Pest fish survey of Hokowhitu (Centennial) Lagoon, Palmerston North

CBER Contract Report 101

Client report prepared for
Department of Conservation

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Executive summary

The koi carp is an ornamental strain of the common carp which is believed to be one of the most ecologically detrimental of all freshwater invasive fish species. Numerous "koi carp" sightings have been made by the public in the Hokowhitu Lagoon, Palmerston North. Because koi carp is designated an unwanted organism under the Biosecurity Act, the Department of Conservation commissioned a survey be undertaken to determine whether koi carp were present in the lagoon. Due to the abundance of aquatic birds and the public nature of the lagoon, nets were unable to be set and thus the use of an electric fishing boat from the University of Waikato was required. This method provided a non-lethal, quantifiable, method of collecting freshwater fish species in a non-wadeable freshwater habitat. The boat operates by supplying a pulsed DC current into the water column where it attracts and then incapacitates fish, allowing operators to remove them from the water with hand nets.

The Centre for Biodiversity and Ecology Research (CBER) at the University of Waikato was contracted to survey the Hokowhitu Lagoon by boat-electrofishing. The objectives were (1) to survey the fish community present in the lagoon, (2) to determine the presence or absence of koi carp and (3) if koi carp were present, to attempt to eradicate them from this locality.

On 12 February 2009, a total of 711 fish (69.2 kg) comprising 593 perch (17.2 kg), 89 goldfish (39.5 kg), 25 shortfin eels (12.5 kg) and 4 common bullies (<0.1 kg) were captured from the lagoon. Koi carp were not amongst the species detected in the lagoon. Perch were the most abundant fish species in the lagoon with a density of 44 fish 100 m^{-2} recorded at one site. Even this high density is likely to be an underestimate as juvenile perch were difficult to capture due to their habit of seeking refuge in the thick macrophyte beds and the true density could be as high as 100 fish 100 m^{-2}. Perch were successfully recruiting in the lagoon with 99% of the perch caught at site 1 being young of the year. The population structure is most likely being controlled by the large adult perch cannibalising the age 0 perch and thus preventing most of the young of the year reaching the next age class. Native species densities were lower than those exhibited by the exotic species although common bully densities are not truly represented as the dense macrophyte beds prevented the capture of these fish by the nets. There was a large size range of eels from 200 mm TL up to 1000 mm TL.

Numerous large (>300 mm FL) highly coloured goldfish, resembling koi carp to the untrained eye, were captured during the survey. Due to the intense electrofishing effort carried out on the lagoon and the lack of koi carp caught, it is concluded that the large, highly coloured goldfish are responsible for the "koi carp" sightings made by the public.

1. Introduction

The Department of Conservation (DOC) contracted the Centre for Biodiversity and Ecology Research (CBER) to survey the Hokowhitu Lagoon (Centennial Lagoon) to determine whether koi carp (*Cyprinus carpio*) were present. There have been numerous reports by the public of koi carp residing in the lagoon. This has caused a debate about whether these are indeed koi carp or if they are merely large coloured goldfish (*Carassius auratus*). With the exception of the two pairs of barbels around the mouth, koi carp resemble goldfish; both species display a wide variation in colour, thus causing confusion in the identification of the species by the public.

Due to the number of aquatic birds present and the public nature of the lagoon, DOC were unable to set nets and thus required a non-lethal sampling method to survey the fish community in the Hokowhitu Lagoon. Te Waka Hiko Hï Ika, New Zealand's only electrofishing boat, was specifically designed to be a non-lethal method to collect freshwater fish species in non-wadeable freshwater habitats. Boat electrofishing has proved to be safe in public areas due to strict safety guidelines. Previous mark-recapture studies on fish species such as koi carp (Osborne et al., 2009) have shown that fish survive electric fishing relatively well.

Koi carp are believed to be one of the most ecologically detrimental of all freshwater invasive fish species (Crivelli, 1983; Zambrano et al., 2001; Davidson, 2002; Dean, 2003; Koehn, 2003) necessitating their eradication if they are found in the lagoon. They have been implicated in major environmental degradation in many freshwater ecosystems due to their feeding mechanisms which result in the turbation of the bottom sediments as well as dislodgement of aquatic plants. Koi carp are able to reach high biomasses, are very tolerant to poor water quality, and contribute significantly to water quality decline earning them the status of an unwanted organism under the New Zealand Biosecurity Act 1993 (Crivelli, 1983; Roberts et al., 1995; Zambrano et al., 1999; Barton et al., 2000; Zambrano et al., 2001). The objectives of the project were:

(1) to survey the fish community present in the Hokowhitu Lagoon
(2) to determine whether or not koi carp were present in the Hokowhitu Lagoon
(3) if koi carp were found to be present, an eradication effort would follow

2. Methods

Electric fishing was conducted using a 4.5-m long, aluminium, custom-made electric fishing boat. The boat has a rigid aluminium pontoon hull with a 2 m beam, and is equipped with a 5-kilowatt gas-powered pulsator (GPP, model 5.0, Smith-Root Inc, Vancouver, Washington, USA) which is powered by a 6-kilowatt custom-wound generator. Two anode poles, each with an array of six electrode droppers, created the fishing field at the bow, with the boat hull acting as the cathode. Electrical conductivity and temperature was measured with a YSI 3200 conductivity meter. The measured conductivity was then used to calculate the settings on the GPP which resulted in the lagoon fished with the GPP set to high range (50-1000 V direct current) and a frequency of 60 pulses per second. We adjusted the percent of range setting of the GPP to between

50 and 70% to give an applied current of 6 A root mean square. We assumed from past experience that an effective fishing field was developed to a depth of 2-3 m, and about 2 m either side of the centre line of the boat. We thus assumed that the boat fished a transect approximately 4 m wide, which was generally consistent with the behavioural reactions of fish at the water surface. This assumption was used to calculate area fished from the linear distance measured with the boat's global positioning system.

On 12 February 2009, 6 fishing passes with durations of approximately 20 minutes per pass were carried out in the Hokowhitu Lagoon (Figure 1). Due to the shallow nature of the lagoon (< 3 m deep), we were able to zigzag from one side of the lagoon to the other, effectively fishing all the habitats in the lagoon (littoral and pelagic zones). All fish species that were stunned by the electrofishing boat were captured, anaesthetised, identified (species level), measured (fork length) and weighed. Any koi carp and (with the permission of Wellington Fish and Game) perch if captured were to be humanely killed according to Waikato University standard protocol. All native fish species and goldfish (with the exception of a few coloured specimens) were subsequently released back into the lagoon once they had recovered from anaesthesia.

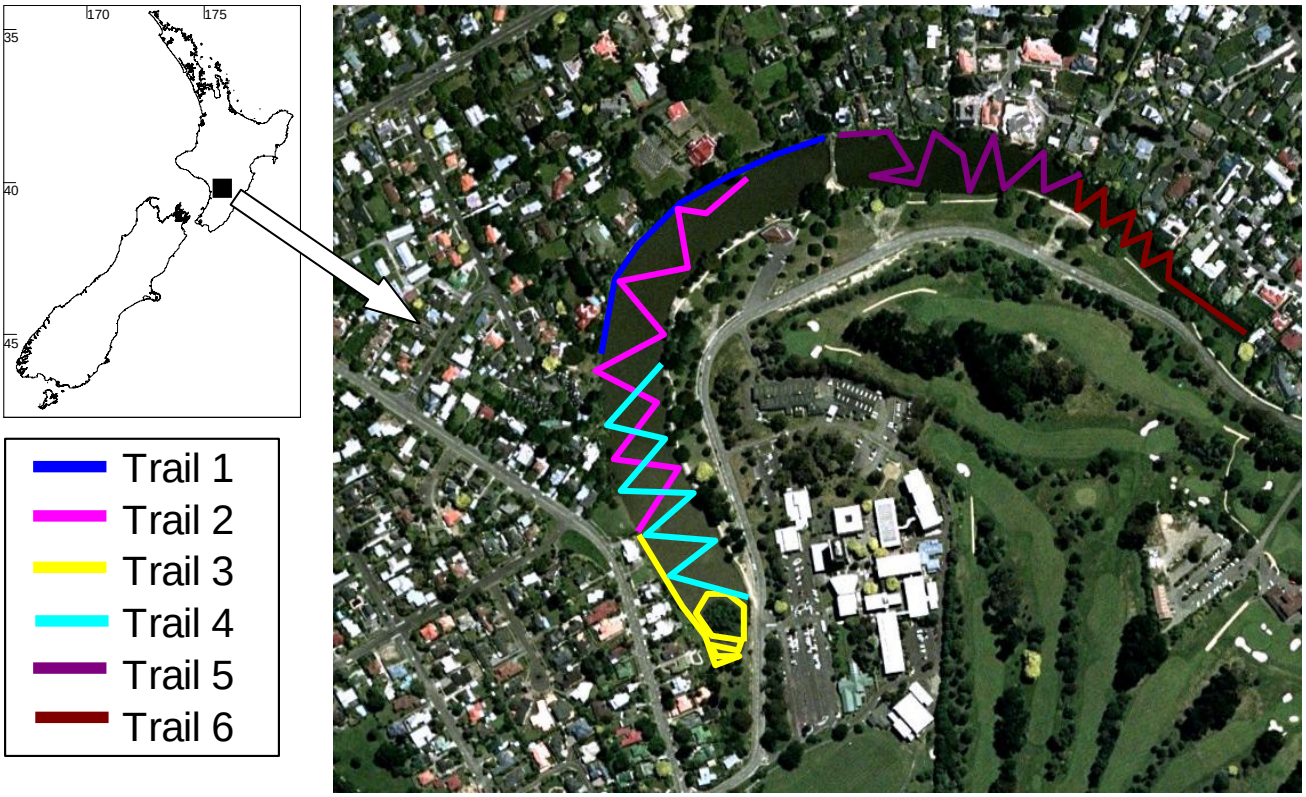

Figure 1. Location of electrofishing passes on Hokowhitu Lagoon, Palmerston North on 12 February 2009.

3. Study Site

Hokowhitu, or Centennial, Lagoon as it is more commonly known, is situated amongst the predominantly residential area of Hokowhitu in Palmerston North (Figure 2). It is

surrounded primarily by residential homes on the northern, western and eastern sides, while the southern side is bordered by the Manawatu Golf Club, Massey University College of Education and the Manawatu River. The centre of the lagoon is located at a latitude of 40º 22' 00.00" S and a longitude of 175º 37' 49.11" E. Inflows into the lagoon include stormwater runoff from the surrounding catchment as well as a newly installed bore. The bore was drilled to 94 m to secure water from an underground aquifer and is designed to release up to 250,000 L of water daily into the lagoon which will enable the level of the lagoon to remain constant throughout the year. The outflow of the lagoon drains into the Manawatu River.

Figure 2: Photo of Hokowhitu Lagoon showing the highly modified nature of the lagoon with the park on the right and the wooden retaining walls separating the water from the land. Photo: Logan Brown.

4. Results

On 12 February 2009, Hokowhitu Lagoon had a water temperature of 22^{o}C and a specific conductivity of 79.1 μS cm^{-1}. The depth of the lagoon ranged from very shallow water near the shore (<0.1 m) to a maximum depth of 2.2 m. The horizontal water visibility (black disc reading) was over 1 m, which provided the personnel onboard the electrofishing boat with good visibility for fish capture. The habitat surrounding the lagoon is highly modified with very little native vegetation remaining. Dense macrophyte beds were present throughout the lagoon which provided refuge for the smaller fish such as juvenile perch and common bullies.

A total of 711 fish were caught during six 20-minute long electrofishing passes which covered a total fished area of 11.39 ha. The fish community in the lagoon was comprised of two introduced species and two native species. Koi carp were not amongst the species caught in the lagoon. Instead, the introduced species captured were goldfish and European perch (*Perca fluviatilis*). The native species captured were the common bully (*Gobiomorphus cotidianus*) and shortfin eel (*Anguilla australis*).

Tables 1 and 2 show that perch were the most abundant fish species in the lagoon with a density of 44 fish 100 m^{-2}. This density estimate was calculated from the first electrofishing trail. Given the time constraints it was determined that further perch density estimates were not warranted in order to more effectively focus on the main objective of detecting koi carp (trail 1 only had a distance fished of 300 m). The densities of goldfish (0.48 to 0.90 fish 100 m^{-2}), shortfin eels (0.00 to 0.67 fish 100 m^{-2}) and common bully (0.00 to 0.33 fish 100 m^{-2}) were all much lower than the density of perch found on trail 1.

Although goldfish densities were much lower than the density of perch they generally had a much larger biomass at each site (Table 3). A total fish biomass of 69.2 kg was removed from Hokowhitu Lagoon. 39.5 kg of goldfish were caught which was over half of the total fish biomass removed from the lagoon (57%), whereas perch (17.2 kg) and shortfin eels (12.5 kg) only contributed 25% and 18% of the biomass respectively.

Table 1: Time, distance and area fished with the associated fish capture in Hokowhitu Lagoon, Palmerston North on 12 February 2009.

Fishing Trail	Time fished (min)	Distance fished (m)	Area fished (m^2)	Number of Perch	Number of Goldfish	Number of Shortfin eels	Number of Common bullies
1	20.3	300	1200	532	9	8	4
2	19.9	558	2232	16	20	0	0
3	20.4	421	1684	6	8	9	0
4	20.2	552	2208	14	17	0	0
5	19.4	521	2084	12	18	2	0
6	18.4	496	1984	13	17	6	0
Total	118.6	2848	11392	593	89	25	4

Table 2: Densities of the four fish species captured in Hokowhitu Lagoon, Palmerston North on 12 February 2009. * no attempt was made to quantitatively measure densities.

Fishing trail	Perch density (fish 100 m^{-2})	Goldfish density (fish 100 m^{-2})	Shortfin eel density (fish 100 m^{-2})	Common bully density (fish 100 m^{-2})
1	44.33	0.75	0.67	0.33
2	*	0.90	0.00	0.00
3	*	0.48	0.53	0.00
4	*	0.77	0.00	0.00
5	*	0.86	0.10	0.00
6	*	0.86	0.30	0.00

Table 3: Biomasses of the four fish species captured in Hokowhitu Lagoon, Palmerston North on 12 February 2009.

Fishing trail	Perch biomass (g)	Perch biomass (g m^{-2})	Goldfish biomass (g)	Goldfish biomass (g m^{-2})	Shortfin eel biomass (g)	Shortfin eel biomass (g m^{-2})	Common bully biomass (g)	Common bully biomass (g m^{-2})
1	1727	2.18	1984	2.50	3411	4.30	4	0.01
2	2784	4.26	6224	9.53	0	0.00	0	0.00
3	1509	1.84	4641	5.66	3618	4.41	0	0.00
4	1371	1.10	5989	4.80	0	0.00	0	0.00
5	4382	5.64	11701	15.06	663	0.85	0	0.00
6	5470	8.53	8939	13.95	4810	7.50	0	0.00

Figure 3 shows the size-frequency distributions of three of the fish species captured in the Hokowhitu Lagoon on 12 February 2009 (common bullies were excluded as the sample size was too small). All three fish species (perch, goldfish and shortfin eels) displayed successful recruitment in the lagoon. European perch displayed a very high recruitment with the young of the year (age = 0) comprising the majority of the population caught (99% of the catch on the first electrofishing pass were young of the year). The survivorship of these age-0 fish is extremely low as very few fish are present in the 60 - 120 mm size class. Goldfish also show successful recruitment but unlike perch they display relatively good survivorship with a large proportion of the population reaching adulthood. Shortfin eels also display successful albeit low levels of recruitment. Survivorship of the shortfin eel seems to be successful as there are numerous individuals over 500 mm long.

Although no koi carp were found in the lagoon, numerous large (>300 mm), highly coloured goldfish which closely resemble koi carp were caught (red circle on Figure 3). Figure 4 shows a few examples of these fish and it is understandable that to the untrained eye these fish may look like koi carp as they are large and have a very bright orange pigmentation similar to that of koi. Twenty of these large, highly coloured individuals were captured and they ranged from a size of 300 mm (0.7 kg) to 400 mm (2.4 kg).

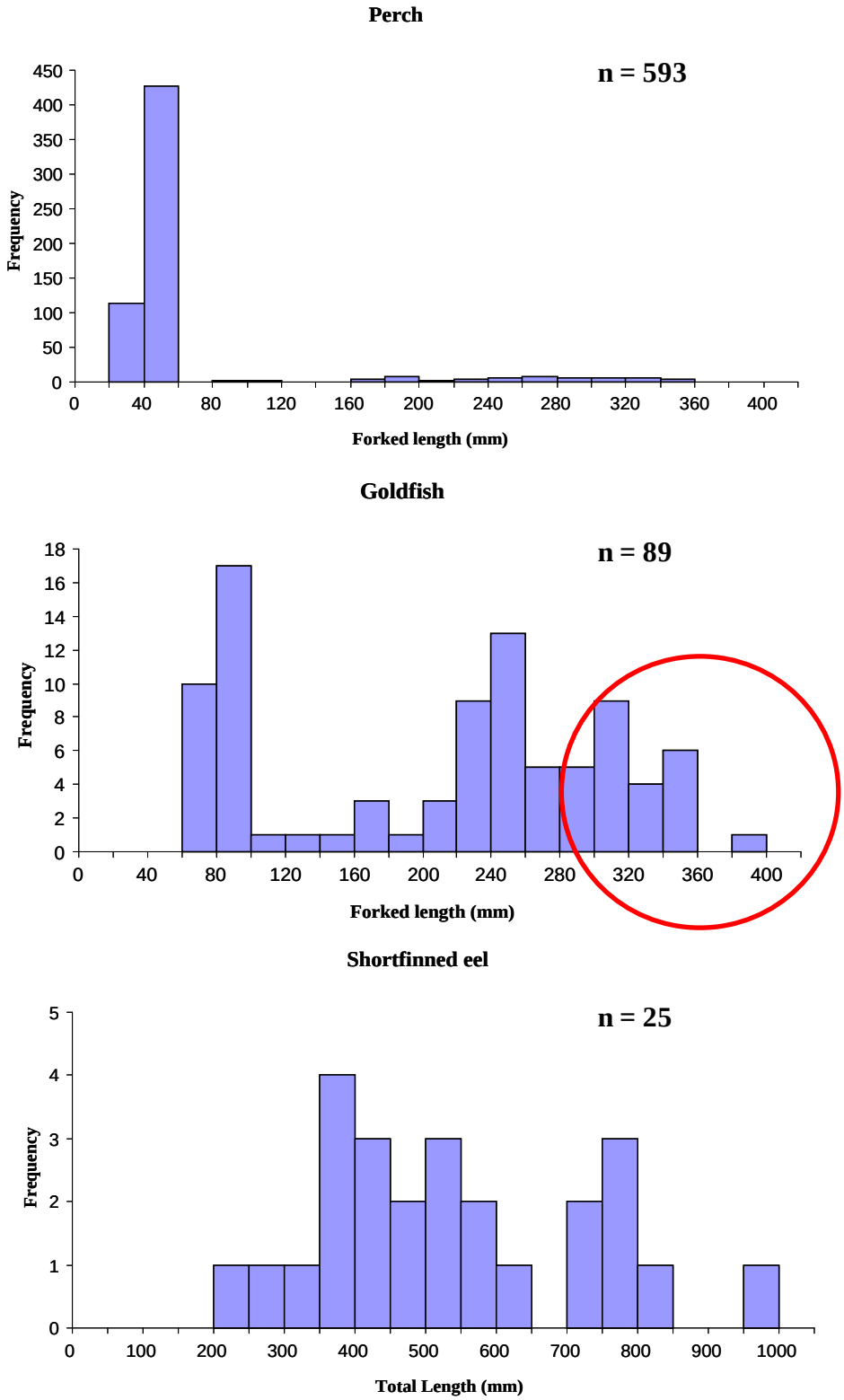

Figure 3: Size-frequency distributions of perch, goldfish and shortfin eels caught in the Hokowhitu Lagoon, Palmerston North 12 February 2009. The red circle indicates the large coloured goldfish which are likely to be responsible for the "koi carp" reports made by the public.

Figure 4: Examples of the large (>300 mm FL), highly coloured goldfish which have been mistaken for koi carp by the public in the Hokowhitu Lagoon, Palmerston North. Photo: Jeroen Brijs.

5. Discussion

On 12 February 2009, an extensive boat-electrofishing survey of the Hokowhitu Lagoon was conducted covering a total distance of 2.85 km and an area of 11.39 ha. A total of 711 fish were caught, which were comprised of european perch, goldfish, shortfinned eels and common bullies, but no koi carp were retrieved. Previous fishing with the electrofishing boat, in waters with similar conductivity and habitats as those in the Hokowhitu Lagoon, has caught a comprehensive size range of eels, smelt, bullies, grey mullet, rudd, brown bullhead catfish, perch, tench, goldfish, and koi carp (Hicks et al., 2005; 2006). The moderate conductivity of the lagoon (79.1 $\mu S\ cm^{-1}$) allowed efficient power transfer from the water to the fish as the conductivity was near the assumed conductivity of the fish. Behavioural reactions of the fish species present in the lagoon to the electrical current confirmed that the power was indeed successfully transferring from the water to the fish. Multiple boat-electrofishing techniques were used such as fishing with the power continuously on as well as "stalking" the fish and then turning on the power. The latter technique prevents the fish from detecting the electric field and escaping before they enter tetany (a stationary and stiff state). Given the intense electrofishing effort carried out and the high catch rates, it is unlikely that koi carp are present.

Perch were the most abundant fish species in the lagoon with a density of 44 fish 100 m^{-2} recorded on the first electrofishing trail. Although personnel onboard the electrofishing boat attempted to collect all the juvenile perch on the first trail it was observed that at least half of the juveniles still managed to avoid capture as they were deeply entwined in the thick macrophyte beds present in the lagoon. Thus the density of 44 fish 100 m^{-2} is still an underestimate of the true density, which could be near 100 fish 100 m^{-2}. The size frequency of perch found in the lagoon shows that there is a high level of recruitment (99% of catch at trail 1 were "young of the year") but survivorship of "young of the year" is very low as almost no individuals in the next size class were caught. Studies have shown that in perch populations it is common that the large adult perch can control the age structure of the population by cannibalising the smaller perch, and a single year-class can be dominant for up to 15 years if the conditions are right (Alm, 1952). We removed a total of 17.2 kg of European perch from the lagoon, which mainly consisted of large adult perch ranging from 170 mm to 360 mm. Alm (1952) found that when he experimentally reduced the size of the dominant year-classes, the numbers of small perch increased in subsequent years and developed into new dominant classes. Thus the removal of the large perch in the Hokowhitu Lagoon may result in an increase in the number of smaller perch reaching the next age class and possibly becoming the next dominant size class

The densities of the native species (common bullies and shortfin eels) present in the lagoon were lower than the exotic species (perch and goldfish). Common bully densities (0.00 to 0.33 fish 100 m^{-2}) were likely to be underestimated as they were not a target species and the presence of dense macrophyte beds made it difficult to retrieve them. Shortfin eels displayed densities ranging from 0.00 to 0.67 fish 100 m^{-2} with a size range from 200 mm to almost 1000 mm. There were numerous eels over 500 mm long which may be a reflection of the absence of eel fishing occurring in the Hokowhitu Lagoon. Studies carried out in New Zealand waterways affected by eel fishing (Beentjes et al., 2006; Hicks et al., 2008) has shown that the frequency of eels decreases significantly once they approach the legal harvestable size (220 g or approximately 480 mm) but this does not occur in the Hokowhitu Lagoon as it is primarily used for recreational purposes (canoeing, kayaking, feeding ducks etc.).

Although the densities of goldfish (0.48 to 0.90 fish 100 m^{-2}) were less than the high density exhibited by perch, a substantial biomass (39.5 kg) of goldfish was removed during the electrofishing survey. Numerous large (>300 mm), highly coloured goldfish were responsible for the majority of the biomass as the individuals ranged from 0.7 to 2.4 kg. After the intense electrofishing effort carried out in the lagoon, we conclude that these large, highly coloured goldfish are responsible for the "koi carp" sightings. Due to the absence of carp further work involving eradication was not required.

6. Acknowledgements

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