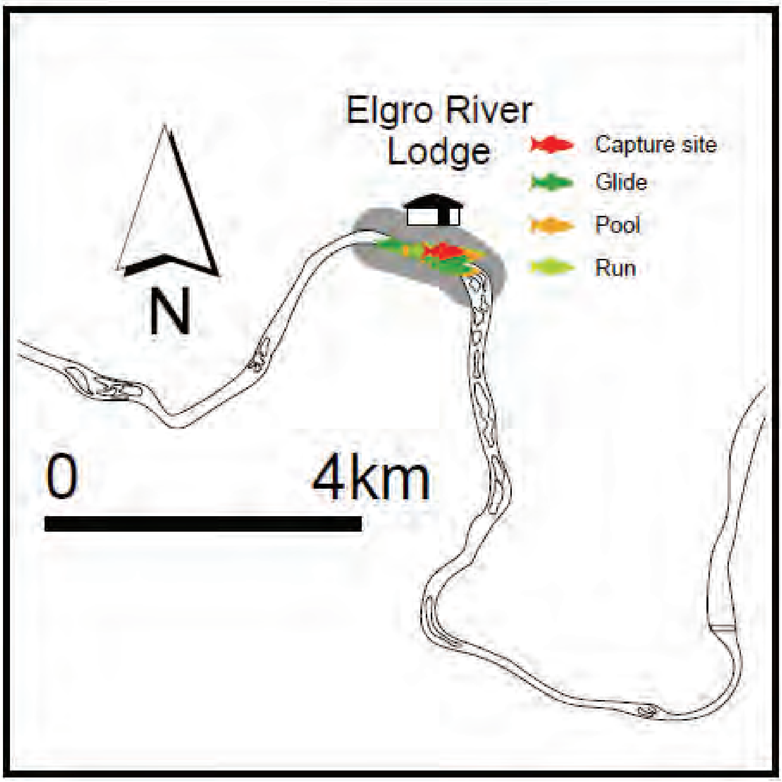
Appendix 67: Graphical representation of the home range of the 5.8 kg, Largemouth yellowfish (*L. kimberleyensis*) tagged with transmitter 142.322 at locality 2 in the study. This individual was monitored on 26 occasions from 26th of May 2009 to the 16th of November 2009.



Appendix 68: Graphical representation of the home range of the 4.1 kg, Largemouth yellowfish (*L. kimberleyensis*) tagged with transmitter 142.331 at locality 2 in the study. This individual was monitored on 18 occasions from 26th of July 2009 to the 7th of May 2010.



Appendix 69: Graphical representation of the home range of the 3.5 kg, Largemouth yellowfish (*L. kimberleyensis*) tagged with transmitter 142.351 at locality 2 in the study. This individual was monitored on 2 occasions from 29th of June 2009 to the 2nd of August 2009.



Appendix 70: Graphical representation of the home range of the 2.7 kg, Smallmouth yellowfish (*L. aeneus*) tagged with transmitter 142.402 at locality 2 in the study. This individual was monitored on 546 occasions from 3rd of April 2009 to the 16th of May 2010.