

Control of feral Goldfish (*Carassius auratus*) in the Vasse River



Report to the Vasse-Wonnerup LCDC

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Project outline and background

The fish fauna of the Vasse River was documented in the following report:

Morgan, D. & Beatty, S. (2004). *Fish fauna of the Vasse River and the colonisation by feral goldfish (*Carassius auratus*)*. Report to Fishcare WA and Geocatch.

Report is available as a pdf at www.scieng.murdoch.edu.au/centres/fish/CurRes%20Freshwater.htm

Recommendations in the above report outlined the need to implement an eradication, or control, program for feral Goldfish (*Carassius auratus*). In that report it was suggested that the introduction of Goldfish into the Vasse River was a relatively recent event and the dominance of juveniles born in October 2003 year could result in a rapid increase in the population over the following years. Preliminary determination of growth rates of Goldfish in the Vasse River indicated that they far exceeded those reported elsewhere for the species. Goldfish are known to be vectors for disease introduction, may prey on native fishes and their eggs and larvae, reduce aquatic plant biomass and re-suspend nutrients further fuelling algal blooms. Furthermore, recent studies have demonstrated that significant growth of cyanobacteria (blue-green algae) is stimulated by the passage through Goldfish intestines (Kolmakov and Gladyshev 2003). Goldfish were shown to consume large amounts of blue-green algae in the Vasse River and they attained lengths of over 40 cm in the Vasse River, and therefore have the potential to contribute to algal blooms. The Goldfish eradication program provides an opportunity to gain an understanding of their biology and ecological impact in the system, particularly with regard to their role in algal blooms.

The Vasse-Wonnerup Land Conservation District Committee funded the Goldfish Control Program in March 2005.

Methodology

During 2003/4 (see Morgan and Beatty 2004) Goldfish were found to be concentrated within specific areas of the Vasse River (see Figure 1). During March 2005 these same areas were the focus of the control program. A generator-powered electrofisher was used in combination with monofilament gill nets to capture the Goldfish between the 17th and 18th March 2005 (Figure 2).

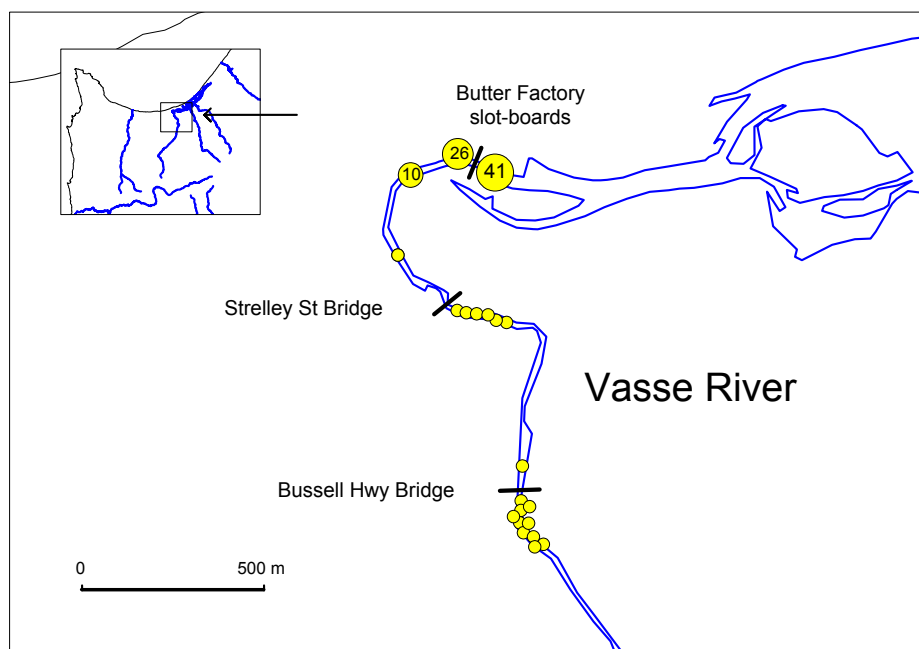


Figure 1 The location (and number) of Goldfish (*Carassius auratus*) captured in the Vasse River during March 2003 and December 2004.

The electrofisher was deployed from a boat ~500 m upstream of the Bussell Hwy Bridge to immediately downstream of the Old Butter Factory slot boards (Figure 1), during which time the majority of this section of the river was electrofished (Figure 2). This was repeated over two successive days. The latitude and longitude of each Goldfish capture was recorded using a GPS and a map of the distribution of Goldfish captures (see above Figure 1) was produced using the MapInfo™ program.

Each Goldfish captured was placed immediately in an ice slurry and, upon return to the laboratory, measured to the nearest 1 mm total length (TL) and weighed to the nearest 1 mg (see Figure 3). A length-weight relationship was produced via testing a number of models and the one that provided the greatest R^2 value adopted as the best fit of the data.

The number of translucent zones of the otoliths (ear bones) is commonly used to determine the age of fish as they are generally laid down annually as a consequence of seasonal variations in water temperature, day-length etc, in much the same way that trees develop growth rings. As there appeared to be distinct cohorts of Goldfish present in our samples (see Figure 4), the otoliths of each Goldfish were removed and viewed through a dissecting microscope using reflected light. The number of translucent zones was counted and it was assumed that these corresponded to year classes (while not specifically validated here, this technique has been validated for the majority of native freshwater fishes in south-western Australia and also for an introduced fish in the region (e.g. Morgan *et al.* 1995, 2000, 2002)). A length-frequency distribution was produced separately for those Goldfish captured in December 2003, March 2004 and March 2005 and was split for each year class, based on the age from otoliths (see Figure 4).

The length of each individual was plotted against its age and a preliminary growth curve (see Figure 5) was fitted using a von Bertalanffy equation with October 1 as an estimated birth date. This estimate was made from the small size of individuals captured in December and from the capture of larval (newly-hatched) Goldfish in other parts of south-western Australia, specifically, North Lake, during early spring.

The von Bertalanffy growth curve is $L_t = L_\infty[1 - e^{-K(t-t_0)}]$, where L_t is the length at age t (years), L_∞ is the asymptotic length of the population, K is the growth coefficient and t_0 is the hypothetical age at which the fish would have zero length.

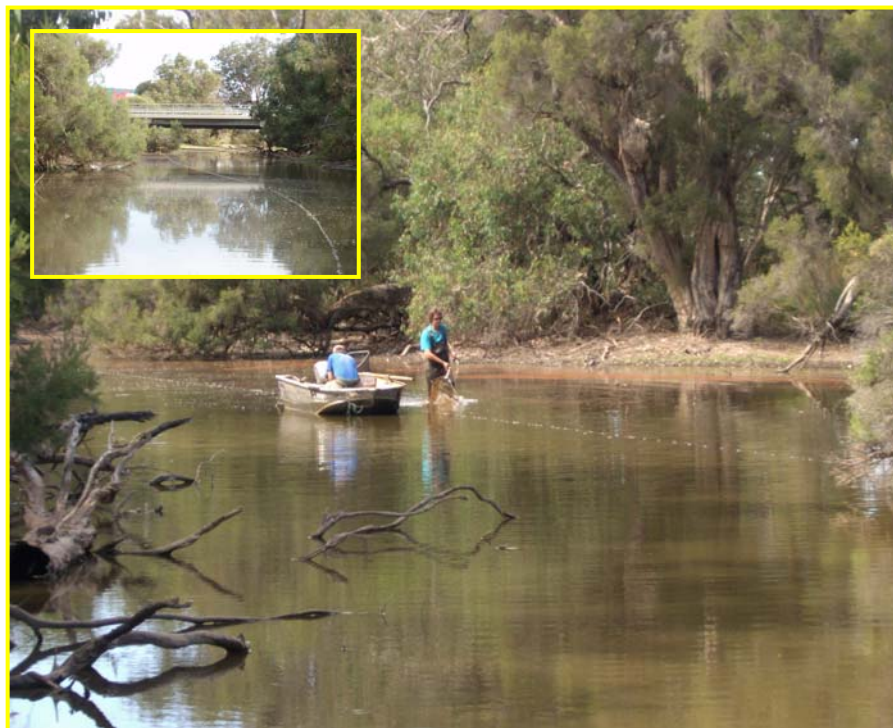


Figure 2 Gill nets and a generator-powered electrofisher were used to capture the Goldfish (Vasse River upstream of Bussell Highway).

Results of the Goldfish control program

During March 2005 (over two days), a total of 105 Goldfish were captured. Approximately 76% of these belonged to the 0+ age class, i.e. they were in their first year of life (Figures 4 and 5). The remaining fish varied in age up to being in their sixth year of life (i.e. 5+) (Figure 4), an age that likely coincided within a year or two after their initial introduction to the Vasse River.

The largest fish captured was 410 mm TL and weighed approximately 1.5 kg. The higher proportion of larger fish captured during 2005 was probably a result of the lower water levels encountered as a result of the removal of the slot boards at the Old Butter Factory which are usually inserted to maintain water levels. Similar to the results of the previous fish survey, fish were concentrated around the slot boards, upstream of Bussell Highway and upstream of the Strelley Street Bridge.

The success of the control program was more apparent in some locations compared to others. The specific electrofisher used is most efficient in water depths of <1.5 m, yet fish that are ‘hit’ can readily escape if they are on the edge of the electrocution field. The use of strategically placed gill nets aids in restricting the movements (escape) of fish. For example, during the first day of electrofishing 16 Goldfish were captured upstream of the Bussell Highway Bridge (see Figure 2), yet on day 2 not one was captured or seen. We are confident that as there was little connectivity to the downstream sites, we effectively eradicated the Goldfish from this part of the river which is <1 m deep and narrow. Approximately half of the juvenile Goldfish captured were captured below the slot boards. On each sampling day 21 juvenile Goldfish were captured below the slot boards. All Goldfish captured were invariably found to be associated with structures, e.g. bridges, snags, shady areas.

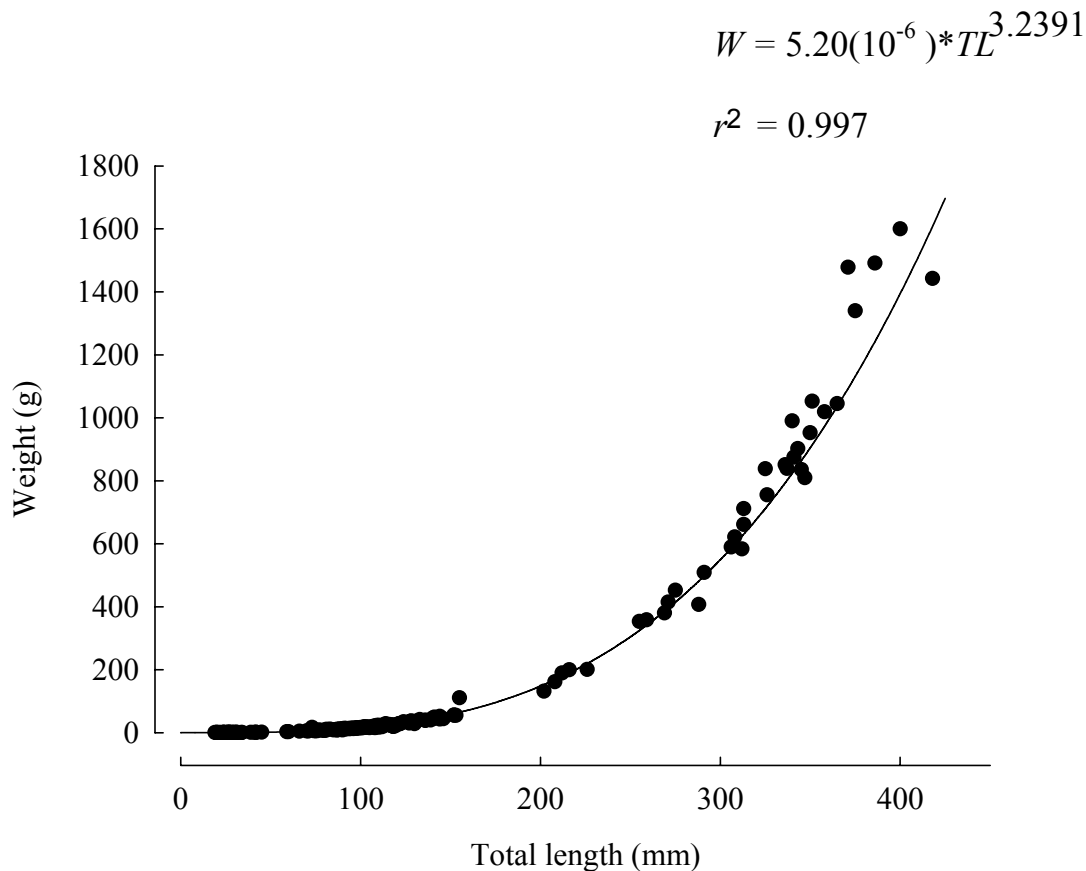


Figure 3 Length-weight relationships of the Goldfish captured in the Vasse River during December 2003, March 2004 and March 2005. In the given equation, W = weight (g) and TL = total length (mm) of the fish.

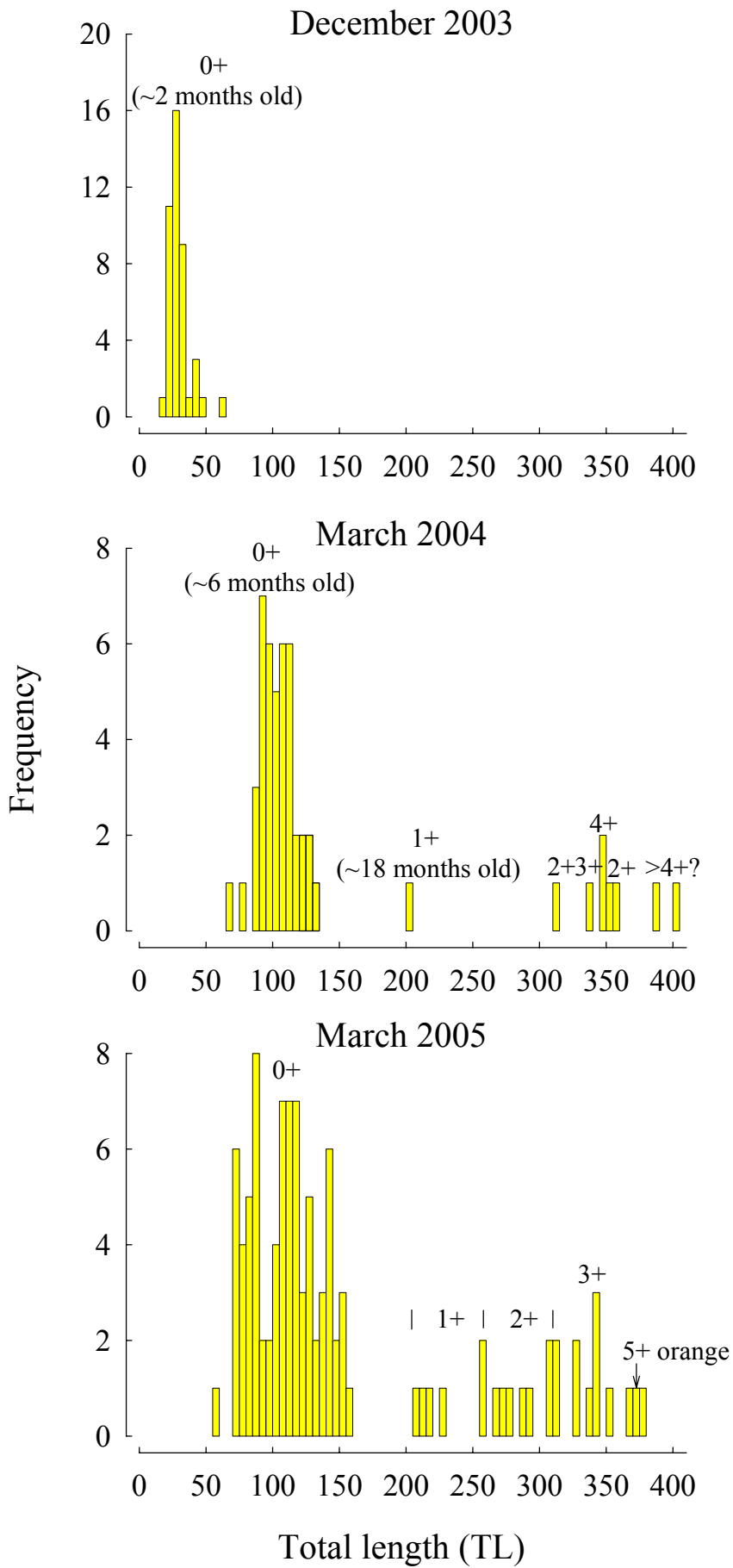


Figure 4 Length-frequency histograms of Goldfish captured in the Vasse River during December 2003, March 2004 and March 2005. The age classes (i.e. 0+, 1+, 2+ etc.) of fish are given.

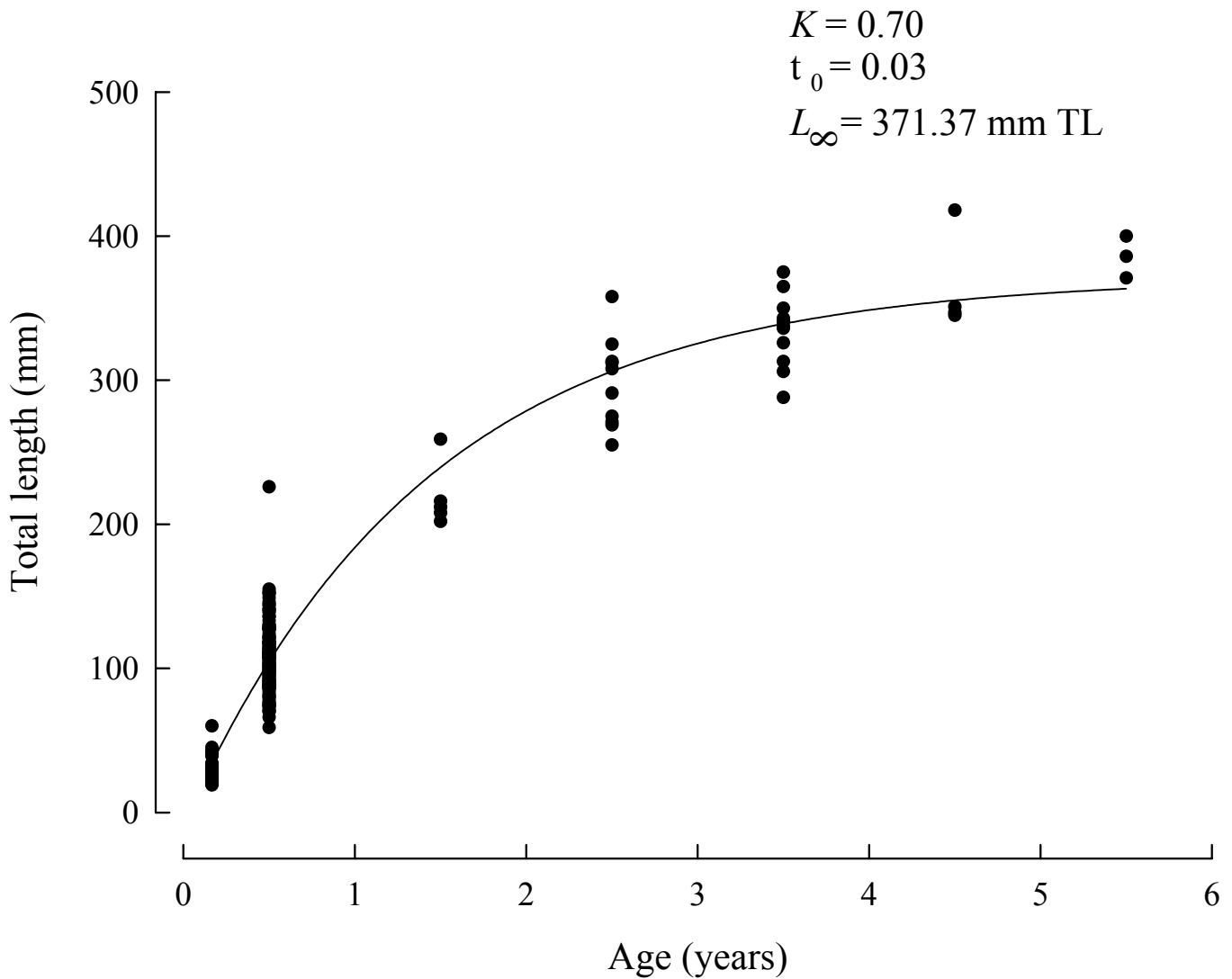


Figure 5 Total length at age of Goldfish captured during the study in the Vasse River including the von Bertalanffy growth curve. N.B. approximate age classes were based on the number of translucent zones on the otoliths and October 1 was assigned as the birth date.

The length-weight relationship for Goldfish in the Vasse River is $W = 5.2(10^{-6})(TL)^{3.2391}$, where W = the wet weight (g) of the fish and TL = the total length (mm) of the fish (Figure 3).

The von Bertalanffy growth equation is $L_t = 371.37[1 - e^{-0.70(t-0.03)}]$, where L_t is the approximate length at age t (in years). For example, at age 1 year, Goldfish attain approximately 183 mm TL, whereas at ages 2, 3, 4, 5 and 6 they reach ~258, 315, 348, 357 and 366 mm TL, respectively (Figure 5).

The age and growth data presented here (Figure 5), while appearing to provide an excellent estimate of length versus age, requires validation before it can be accepted. Thus, more older fish are required from throughout the year so that changes in the otoliths translucent/opaque zones can be verified as annuli (i.e. marginal increment analysis) (e.g. Morgan *et al.* 2000). Generally, sexes are also plotted separately. Further eradication of Goldfish would provide an excellent opportunity to examine the biology and ecological impact of this species, a study that would be the first of its kind on this species in Australia. The only

previous age and growth study on wild Goldfish populations in Australia was by Mitchell (1979) who used scales to age fish from South Australia. In terms of comparisons with the Vasse River population, the growth rates here substantially exceed those in Mitchell's study and are similar but higher to those published by Izci (2001) for a wild population of Goldfish in Turkey. Mitchell found one fish living for over 10 years that weighed over 2 kg. From the length-weight relationship in the Vasse River it is predicted that Goldfish would attain 2 kg at 447 mm TL.

Many of the larger fish had gonads that had clearly spawned and are classed as 'spent'. Examination of some of the 0+ cohort (6 month old fish) revealed that gonadal development was commencing and that they will spawn at the end of their first year of life. The numerical dominance of the 2003 and 2004 year class, all of which had lost any orange coloration evident in some individuals in older age classes and had thus reverted to the 'wild-type' colour, and their potential to breed will lead to a population increase during late 2005 and beyond. The persistence of orange coloration in some of the largest individuals, together with the unreadable otoliths on some of these, perhaps as a result of living in captivity, suggests that they may have been either the original stock introduced into the Vasse River or they are first or possibly second generation – their age however is not known, hindering an estimation of their first year of introduction.

Red Spot Disease (Epizootic Ulcerative Syndrome)

During sampling in 2005, Red Spot Disease, which is synonymous with Epizootic Ulcerative Syndrome, was thought to be infecting both Goldfish and native fish (Sea Mullet *Mugil cephalus*, Nightfish *Bostockia porosa* and Western Pygmy Perch *Edelia vittata*) as these were found with red spots or lesions visible on their bodies (see Figure 6). In light of these findings, samples of what were believed to be infected fish were taken to the Animal Health Unit at the Department of Agriculture. Subsequent PCR tests by Heather McLetchie revealed positive results in one Goldfish and two Sea Mullet. Red Spot is caused by the fungus *Aphanomyces invadans* and is endemic in Australian waterways. Red Spot is a notifiable disease and if detected it should be reported to a State Government Veterinary Officer or Stock Inspector within 24 hours. Often during periods of high stress, such as when environmental conditions are poor, the fish will become susceptible to Red Spot. The substantial algal blooms and high temperatures of the Vasse River at the time of sampling no doubt contributed to the high degree of these infections.

Samples of the infected fish were kept refrigerated (if dead) before being transported to the Fish Health Unit at the Dept of Agriculture. On arrival the fish with lesions were photographed. Approximately 5 mm thick sections from the lesions and immediate surrounding tissue were removed and fixed into 10 % buffered formalin for histological processing. The Office International des Epizooties (OIE) recommends that Red Spot Disease be diagnosed using histological techniques, with sections stained with Hematoxylin and Eosin and Grocotts Gomori stain for identification by a fish pathologist. Using this methodology, Red Spot Disease was shown to be present in one of the Goldfish and several of the Sea Mullet. These were all fish with noticeable lesions, which were either ulcerated or beginning to ulcerate. Small samples of the tissue directly adjoining the lesion were removed and placed onto glucose-peptone (GP) agar using aseptic techniques. The tissue was placed within a metal ring that is fixed to the surface of the GP plate. This helps prevent contamination of the slow growing fungus by the faster bacterial and other fungal contaminants, which are often found in conjunction with Red Spot Disease. The *A. invadans* is able to grow through the agar under the ring, whilst the contaminants are left within. All the lesions were cultured however, none of the resulting growth was *A. invadans*. This is not unusual as it is a difficult fungus to culture, dies easily and even with the help of the metal ring is susceptible to contamination. All the fish lesions were tested using PCR, with the primers used, which were designed by Heather McLetchie, specific for *A. invadans*. This PCR is in the process of being validated as an alternative to the present OIE method. The fish, which

tested positive using histological techniques, also produced very clear positive results for the PCR. The other fish with only a ‘globular-like’ surface spot returned negative results. These spots may be caused by the disease and if so are probably in their very initial developmental stages (although the PCR should pick up even tiny quantities of the fungus), alternatively they may be caused by some other disease or environmental factor.

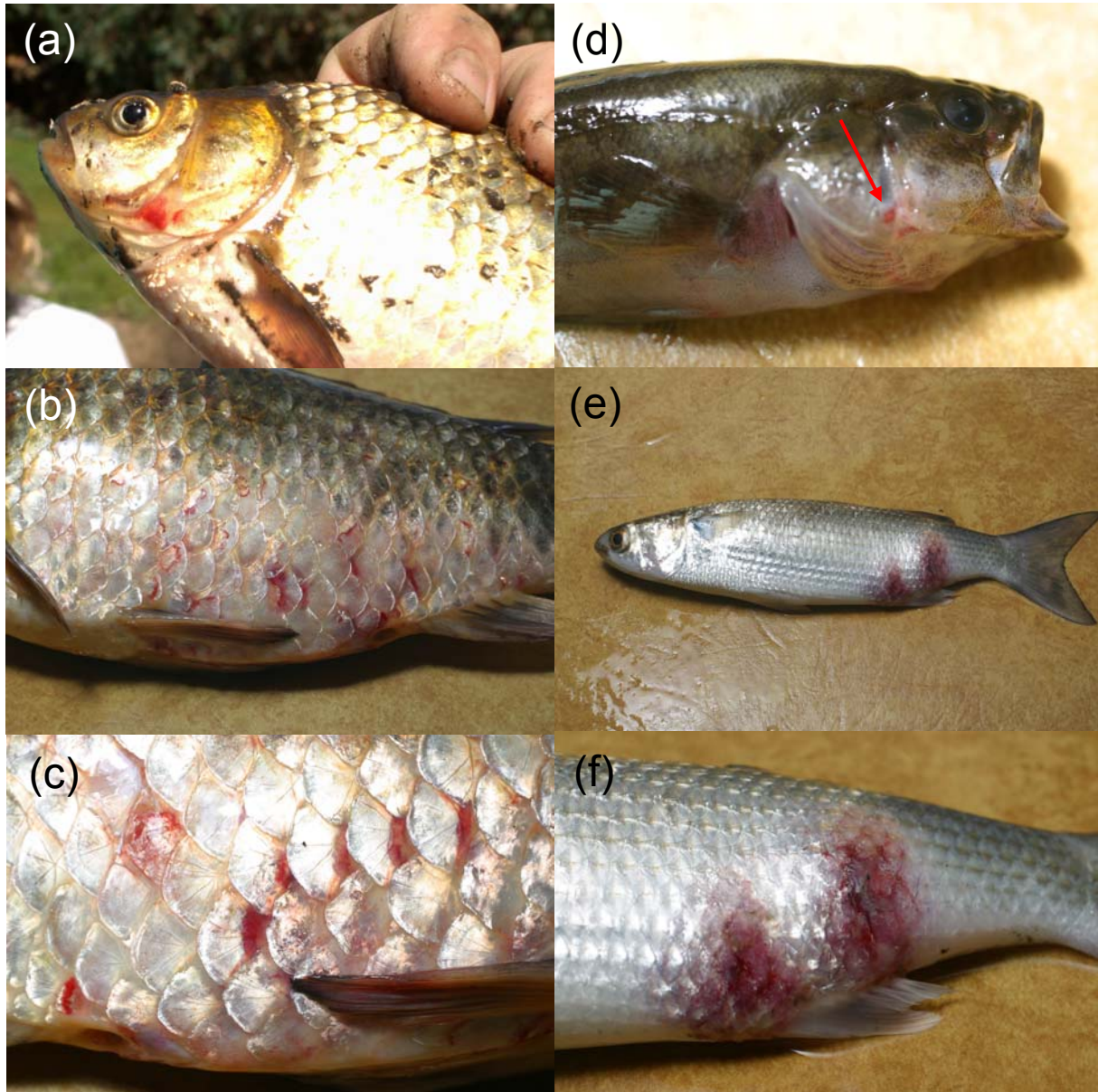


Figure 6 Red-spot disease from (a-c) Goldfish, (d) Nightfish and (e-f) Sea Mullet. N.B. Not validated for the Nightfish, but was verified using PCR and histological techniques for Goldfish and Sea Mullet.

Future control program

During the December 2003 and March 2004 fish survey a total of 91 Goldfish were captured. During 2005 a further 105 Goldfish were removed from the river in two days. The timing of removal is important with lower water levels permitting more effective captures. While it is unlikely that Goldfish will be eliminated from the system, their ecological impact can be

minimised through a well implemented control program. This would involve a more intensive program that lasts one or two weeks each year between mid-summer and early autumn when water levels are at their lowest. Their restriction to specific areas/habitats of the lower Vasse River provides an opportunity to focus future eradication opportunities to maximise efficiency.

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