FISHING FOR ANSWERS:

Improving welfare for aquarium fish

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Abstract

More than 1.5 billion fish are traded internationally each year. Fish are the most numerous type of pet and are kept in approximately 10% of Western households. Several studies indicate that most people do not consider fish welfare to be important, although scientific evidence shows that fish are behaviourally complex and feel pain.

The aim of this thesis is to develop pathways for improving the welfare of pet fish. The welfare of captive fish is influenced by factors contributing to fish health (such as water quality, stress and behavioural needs) as well as factors contributing to the owner’s provision of care (such as knowledge, attitudes, social norms and media coverage). The relationships between these factors were explored using three methods: a survey of fish owners; an intervention using a short film to improve owner attitudes and behaviour; and the development of preference and motivational testing for determining the value of enrichment for fish.

The survey identified fish owners’ perceptions of the main welfare issues affecting pet fish and helped model the attitudes that underlie aquarist behaviour. Fish owners responding to the survey (n = 534) reported that disease and old age were the most common causes of death for their pet fish, although it is likely that many of them underestimated the role of water quality in fish health. The majority of respondents (73%) reported that they are knowledgeable about fish care and actively share and seek information about their fish. However, more than a quarter of respondents (27%) admitted that they had limited knowledge of fish care and rarely sought information or social support for their hobby. Almost all respondents provided structural enrichment such as gravel and shelters for their fish, but less knowledgeable owners were more likely to provide artificial plants than real ones.

Providing fish owners (n = 195) with a short film encouraging them to clean their aquaria weekly did increase the frequency of tank cleaning, but only if they already intended to do so. There was no measurable change in attitudes after watching the film, but using a positively framed film appeared to increase recall of the key message compared to the negatively framed film.
Preference and motivational tests were found to be useful methods for studying the value of environmental enrichment for fish. Goldfish were found to spend an equal amount of time and effort to access both real and artificial plants. This suggests that keeping artificial plants rather than real plants does not, in itself, influence welfare compared to real plants. However, participants in the film intervention showed an association between owning artificial plants and cleaning out the tank less frequently, which could exacerbate water quality issues.

These results emphasise that fish owners are not a homogenous group. Most aquarists who responded to the survey are dedicated to their hobby and aim to maximize fish welfare, but they are limited by a shortage of scientific research on ornamental fish species. Less committed fish owners are hard to reach through traditional communication channels, but targeted attempts should be made to improve their engagement with animal welfare. Further research should focus on the influence of message framing on behavioural change and on clarifying the value of enrichment for fish health.
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Declaration of Authorship and Publications Arising

This thesis has been structured as a series of papers, with each main chapter being prepared for publication in peer reviewed journals. All co-authours have agreed to the inclusion of the work in the thesis and the bibliographical details and contributions are outlined below.

Sullivan, M., Longnecker, N. & Blache, D.

‘How does keeping fish in aquariums influence their welfare?’ *Animal Welfare*, under review. (Chapter Two)

I designed the survey, collected the data, analysed the data and wrote the paper. Prof Longnecker contributed to the development of ideas, reviewed question design and edited the paper. Assoc/Prof Blache reviewed statistical methods, edited the paper and provided advice on manuscript submission.

Sullivan, M., Blache, D. & Longnecker N.

‘Aquarists’ knowledge, social norms and beliefs about pet fish’, *Anthrozoos*, in preparation. (Chapter Three)

I designed the survey, collected the data, analysed the data and wrote the paper. Assoc/Prof Blache reviewed statistical methods and edited the paper. Prof Longnecker reviewed question design and provided editorial guidance.

Sullivan, M., Longnecker, N. & Blache, D.


I created the short films, designed and ran the survey, analysed the data and wrote the paper. Prof Longnecker contributed to the development of the methodology, reviewed the script of the short films and edited the paper. Assoc/Prof Blache recommended statistical tests and edited the paper.

Sullivan, M., Lawrence, C. & Blache, D.

‘Why did the fish cross the tank? Using motivational tests to measure the importance of plants to fish’, *Applied Animal Behaviour*, in preparation. (Chapter Four)
I designed the experiment; obtained and cared for the goldfish; gathered and analysed the data; and drafted the paper. Assoc/Prof Lawrence reviewed the experimental design, sourced and provided experimental equipment and laboratory space and edited the paper. Assoc/Prof Blache contributed to the development of ideas, suggested appropriate statistical analyses and edited the paper.

Conference Papers and Presentations


**Sullivan, M.** (2012) ‘TV or not TV?’ Speakers corner presentation at the 12th International Conference on Public Communication of Science and Technology in Florence, Italy 18-20 April. (Partially included in Section 1.11)


**Sullivan, M. & Longnecker, N.** (2013) ‘Can Youtube be used to change the way people care for their pets?’ 5th Biennial Australian Animal Studies Group Conference. Sydney, Australia, 8-10 July. (Based on data from Chapter 4)

1 School of Thought: Literature Review

1.1 Introduction

Worldwide, more than 1.5 billion fish enter the pet trade every year (Ploeg 2007). Pet fish are kept by over 10% of Western households, in far greater numbers than dogs or cats (Australian Companion Animal Council 2010). Yet despite their ubiquity, domestic fish remain unprotected and under-researched, particularly with regards to welfare issues.

The aim of this thesis is to develop strategies for improving the welfare of pet fish.

Animal welfare is concerned with balancing the interests of animals and humans. I decided to address both sides of the issue by researching both fish and their owners. The aim is not to determine how a fish may be kept in a captive environment, as this is already known. Rather, I aimed to discover what aspects of fish welfare need to be improved, to determine whether intervention through the media could be used to promote better care by fish owners, and to develop methods for testing factors relevant to fish welfare.

The thesis therefore touches on three different scientific disciplines: animal welfare science (how do animals cope in captivity?), anthrozoology (how do humans interact with animals?) and communication sciences (how can we change human behaviour towards animals?). This makes for a very wide-ranging thesis, but I believe it is important to provide an overarching framework that can guide our understanding of where gaps in the research are and how researchers from different disciplines can complement each other. In most animal welfare issues, scientists in these three disciplines work independently even though they share a common goal of improving animal welfare. Since fish welfare is a relatively new area for animal welfare, there is an opportunity to develop more cohesive strategies for improving the welfare of pet fish.

To achieve my aims, I conducted a literature review (Chapter One) to examine relevant issues surrounding ornamental fish welfare. In the literature review I will develop the argument that legislators, researchers and fish owners frequently neglect fish, and that this state of affairs should be addressed. I first consider factors that influence the
animal, including why fish merit welfare consideration, areas of concern for welfare in captivity and the measurement of welfare. I then discuss factors important for aquarists, including why people keep pets, attitudes towards pet fish, theories of behaviour change and the influence of the media on behaviour towards animals. Finally, I summarise the most important conclusions from the above and describe the research questions that arise.

The rest of the thesis consists of a series of related research papers being prepared for publication. Chapter Two describes a survey aimed at determining the current state of pet fish welfare and the frequency of welfare problems as perceived by fish owners. Data from the same survey are used in Chapter Three to identify characteristics of fish owners that are associated with knowledge of fish biology. Chapter Four examines whether information about fish welfare can be effectively disseminated to pet owners through short films accessed online. Chapter Five describes the development of new methods for measuring the importance of enrichment for fish welfare. The thesis concludes with a general discussion of the results and implications for future research (Chapter Six).

All fish species are referred to by their common names throughout the thesis, with a full list of scientific names provided in Appendix A. The terms ornamental, domestic and pet are used interchangeably to refer to pet fish. A glossary of other scientific terms used is provided at the end of the thesis. Lastly, although the thesis primarily focuses on developing broad strategies to improve pet fish welfare at a societal level, it is also important to consider the welfare of individual pet fish. As a complement to the main thesis, a method for quantitatively measuring the welfare of individual fish has been developed and is attached as Appendix E.

**Fish Characteristics**

1.2 The scale of the issue— how many pet fish are there?

Trying to determine the overall number of fish kept as pets is like trying to catch a goldfish barehanded in the dark— it’s confusing and slippery. The very few statistics available about the ornamental fish trade are unreliable. The United Nations Comtrade
data from 2006 shows that 53.3 million kilograms of ornamental fish were exported worldwide, but that only 18.3 million kilograms of ornamental fish were reportedly imported worldwide (UNEP 2007). Ploeg (2007) explains that the 35 million kilogram discrepancy is a result of nations failing to provide data, different exclusions for freight, and incorrect invoicing for tax purposes. Once these problems are accounted for, there is still the difficulty of converting kilograms of fish into the number of individual animals. A rough estimate puts the total number of individual fish traded in 2004 at around 1.5 billion (Ploeg 2007).

There is even less agreement on the number of different species of ornamental fish that are commercially traded, which is variously stated to be 3450 (O'Sullivan et al. 2008), 4000 (Whittington & Chong 2007), 5950 (Miller-Morgan 2010) and over 8000 (Bartley 2000). However, most sources agree that over 90% of fish traded are captive-bred freshwater species (Bartley 2000; O'Sullivan et al. 2008; UNEP 2007) and sales appear to be dominated by as few as 30 key species (O'Sullivan et al. 2008).

The total international sales value of the ornamental fish industry—including fish, food and accessories—is estimated to be US$15 billion (Ploeg 2007). This value has been growing steadily since 1985, at a rate of about 14% per year (Bartley 2000). This can be seen in the expansion of the international trade, which has grown from 28 countries exporting fish in 1976 to 146 countries in 2004 (Ploeg 2007).

Although the ornamental fish industry is international, there is an important divide between developed and developing countries. Developing areas—such as African and Amazonian countries, Thailand, Sri Lanka and Malaysia—tend to be exporters because ornamental fish are one of the highest value products per kilogram that can be harvested from local rivers and reefs (UNEP 2007). Keeping fish as pets can be a relatively expensive hobby, so as a rule it is more prevalent in developed countries (Miller-Morgan 2010). This is reflected in the main importers of ornamental fish—Europe, United States, Japan, Singapore and Australia (Ploeg 2007).

Fish are not the most popular pet kept, with 36% of Australian households keeping dogs and 23% keeping cats, compared to only 13% owning fish (Australian Companion Animal Council 2010). However, fish are by far the most numerous pet in Western countries (Table 1.1).
Table 1.1. Number of pets owned in Australia, the UK and the US.

<table>
<thead>
<tr>
<th>Type of pet</th>
<th>Australia¹</th>
<th>United Kingdom²</th>
<th>United States³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish</td>
<td>33.9⁴</td>
<td>40-50</td>
<td>151.1</td>
</tr>
<tr>
<td>Dog</td>
<td>3.4</td>
<td>8</td>
<td>78.2</td>
</tr>
<tr>
<td>Cat</td>
<td>2.4</td>
<td>8</td>
<td>86.4</td>
</tr>
<tr>
<td>Bird</td>
<td>8.1</td>
<td>1</td>
<td>16.2</td>
</tr>
<tr>
<td>Small mammals</td>
<td>1.1⁵</td>
<td>1.9</td>
<td>16</td>
</tr>
</tbody>
</table>

1. (Australian Companion Animal Council 2010)
2. (TNS 2012)
3. (APPA 2011-2012)
4. Number of fish imported into Australia, no data available on the number of fish owned (O'Sullivan et al. 2008).
5. Horses and reptiles are not separated from small mammals in Australian statistics.

Most of the research in this thesis focuses on Australian fish owners. It is expected that results would be similar in other developed countries, but research would be required to verify this. Australia imported 33.9 million fish in the 2006/2007 financial year and the ornamental fish sector (including accessories) is worth an estimated $303.9 million (O'Sullivan et al. 2008). Nationwide, there are over 200 licenced fish breeders and 1200 pet and aquarium stores (O'Sullivan et al. 2008).

The large number of individual animals and different species involved in the ornamental fish trade should have long ago marked it as a potential animal welfare issue. Yet, as we shall see, the level of uncertainty surrounding even basic statistics in the ornamental fish trade is symptomatic of the wider neglect of fish by society.

1.3 What is animal welfare and how is it protected?

Interaction with animals is an integral part of human society, involving food, recreation, medicine, materials, sport, tourism and emotional support (reviewed in Serpell 2009). In order to ensure that these interactions are mutually beneficial the welfare of the animals must be considered. Animal welfare is the condition of an animal in relation to how well it is coping with its environment (Broom 1991). An animal that is healthy and thriving is therefore considered to have ‘good’ welfare in that environment. Conversely, an animal that is stressed or unhealthy is failing to cope with its environment and is
considered to have poor welfare. The concept is relevant to both wild and captive animals, but ‘animal welfare’ as an issue is primarily concerned with the welfare of animals under human care (Broom 1991).

Good animal welfare is important not just because of the intrinsic value of organisms and our moral responsibility towards them, but also because mistreating animals can decrease their economic productivity (Hemsworth et al. 2009; Huntingford et al. 2006) and may reflect interpersonal behaviour towards other people (Serpell 2009). Animal welfare philosophy arises from a belief that animal use is acceptable, but that people have a moral responsibility to care for the wellbeing of the animals we use (Carenzi & Verga 2009; Dawkins 2006).

Animal welfare is a relatively new idea. Until the 19th century animals were protected solely with regards to ownership—as private property—and only certain animals were considered worthy of protecting at all (Sandoe et al. 2004). Animals were considered to be unfeeling automatons, with no concept of pain or suffering. Under this assumption, providing for animal welfare is not imperative because it makes no difference to the animal (Brydges & Braithwaite 2008; Sandoe et al. 2004). The first animal welfare legislation (Martin’s Law 1822) was concerned only with banning public displays of animal cruelty (Hardouin-Fugier 2006). It was not until the 1960s that public awareness and legislation to protect animal welfare began to burgeon, driven at least in part by an increase in scientific understanding of animals (Broom 2011).

Over the last few decades animal welfare research has focused on improving accountability and expanding moral concern to animals such as invertebrates, livestock
and fish (Lawrence 2008). The conceptual difference underlying these changes is the recognition that animals can suffer (Veissier & Forkman 2008). The fundamental moral belief – that humans should not cause animals pain – remains the same as in the 18th century, but the interpretation of which animals can suffer has changed (Dawkins 2008).

Animal welfare issues tend to develop in a fairly predictable fashion (Figure 1.1), although the nature of individual issues is complex. However, most researchers look at only one stage of the animal welfare process and there has been little interest in the overall evolution of issues.

Welfare is still considered to be most important for animals that are thought to be capable of suffering (Sandoe et al. 2004). For example, the Australian Strategy for Animal Welfare ‘covers the care, uses and direct and indirect impacts of human activity on all sentient species of animals’, whereas being sentient is defined as having, ‘the capacity to have feelings and to experience suffering and pleasure. Sentience implies a level of conscious awareness’ (DAFF 2008). The European Union officially recognised animals as sentient in 1997 (European Union 1997), reflecting the widespread belief amongst the general public that animal welfare is important (Coleman 2008). However, public recognition of the importance of animal welfare for vertebrates appears to stop short of fish. Only 20% of Finnish citizens believe that Atlantic salmon are able to think and 40% were not aware that fish could feel pain (Kupsala et al. 2013), while American students typically rate fish as being less intelligent than mammals (Driscoll 1995). In Figure 1.1, fish welfare is at the point where scientific research has determined that fish are behaviourally complex (discussed in Section 1.3) but this has so far failed to translate into increased public concern or improved protective legislation.

As a result of the lack of public concern for fish welfare, legislation addressing animal cruelty towards fish is typically inconsistent and lagging behind protection for mammals (Johansen et al. 2006; Voas 2008). For example, Western Australia states that the Animal Welfare Act (Government of Western Australia 2002) intends to,

reflect the community’s expectation that people who are in charge of animals will ensure that they are properly treated and cared for. Under the Act, an animal is defined as a live amphibian, reptile, bird or mammal other than a human. This includes companion animals, native animals, livestock, animals in zoos and animals used for research and teaching but not invertebrates or fish.

(DAFF n.d.) [Emphasis added]
Australia has different animal welfare laws in each state, resulting in fish being protected in some areas and specifically excluded from protection in others (Figure 1.2; Panaquatic Health Solution Pty Ltd 2006). Animal cruelty laws in the United Kingdom offer better protection for ornamental fish, but once again ‘the normal course of fishing’ is specifically excluded from the welfare legislation (United Kingdom 2006). The United States has no legislation that deals directly with fish welfare, although there are regulations for food safety and disease control that have implications for fish health (Burns 2005). On an international scale, the World Organisation for Animal Health recently released a code setting standards for aquatic animal health (Aquatic Animals Commission 2012). Although it is mainly concerned with the control of disease, the code also contains guidelines on the handling, transport, holding and slaughter for farmed fish— but not ornamental fish.

Despite the lack of legislation, there have been occasional cases of people being charged for cruelty to pet fish, including a U.S. woman who poisoned her husband’s tank with bleach during a domestic dispute (Clarke 2006) and three U.K. teenagers who stabbed and poisoned catfish being raised at a local school (Practical Fishkeeping 2011a). It is often difficult for animal welfare agencies to successfully prosecute in such cases due to a lack of time and evidence (Practical Fishkeeping 2011b; Voas 2008), although two men in the UK were successfully fined and banned from owning aquatic animals for ten years after they were found sending unlabelled and incorrectly packaged live fish and turtles through the post (Daily Mail Online 2012). In another high-profile case, a Danish artist who placed live fish in blenders was pardoned after a judge ruled that the fish died painlessly and it was therefore humane (BBC News 2003). Oddly, only the deaths of the fish were considered and the welfare problems associated with keeping fish in small blenders without filtration or shelter were not addressed.

Fish used in scientific research are normally better protected than pet fish, as scientific establishments have strict ethical regulations. In spite of this, there are several loopholes that make monitoring difficult. Some scientific procedures that are banned in mammal testing are still permitted on fish, and reporting of the experimental procedures conducted is poor (Johansen et al. 2006). Most countries only collect data on the overall number of fish used, making it impossible to determine which species are most affected (Reed & Jennings 2010).
The exception to the rule is Switzerland, which possibly has the world’s most comprehensive legislation protecting ornamental fish. Switzerland’s Animal Welfare Act (Interpharma 2008) sets minimum requirements for transport, holding water quality, stunning and slaughter of fish. There are also minimum aquarium sizes for pet fish larger than 20cm (Annex 2, Table 8, Interpharma 2008) and pet fish are required to be provided with ‘adequate social contacts’ (Article 13, Interpharma 2008). The welfare laws pertaining to other pets are even stricter, including a law that requires potential dog owners to acquire a certificate of competence before purchasing a dog (Article 68, Interpharma 2008).

Introducing legislation can encourage people to place greater value on welfare-related behaviours (Rohlf et al. 2010). However, introducing legislation to protect pet fish is not a comprehensive solution. Laws only set minimum standards for care, while actual care should aim to actively promote good welfare (Voas 2008). Good legislation should be effective, economically viable and legally enforceable (Knierim et al. 2011). Enforcing welfare legislation for fish may help to prosecute unusual cases of cruelty, but it is not practically enforceable to legislate for everyday care. Voluntary industry standards and public incentives can be helpful (Knierim et al. 2011), but it may be more effective to focus on changing societal perceptions of fish.

Having inconsistent legislation that is full of loopholes reflects a lack of care shown by society towards fish (Walster 2008) and the need for a greater consideration of non-mammalian animals. Since both legislation and societal perception hinge on the recognition of fish as sentient animals, it is important to clearly establish that fish are worthy of the same level of protection afforded to other vertebrates.
Figure 1.2. Differences between Australian states in the legislative protection of fish welfare.

(Based on data from Panaquatic Health Solution Pty Ltd 2006)
1.4 Are fish worthy of protection?

Broom (2007) states that animals should be judged worthy of legal welfare protection based on their ability to feel pain, complexity of their behaviour, learning ability, brain functioning, and indications of emotions and awareness. This list is of limited usefulness, particularly as emotions and cognitive processes are extremely difficult to study directly (Sandoe et al. 2004; Veissier & Forkman 2008). For example, after decades of research we have still not been able to design studies that conclusively show whether animals possess a theory of mind (Penn & Povinelli 2007) or can mentally time travel (Mendl & Paul 2008). This is unsurprising given that researchers still struggle to understand even human consciousness (Dawkins 2006; 2012). In addition, cognition and behaviour are closely linked to life history and vary greatly even within a population, making them inappropriate criteria to use for determining the ‘worthiness’ of a species for protection (Brydges & Braithwaite 2008).

Nevertheless, there are some excellent studies that demonstrate the capability of animals to suffer (reviewed in Boissy et al. 2007). At the very least, all vertebrates possess a central nervous system, making them physiologically capable of feeling pain (Davie & Kopf 2008). They also respond behaviourally to pain. For example, pigs are more vocal and have an increased heart rate when castrated without anaesthetic (White et al. 1995). Many other animals, including sheep, rodents and birds, appear to show emotional responses to pain (reviewed in Boissy et al. 2007), although some authors still argue that we are over-anthropomorphising mental ability in animals which have none (Rose 2007).

Pain and Emotions

Pain in animals is typically defined as an aversive sensory experience caused by damage to tissues, which elicits protective physiological and behavioural reactions (Sneddon 2003a; 2007; 2009). Fish are known to have similar pain receptive neurons (nociceptors) to other vertebrates, including humans (Sneddon 2003b). There are some differences: the proportions of different nociceptor types varies and some nociceptors appear to be more sensitive than in humans, which is probably an adaption to the challenges of living in water (Sneddon 2003b; Sneddon et al. 2003a). However, fish nociceptors seem to respond in the same way as human nociceptors; for example, both
fish and humans have the same reaction to morphine (Sneddon 2003a; Sneddon et al. 2003b).

As well as displaying a physiological reaction, fish respond behaviourally to pain (Sneddon 2007). When injected with acid, rainbow trout rock back and forth, rub against the ground and take longer to resume eating compared to control fish injected with saline (Sneddon 2003a; Sneddon et al. 2003b). Furthermore, rainbow trout can adapt this behavioural response to pain to suit their circumstances. Pain will distract rainbow trout from responding to unfamiliar objects and familiar conspecifics, but they do respond if placed in a tank with unfamiliar fish (Ashley et al. 2009; Sneddon et al. 2003b). This suggests that maintaining social status takes a higher priority than pain (Ashley et al. 2009).

Fish clearly meet the requirements needed to experience physiological pain (Sneddon 2007), but this may not be enough. In addition to being a sensory experience, pain should be a conscious experience with an emotional component (Broom 2007; Cottee 2012; Merskey & Bogduck 1994; Rose 2007; Sneddon 2009). In order to feel ‘true’ pain, the fish must be motivated by emotions such as fear, rather than simple reflexive responses (Cottee 2012).

Anglers are less likely to attribute pain perception to fish (Muir et al. 2013) and commonly argue that if fish were able to feel ‘true’ pain they would not be so easy to recapture (Rose 2007). However, scientific evidence shows that fish that have been captured and released do learn to avoid recapture (Asky et al. 2006a; Gilbert et al. 2001). Fish that have been captured and released take up to four days to return to normal behaviour (Neat et al. 2009). Short-term mortality of captured-and-released fish can be as high as 40% (Fabrizio et al. 2008), but can be greatly reduced if anglers take precautions such as minimizing handling, avoiding damage to gills and using appropriate tackle (Arlinghaus et al. 2007; Broadhurst et al. 2012).

Physiologically, fish are equipped to feel emotion (Braithwaite et al. 2011). Rodriguez et al. (2005) removed the cerebellum of goldfish, which is a region of the brain linked to processing information involved in spatial, relational and emotional learning. They found that the altered goldfish responded in a similar way to cerebellum-incised mammals. In other experiments designed to test for fear, rainbow trout and mice show an identical response (Yue et al. 2004).
The response to stress is also similar between fish and other vertebrates, both physiologically and behaviourally (Galhardo & Oliveira 2009). For example, both dominant fish and baboons respond to stress by acting more aggressively to subordinate animals (Galhardo & Oliveira 2009). As in mammals, stress appears to inhibit memory and learning ability in fish (Gjoen & Overli 2009). An extensive review of zebra fish in neuroscience research concluded that they are good models for anxiety research because they actually exhibit anxiety, rather than fear or arousal, which can appear similar (Maximino et al. 2010). This suggests that the basic plan for the brain has been evolutionarily conserved across the vertebrates (Rodríguez et al. 2005).

All the emotions discussed so far—stress, fear, anxiety—have been negative emotions. There have been few studies on the importance of positive emotions in fish (Kittilsen, 2013) or other vertebrates (Balcombe 2009), even though good welfare should aim to maximise pleasure as well as minimising pain (Boissy et al. 2007). It is therefore interesting to note that zebra fish become addicted to cocaine, which in humans is used to up-regulate mood (Parker & Brennan 2012) and that goldfish prefer amphetamines (a stimulant) to pentobarbital (a sedative) (Lett & Grant 1989). Several species show anticipatory behaviour before expected rewards (Nilsson et al. 2008; Nilsson et al 2010), which could be considered a positive state (Kittilsen, 2013). Additionally, the dopaminergic system (associated with reward systems and social behaviour) appears to play a similar role and is found in the same regions of the brain in fish as in other vertebrates (O'Connell et al. 2011). These studies suggest that fish could experience positive states and that, again, the basic neurological pathways are similar to those in other vertebrates.

Drug companies appear to have accepted that fish emotions are analogous to those of humans, as zebra fish are increasingly popular as a model species (Cottee 2012). A recent review paper from a consortium of zebra fish researchers asserts that the issue of whether fish feel emotions has been settled, and that prolonging the debate is a distraction from more important research. They conclude the paper with,

… it is time to move full-speed forward – from discussing whether or not fish have emotionality to addressing more important fundamental questions of zebrafish affective behaviors and their proximate mechanisms.

(Kalueffa et al. 2012)
In summary, emotions have not been well explained in the scientific literature (Boissy et al. 2007) and we have no reliable method to prove or disprove sentience in animals (Volpato et al. 2007). Assessment of pain in animals will always be subjective to some extent (Ashley et al. 2009). However, fish have fulfilled the same criteria for feeling pain and emotions as other animals that are commonly considered sentient, such as cats and dogs (Cottee 2012; Yue et al. 2008). Therefore, it is most parsimonious to consider that all vertebrates can feel pain, or that none can (Sneddon 2009). For the purposes of this thesis it has been accepted that fish can feel pain. Their experience of pain and emotions are likely to be species specific (Braithwaite et al. 2011; Reilly et al. 2008) and different from that of humans, but it still constitutes an aversive experience for fish that should be avoided in order to maintain high standards of welfare (Cottee 2012).

**Cognitive Function**

The intelligence of an animal is not necessarily linked to their ability to feel pain (Bekoff 2007). Having greater intelligence may actually help animals to deal with pain in some circumstances, for example, if they can rationalize the pain or recognise that it will only be short lived (Broom 2007). Nevertheless, intelligence and consciousness are other factors that are often considered an important in whether animals should be afforded protection (Broom 2007; Broom 2010; Knight et al. 2004).

It has been argued that the fish brain is simply too ‘primitive’ to be capable of consciousness and emotions because it lacks a complex neocortex (Iwama 2007; Rose 2007). However, consciousness and intelligence are not limited to the neocortex (Galhardo & Oliveira 2009; Dawkins 2012). Many studies have shown that fish and mammal brains follow the same basic pattern and have surprisingly similar functionality (Broglio et al. 2010; Broglio et al. 2003; Martin et al. 2011; Rodríguez et al. 2005; Wullimann & Mueller 2004).

Cabanac et al. (2009) suggested that consciousness did not evolve until the rise of the amniotes (i.e. terrestrial vertebrates). This opinion is not unique to Cabanac (2009) — several surveys have found that most members of the general public intuitively line up animals along a phylogenetic scale of intelligence, with invertebrates and fish down the bottom and primates and humans at the top (Driscoll 1995; Herzog & Galvin 1997; Maust-Mohl et al. 2012; Nakajima et al. 2002). However, a more rigorous examination of this belief shows that it is incorrect and that evolution is more complex than most people suppose.
Cognitive traits do not evolve linearly, but rather evolve in response to environmental pressures (Horik & Emery 2011). This means that different species that face similar environmental challenges are likely to converge on similar cognitive abilities. As a result, intelligence varies too greatly within species lineages to be neatly lined up along a phylogenetic tree (Bolhuis & Wynne 2009). For example, wasps (Tibbetts 2002), fish (Griffiths 2003), sheep (Kendrick et al. 2001) and people can all recognise individuals of their own species, because animals that live in social groups gain an evolutionary benefit from being able to tell each other apart (Mateo 2004; Sheehan & Tibbetts 2011).

Given that fish have existed for 500 million years, it would be surprising if they had not evolved cognitive abilities that contribute to their evolutionary fitness (Laland et al. 2003). ‘Missing’ cognitive abilities in fish, such as REM sleep and play behaviour (Cabanac et al. 2009) are not necessarily missing at all—they simply have not yet been looked for. This gap in research is due to the historical bias of limiting cognitive studies to mammals, particularly primates (Jaaro & Fainzilber 2006). However, primate research is less rigorous and can be prone to methodological flaws and, consequently, there is now stronger evidence for cognition in fish than in primates (Bshary et al. 2002). In one study where foraging decisions were directly compared between cleaner wrasse, capuchin monkeys, chimpanzees and orang-utans the fish clearly outperformed the three primate species at learning the task (Salwiczek et al. 2012). The evolution of different cognitive abilities appears to be closely linked to specific selection pressures (Bshary et al. 2002; Gonzalez-Volyer et al. 2009; Håstein et al. 2005). For example, the telencephalon region of the brain is larger in monogamous cichlid species compared to related polygamous cichlid species (Pollen et al. 2007) while female guppies selectively mate with males who are better learners (Shohet & Watt 2009).

Over the last few decades research into fish behaviour has expanded rapidly (Brown et al. 2006) and it has been demonstrated that fish possess a range of sophisticated behaviours (Table 1.2, and reviewed in Brown et al. 2006). Since there are over 27 000 known species of fish (Laland et al. 2003), the full range of behaviours listed in Table 1.2 will not be found in every species. Nor are all these behaviours likely to be truly complex, for example, bees (Apis mellifera) appear to be able to both count and use landmarks for navigation (Dacke & Srinivasan 2008), suggesting that these behaviours may use simple cognitive strategies or rules of thumb rather than sophisticated cognitive mechanisms. However, since the neural mechanisms underlying behaviour are not yet well understood, a wide range of potentially sophisticated behaviours are listed in Table
1.2. Despite these limitations, the few species that have been well studied tend to show a variety of advanced cognitive behaviours. For example, bluestreak cleaner wrasse are able to keep track of time and place when foraging (Salwiczek & Bshary 2011); manipulate their cleaning clients (Bshary & Wurth 2001); cooperate with partners; and punish those partners if they cheat (Raihani et al. 2010).

In conclusion, fish meet Broom’s (2007) criteria of being worthy of welfare protection. They feel pain, display complex behaviour and there are indications they may be able to feel emotions. Fish have both the capability to suffer and the intelligence to be aware of their suffering, placing a moral obligation on fish owners to maximise the welfare of their pets.
Table 1.2. Summary of research on cognitive abilities displayed by fish.

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Description</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adjust behaviour based on future payoffs</td>
<td>The bicolour cleaner wrasse is the only non-human animal known to change its behaviour based on future payoffs, instead of just considering the present circumstances.</td>
<td>(Oates et al. 2010; Salwiczek et al. 2012)</td>
</tr>
<tr>
<td>Appraise other fish and make decisions on who to associate with</td>
<td>European minnows prefer to school with conspecifics that are poor competitors. Fish prefer to associate and mate with individuals who are likely to cooperate during inspections of potential predators. Wild guppies form complex but stable social structures, with some individuals persistently found in the same pairs.</td>
<td>(Metcalfe &amp; Thompson 1995)</td>
</tr>
<tr>
<td></td>
<td>(Reviewed in Brown et al. 2006)</td>
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<tr>
<td></td>
<td>(Crocket et al. 2006)</td>
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<tr>
<td>Associate events which are separated in time</td>
<td>Cod quickly and reliably learn to associate events separated by sixty seconds and remember the association for at least three months. They learn faster and tolerate longer gaps between the events than mice and pigeons in similar experiments.</td>
<td>(Nilsson et al. 2008)</td>
</tr>
<tr>
<td>Categorise objects</td>
<td>Malawi cichlids were able to learn the categories ‘snail’ and ‘fish’ and assign unfamiliar pictures to the correct category.</td>
<td>(Schleussel et al. 2012)</td>
</tr>
<tr>
<td>Cooperation</td>
<td>Many species cooperate to brood eggs, inspect predators, forage and defend territories.</td>
<td>(Reviewed in Brown et al. 2006)</td>
</tr>
<tr>
<td>Cooperative hunting</td>
<td>Groupers actively signal to moray eels and octopus to initiate cooperative hunting. Goatfish take on individual roles while hunting as a school. Yellowtail may take on specialized roles during cooperative hunting and refrain from selfish hunting attempts until the prey is well positioned for the whole group.</td>
<td>(Bshary et al. 2006; Vail et al. 2013)</td>
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<td></td>
<td>(Strübin et al. 2011)</td>
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<td></td>
<td>(Schmitt &amp; Strand 1982)</td>
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<tr>
<td>Counting</td>
<td>Mosquitofish can discriminate between different quantities and use true counting for up to at least three objects.</td>
<td>(Agrillo et al. 2009)</td>
</tr>
<tr>
<td>Create internal spatial maps</td>
<td>Gobies can accurately jump between tidal rock pools to escape predators, but only when they have previously explored the pools at high tide. Fish appear to create and process internal maps in a similar way to terrestrial vertebrates.</td>
<td>(Aronson 1971; Braithwaite &amp; de Perera 2006)</td>
</tr>
<tr>
<td>Behaviour</td>
<td>Description</td>
<td>Reference</td>
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<td>-------------------------------------------------------------</td>
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<tr>
<td>Display frustration</td>
<td>Atlantic salmon react aggressively if they do not receive an expected food reward.</td>
<td>(Vindas et al. 2012)</td>
</tr>
<tr>
<td>Eavesdrop (gather information by watching others)</td>
<td>Female fish base their mating preferences on observed battles between males. Males and females prefer mates that they observe being courted by other fish.</td>
<td>(Reviewed in Brown et al. 2006)</td>
</tr>
<tr>
<td>Executive functioning</td>
<td>Zebra fish quickly learn a complex five-step operant training task that was created to study executive functioning and impulse control in rats.</td>
<td>(Parker et al. 2012)</td>
</tr>
<tr>
<td>Individuals have consistent personalities</td>
<td>Individual fish show differences in their shyness, exploratory behaviour, activity, aggressiveness and sociability that appear to be consistent over time.</td>
<td>(Conrad et al. 2011; Dziewczynski et al. 2010)</td>
</tr>
<tr>
<td>Infer social hierarchy by observation</td>
<td>Female Burton’s cichlids that were allowed to watch fights between male conspecifics were able to use these known relationships to infer which fish would win when paired in a new combination.</td>
<td>(Grosenick et al. 2007)</td>
</tr>
<tr>
<td>Learn to avoid fishing equipment</td>
<td>Rainbow trout treat hooks more carefully after a single capture.</td>
<td>(Asky et al. 2006b)</td>
</tr>
<tr>
<td>Maintain cultural traditions</td>
<td>Some fish populations develop behavioural patterns, such as schooling sites and routes, which are not genetic or even optimal but are nevertheless maintained across generations.</td>
<td>(Laland &amp; Hoppitt 2003)</td>
</tr>
<tr>
<td>Make decisions about trade-offs</td>
<td>Fish are safer in shoals that are denser, larger and made up of familiar individuals. Three-spined sticklebacks make decisions about which shoal to join when these features conflict, e.g. Larger school of unfamiliar individuals.</td>
<td>(Frommen et al. 2009)</td>
</tr>
<tr>
<td>Make generalisations based on prior hunting experience</td>
<td>Atlantic salmon are able to generalize from prior hunting experience to deal with new types of prey.</td>
<td>(Brown et al. 2003)</td>
</tr>
<tr>
<td>Migrate</td>
<td>Many species complete migrations, such as salmon, which remember and return to their birthplace, and cardinalfish, which return to specific mating territories after six months.</td>
<td>(Brown et al. 2006; Fukumori et al. 2010)</td>
</tr>
<tr>
<td>Mirror recognition</td>
<td>Burton’s cichlids show different brain activity when challenging a mirror compared to another male.</td>
<td>(Deshjardins &amp; Fernald 2010)</td>
</tr>
<tr>
<td>Behaviour</td>
<td>Description</td>
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<td>----------------------------------------</td>
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<tr>
<td>Operate triggers to obtain food</td>
<td>Commercial aquaculture systems for rainbow trout use mechanical self-feeders that deliver food when fish press a hanging pendulum.</td>
<td>(Alanärä 1996)</td>
</tr>
<tr>
<td>Recognise and deceive eavesdroppers</td>
<td>Male Siamese fighting fish who lose a fight spend more time courting females who did not see the fight. Male Atlantic mollies redirect their attentions to non-preferred females when they know another male is eavesdropping.</td>
<td>(Herb et al. 2003; Plath et al. 2008)</td>
</tr>
<tr>
<td>Recognise each other</td>
<td>Individual fish of many species prefer to associate with familiar rather than unfamiliar conspecifics. Male fish avoid fights with familiar neighbours and fish that have previously beaten them.</td>
<td>(Reviewed in Brown et al. 2006; Griffiths 2003)</td>
</tr>
<tr>
<td>Referential gestures</td>
<td>Groupers and coral trout use deliberate gestures to indicate the location of prey to hunting partners.</td>
<td>(Vail et al. 2013)</td>
</tr>
<tr>
<td>Remember landmarks and places</td>
<td>When coral features are removed, butterfly fish search for them in their previous position. Multiple species have been shown to use visual and chemical landmarks to navigate between food patches or along migration routes. Many species avoid feeding patches where they have previously observed predators.</td>
<td>(Reviewed in Brown et al. 2006; Reese 1989)</td>
</tr>
<tr>
<td>Social learning</td>
<td>Fish that do not participate in inspecting predators change their behaviour when an inspecting fish returns. Several species learn to recognise new predators by observing the fright responses of conspecifics. Socially learnt information may be retained for longer than other learned cues. Naive guppies learn to escape trawl nets by associating with more experienced individuals.</td>
<td>(Reviewed in Brown &amp; Laland 2002; Brown &amp; Laland 2003; Brown et al. 2006)</td>
</tr>
<tr>
<td>Tell the time</td>
<td>Like most animals, fish have an internal circadian clock. At least some species are able to learn associations between specific times and places to anticipate feeding.</td>
<td>(Reebs 1999)</td>
</tr>
<tr>
<td>Tool Use</td>
<td>Stingrays use water as a tool to extract food from test tubes. Several species of wrasse use rocks to smash open clams.</td>
<td>(Kuba et al. 2009)</td>
</tr>
<tr>
<td></td>
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<td>(Bernardi 2012; Brown 2012)</td>
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</table>
1.5 Potential welfare issues for pet fish.

The aim of animal welfare science is to ensure that animals are provided with the best possible standards of care in captivity. However, defining standards for acceptable animal welfare is complex as it involves multiple competing viewpoints held by diverse stakeholders, including industry, animal rights groups, scientists, government, media and the general public (Appleby 2004; Vanhonacker et al. 2008; Verbeke 2009). As a result, animal welfare science is intrinsically interdisciplinary and collaborative (Lund et al. 2006). There are two main approaches to maximising welfare (adapted from Fraser 2003, 2008; Cottee 2012). The first is that welfare can be optimised by meeting the physiological health needs of the animal (e.g. Arlinghaus et al. 2007; Carenzi & Verga 2009). The advantage of this approach to welfare is that health can be measured and described objectively (Dawkins 2006). The second approach to welfare states that the animal should be able to live under conditions that it has freely chosen and which meet its behavioural needs (Carenzi & Verga 2009; Volpato et al. 2007). However, measuring behaviour or mental state is difficult and requires knowledge of what behaviours are most relevant to welfare (Wechsler 2007).

The two measures conflict because good health does not always correlate with the behavioural needs of the animal. For example, providing bedding material increases the risk of some diseases in pigs, but nevertheless is highly valued by the animals for comfort and exploratory behaviours (Tuyttens 2005). Sometimes animals will freely choose conditions or behaviours that are pleasurable but have poor outcomes for both physical and psychological health (Dawkins 2008), such as rats that become addicted to cocaine (Deroche-Gameonet et al. 2004). For these reasons Dawkins (2008) argues that maintaining good health is a prerequisite for good welfare, but is not a guarantee of good welfare.

Different stakeholders tend to prefer one or the other of the two approaches. Producers, for example, prefer to use health-related measures, while consumers tend to rate behaviour as more important (Vanhonacker et al. 2008; Verbeke 2009). The two definitions do not necessarily exclude each other, but reflect different priorities towards a complex issue (Huntingford & Kadri 2009). Both physical and mental health should
be used in combination to triangulate a true definition of good welfare (Dawkins 2006; Fraser 2008).

The most comprehensive and widely accepted approach towards ensuring good animal welfare invokes the Five Freedoms. The Five Freedoms are essentially a checklist of statements that unifies both approaches to welfare (Fraser 2008). The concept was first suggested by the Brambell Report and subsequently developed in the 1970s by the Farm Animal Welfare Council (2009) of Great Britain. In their current form, the Five Freedoms state that animals should be kept:

- Free from hunger and thirst, with access to fresh water and a healthy diet;
- Free from discomfort, because an appropriate environment is provided;
- Free from pain, injury and disease, by providing prevention, diagnosis and treatment;
- Free to express natural behaviour, which may include providing sufficient space, facilities and companions;
- Free from fear and distress, by ensuring the conditions and treatment avoid mental suffering.

(Farm Animal Welfare Council 2009)

Ideally, the Five Freedoms are to be given equal weighting, as proponents of the two different approaches to welfare may place more importance on some freedoms than others (Barnett & Hemsworth 2009). Critics of the Five Freedoms state that they focus too strongly on minimizing negative conditions, rather than maximizing positive welfare (Boissy et al. 2007; Farm Animal Welfare Council 2009; Radford 2004). It is also important to recognise that the Five Freedoms should be considered and balanced across the entire lifespan of the animal (Green & Mellor 2011). For example, vaccinations temporarily infringe on an animal’s freedom from discomfort and pain, but this is offset by lifetime gains in freedom from pain and disease.

Despite this, the Five Freedoms are recognised worldwide and have been used widely in animal welfare science over the last four decades (Farm Animal Welfare Council 2009). As such, they provide a theoretical basis for approaching welfare for the rest of this thesis.
There is considerable overlap between the Five Freedoms for all animals (Botreau et al. 2007), but this is particularly true in fish. Fish health (the third freedom) is complex and closely linked to the environment (the second freedom) (Figure 1.3). For example, both wild and captive fish populations can carry subclinical infections that pose no threat to health and show no symptoms under good environmental conditions (Gomez et al. 2004; Zanoni et al. 2008). However, if a fish becomes stressed it is less able to fight the disease and will manifest symptoms. For example, zebra fish who were exposed to stressful handling or exposed to Mycobacteria experienced very few deaths (< 3%). When the two conditions of stressful handling and disease exposure were combined the zebra fish colony suffered a 14% mortality rate (Ramsay et al. 2009b). Similarly, after exposure to Aeromonas salmonicida bacteria 90% of goldfish who were subjected to handling stress developed lesions, compared to 40% of goldfish that were not handled (Dror et al. 2006). Even if a fish has no pre-existing subclinical infections, stressed animals are vulnerable to ubiquitous environmental bacteria such as Aeromonas hydophila (Hazen et al. 1978; Loh & Landos 2011).

Water quality is the single most important factor for ensuring freedom from disease in fish (Johansen et al. 2006). Poor water quality can harm fish directly, by affecting respiratory and osmotic functions, or it can make fish more susceptible to disease, for example, by reducing their immune resistance (Loh & Landos 2011). However, any stressor — mental or physical — can potentially increase the risk of disease in fish. Environmental stressors that can impair fish welfare are listed in Table 1.3A, while other keeping practices that can cause stress are listed in Table 1.3B. These two tables describe factors that are under the control of the individual aquarist and can be addressed by responsible pet ownership. For example, many fish are kept at suboptimal pH and water hardness because the aquarist has

![Figure 1.3. Diseases in fish arise through interactions between the animal, the pathogen and the environment (Snieszko 1974).](image-url)
chosen to keep several species together that have different requirements (Etscheidt & Manz 1992), which could be easily resolved by keeping species assemblages that are more compatible.

As can be seen from Tables 1.3 A & B, there are scores of factors that can be problems for fish welfare if good husbandry procedures are not adhered to. Some of these problems relate to freedom from hunger (e.g. feeding practices), others to freedom to express natural behaviour (e.g. boredom, enrichment) and others to freedom from fear and distress (e.g. density, unsuitable species). However, it is not clear how widespread any of these problems are in home aquaria. Etscheidt and Manz (1992) conducted the only study that has quantitatively measured the quality of life for pet fish. They surveyed 103 different aquaria in 86 German households and determined that many basic welfare requirements, such as adequate water quality and appropriate species assemblages, were often not being met. The aquarium industry has changed significantly since Etscheidt and Manz conducted their study in 1992 (Adams 2010; Gay 2013; Rhyne & Tlusty 2012). The technology and quality of aquarium equipment has improved immensely, which should have led to better welfare. However, as fish keeping has become easier, cheaper and more accessible it has also become more attractive to novices, who might be less knowledgeable or mindful of animal welfare.

Although this thesis is primarily concerned with behavioural change in aquarists, it is worth noting that there are several welfare problems in ornamental fisheries that are outside the control of individual aquarists (listed in Table 1.3C). Knowledgeable aquarists can avoid contributing to these problems. For example, although legislation and international cooperation are required to solve the issue of wild collection, individual aquarists can avoid contributing the problem by buying locally bred fish.
### Table 1.3. Factors that influence fish welfare.

#### Table 1.3. A Environmental factors that are important for fish welfare.

<table>
<thead>
<tr>
<th>Welfare Concern</th>
<th>Description</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia</td>
<td>High ammonia decreases the functioning of the gills, causing cell damage, increasing water absorption and decreasing ability to excrete toxins. Very high ammonia can be deadly. New aquaria, increased feeding, overstocking and damage to the filter can cause ammonia spikes. A healthy tank should have ammonia levels below 0.25mg/L at all times.</td>
<td>(Loh &amp; Landos 2011; Tomasso 1994)</td>
</tr>
<tr>
<td>Chlorine and heavy metals</td>
<td>Chlorine and heavy metals (often present in tap water) affect gill functioning and can kill fish.</td>
<td>(Loh &amp; Landos 2011)</td>
</tr>
<tr>
<td>Hardness</td>
<td>Water hardness (a measure of ions in the water), influences pH and mineral deficiencies in fish. In over 80% of aquaria the hardness is not kept at an optimal level for all species.</td>
<td>(Etscheidt &amp; Manz 1992; Loh &amp; Landos 2011)</td>
</tr>
<tr>
<td>Lighting</td>
<td>Some colours of aquarium lights, in particular red lights, seem to negatively effect growth and oxidative stress. Photoperiod (the number of hours of light in a day) also influences fish physiology and behaviour.</td>
<td>(Johansen et al. 2006; Shin et al. 2011; Volpato et al. 2004)</td>
</tr>
<tr>
<td>Nitrate</td>
<td>Slows growth and reduces immune resistance to disease. Nitrate is taken up by live plants, or can be removed by regular partial water changes. Nitrate should be kept below 20mg/L.</td>
<td>(Etscheidt &amp; Manz 1992; Loh &amp; Landos 2011; Weber 2010)</td>
</tr>
<tr>
<td>Nitrite</td>
<td>Interferes with oxygen transport in the bloodstream. Nitrite should be kept below 0.2mg/L.</td>
<td>(Loh &amp; Landos 2011; Tomasso 1994)</td>
</tr>
<tr>
<td>Noise</td>
<td>Noise from water pumps and air stones can depress growth and increase chronic stress. Stereos and televisions built into tanks could damage fish auditory processing, although under some conditions music may speed growth.</td>
<td>(Anderson et al. 2011; Papoutsoglou et al. 2008; Smith et al. 2004; Soo &amp; Todd 2009)</td>
</tr>
<tr>
<td>Oxygen</td>
<td>Stocking density, temperature, algal blooms and low water mixing can decrease dissolved oxygen levels. Too much or too little oxygen will kill fish. One fifth of tanks are estimated to have insufficient oxygen.</td>
<td>(Etscheidt &amp; Manz 1992; Loh &amp; Landos 2011)</td>
</tr>
<tr>
<td>Welfare Concern</td>
<td>Description</td>
<td>References</td>
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<tr>
<td>pH</td>
<td>Influences oxygen diffusion into the fish bloodstream. High pH also makes ammonia more toxic.</td>
<td>(Loh &amp; Landos 2011; Thurston et al. 1981)</td>
</tr>
<tr>
<td>Salinity</td>
<td>Inappropriate salinity kills fish through osmotic stress, where the fish cannot regulate the concentration of salt in their body. Salinity can slowly build up through evaporation, when the water is just topped up without doing a partial water change.</td>
<td>(Loh &amp; Landos 2011)</td>
</tr>
<tr>
<td>Temperature</td>
<td>Fish are ectothermic, so water temperature affects metabolic rate, growth, feeding, reproduction, disease resistance, respiration rate and many other physiological factors. 36% of aquaria are kept at temperatures that are not optimal for all the species kept.</td>
<td>(Etscheidt &amp; Manz 1992; Johansen et al. 2006; Loh &amp; Landos 2011)</td>
</tr>
<tr>
<td>Welfare Concern</td>
<td>Description</td>
<td>References</td>
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<tr>
<td>Boredom</td>
<td>Ornamental fish show stereotypical behaviour, which is normally understood to be a sign of boredom or frustration in captive animals.</td>
<td>(Soo &amp; Todd 2009)</td>
</tr>
<tr>
<td>Colour</td>
<td>Many aquarists choose brightly coloured substrates or backgrounds that may cause ongoing stress for fish.</td>
<td>(Etscheidt &amp; Manz 1992)</td>
</tr>
<tr>
<td>Density</td>
<td>Keeping fish at inappropriate densities upsets natural shoaling, courtship behaviours, foraging skills and anti-predator behaviours. High densities can lead to increased aggression and coerced mating. High density can stress fish even in the absence of other environmental stressors. Over half of home aquaria are considered overstocked.</td>
<td>(Brockman et al. 2010; Delaney et al. 2002; Etscheidt &amp; Manz 1992; Hutter et al. 2010; Johansen et al. 2006; Oldfield 2011; Saxby et al. 2010)</td>
</tr>
<tr>
<td>Enrichment</td>
<td>Enrichment can improve welfare for fish, but if used incorrectly can harm fish by introducing toxins and pathogens, interfere with monitoring of fish and entangle animals.</td>
<td>(Kistler et al. 2011; Williams et al. 2009)</td>
</tr>
<tr>
<td>Handling</td>
<td>Handling and netting increases stress in fish, although keeping fish in water while moving them can reduce stress compared to using nets.</td>
<td>(Brydges et al. 2009; Ramsay et al. 2009a)</td>
</tr>
<tr>
<td>Feeding</td>
<td>Poor quality food can reduce growth and cause vitamin deficiencies. A varied diet is important for fish health, but nearly 30% of aquarists feed only commercial flake food. Feeding too little impairs growth, while too much food increases the risk of nitrogen poisoning as the uneaten food rots. Feeding time and frequency can impact mortality. Floating food can cause bottom-feeding fish to starve or swallow too much oxygen. Fish allowed to self-feed are less stressed than those fed at scheduled times.</td>
<td>(Endo et al. 2002; Etscheidt &amp; Manz 1992; Loh &amp; Landos 2011; Lopez-Olmeda et al. 2012)</td>
</tr>
<tr>
<td>Old age</td>
<td>Low level environmental stressors such as pollutants and nutritional deficiencies can cause problems in long lived species.</td>
<td>(Weber 2010)</td>
</tr>
<tr>
<td>Quarantine</td>
<td>Correct quarantine procedures are rarely followed in home aquaria, although they are important for disease prevention.</td>
<td>(Kent et al. 2009)</td>
</tr>
<tr>
<td>Welfare Concern</td>
<td>Description</td>
<td>Selected References</td>
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<tr>
<td>School composition</td>
<td>Territorial species may fight. Even in the absence of aggression, fish can be stressed by the presence of larger or more dominant conspecifics. Small fish, such as white cloud minnows and tetra, shoal better in larger groups.</td>
<td>(Kadry &amp; Barreto 2010; Oldfield 2011; Saxby <em>et al.</em> 2010)</td>
</tr>
<tr>
<td>Size and shape of</td>
<td>It is almost impossible to keep environmental parameters constant in small bodies of water, but many mini-aquariums that hold less than one litre are available for sale.</td>
<td>(Walster 2008)</td>
</tr>
<tr>
<td>aquaria</td>
<td></td>
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<tr>
<td>Substrate</td>
<td>Choice of substrate size is important to encourage natural foraging and breeding behaviour.</td>
<td>(Galhardo <em>et al.</em> 2008; Smith &amp; Gray 2011)</td>
</tr>
<tr>
<td>Shelters</td>
<td>Shelters reduce aggression in some species of fish, but increase aggression in some territorial species.</td>
<td>(Barreto <em>et al.</em> 2011; Kadry &amp; Barreto 2010)</td>
</tr>
<tr>
<td>Species assemblages</td>
<td>Aggression and predation is common between species, but could be avoided with more thoughtful choice of species. Even visual contact with predators in adjacent aquaria can increase stress. 19% of aquaria contain a mixture of predatory and peaceful fish.</td>
<td>(Barcellos <em>et al.</em> 2007; Etscheidt &amp; Manz 1992; Sloman <em>et al.</em> 2011)</td>
</tr>
<tr>
<td>Unsuitable species</td>
<td>Some species that are known to be extremely difficult to maintain in captivity or that grow too large for home aquaria are still regularly traded in pet stores.</td>
<td>(BIAZA 2006; O'Sullivan <em>et al.</em> 2008)</td>
</tr>
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</table>
Table 1.3.C Welfare problems with the ornamental fisheries industry.

<table>
<thead>
<tr>
<th>Welfare Concern</th>
<th>Description</th>
<th>References</th>
</tr>
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<tbody>
<tr>
<td>Artificial selection</td>
<td>Domestication, hybridisation and selection of fish to create artificial types can impair welfare by impairing swimming, eyesight and survival, or by increasing aggression.</td>
<td>(Blake <em>et al.</em> 2009; Fossa 2004; Ruzzante 1994; Verbeek <em>et al.</em> 2007)</td>
</tr>
<tr>
<td>Artificial sex reversal</td>
<td>Siamese fighting fish breeders use hormones to artificially manipulate females to mature as males, which fetch a higher price.</td>
<td>(Kirankumar &amp; Pandian 2002)</td>
</tr>
<tr>
<td>Cosmetic modifications</td>
<td>Modifications to improve sales include injecting coloured dye, tattooed symbols and amputated tails. Injecting dyes increases mortality and causes muscle and tissue damage in fish that survive.</td>
<td>(ABC Online 2009; Fossa 2004; Gomez 2012; Walster 2008)</td>
</tr>
<tr>
<td>Culling</td>
<td>Producers routinely cull fish of unpopular colours or shapes without anaesthesia.</td>
<td>(Walster 2008)</td>
</tr>
<tr>
<td>Diseases</td>
<td>Over 70% of ornamental fish shipments being imported into Australia contained high levels of parasites. Unhealthy and dying fish with high parasite loads are commonly sold at pet stores.</td>
<td>(Evans &amp; Lester 2001; Wickins <em>et al.</em> 2011)</td>
</tr>
<tr>
<td>Euthanasia</td>
<td>The most common forms of euthanasia, such as asphyxiation and decapitation, have a highly negative impact on welfare. Low impact methods, such as anaesthetics and electrical stunning, are not widely available for pet owners.</td>
<td>(Robb &amp; Kestin 2002)</td>
</tr>
<tr>
<td>Lack of species specific knowledge</td>
<td>Habitat and water quality needs are species specific. Few species have been sufficiently well researched to determine their welfare requirements.</td>
<td>(Johansen <em>et al.</em> 2006)</td>
</tr>
<tr>
<td>Learning ability</td>
<td>Brain size and learning ability is decreased in captive fish compared to wild counterparts.</td>
<td>(Burns <em>et al.</em> 2009)</td>
</tr>
<tr>
<td>Rearing conditions</td>
<td>Commercially farmed fry are often reared separately to older fish, which may deprive them of learning opportunities that influence their social skills later in life.</td>
<td>(Gomez-Laplayza &amp; Gil-Carnicero 2008)</td>
</tr>
<tr>
<td>Welfare Concern</td>
<td>Description</td>
<td>Selected References</td>
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<tr>
<td>Transport</td>
<td>Although domestic production of fish is increasing in Australia, 17.7 million fish are still imported from overseas each year. Problems can arise either in transport between suppliers or transport home by the customer. Mortality during transport varies and is caused by a number of problems including lack of oxygen, rough handling, ammonia build up, gill damage and secondary infections.</td>
<td>(Huntingford et al. 2006; Manuel et al. 2013; O'Sullivan et al. 2008; Walster 2008)</td>
</tr>
<tr>
<td>Veterinarians</td>
<td>Most small animal veterinarian vets have little knowledge of fish health and specialist fish vets are rare. Proper veterinary care is undervalued by the industry.</td>
<td>(Miller-Morgan 2010; Walster 2008)</td>
</tr>
<tr>
<td>Wild collection</td>
<td>Collection of fish from wild populations can lead to many problems, including overfishing, environmental degradation and physical harm to fish.</td>
<td>(Walster 2008; Wijesekara &amp; Yakupitiyage 2001)</td>
</tr>
</tbody>
</table>
Aquaculture and aquarist techniques have greatly improved over the last few decades, leading to better survival and faster growth rates for fish. However, production environments often prioritise physical welfare over behavioural welfare (Cheng 2007). It is easier to clean and maintain water quality in aquaria that are completely bare, but this provides no environmental stimulation for the fish (Williams et al. 2009). Lack of stimulation can be somewhat compensated for by selectively breeding animals that cope better with the captive environment; for example, domestic rainbow trout have been bred for higher stress tolerance (Cheng 2007; Gjoen & Overli 2009).

Nevertheless, there are some behaviours that are likely to be essential to animal wellbeing and are difficult or impossible to select against (Jensen & Pedersen 2008). For example, goldfish forage even when they are not hungry, suggesting that the act of foraging itself is rewarding (Smith & Gray 2011). Similarly, burbot have reduced growth when deprived of a stony substrate, even when there are no predators and a substrate is not required for survival (Fischer 2000). For these species, access to substrate is necessary to ensure their freedom to express natural behaviours and freedom from distress.

Enrichment consists of any change made to the captive living conditions of an animal that improves its health and ability to mimic natural behaviours while decreasing unnatural behaviours (Smith & Gray 2011; Young 2003). Environmental enrichment, also known as structural enrichment, consists of adding objects or structures to the environment for the animal to interact with. In an aquarium, for example, environmental enrichment can include substrate, shelters, plants, wood and stones (Williams et al. 2009).

The objective of environmental enrichment is often to make the enclosure resemble the natural habitat of the animals. This can be difficult with fish due to the wide range of species, combination of species kept, limited information about wild fish habitats (Williams et al. 2009), and changing habitat requirements as fish age (Weber 2010). There are also risks associated with using enrichment; for example, live food can introduce pathogens; plastic shelters can leach chemicals; substrates can make cleaning more time consuming; and plants can obscure fish from view and make behavioural
monitoring difficult (Williams et al. 2009). Yet despite these limitations, environmental enrichment has been demonstrated to be valuable for many species.

Simple structures can significantly improve health outcomes for fish. Atlantic salmon who have access to shelters have 30% lower metabolic costs and are less stressed than those without (Millidine et al. 2006). Shelter is especially important to nocturnal species such as burbot, who develop more skin lesions and require more food when deprived of shelter (Wocher et al. 2011). Simple artificial structures and substrates also increase growth in both Atlantic salmon and burbot (Fischer 2000; Naslund et al. 2012).

Conversely, Saxby et al. (2010) found that aquarium fish did not spend more time in the structurally enriched area of the tank. However, this does not mean that the fish did not benefit at all from the enrichment, as Atlantic salmon had reduced stress in the presence of a shelter even if they didn’t actually utilise it (Millidine et al. 2006). Other species may need more complex or natural enrichment to benefit. Zebra fish preferentially spent time near artificial plants (Delaney et al. 2002), but not near glass rods, suggesting that the rods are not similar enough to the natural habitat to provide shelter (Wilkes et al. 2012).

Environmental enrichment appears to improve learning ability in some fish species. Both cod (Strand et al. 2010) and Atlantic salmon (Brown et al. 2003) learn to forage on novel prey faster when provided with enrichment (rocks and plants). Zebra fish reared in aquaria enriched with artificial plants learn to navigate a maze faster than control fish from an unenriched aquaria (Spence et al. 2011). Atlantic salmon grown in an enriched environment with additional substrate had larger brains than those in a bare aquarium, and removing the enrichment resulted in the size difference gradually disappearing as the fish grew (Naslund et al. 2012).

However, these results have not been replicable in all species. Environmental enrichment (in the form of artificial plants, substrate and pots) did not influence learning ability or temperament in three-spined sticklebacks (Brydges & Braithwaite 2009). Nor did enrichment increase the brain size of captive Chinook salmon or guppies, even though wild fish had larger brains (Burns et al. 2009; Kihslinger et al. 2006). It is unclear whether the lack of an effect of enrichment in these cases stems from species differences in environmental plasticity, use of irrelevant or insufficiently complex enrichment, experimental design, or the stress of captivity outweighing any influence of enrichment (Brydges & Braithwaite 2009; Kihslinger et al. 2006).
Not only does structural enrichment vary in value for different species of fish, its value can change depending on the social structure or life history of the species. Small fish, such as white cloud minnows and tetra, use environmental enrichment more often when in small shoals, possibly because being in a larger shoal makes them less vulnerable to predation (Sloman et al. 2011). Male Mozambique tilapia, a nest-building species, were strongly motivated to obtain access to and interact with a substrate, while females were unaffected by the presence or absence of a substrate (Galhardo et al. 2011; Galhardo et al. 2008). Structural enrichment may even reduce welfare in some species. Nile tilapia which are introduced to an enriched aquaria fight more intensely, with more bites, slaps and mouth wrestling, possibly because the habitat is more valuable than in a bare tank (Barreto et al. 2011). Conversely, in other species such as pearl cichlids, structural enrichment actually decreased aggressive behaviour because fish had reduced visibility of competitors (Kadry & Barreto 2010).

Social interaction is extremely important for many species and can be a valuable source of behavioural enrichment, even independently of structural enrichment. This is particularly true for group-living species, as shoaling fish will preferentially spend up to 91% of their time within a group (Gill & Andrews 2001). Keeping aquarium fish in species appropriate shoal sizes reduces aggression and improves feed uptake (Saxby et al. 2010). Choosing a good mixture of species can also improve welfare. For example, tiger barbs are less aggressive towards smaller white cloud minnows and tetra when angelfish are present, because they spend more time avoiding the larger angelfish (Sloman et al. 2011). Unfortunately, there is little scientific guidance on ideal shoal size and species combinations for aquarium fish (Saxby et al. 2010; Sloman et al. 2011) and keeping fish in inappropriate social situations can severely impact on their welfare. Zebra fish kept in high densities display group spawning, as females are unable to escape from males to perform their preferred natural behaviour of avoiding other females and selectively choosing mates (Delaney et al. 2002; Hutter et al. 2010). Subordinate Atlantic salmon double their resting metabolic rate and show increased stress when kept with a larger, dominant fish even when no apparent aggression takes place (Millidine et al. 2009).

Although enrichment can be valuable to many species, Etscheidt and Manz (1992) found that most aquarists do not supply sufficient enrichment. In their survey of home aquaria only 17% of fish owners provided live prey for foraging and 44% provided an adequate number of plants for shelter. Over half (56%) were overstocked and 19% had
an inappropriate mixture of aggressive and peaceful species. Few people had sufficiently large shoals of small fish, mainly because aquarists preferred diversity of species over larger numbers of one species and did not replace shoal members when they died. It is difficult to determine how problematic interspecies aggression is for ornamental fish. Most of the enrichment research to date has focused on species used in aquaculture or laboratory research, which is not necessarily generalisable to ornamental species (although see Kistler et al. 2011; Saxby et al. 2010; Sloman et al. 2011).

Enrichment can be an important tool to encourage animals to express healthy behaviour, but it also varies in its applicability. Different species will respond differently to the same enrichment (Tuyttens 2005). Enrichment that seems similar to us may appear very different to animals (Fraser & Nichol 2011). The value of enrichment may depend on environmental cues (Jensen & Pedersen 2008); for example, shelter is more valuable to white cloud minnows and tetras when they are kept in smaller shoals (Sloman et al. 2011). Nor are all natural behaviours likely to be equally important for animal welfare (Vinke et al. 2008) and some natural behaviours, such as aggression and predation, can even impair animal welfare (Fraser & Nichol 2011). Behaviours that were adaptive in the environment where the animal evolved can prove to be harmful in an artificial environment. For example, the human preference for fatty foods was adaptive when food was in short supply, but now contributes to widespread obesity (Mason & Burn 2011). It is therefore important to measure the effect of enrichment to ensure it is actually beneficial for animal welfare (Williams et al. 2009).

1.7 Measuring fish welfare

Animal welfare relies on scientific data as a basis for making moral decisions. Scientists are increasingly expected to advise stakeholders in making moral and ethical decisions that are outside the scope of their research (Appleby 2004; Lund et al. 2006; Sandoe et al. 2004). Yet scientific studies are plagued by limitations, including ontological uncertainty about whether animals are sentient and capable of feeling pain; conceptual disagreements over value-laden terms such as ‘stress’ and ‘suffering’; a general lack of data; and difficulties in balancing welfare with practical and economic priorities (Sandoe et al. 2004). It is therefore important to do research that assesses welfare while
avoiding making assumptions about what constitutes ‘good’ welfare and seeks practical, effective solutions to any problems (Williams et al. 2009).

The influence of environmental features on welfare can be measured using a variety of techniques including physiological, behavioural and chemical assessments (Williams et al. 2009). For example, studies on the influence of shelters on fish have used measures as diverse as oxygen consumption (Millidine et al. 2006), growth rates (Wocher et al. 2011), cortisol levels (Wilkes et al. 2012) and behaviour (Millidine et al. 2006; Wilkes et al. 2012; Wocher et al. 2011). All of these methods are valid and provide useful information, however, in order to determine the importance of enrichment it is first necessary to establish that animals are using the resource. Two of the most common methods for measuring the influence of enrichment on welfare are preference and motivational testing, both of which look at measures of resource use.

Preference tests involve allowing the animal to choose between resources. This can be done by placing resources at the end of Y- or T-shaped mazes and observing which branch animals choose most often; or by allowing animals access to several resources simultaneously and measuring how much time they spend in the vicinity of the resource (Kirkden & Pajor 2006).

Preference tests are useful because they are straightforward to run and offer a simple, relative measure of preference under certain conditions (Veissier & Forkman 2008). However, preferences should be interpreted with caution as they often depend on the context and can change depending on time of day, previous experience, hunger, number of cues, and environment (Bateson 2004). For example, the choice of bedding material in pigs is dependent on the temperature (Fraser & Nichol 2011). Preference tests are also limited because they only give a relative measure between the resources offered (Veissier & Forkman 2008). This effectively means that when comparing two resources you cannot distinguish between the animal wanting to obtain a preferred resource and wanting to avoid a non-preferred resource (Kirkden & Pajor 2006). Nor can preference tests effectively compare non-substitutable resources, such as bedding and food (Kirkden & Pajor 2006).

Motivational testing provides a solution to these limitations. In motivational testing the animal is required to pay an increasing cost each time it wants to access the resource (Hursh 1980; Kirkden & Pajor 2006). The cost to the animal should be independent of the resource (Kirkden & Pajor 2006) and normally consists of effort expended to press
on a lever or door to enter the resource compartment (e.g. Galhardo et al. 2011; Mason et al. 2001). A resource for which the animal shows inelastic demand is highly valued, whereas animals will decrease their use of less valued resources as the price increases (Figure 1.4, Fraser & Nichol 2011; Hursh 1980; 1984).

When performed correctly, motivational tests can be a powerful tool for measuring the desires of animals and ranking different resources (Kirkden & Pajor 2006). However, there are some important limitations. Animals may show a strong motivation to obtain resources that provide a high reward but are bad for their long-term welfare (e.g. recreational drugs) (Bateson 2004; Kirkden & Pajor 2006) or fail to recognise the value of artificial resources that are beneficial for welfare (Elmore et al. 2012). For example, sows were not motivated to obtain rubber flooring, even though it reduces lesions and increases range of movement compared to concrete floors (Elmore et al. 2012).

Both preference and motivational tests should be interpreted carefully. Many species have a strong urge to monitor their environment, which can result in occasionally choosing a non-preferred option in the course of exploration (Fraser & Nichol 2011; Sherwin 2007). Large individual differences between animals in their willingness to work and obtain resources can also confuse analysis, although as long as individual differences are consistent then population preferences can still be determined (Lee et al. 2011). However, these difficulties are worthwhile as preference and motivational tests are the best methods we currently have of objectively measuring animal desires (Dawkins 2008). The value of resources can be triangulated by using preference tests to

**Figure 1.4. The influence of increased cost on the use of resources by animals in motivational tests.**
determine what animals want and motivational tests to determine how much they want it (Kirkden & Pajor 2006).

It is important to determine the most appropriate measure of work as this can change the results of the test. For example, mice changed their willingness to pay when required to perform a nose-poke rather than press a lever (Chaney & Rowland 2008). The cost task should be chosen carefully as certain tasks may be easier to associate with rewards than others and operant training to perform the task can prompt the animal to associate the action with a reward, rather than resource access (Kirkden & Pajor 2006). Ideally, the task should be presented at regular intervals with an increasing schedule of costs, to maintain consistency for factors such as fatigue and familiarity with the resource (Asher et al. 2009).

Only two studies to date have used motivational testing on fish. Galhardo et al. (2011) tested the value of substrates, mates and food to male Mozambique tilapia, who were required to push a door to access the resource. Garcia (2011) trained female zebra cichlids to swim through hoops for access to films of male zebra cichlids. Both of these studies focus on the evolution of mating behaviours, rather than on the value of enrichment, but they demonstrate that motivation can be quantified in fish.

At present, there is little information on which types of enrichment are most beneficial for the welfare of ornamental fish species. Preference and motivational testing are likely to be a useful tool for gathering data on enrichment, but knowledge alone will not improve fish welfare. Pet fish are reliant on their owners to provide suitable enrichment, so it is the behaviour of people that we turn to next.

**Human Characteristics**

**1.8 Why do people keep pets?**

Pet ownership is pervasive in Western cultures, with 63% of Australian and American households and 53% of United Kingdom households keeping at least one pet (Australian Companion Animal Council 2006, Table 1.1). Since pets have no obvious evolutionary function, there are several potential explanations as to why pet ownership
has become so prevalent in human society. The three main contenders are that pets provide health benefits, that pets are a social parasite and that pets are a cultural meme.

The pet care industry often points to the health benefits of pets (e.g. Australian Companion Animal Council n.d.). Pet owners have fewer allergies, fewer heart attacks, visit the doctor less often, have lower anxiety and depression and enhanced feelings of competence and self-esteem (reviewed in Wells 2009). People who own dogs are more likely to rate their health as good, less likely to feel lonely, and more likely to perceive their suburb as a friendly place to live (Wood et al. 2005). The strongest evidence comes from Heady and Grabka’s (2007) five-year longitudinal study of over 10 000 people from Germany and Australia that found pet owners make 15% fewer visits annually to the doctor than non-pet owners.

Yet the relationship between pets and human health is far from conclusive, due to a lack of well-designed longitudinal studies that could demonstrate a causal link—it may be that healthier people are more likely to purchase pets (Herzog 2011; Wells 2009). There are a number of studies that show neutral, conflicting or negative effects of owning pets (reviewed in Herzog 2011), including a large-scale study of 40,000 Swedish people that showed pet owners had better general health, but worse mental health and more head and neck pain than non-pet owners (Müllersdorf et al. 2010). The benefits of pet ownership are particularly uncertain for elderly people, for whom pets are associated with a greater use of painkillers, depression symptoms and more fractures from tripping over animals (Parslow et al. 2005; Pluijm et al. 2006). Many of the health benefits associated with pets may stem from increased physical activity of pet owners (Müllersdorf et al. 2010). This may explain why people who acquired a dog showed continued health improvements over ten months that were not seen in cat owners (Serpell 1991).

Even accepting that pets provide at least some health benefits, pets also pose a health risk. Dog bites in the United States account for 20 deaths, 670 hospitalisations, 37 000 medical visits and 187 000 untreated bites every year (Weiss et al. 1998). Pets can also transmit dozens of diseases, including toxoplasmosis, giardia, tinea, salmonella, cat-scratch disease, rabies and worms (Rabinowitz et al. 2007). It is estimated that two billion people worldwide are infected with pet-borne parasitic worms that can cause problems as varied as skin lesions, muscle damage, intestinal pain and blindness (Traversa 2012). Even fish carry diseases that can affect people, the most common
being fish tank granuloma (*Mycobacterium* spp.), which causes skin lesions and tissue infections (Decostere *et al.* 2004).

From an evolutionary standpoint pet ownership makes little sense. As well as posing a significant disease and injury risk, pets cost time and money (Archer 1997; Serpell 2003). For instance, in 2009 Australian consumers spent over $6 billion on their pets (Australian Companion Animal Council 2010). Given that pets impose such a cost on people who spend time caring for them, Archer (1997) posits that pets are social parasites that manipulate human social behaviour for their own reproductive success. He has shown that humans prefer animals with infant-like features, which may help to initiate the same type of attachment processes seen between parents and children (Archer & Monton 2011). Over three-quarters of pet owners describe their animals as ‘children’ (Serpell 2003) or as ‘members of the family’ (Anderson 2003; Kubinyi *et al.* 2009). However, human-pet relationships are not replicas of parent-child relationships. Children relate to pets more as friends, sharing secrets and using them for emotional support when upset (Melson 2003). When asked to name important individuals in their life, children include an average of two pets in their list (Bryant 1985). Serpell (2003) points out most parasites generally take advantage of the host without consent, whereas humans understand the cost of having a pet and willingly pay it. Pets also suffer a great deal from their relationship with people, as many domesticated breeds have severe health problems caused by artificial selection (Blake *et al.* 2009; Serpell 2003) and sometimes suffer from high rates of neglect and euthanasia (Marston & Bennett 2009). If pets are a parasite, they are an artificially selected parasite.

Herzog (2010) hypothesises that pets are a meme, a behaviour acquired through cultural practices rather than evolutionary selection. Owning pets appears to run in families, as children who have pets are more likely to own pets when they grow up (Kidd & Kidd 1998; 1999; Paul & Serpell 1993). Pet ownership also varies according to ethnic background (Risley-Curtiss *et al.* 2006) and religion (Knobel *et al.* 2008) and the popularity of dog breeds follows a pattern similar to other culturally informed purchasing behaviours, such as fashion and music choices (Herzog 2006). All of this suggests that pets are associated with certain cultural backgrounds rather than genetics (Herzog 2010). However, a recent study that compared identical and non-identical twins indicates that genetics may be more important than previously supposed, accounting for over a third of the variance in time spent playing with pets (Jacobson *et al.* 2012).
Health, parasite and memes—these provide evolutionary level explanations for keeping companion animals, but are not the same as the proximate, everyday reasons that people give for why they keep pets (Wrye 2009). An American study found that the most common reasons for owning pets were that people would be lonely without pets; pets help to keep people active (for dog owners); pets serve a useful function; pets provide support in difficult times; and pets benefit other members of the family (e.g. children) (Staats et al. 2008). Respondents from a study in the Netherlands reported that they kept pets for company and a sense of social security (Endenburg 1995). A common thread running through studies on pet keeping is that pets provide additional social support for their owners (reviewed in Serpell 1986). The key word here is ‘additional’—given the widespread prevalence of pet ownership, it is dangerous to interpret pets as a ‘social crutch’ for those who are chronically lonely or socially awkward (Serpell 2003). Pets are not a substitute for human relationships, but they do provide additional support when people are going through hard times or have less everyday social contacts due to their life circumstances (Archer 1997; Duvall Antonacopoulos & Pychyl 2010). For example, single students living at college were more likely to state that they would be lonely without their pets than older, married respondents with a family (Staats et al. 2008). Conversely, married couples may appreciate pets because human-pet relationships tend to have less conflict than human-human relationships (Bonas et al. 2000).

Further evidence for the social support function of pets comes from a study that shows interacting with pet dogs increased owner’s levels of oxytocin, a hormone closely associated with social bonding in humans (Nagasawa et al. 2009). However, it is important to note that although pets are perceived to provide social support by their owners, pet-human relationships do not appear to offer the same measurable benefits of reducing loneliness and increasing lifespan that are seen in studies of human-human relationships (Gilbey et al. 2007; Gillum & Obisesan 2010; Holt-Lunstad et al. 2010). Nevertheless, the perception of increased social support appears to be an important motivating factor that drives people to acquire and care for pets (Gilbey et al. 2007).
1.9 Why do people keep fish?

Collis and McNicholas (1998, p115) proposed five components of social support that are fostered by our relationships with pets. These are emotional support, social integration, esteem support, practical or informational support and opportunity for nurturance (Collis & McNicholas 1998; Serpell 2003). Although it is easy to see how well studied pets such as dogs and cats might fulfil these needs, it is more difficult to see how they apply to fish.

The first component, emotional support, is defined as providing comfort in times of stress and is the most easily applied to aquarium fish. Elderly people who observed an aquarium had reduced pulse rates and muscle tension, as well as perceiving the experience as relaxing (DeSchriver & Riddick 1990). In the 1990s some doctors apparently recommended that patients with high blood pressure purchase fish tanks for stress reduction (Kidd & Kidd 1999). However, this is unlikely to be the sole reason for keeping a fish tank, as watching a film on tropical fish can reduce stress more than watching live fish (DeSchriver & Riddick 1990).

Social integration, the feeling of being part of a community with common interests, seems an unlikely benefit of fish keeping. Unlike dog owners, fish owners cannot take their pets out in public with them, so there is less opportunity to create face-to-face interaction (Wood et al. 2005). However, DeSchriver and Riddick (1990) observed that their study participants who observed aquariums were more sociable and started unprompted conversations about their favourite fish with other participants. They suggest professionals who work with elderly clientele consider using aquaria as catalysts to create dialogue and build relationships. Other indicators that fish may serve as social integrators include fish shows and clubs (Hargrove & Hargrove 2006); online aquarium discussion boards and forums; and reports that fish have facilitated friendships with neighbours who were asked to care for aquaria when owners are on holidays (Wood et al. 2005).

Pet fish may play a useful role in the formation of children’s biological knowledge, providing informational support. Hatano and Inagaki (1993) found that six-year-old children who cared for pet goldfish had more accurate knowledge of general animal biology than children who cared for rabbits or ducks. Pet ownership is also linked to increasing self-esteem and responsibility in children (Van Houtte & Jarvis 1995), which
suggests that pets can provide esteem support and opportunity for nurturance. Most research has focused on dogs and cats, but parents seem to think fish ownership is helpful for children: nearly half of Australian households who keep fish state that they do so for the benefit of their children (Franklin 2006).

Practical support involves providing tangible resources or assistance (Collis & McNicholas 1998). Keen fish owners can profit financially from breeding and trading fish, as demonstrated by Gilligan’s (2000) account of a troubled teenager in foster homes who took up aquarium keeping. He was able to make new friends at school who shared his interest and then financially benefitted by trading tropical fish and working at the local pet store. Fish hobbyists can make small profits by swapping or selling their fish to other hobbyists, or can even expand to a business with regulated breeding and collecting of fish for commercial sale (O'Sullivan et al. 2008).

Fish can therefore meet each of the five dimensions of social support, but they are still difficult to reconcile with traditional notions of pet ownership. According to Archer (1997), animals that make appropriate pets are clean, diurnal, furry, trainable, safe, and show love, affection and other social responses towards people. Fish are clean, safe and trainable, but they provide less opportunity for interaction and touch, so the level of attachment and social support fish provide is likely to be less than that of other pets (Langfield & James 2009).

Fish seem to be kept for quite different reasons to other pets. Nine in-depth interviews with fish owners revealed that rather than keeping pets for social support, their reasons for owning fish were that fish are appealing and attractive to watch; they had fish as childhood pet that carried through to adulthood; they were unable to keep other pets, because of travel, allergies or housing restrictions; or they received the fish as a gift (Langfield & James 2009). In a survey of 100 aquarists in the United States, 72% described their fish as pets, 32% described them as an educational experience, 22% as room decorations, 10% as a hobby and only 4% described their fish as companions (Kidd & Kidd 1999). No respondents described their fish as a ‘family member’, which is the term used to describe pet dogs in up to 93% of households (Kubinyi et al. 2009). Fishkeeping is listed as the second most popular ‘hobby’, after photography (Miller-Morgan 2010). Fish owners enjoy caring for their fish and decorating the aquarium, but rarely show emotional attachment or attributed personalities to their pets (Langfield & James 2009). The main benefits of aquariums were considered to be relaxation, stress reduction and entertainment (Kidd & Kidd 1999; Langfield & James 2009). Overall,
fishkeeping appears to be an enjoyable hobby, but does not provide as much physical and emotional interaction as keeping other dogs and cats (Kidd & Kidd 1999; Langfield & James 2009).

Emotional Attachment to Fish

The traditional definition of a pet that we have been working with so far is an animal that is kept for pleasure, as opposed to animals kept for work, food, research or monetary gains. An alternative definition of pet is an animal in which humans have emotional investment (Serpell 2009; Wrye 2009). Wrye (2009) even extends the concept of petness to objects such as electronic pets. Indeed, one experiment showed that residents at a United States nursing home became equally attached to and involved with a robotic dog as they did a real dog (Banks et al. 2008).

Most studies assume that all pets are equal, but this is probably not the case (Serpell 2009; Zasloff 1996). People tend to relate less well to fish than to mammals and birds (Driscoll 1995; Kupsala et al. 2013), suggesting that people may be less attached to their pet fish than other pets. Emotional attachment is likely to be much lower for fish than other pets. This is not necessarily a bad thing. Although 90% of dog owners say they can tell their pet’s moods and emotions (Hills 1995), few dog owners can accurately describe their dog’s body language (Kerswell et al. 2009). In experimental trials dog owners and professional trainers performed no better than non-owners at correctly identifying dog behaviours (Tami & Gallagher 2009). People appear to interpret pet behaviour based on their own expectations, not on the behaviour itself, which can lead to inappropriate training methods (Bradshaw & Casey 2007). For example, Horowitz (2009) conducted an experiment where dogs were placed in a room and ordered not to eat a treat, which was removed by the experimenter after the owner left the room. Dogs who were scolded by their owner were perceived to respond with a ‘guilty look’, regardless of whether the dog or the experimenter took the biscuit. The dog’s high level of responsiveness to human cues means that people wrongly attribute them emotions such as guilt, leading to inappropriate punishment (Casey 2005).

Anthropomorphism can also cause problems outside of training. Rabbit owners who anthropomorphized their pets more were more likely to choose visually attractive but unhealthy foods, rather than boring but nutritional food (Edgar & Mullan 2011).

Unfortunately, a lack of attachment to fish may also mean that their owners value them less. The more attached to their pets people are, the more benefits of owning a pet they
report (Serpell 2003). People who are less attached to their pets may also pay less attention to them. For example, a study of cat owners showed that people who viewed their cat as a ‘mouser’ took less care of their pet than owners who described their cat as a ‘companion’ (Ramon et al. 2010). Dog owners who report being more attached to their pets provide more enrichment and resources for their pets (Shore et al. 2005). By comparison, many people do not even name their pet fish (Langfield & James 2009), which is a key step in recognizing animals as individuals (Borkfelt 2011). Perhaps as a result, fish owners show little grief over their pets’ deaths (Langfield & James 2009) and may not value individual fish enough to spend money on veterinary care (Miller-Morgan 2010).

In his book on the history of aquaria, Bernd Brunner argues that the objectification of aquarium keeping as a hobby has discouraged recognition of fish as sentient pets:

Despite occasional magazine articles on the “appropriate keeping” of animals or on how to counteract animal cruelty, there was no real pity for fish, and the legitimacy of the aquarium was never called into question. The question of whether the fish were being kept inappropriately was never asked…. Aquarium is such a harmless word, obscuring the fact that it’s really about plants and animals caged in a tank.

(Brunner 2005, p. 83)

Fish are not the only pets that are treated in this way—birds, in particular, face similar problems (Table 1.4). There is less information on small mammals, but they are likely to be subject to some of the same problems including behavioural problems, a poor understanding of health amongst owners and misconceptions about their biology (Mullan & Main 2006; Normando & Gelli 2011).
Table 1.4. Common misconceptions about the biology of pet birds and fish that may lead to poor welfare outcomes.

<table>
<thead>
<tr>
<th>Misconception</th>
<th>Bird Examples</th>
<th>Fish Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viewed as a group, rather than as individuals.</td>
<td>People misunderstand birds because they are viewed as a flock, not individual animals (Anderson 2003).</td>
<td>Fish are often sold in bulk e.g. ‘Comets 5 for $10’ (City Farmers 2011). Fisheries and exporters measure catch by weight, not number of fish (Ploeg 2007; Stibbe 2006).</td>
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<tr>
<td>Difficult for people to relate to.</td>
<td>“[In zoos] birds do not excite much interest or hold visitors’ attention for very long. People just do not seem to be able to relate to birds.” (Mullan &amp; Marvin 1998).</td>
<td>People are not as interested in the aquatic environment and feel they cannot interact as easily with aquatic animals (Kidd &amp; Kidd 1998).</td>
</tr>
<tr>
<td>Incorrectly perceived to be low maintenance.</td>
<td>Many internet websites suggest this. For example, ApartmentRatings.com (2010) suggests keeping fish because ‘you should not have to clean the tank more than once a month’ or birds because ‘their care takes less than ten minutes, does not have to be daily, and can be done by almost anyone.’ Most reference books recommend a minimum of 15% water change weekly for fish (Hargrove &amp; Hargrove 2006) and dedicated bird owners commonly spend over three hours a day interacting with their pets (Anderson 2003).</td>
<td></td>
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<tr>
<td>Aesthetically pleasing; living interior decoration.</td>
<td>Birds are sometimes thought of as a decorative pet (Anderson 2003).</td>
<td>Aquariums are frequently installed in public spaces, such as shopping centres, to complement the interior design (Soo &amp; Todd 2009).</td>
</tr>
<tr>
<td>Lack of awareness about health and sensitivity to environmental factors</td>
<td>Most veterinarians lack knowledge about bird physiology. Birds often suffer from subclinical illnesses and are vulnerable to indoor air pollutants (Anderson 2003).</td>
<td>Disease in fish is complex and often intertwined with environmental stressors (Johansen et al. 2006). There is limited training for general practice vets (Loh &amp; Landos 2011).</td>
</tr>
<tr>
<td>Perceived to be well suited to captivity</td>
<td>Stereotypical behaviours are common in captive birds and include spot picking, route tracing and misdirected sexual behaviours (Van Hoek &amp; Cate 1998).</td>
<td>Fish develop stereotypic behaviours (Soo &amp; Todd 2009) and stocking densities and species assemblages can impair natural behaviour (Saxby et al. 2010).</td>
</tr>
<tr>
<td>Many people have a poor understanding</td>
<td>New bird owners often have little existing knowledge about birds and</td>
<td>Many fish owners keep their pets in sub-optimal conditions</td>
</tr>
<tr>
<td>of care and welfare.</td>
<td>find it difficult to acquire information (Van Hoek &amp; Cate 1998).</td>
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<tr>
<td>Potentially long lived, but often die prematurely due to poor care.</td>
<td>Young <em>et al.</em> (2011) analysed records for 262 parrot species kept in zoos and found the normal lifespan to be far shorter than expected. For example, galahs can live over 70 years but had a median age of just two years.</td>
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<tr>
<td>Highly intelligent, but perceived as stupid.</td>
<td>Students credit birds with lower intelligence than almost all mammals, although still greater than fish and reptiles (Nakajima <em>et al.</em> 2002). 'Birdbrain' is a common insult meaning stupid.</td>
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<td></td>
<td>Fish that can live for decades often survive for only a few weeks when kept by beginners (Weber 2010).</td>
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<td></td>
<td>The commonly held myth states that fish have a three-second memory (Mythbusters 2004) and public surveys rate fish cognition lower than other vertebrates (Kupsala <em>et al.</em> 2013; Nakajima <em>et al.</em> 2002).</td>
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1.10 What influences pet owner behaviour?

Attitudes toward fish

Erroneous beliefs and general lack of understanding contribute to the way people form their attitudes about fish. Attitudes are a mental evaluation or way of thinking about a subject along a continuum of like/dislike or positive/negative attributes (Ajzen 1991; Ajzen & Fishbein 2000; McCleery et al. 2006). In general, people have more positive attitudes towards animals that are phylogenetically close to people (e.g. monkeys), ‘cute’ or loveable (e.g. dogs), rare or endangered (e.g. panda), useful (e.g. sheep), or are perceived as intelligent (e.g. dolphin) (Driscoll 1995; Knight et al. 2004; Serpell 2004). More negative attitudes are held for animals that are viewed as dirty (e.g. cockroaches), dangerous (e.g. sharks), unlovable (e.g. slugs) or unresponsive (e.g. turkey) (Driscoll 1995; Serpell 2004). Companion animals normally attract more positive attitudes than livestock (Levine et al. 2005). Attitudes can also vary towards the same species in different contexts (Serpell 2004). For example, people differentiate between dogs kept as pets and dogs kept for food in South Korea (Podbersek 2009).

Fish are generally perceived to be useful—because they are a source of food—but unintelligent and unlovable (Driscoll 1995). After surveying 1890 Finnish citizens Kupsala et al (2013) suggested that fish are viewed as a ‘kind of semi-animal’, an attitude which downplays the importance of fish welfare and could make killing fish more acceptable. In a direct comparison of attitudes toward fish and pigs, Frewer et al. (2005) found that people were less likely to feel compassionate, guilty or responsible for welfare in fish. If attitudes are predictive of behaviour then it would not be surprising if pet fish are poorly cared for.

Measuring attitudes

Early behavioural models assumed that attitudes would correlate with behaviour (Rise et al. 2010), for example, that if you have positive attitudes towards animal welfare then you would be less likely to buy factory farmed food, or to mistreat your pets. However, general attitudes towards issues have repeatedly been shown to be poor predictors of specific behaviours (Ajzen 1991; McCleery et al. 2006). This is because behaviours are specific to a given situation, whereas general attitudes measure beliefs about the outcome of the behaviour, not the salient behaviour itself (Ajzen & Fishbein 2000).
Attitudes should therefore be measured along a bipolar continuum with regards to a specific, target behaviour (Ajzen 2002; Groves et al. 2013). For example, if measuring people’s attitudes toward keeping fish in large tanks it would not be relevant to ask, ‘Should fish be kept in large tanks?’ with a multiple-choice answer consisting of ‘yes’, ‘no’ and ‘maybe’. Rather, the attitude should be measured with questions such as ‘Keeping my fish in a large tank is:’ and answers should use a five-point Likert scale from ‘harmful to my fish’ to ‘beneficial to my fish’. Several attitudes often need to be measured as it can be difficult to identify the exact attitude that is most relevant to the behaviour (Ajzen & Fishbein 1977). In the example of ‘keeping my fish in a large tank is:’, the relevant attitude could also be measured on a scale of ‘more difficult’ to ‘easier’, or ‘expensive’ to ‘inexpensive’.

Even so, most people do not have consistent, easily accessible attitudes towards every situation (McCleery et al. 2006). Rather, people have a large number of beliefs about any topic and then spontaneously select the most accessible beliefs to form attitudes on the spot; close examination of ideas is reserved only for important issues (Ajzen & Fishbein 2000). This helps to explain why attitudes towards animal welfare do not predict purchasing of welfare friendly products but do predict high-involvement community directed behaviours, such as letter writing and donations to welfare charities (Coleman 2008). For example, consumers are willing to pay more for farmed fish with fewer diseases (a food quality issue) than for fish with fewer injuries (a welfare issue) (Grimsrud et al. 2013). When shopping for food, people are more likely to make decisions based on accessible beliefs about food quality and price rather than animal welfare implications (Verbeke 2009). But if attitudes alone are not predictive of behaviour, then how might we model the behaviour of fish owners?

The most widely accepted model for human behaviour is Ajzen’s (1991) Theory of Planned Behaviour, which states that attitudes, social norms and behavioural control can together be used to predict intentions. In turn, intentions predict the adoption of behaviours (Figure 1.5). A meta-analysis of 161 studies across various behaviours found that on average the Theory of Planned Behaviour can account for 27% of the variance in a behaviour, which is considered a medium to large effect (Armitage & Conner 2001).
Figure 1.5a. Model of the Theory of Planned Behaviour.

Social Norms

Social norms are beliefs about the social acceptability and prevalence of a behaviour and can have a powerful influence on intentions (Cialdini & Goldstein 2004). It has been suggested that social norms are the least important component of TPB and provide little additional predictive power to the model in most cases (Armitage & Conner 2001), or are most relevant to social behaviours such as drinking and smoking (Manning 2009). Conversely, Nolan et al. (2008) propose that social norms often go undetected because most methodologies rely on self-reporting of motivation. Their participants reported that norms were unimportant when making decisions about energy conservation. Yet the group that received a doorhanger with a message about neighbourhood energy usage saved significantly more power than other groups who received messages concentrating on environmental responsibility, social responsibility or financial savings. There has been little research into how social norms about animal welfare influence behaviour. However, Rohlf et al. (2010) found that behaviours related to responsible dog ownership, such as microchipping, could be predicted from the owner’s beliefs about how family and friends perceived the behaviour.

With regards to fish ownership, most people perceive fish welfare as being less important than livestock welfare (Frewer et al. 2005), which may suggest that there is little social pressure to be a good fish owner. However, social norms may be more important within specific fish owner communities. As discussed earlier (Chapter 1.9), fish can provide some social support, but it is not known how often fish owners interact or share information on what are considered socially acceptable husbandry behaviours.
**Behavioural Control**

Intentions alone should be highly predictive of behaviour, providing the behaviour is completely under the control of a person (Ajzen 1991; Armitage & Conner 2001). This is rarely the case, as there are multiple barriers to actual and perceived behavioural control (Ajzen 1991). Actual barriers to control can include a lack of resources, facilities and support (Maiteny 2002). For example, most horse owners know that horses prefer to be kept socially, but continue to keep them in single stall housing because this is often the only option available (Visser & Van Wijk-Jansen 2012).

Other behaviours are affected by perceived control rather than actual control. For example, horse owners know that stereotypic behaviours (e.g. cribbing, windsucking) are a result of boredom, but typically treat the symptoms, rather than the underlying cause because it is perceived to be easier (Visser & Van Wijk-Jansen 2012). Perceived barriers can relate to perceptions of the severity of the problem, the benefits of changing behaviour, the difficulty of the new behaviour, habits, past experience, and beliefs about personal responsibility (Ajzen 1991; Cottrell & Meisel 2003; Wells et al. 2010). In some cases, both perceived and actual barriers can play a role. For example, sheep farmers may hold negative attitudes towards mulesing, but still continue the practice because they do not believe other available methods are as effective at preventing flystrike (actual) and because they believe that changing their behaviour would be an admission that they were wrong (perceptual) (Wells et al. 2010).

Behavioural control should be high for aquarists, as they have complete responsibility for the care of their fish. Actual barriers to fish care may include the cost of equipment and space requirements of aquaria (Tullock 2006). Perceived barriers to optimal care can include the desire to keep incompatible species because they are visually attractive (Etscheidt & Manz 1992), the perception that fish are unable to feel pain (Kupsala et al. 2013) and a lack of knowledge about fish care.

**Knowledge**

Knowledge is not specifically included in the Theory of Planned Behaviour, but can influence all three factors, especially attitudes and perceived behavioural control. Knowledge is often associated with positive attitudes and behaviour towards animals. Positive attitudes and beliefs about bats and birds were correlated with greater knowledge of their biology (Prokop et al. 2009; Prokop et al. 2008; Sexton & Stewart 2007); children with a greater knowledge of animal biology keep more pets (Prokop & 48
Tunnicliffe 2010); knowledge of dolphin biology was associated with fewer harassment behaviours from tourists (Barney et al. 2005); knowledge of reef protection predicted personal responsibility in scuba divers (Cottrell & Meisel 2003); and any sort of recreational involvement with animals, such as fishing, hunting and bird watching, is associated with an increased knowledge of those animals (Serpell 2004). Specifically with regards to pets, people with a greater knowledge of rabbit biology are more likely to neuter and provide companionship for their pet rabbits (Edgar & Mullan 2011) and pet owners who relinquish their animals to shelters have more misconceptions about pet care and biology than owners who keep their pets (New et al. 2000). In many of these studies the causal relationships are not clear and it cannot be determined if knowledge leads to positive attitudes or vice versa (Prokop et al. 2008). Tisdell et al. (2007) found that information provided about lesser-known species increased their likability, but for well known and familiar animals information provision alone is not likely to be enough to change attitudes (Coleman 2010).

A basic knowledge of an animal’s biology is a pre-requisite to providing good welfare (Hemsworth et al. 2009). This is particularly true for fish, as most people have more difficulty intuitively identifying with the aquatic environment (Kidd & Kidd 1998). It is easy to recognize that a dog needs food and shelter because these are things we value for ourselves; it is more difficult to recognize that a fish requires balanced water chemistry because it is not a need we are familiar with. The general public appear to have a poor knowledge of fish behaviour compared to other animals. Kupsala et al. (2013) found that only 40% of people could correctly identify that Atlantic salmon can become stressed and just 34% knew that salmon can recognize each other. Further, people report a much higher level of uncertainty in attributing pain, fear, stress and cognitive abilities to fish than to other animals such as chickens, pigs and cattle (Frewer et al. 2005; Kupsala et al. 2013). It is not known how knowledgeable aquarists are about fish behaviour and biology, but given that many aquarists keep their fish in sub-optimal conditions (Etscheidt & Manz 1992) they may be lacking a detailed knowledge of water quality and species-specific behavioural requirements.

Once people have formed an opinion about an issue they often stop looking for more information and their beliefs are highly resistant to change (Vetter 2010). Instead of focusing solely on improving knowledge, it is normally necessary to target underlying beliefs and attitudes towards specific behaviours (Hemsworth et al. 2009).
Figure 1.5b. Expanded model of the Theory of Planned Behaviour (adapted from Ajzen 1991; Albarracin et al. 2005; Hemsworth & Coleman 2005).

All the factors discussed (including gender, knowledge, actual and perceived behavioural control) as well as other potentially important influences can be added to the Theory of Planned Behaviour to create a fuller picture of the concepts underlying behaviour and behavioural change interventions (Figure 1.5b).

Interventions

Once we understand the factors that contribute to behaviour, it should be possible to intervene with programs, workshops or advertising that targets specific behaviours. A meta-analysis of 47 studies on behavioural interventions showed that they averaged a medium to large effect on intentions, which in turn had a small to medium change in behaviour (Webb & Sheeran 2006). In relation to animal welfare, interventions work best if targeted at the people who are directly responsible for the animals (Whay 2007) and contain elements of education, to increase knowledge, and persuasion, to change attitudes (Coleman 2010).

Paul Hemsworth, Graeme Coleman and colleagues have implemented effective interventions in commercial pig and cattle farms. In a number of related studies they showed first that animal productivity is correlated with poor handling (Hemsworth et al. 1986; Hemsworth et al. 2000), that poor handling is correlated with poor attitudes (Coleman et al. 1998; Hemsworth et al. 2000) and that behavioural intervention programs succeeded in improving handling skills, reducing animal fear, increasing animal productivity and increasing employee retention (Coleman et al. 2000; Hemsworth et al. 1994; Hemsworth et al. 2002). The behavioural interventions used consisted of a one-hour session focused on imparting information, another session targeting specific behaviours with film examples and follow-up with posters and newsletters in the workplace (Hemsworth et al. 1994).
These interventions were based on theoretical cognitive behavioural principles and feature several techniques that have been shown to change behaviour, including providing information based on the observed behaviours and outcomes, allowing questions, targeting specific skills and using personalized messages (Hemsworth et al. 1994; Webb & Sheeran 2006). In a meta-analysis across a range of disciplines, Webb and Sheeran (2006) showed that interventions were more successful if they were based on the Theory of Planned Behaviour, used social support, provided incentives and were delivered by an educator or researcher.

Cautions and Limitations

The Theory of Planned Behaviour is designed to be applied to specific goal-orientated behaviours. Each component may vary in importance depending on the situation (Ajzen 1991). The Theory of Planned Behaviour is also open to the addition of other variables if required (Rise et al. 2010). For example, there is evidence that past behaviour (e.g. habits) and self-identity can add further predictive power on top of their existing inclusion as a contributor to attitudes (Ajzen & Fishbein 2000; Rise et al. 2010; Webb & Sheeran 2006).

The Theory of Planned Behaviour states that intentions are a reasonable predictor of behaviour, capturing the motivation and effort that a person is willing to put towards the behaviour (Ajzen 1991). Many studies therefore look at intention as a proxy for behaviour, but it is still important to measure actual behaviour (Webb & Sheeran 2006), as the predictive value for intention tends to over-estimate behaviour by about 10% (Armitage & Conner 2001). The gap between intentions and behaviour increases as time passes, as new factors intervene and influence intention (Ajzen 2011; Webb & Sheeran 2006).

The method by which behaviour is measured can also influence results. Self-reporting of behaviour is not as reliable as external monitoring (Armitage & Conner 2001), although the reliability of self-reporting may depend on how socially acceptable the behaviour is (Webb & Sheeran 2006), reflecting the influence of perceived social norms. Lastly, not all behaviours will follow the Theory of Planned Behaviour, as some interventions may activate behaviour without conscious planning and intentions being held by participants (Webb & Sheeran 2006), as has been discussed in the case of social norms (Nolan et al. 2008).
1.11 Influence of the media on behaviour

Targeted, hands on interventions such as Coleman and Hemsworth’s workshops for livestock handlers (Coleman et al. 2000; Hemsworth et al. 1994; Hemsworth et al. 2002) are effective at changing behaviour, but are resource intensive and limited in their reach. Mass media campaigns are considered to be the most effective method to implement widespread change, but even so they will only reach 5-10% of the population (Coleman 2010) and increase the uptake of the target behaviour by an average of 5% amongst the target population (Snyder 2007). In the long term, social change is needed to sustain individual behavioural changes (Evans 2009). Given that pet owners are unevenly dispersed through the population, mass media is still likely to be an efficient way of reaching aquarists.

After completing formal education, most people rely on the media to obtain scientific information, especially film and television (Bienvenido 2008; Dhirgra 2006; Hwang & Southwell 2009; Miller et al. 2006). Unfortunately, science is not particularly well suited to television. Science is often abstract, systematic, structured and slow, whereas film is visual, immediate and relies on narrative structure (Van Dijck 2006). Popular media depictions of science tend to simplify information and eliminate scientific uncertainty (Bienvenido 1998).

Simplification of scientific information is prevalent in animal films, which are typically highly cinematic, artificial and build unrealistic expectations among the audience (Bouse 2003). Most wildlife films are scripted to conform to the expectations of the genre and the pre-conceived ideas of the writers (Bouse 1998). Close-ups and action shots help to humanize the animals and sustain viewer interest, while shots of multiple animals are cleverly edited together to tell a story about the life of an individual animal (Bouse 2003; Ladino 2009). The tradition of wildlife documentaries has built an expectation in audiences that animals are interesting, and filmmakers are required to meet the expectations of the audience (Bouse 1998). In reality, most animal behaviour is far more boring and involves a lot of time spent sleeping (Bouse 2003). Science in film is focused on manufacturing an image of science and nature, rather than representing actual scientific processes (Kirby 2003). It may therefore be difficult to realistically communicate the science of animal welfare in film or media, as the nature of the content conflicts with both audience expectations and filmmaker’s current practices.
Fish are less anthropomorphised than other animals and more likely to be neglected or portrayed as food objects. In David Attenborough’s *Blue Planet* fish were portrayed primarily as food for more charismatic species, with five out of six episodes featuring baitballs being attacked by predators (Jefferies 2003). Film critic Yar Habnegnal (2007) points out that animated movies such as *Madagascar* and *Happy Feet* continue to objectify fish even when anthropomorphising all other animals. He writes:

> All the fish look the same; they lack personal attributes, do not speak and presumably have no language. And when they die we never see emotions, expressions of pain or blood.

(Habnegnal 2007, p. 3)

Similarly, children’s television typically condemns maltreatment of mammals while ignoring cruelty to fish and invertebrates (Paul 1996). The exception to the rule is the animated film *Finding Nemo* which, as we shall see, failed to change the audiences’ ingrained perceptions of fish.

Documentary makers defend their narrative portrayal of the natural by arguing that they establish intimacy with animals, which is important in forming positive attitudes towards animals, which in turn builds support for wildlife conservation (Bouse 2003). So far, there is very little evidence that environmental films lead to pro-environmental behaviour, but this may be due to a lack of research rather than a lack of effect (Bouse 2003; Ladino 2009; Valenti 2010). Recreational consumption of film and television appears to be related to children’s attitudes towards the environment, possibly because they are a long-term and continuous influence (Eagles & Demare 1999). For example, 95% of school students report that they learn about the ocean from movies and television (Cummins & Snively 2000) and a documentary about insects increased children’s knowledge and positive attitudes in a classroom lesson (Barbas *et al.* 2009). Consuming environmental media is also related to positive knowledge and attitudes about conservation in adults, but cause and effect are difficult to untangle as people normally watch shows that reflect their pre-existing interests (Holbert *et al.* 2003). This is similar to the relationship discussed earlier between knowledge and recreational involvement with animals, where the direction of causation is unclear (Prokop *et al.* 2008).
Studies have shown that film can have a powerful influence on behaviour. For example, people who watched *Border Security*, an Australian reality television show about airport customs, paid more attention to filling out their customs declaration cards (Meade 2011). Similarly, targeted medical dramas have been shown to increase the number of people signing up for organ donation (Morgan *et al.* 2009). The influence of film appears to be cumulative: women who watched episodes of both *ER* and *Grey’s Anatomy* that featured breast cancer were more likely to have their breasts screened than women who watched just one of the programs (Hether *et al.* 2008).

Films can also have a negative effect on the audience’s behaviour. Sometimes this is unsurprising; for example, movies that feature characters who smoke increase the uptake of smoking by teenagers (Sargent 2005). However, often the negative impacts of films are unintended. For example, the popular crime shows contribute to misconceptions about genetics and DNA evidence amongst both school children (Donovan & Venville 2012) and adults (Ley *et al.* 2012). Even medical dramas, which are normally beneficial for public health, can have unintended impacts. Hawton *et al.* (1999) found that when someone is shown to overdose on paracetamol in a TV show, attempted suicide admissions to real hospitals increase. In interviews, patients stated that they were inspired by the TV show to act on pre-existing suicidal thoughts and many admitted they even used the same brand of paracetamol that was shown in the episode.

The impact of media on behaviour is not necessarily sustained over time. Al Gore’s 2006 documentary *An Inconvenient Truth* grossed $49 million worldwide and increased viewer’s knowledge, concern about the environment, willingness to take action on climate change and purchase of carbon credits to offset flights (Jacobsen 2011; Nolan 2010). Unfortunately, these effects were only temporary, with behaviour and sales of carbon credits returning to normal within a month (Jacobsen 2011; Nolan 2010). A similar climate change documentary, *The Age of Stupid*, was also found to cause temporarily improvement in attitudes and behaviours; with viewers reverting back to baseline levels within 10-14 weeks of watching the film (Howell 2011).

These examples show that films can have either a positive, negative or neutral influence on the audience. As mentioned earlier, fish are normally portrayed as prey objects and do not generally star in films and media campaigns. However, there are a few cases
where fish have featured prominently in the media with differing results and these are discussed in depth.

Case Study 1: The End Of The Line

Based on the book of the same name, The End of The Line was an 85-minute documentary that delved into the international problem of overfishing. Britdoc Productions (n.d.) commissioned a comprehensive evaluation of End of the Line, one of the very few well-designed studies on the effect of documentary films on peoples’ behaviour. Overall, 2% of people in the United Kingdom watched End of the Line and 9% were aware of the film. This is successful given that most mass media campaigns are only expected to reach 5-10% of the population (Coleman 2010).

Sales of sustainably procured fish in the Waitrose supermarkets in the United Kingdom rose by 15% within a month of release; 750 000 people used the online app to check where their fish came from; and corporate catering companies and pet food giant Whiskas pledged to use only sustainably sourced fish (Britdoc Productions n.d.).

Before watching the documentary only 43% of audience members were willing to commit to purchasing sustainable seafood; this rose to 84% after the screening. Most importantly, focus groups showed that audience members were still abiding by their commitment to buy sustainable fish twelve months after they watched the documentary. Overall, The End of the Line had an strong positive effect on audience behaviour (Britdoc Productions n.d.).

Case Study: Sea Kittens

In 2009, the People for the Ethical Treatment of Animals (PETA) group launched the Save The Sea Kittens campaign, which is still available online at http://features.peta.org/PETASeaKittens. Sea Kittens was an Internet media campaign that appeared to be targeted at children and aimed to encourage them to stop eating fish. The website consists of interactive bed time stories; a game that involves decorating fish with clothes and accessories; downloadable web banners and desktop backgrounds; and the option of buying plush toy Sea Kittens.
PETA explain the name of the campaign,

When your name can also be used as a verb that means driving a hook through your head, it's time for a serious image makeover. And who could possibly want to put a hook through a sea kitten?

(PETA 2009, *About the campaign*)

The PETA Sea Kitten campaign has been widely declared a failure. Encyclopaedia Dramatica described the website as, “something you'd expect from a *Powerpuff Girls* fansite, rather than a webpage for an anti-fishing campaign” (*Sea Kittens* n.d.) and a parody website was created to advertise steaks (Carlson & Krangel 2009). Offline, satirical television host Steven Colbert ridiculed the campaign, declaring he was going to eat some ‘landfish’ (a.k.a cats) (Hoskinson 2009). In the five years since the campaign has launched, the Sea Kitten petition gathered less than 7400 signatures. For comparison, a PETA petition to free an elephant raised 60 000 signatures (Baier 2013) and a petition to ban horse-drawn carriages in New York over 100 000 signatures (Kretzer 2013). There are no data to suggest that the Sea Kitten campaign convinced anyone to give up fishing or eating fish, but neither is there any evidence to suggest it increased unwanted behaviours.

*Case Study 3: Finding Nemo*

While the impact of medical dramas, forensic science and documentaries have been relatively well researched, the influence of animated films is less well understood. Many recent animated movies have strong environmental conservation themes and reach large audiences. *Happy Feet* looked at how overfishing affects penguins and grossed $370 million; *Rio* examined illegal poaching and smuggling of endangered animals and made $470 million; *Avatar* promoted conservation of the natural environment and made $2780 million worldwide; and *Finding Nemo* grossed $865 million (Yong *et al.* 2011).

*Finding Nemo* is a popular children’s animated film that centres around the capture of a clownfish from his home on the Great Barrier Reef and his subsequent efforts to escape from a fish tank and reunite with his father. Several of the other characters display stereotypic or slightly insane behaviour that are inferred to have been caused by their confinement in the aquarium, such as being obsessed with the aerator bubbles and talking to reflections in the tank wall. The leader of the tank is Gil, a moorish idol, who
has his own obsession with escaping the aquarium and returning to the ocean. He states, “Fish aren’t meant to be in a box, kid. It does things to ‘ya” (Stanton & Unkrich 2003).

It was commonly anticipated that these subtexts in *Finding Nemo* would encourage its audience to empathise with fish. Right-wing Australian political commentator Andrew Bolt asserted that the film encouraged “nature-worshipping New Age-ism” and taught “a morality that is so impractical or shallow that it soon becomes a game of pretend” (MediaWatch 2003, para 4 & 7). Meanwhile, PETA (n.d.) wrote that “PETA hopes kids who see *Finding Nemo* will take its sealife-saving message to heart and is urging them not to eat the real-life counterparts of the movie’s stars.”

However, *Finding Nemo* failed to inspire the expected reaction in viewers. Regardless of the strong anti-captivity message in the film, consumers became interested in owning clownfish and reef aquaria. Sales of clownfish rocketed, with demand quickly outstripping supply (Atkinson 2003; Jackson 2003; Plate 2007; 2008). Breeders, collectors and pet stores appreciated the extra business, even while raising concerns that many fish were purchased by customers without the knowledge or expertise to care for them (Atkinson 2003). Many clownfish were also unsustainably harvested from the wild, depleting fish stock in unregulated countries such as Vanuatu, despite celebrity appeals and media coverage of the problem (Corcoran 2004; Jackson 2003). How is it that viewers gained an appreciation for clownfish while ignoring the welfare and conservation messages of the film? One possibility is that they didn’t take the messages seriously because animation lacks believability. Even young children are able to clearly distinguish between real people and fictional characters (Skolnick & Bloom 2006).

Blogger Nathan Hill (2012) argues that *Finding Nemo* did have a positive influence on the fish trade, bringing in new hobbyists, boosting marine sales and increasing knowledge. However, including ‘hard information’ in a film may also help to perpetuate misinformation. For example, geology students who watched the sci-fi movie *The Core* retained incorrect information that was presented alongside scientifically accurate information (Barnett *et al.* 2006). Since *Finding Nemo* presented both accurate (e.g. clownfish live in anemones) and fictitious (e.g. the character Dory suffers from short-term memory loss) information together, it can be difficult for viewers to separate the two. This may help to perpetuate some myths about fish, such as that fish have a three-second memory. Misinformation is sometimes more likely to be remembered over time than facts, as when provided with a compelling storyline people spend less time monitoring the credibility of the film (Barriga *et al.* 2010).
1.12 Framing animal welfare

As these case studies show, using media as a behavioural intervention can be successful in changing behaviour (e.g. *End of the Line*), have no effect (e.g. *Sea Kittens*) or change behaviour in the opposite direction to that which was intended (e.g. *Finding Nemo*). This may be a result of the way in which the target issue is approached. Most societal and scientific issues can be approached from different viewpoints, emphasising different values and considerations of the same essential argument. Choosing a single viewpoint for communicating an issue is known as framing and can have significant effects on the way in which the audience responds (reviewed in Chong & Druckman 2007; Kahneman 2011). For example, people perceive minced beef to be less greasy when it is labelled as ‘75% lean’ compared to ‘25% fat’ (Levin & Gaeth 1988).

Animal welfare is a good case topic for studying the influence of framing, as it is an issue that has an extremely broad potential audience who hold conflicting values and viewpoints. Animal welfare is highly valued by the general public (Bennett 1998), but most people lack knowledge about specific welfare topics (Tawse 2010). In theory, this means that there is a large audience who are prepared to act on animal welfare issues if the relevant organisations can communicate their message effectively.

At this point, it is helpful to note the difference between animal rights and animal welfare. Animal rights philosophy argues that animals have intrinsic rights and should therefore not be used by humans for any purpose (Regan 2004). For example, an animal rights activist might boycott meat entirely, whereas a person who values animal welfare may seek out free-range products rather than factory farmed animals. Groups concerned with animal welfare tend to ask people to make small changes to their consumer behaviour— a more achievable communication goal than the lifestyle changes required by animal rights groups (Mika 2006).

Organisations can choose to frame their message positively or negatively. A meta-analysis of framing studies found that positive frames are more effective than negative frames when people are evaluating information about product attributes (Levin *et al.* 1998). For example, Chang (2006) had consumers watched an advertisement for sneakers that either suggested owning the shoes would improve their self-esteem (positive) or that not having good sneakers would lead to low self-esteem (negative). Respondents who received the positive frame paid more attention and rated both the product and the brand as more likeable. Positive messages are also more effective when
people are being asked to take preventative health measures, such as wearing sunscreen or giving up smoking (Chang 2006). Despite this, most animal rights advertisements use negative message framing. Past advertisements have included graphic depictions of face-branding cattle, euthanized animal shelter kittens, and blood pouring from a fur coat (Jones 1997). Advertisements from rights organisations are frequently banned or refused by advertisers for containing overly explicit graphics (PETA 2010).

As well as being less effective than positive frames, shock tactics may actually be counterproductive by distressing viewers but leaving them unwilling or unable to act on their emotions. For example, in climate change campaigning negative fear-laden frames are thought to disempower the audience and fail to encourage deeper engagement (O’Neill & Nicholson-Cole 2009). Likewise, humanitarian charities are finding that people can become overwhelmed and seek to justify their apathy by questioning the validity of aid organisations (Seu 2010).

Negative framing in political advertising has been shown to produce a backlash against the attacker (Jasperson & Fan 2002), but even more of a concern is that long-term negative campaigning can reduce public trust in the government and the political system (Lau et al. 2007). Participants in a focus group for animal rights advertisements reported that they felt powerless and ‘resigned in advance’ before they even watched the ad (Lauritsen 2013). Mika (2006) looked at morally shocking advertisements for vegetarianism and found that non-activists had a nearly unanimously negative reaction. Many people were offended and expressed reduced support for the advertiser.

However, evidence from donation studies contradicts the view that positive frames are always more effective (Keivom-Lockhart 2013). For example, Haynes et al (2004) found that university students exposed to depressing, negative images of dogs were willing to donate more money and time than if exposed to a warm, happy dog. Since this study only tested intentions to donate in a captive audience, real audiences may not react in the same way. Many consumers may simply avoid or switch-off to advertisements that they find emotionally distressing, as described by advertising creative director Andy Firth who said,

You can see animal welfare ads a mile off. A sad looking animal and you already know what it’s about. Consequently, you choose not to read it. You already know how it will make you feel.

(Duncan 2008, para 3)
Some of Lauritsen’s (2013) participants reported that they had never realised that the point of a frequently seen animal rights television advertisement was to raise money for the World Society for the Protection of Animals, as they never watched it all the way through because it was too distressing.

Jaspar and Poulsen (1995) found that most members of animal rights groups were recruited through shocking images and literature. However, shock frames may only appeal to a limited segment of the population. Animal rights groups are predominantly made up of women – over 70% in most groups (Herzog 2007) – who are non-religious college graduates (Jasper & Poulsen 1995; Mika 2006). The frames that are effective for this group may alienate others (Mika 2006). Additionally, since participants are less susceptible to framing when they have already formed strong moral judgements about the issue (Levin et al. 1998) animal rights supporters may have already formed their opinions before being recruited.

Consequently, it is important to consider whether negative frames are a useful tool to promote animal welfare or whether their continued use may lower the credibility of the entire discipline. The next logical step for research is field testing and experimental manipulation of frames. Such an experiment would have to be carefully designed; even simple manipulations of an image can have unexpected effects (Haynes et al. 2004), while preserving an image and changing the framing text can lead to a disconnect between the words and the visuals (Nabi 1998).
1.13 Summary and Research Questions

Given that approximately 1.5 billion fish are traded worldwide every year, there must be many times that number of fish currently living in captivity as pets. Yet, despite the scale of their numbers, pet fish receive very little legal protection or scientific interest. Scientific evidence suggests that fish are equally capable of feeling pain and behaving intelligently as other pets such as dogs and cats, but they are not afforded the same level of respect or attention.

Prevailing social norms and attitudes towards fish portray them as two-dimensional animals that are unlovable and unintelligent, which is reflected by the portrayal of fish as objects in the popular media. However, even if fish owners have positive attitudes and beliefs regarding their pets, they still require sufficient knowledge of correct husbandry procedures to ensure good welfare.

The main factor influencing the welfare of fish in captivity is water quality, which is closely linked to stress and disease. In addition, fish are also likely to have species-specific behavioural needs that, if met, can help to reduce the impact of stress and improve welfare.

Ultimately, the welfare of pet fish is dependent on both their immediate environment within the aquaria and the cultural environment surrounding their owner. The relationship between the attributes of the environment and owner characteristics impacts on the overall welfare of pet fish as shown diagrammatically in Figure 1.6. The structure of this thesis is built around unanswered questions about the factors and relationships that contribute to fish welfare (Figure 1.7).

Firstly, there are very few data on the environment that aquarists provide for their fish. In order to identify what challenges to their welfare pet fish might be facing, we first need to know basic information such as average aquarium size, causes of death for pet fish and the types of enrichment commonly provided to pet fish. This leads to the first research question:
What are the main welfare problems identified by fish owners?

Secondly, the level of care provided to fish is likely to be influenced by factors such as attitudes, social norms and understanding of fish biology. It is important to identify how each of these factors contribute towards husbandry behaviours:

What owner attributes are associated with quality care of pet fish?

After identifying the common problems with fish welfare and owner attributes, the next logical step is to determine how information about improving fish welfare can be effectively disseminated to owners. Pet owners are a dispersed group and could be difficult to reach with targeted campaigns. An efficient way to spread welfare information is through the mass media, which is concerning as current media depictions of animals and fish can be misleading. The public might be being further alienated from animal welfare campaigns by the use of negative frames and shock tactics. Thus, although media is known to have a powerful influence on behaviour, it is unclear if this can be applied to fish welfare and if the influence will vary with owner attributes.

Can short films improve knowledge, attitudes and behaviour towards aquarium fish?

Even if films are successful in encouraging behavioural change, owners will be limited by the high amount of scientific uncertainty surrounding ornamental fish behaviour. Providing enrichment may enable fish to cope better with stressful situations, but the value of different sorts of enrichment has not been quantified for common aquarium species. This brings us to our next research question:

How can we objectively measure the value of enrichment for aquarium fish?

By answering these questions, we will be able to develop best practice recommendations for fish owners, communicators and researchers.
Figure 1.6. A diagrammatic representation of the fish and human factors that can influence fish welfare.
2. What are the main welfare problems identified by fish owners?

3. What owner attributes are associated with quality care of pet fish?

4. Can short films improve knowledge, attitudes and behaviour towards pet fish?

5. How can we objectively measure the value of enrichment for captive fish?

Figure 1.7. Relationship between ornamental fish welfare and the research questions addressed in this thesis.

Research questions are numbered according to the relevant chapter.
2 Casting a wide net: What are the main welfare problems identified by fish owners?

2.1 Introduction

The global ornamental fish trade involves over 1.5 billion fish and is valued at $15 billion per annum (Bartley 2000; Ploeg 2007). In Australia, 33.8 million individual fish pass through the pet trade each year (O'Sullivan et al. 2008), destined for the 13% of households that keep aquaria (Franklin 2006). Over 2000 different freshwater species and 1500 saltwater species are available to hobbyists (O'Sullivan et al. 2008). The number of animals involved, the diversity of species traded and the variety of housing environments, combined with a lack of regulation in some countries and the discrepancy in regulations between states and countries, leave fish vulnerable to inadequate care (Panaquatic Health Solution Pty Ltd 2006). There is little information on the environmental conditions and level of care provided to privately owned ornamental fish (Etscheidt & Manz 1992; Huntingford et al. 2006). The aim of the research reported in this chapter was to obtain demographic data about fish owners and how they care for their pet fish.

As with other animals, fish welfare can be described using the five freedoms: freedom from hunger and thirst; freedom from discomfort; freedom from pain, injury and disease; freedom to perform natural behaviour; and freedom from fear and distress (Farm Animal Welfare Council 2009; Huntingford & Kadri 2008). Although all the freedoms are interconnected, the two most problematic freedoms for domestic fish are ensuring freedom from disease and freedom to express natural behaviour; both of which are highly related to aquaria settings (Johansen et al. 2006; Saxby et al. 2010).

Health

Disease is a major threat to ornamental fish welfare. Rapid turnover of fish is often considered normal within the industry (Etscheidt & Manz 1992; O'Sullivan et al. 2008). Two different surveys of Australian import shipments and pet stores both found that over 70% of fish were diseased, mostly with parasites, as well as some bacteria and viruses (Evans & Lester 2001; Wickins et al. 2011). Disease rate is also high in wild fish; for example, up to 50% of wild guppies are infected with Gyrodactylus parasites.
Van Oosterhout et al. (2003) and larval flatworms can reach 100% prevalence in wild zebra fish populations (Spence et al. 2008). However, in one study, wild guppies appeared to actively avoid infected conspecifics, a behaviour that would not be possible in an aquarium (Croft et al. 2011).

Many diseases are subclinical and can only be detected with specialised tests, with symptoms only becoming visible when environmental conditions change or the fish becomes stressed (Gilad et al. 2003; Johansen et al. 2006; Ramsay et al. 2009b). Diseases are normally exacerbated by poor water quality and most home aquaria have sub-optimal pH levels, high ammonia or nitrite levels, and insufficient oxygen for maintaining fish health (Etscheidt & Manz 1992). Psychological stressors, such as handling, disturbance, aggressive tankmates and noise can also predispose fish to health problems (Dror et al. 2006; Pasnik et al. 2010).

The interdependent interactions between pathogens, environment and stress means that correct diagnosis and treatment is necessary for optimal fish care. Because evolutionary pressure from predators has favoured fish that do not show signs of weakness fish have a high threshold for disease and may not display obvious symptoms until it is too late for treatment (Johansen et al. 2006). Despite this, many fish owners may not be knowledgeable about their fish diseases and veterinary care is undervalued by both hobbyists and the aquarium industry (Miller-Morgan 2010). This is probably because it is cheaper to replace fish than to treat them, since the average wholesale price per fish is just $AUD0.30 (O’Sullivan et al. 2008). It can also be difficult to find specialist care as most small animal veterinarians have little training or knowledge in fish medicine (R. Loh, personal communication, 17th July 2011) and there is a shortage of specialist aquatic veterinarians (Miller-Morgan 2010). While several institutions in Australia offer postgraduate programs in fish pathology, only veterinarians are permitted to diagnose fish diseases and prescribe medication.

Environment

The freedom to express natural behaviour is likely to be linked closely to health in fish. For example, it is now well established in aquaculture that sustained swimming improves growth and reduces stress (Huntingford, 2013). Keeping fish in aquaria may restrict sustained swimming and may also disrupt other behaviours. For example, in the United States and Australia captive betta are typically kept isolated in very small (1-2L) tanks, whereas in the wild they form loose breeding aggregations with nests spaced
around one metre apart (Jaroensutasinee & Jaroensutasinee 2001). Group spawning in zebra fish appears to be an artifact of captivity, as given more space the females are able to better control their mate choice (Hutter, 2010). These examples demonstrate that although ornamental fish can survive and are commonly kept in confined environments this does not necessarily mean their welfare is good, in the same way that reducing space allowance for farmed pigs does not reduce growth rates but still results in poor overall welfare (Turner, 2000).

Extremely small aquaria, such as fish bowls, can impact on both health and freedom of behaviour, as they do not have a large enough volume to maintain consistent water quality and temperature (Walster 2008). The problem of confinement is related to economics of fish keeping. Fish owners might prefer to keep fish in a small tank since larger tanks take more room, are more expensive, can be difficult to maintain and may need reinforced floors and stands to support the weight of the water (Tullock 2006). Regardless of the tank size, provision of appropriate environmental enrichment may be an option to encourage fish to maintain their natural behaviour.

Enrichment consists of any activity, object or stimulus provided to a captive animal with the intention of increasing their behavioural diversity and improving their ability to cope with stress (Young 2003). For example, having access to sand or fine gravel is known to encourage natural foraging behaviour in goldfish (Smith & Gray 2011) and Mozambique tilapia (Galhardo et al. 2008). The benefits of other forms of enrichment are less clear. Shelters and plants can decrease aggression in some species of aquarium fish, such as the Midas cichlid (Oldfield 2011), but are unimportant or may even increase aggression in other species (Sloman et al. 2011). Nor can enrichment fully mimic the complexity of a natural environment. Burns et al. (2009) found that guppies reared in structurally enriched aquaria still had significantly smaller brains than their wild counterparts. Enrichment can even pose health risks to fish, such as entanglement or the introduction of toxins and pathogens (Williams et al. 2009). Despite the lack of scientific evidence, most aquarists consider enrichment to be important for fish (Sloman et al. 2011) and the annual Australian market for fish accessories is worth $174.7 million, or $1.32 for every $1 spent on fish (O’Sullivan et al. 2008).

Captive fish are completely dependent on their owners to provide a suitable environment, so it is important that aquarists are knowledgeable about fish welfare and biology. Knowledge of animal biology has been linked to direct experience with
animals and positive attitudes towards animals in studies relating to bats (Prokop et al. 2009), birds (Prokop et al. 2008) and toads (Tomazic 2011). Rabbit owners who are more knowledgeable about their pets’ biology have greater intentions to neuter their pets, feed them an appropriate diet and provide social companions (Edgar & Mullan 2011). Although the causality and directionality of the links between knowledge, experience and welfare has yet to be established (Serpell 2004), all three are important factors in determining how well people care for their pets.

There is very little information on the conditions of fish kept in home aquaria, which makes it difficult for researchers to determine the animal welfare issues and how welfares problem for pet fish are widespread. The aim of this study is to collect basic data on fish health and housing conditions in home aquaria. Data were gathered from a large online survey in which fish owners self-reported their knowledge of fish biology and the physical conditions in which fish were kept.

Such a survey is intrinsically limited in the amount of detail that can be gathered from respondents— in order to gather accurate information on water quality and exact cause of death we would need to visit individual houses as in Etscheist and Manz (1992), but the sample would then be limited by time and distance. Using an online survey allows us to collect a larger and more representative dataset from a variety of experience and inexperienced fish owners across a large geographical area, painting a more accurate picture of welfare conditions that we can use to prioritise further research into fish welfare. This is important, because our current understanding of welfare in pet fish is so poor that we don’t even know what the welfare issues are.

2.2 Materials and Methods

The online survey was approved by The University of Western Australia’s Human Ethics Committee (RA/4/1/2638). Participants were recruited via social media and advertisements on 23 online forums related to aquarium keeping, pets and science. Australian websites were targeted, but participation was not limited in any way. The survey was administered using SurveyGizmo (Widgix 2005-2011) and ran from February to May 2010.
The survey was open to people who currently owned fish as well as those who did not currently own fish, but had kept fish as pets in the past. Previous fish owners were included to compensate for the bias towards responsible owners that is found in most convenience sample pet surveys (Rohlf et al. 2010; Schepers et al. 2009). The questions were developed based on a literature review of similar studies (see Chapter 1), refined in a focus group with other researchers and pilot tested with six fish owners. Initially the survey included more questions on water quality, but in the pilot test it was found that less knowledgeable owners found these questions difficult to answer accurately.

Past owners were filtered through an abridged version of the survey that contained only relevant questions (see Table 2.1 for summary; the full survey is provided in Appendix C). Data were collected on time elapsed since past owners had kept fish to control for memory degradation and was found to have no statistically significant influence on responses. For all other questions data from both current and past owners were analysed together (a more detailed discussion of differences between current and past owners can

<table>
<thead>
<tr>
<th>Question</th>
<th>Respondents who previously kept fish (n = 147)</th>
<th>Respondents who currently keep fish (n = 387)</th>
</tr>
</thead>
<tbody>
<tr>
<td>How many fish do you own?</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>What species/types of fish do you own?</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>How many different tanks do you have?</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>What size is your smallest tank?</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>How long have you owned aquarium fish?</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>How knowledgeable about fish care and biology are you? [5-point scale]</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>[Do/did] you provide any items to make your tank more natural or interesting? [Checklist]</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Have you had any pet fish that died?</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>What do you think may have caused the fish to die? [Checklist]</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>[Do/would] you take your fish to the vet if it is ill?</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Demographics [Gender, age]</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
be found in Chapter 3). Respondents who had never owned fish or who provided substantially incomplete data were excluded from the analysis.

Fish health was examined by asking participants to read a list of possible causes of death in fish and select all that they had experienced. Respondents were able to submit causes of death other than the options listed and were also asked whether or not they would seek veterinary treatment if one of their fish was ill.

Housing conditions that could limit the ability of aquarium fish to express their natural behaviour were estimated using two items. The first related to confinement and required respondents to calculate the volume of their smallest tank. The second listed a number of enrichment items and participants selected all of the items they provide for their fish.

The level of an aquarist’s experience is likely to be a mediating factor in their provision of care. Therefore, aquarists were asked how long they had been keeping fish and to self-rate their own knowledge of fish care and biology. Knowledge was scored on a six-point scale from zero (“I know nothing about fish”) to five (“I am an expert on fish”). When considering skill specialization in a study of recreational anglers, simple self-classification measures such as this question were found to be just as good at estimating expertise as complex, multivariate measures (Needham et al. 2009). Data were gathered on the types of species kept, the quantity of individual fish and the number of tanks maintained. Demographic data on age and gender were collected.

Statistical analysis was completed in Microsoft Excel and SPSS (IBM 2011). Non-parametric statistics were used, as the data were gathered using categorical and ordinal scales and do not follow a normal distribution. The Mann-Whitney U test (the non-parametric equivalent of an independent-samples t-test) was used to test for differences between groups, as it is the only non-parametric test suitable for comparing two categorical groups on a five-point scale (Pallant 2011). Mann-Whitney U tests can indicate a significant difference, but do not tell you the size of the difference. To account for this the effect size (r) was also calculated (Cohen 1988). An r above 0.5 is considered a strong effect, r of 0.2 - 05 a moderate effect and r below 0.2 a weak effect (Pallant 2011).

The population of all fish owners in Australia is estimated to be 2.95 million people, based on 13% of households keeping fish (Franklin 2006) and using 2011 census data (Australian Bureau of Statistics 2011). As a minimum target sample size of 384 fish owners was required to reach a confidence level of 95% ± 5%, the number of 70
respondents (n = 534) was considered to be adequate for estimating pet fish owners’
behaviours, attitudes and knowledge about fish.

2.3 Results

Of the 534 responses, 387 (72%) respondents were current fish owners and 147 (28%)
were people who had previous experience owning fish. Since not all questions were
compulsory, some questions gathered less than 534 answers and this is noted where
applicable.

Nearly half (47%) of fish owners (n = 381) had kept over 30 individual fish. Fewer kept
10-30 fish (28%) or 2-10 fish (21%). Only 5% of respondents kept a single fish. Most
commonly, respondents had either one (28%) or two (18%) aquaria, but there was a
large spread with three-quarters of respondents having between one and six aquaria,
with a median of three. The most common fish kept were catfish, goldfish and cichlids
(Table 2.2). Most participants kept a mixture of fish species, but 29% kept just one type.

More males (n = 320) than females (n = 200) participated and most respondents (86%)
were between 26 and 55 years of age. Data was cross referenced with another recent
study to confirm the representativeness of the population of respondents, since online
surveys can easily be biased due to self-selection (Bethlehem 2010). O’Sullivan et al.
(2008) estimated that the population of fish owners consisted of 43% serious aquarists,
42% moderate hobbyists and 14% irregular owners. The population distribution in this
study was similar, with 34% serious aquarists (score 4-5 for knowledge), 43% moderate
hobbyists (score 2-3 for knowledge) and 23% irregular owners (scored 0-1 for
knowledge). Frequencies of distribution were not different between the two studies (p =
0.19 Chi-square test).

Fish Health

The most frequent cause of death reported for fish was ‘disease and illness’ (59%),
followed by ‘old age’ (47%) and ‘eaten or attacked by other animals’ (46%, Table 2.3).
Respondents also identified other potential hazards for fish, such as equipment failure
(n = 14, e.g. “tank cracked”), inappropriate handling (n = 6, e.g. “my grandchild
decided to cuddle one”) and hazardous accessories (n = 5, e.g. “choked on décor item”,
“caught in filter”). Only 7% of respondents agreed with the statement ‘I would consult a
vet if my fish became ill’.
Table 2.2. Type of fish kept by respondents.

Listed by popularity. Only types kept by more than 10% of respondents (n = 533) are included.

<table>
<thead>
<tr>
<th>Type of Fish</th>
<th>% of owners</th>
</tr>
</thead>
<tbody>
<tr>
<td>Catfish (Corydora spp.)</td>
<td>42</td>
</tr>
<tr>
<td>Goldfish (Carassius auratus)</td>
<td>39</td>
</tr>
<tr>
<td>Cichlids (Cichlidae)</td>
<td>38</td>
</tr>
<tr>
<td>Tetra (Characidae)</td>
<td>33</td>
</tr>
<tr>
<td>Livebearers (Poeciliidae)</td>
<td>31</td>
</tr>
<tr>
<td>Siamese fighting fish (Betta splendens)</td>
<td>24</td>
</tr>
<tr>
<td>Cyprinids (Barbs and Danios)</td>
<td>16</td>
</tr>
<tr>
<td>Australian Native Species</td>
<td>14</td>
</tr>
<tr>
<td>Clownfish (Amphiprioninae)</td>
<td>12</td>
</tr>
</tbody>
</table>

Table 2.3. Common causes of death reported for aquarium fish.

Respondents (n = 533) were asked to select all causes of death they had observed in their own aquaria.

<table>
<thead>
<tr>
<th>Cause of Death</th>
<th>% Experienced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disease or illness</td>
<td>59</td>
</tr>
<tr>
<td>Old age</td>
<td>47</td>
</tr>
<tr>
<td>Eaten or attacked by another animal</td>
<td>46</td>
</tr>
<tr>
<td>Jumped from the tank</td>
<td>35</td>
</tr>
<tr>
<td>Unsure</td>
<td>31</td>
</tr>
<tr>
<td>Poor water quality</td>
<td>23</td>
</tr>
<tr>
<td>Vanished from tank</td>
<td>15</td>
</tr>
<tr>
<td>Inappropriate temperature (including power failure)</td>
<td>13</td>
</tr>
<tr>
<td>Incorrect feeding</td>
<td>11</td>
</tr>
</tbody>
</table>
**Behavioural Constraints**

Two thirds of aquarists had either small (7-55 L, 31%) or medium (56-150 L, 33%) tanks. Large tanks (151+ L) were maintained by 22% of respondents and 4% kept their fish in outdoor ponds. Fish bowls were kept by 10% (n = 39) of respondents; however, most of these (n = 28) also kept larger tanks and three specifically mentioned they only used the fish bowl for quarantine purposes.

Nearly all aquarists provided some form of structural enrichment. Only 4% said they had a completely bare tank. Substrate, such as gravel or sand, was most common (92%), followed by shelters (68%) and plants (52% real plants, 18% artificial plants and 17% kept both). Behavioural enrichment was less common, with 39% of respondents supplying live food and 9% training their fish to do specific tasks.

**Experience**

Respondents typically had a long history of owning fish, with 34% having kept fish for more than eleven years, 19% having kept fish for six to ten years, 37% for one to five years and 10% having kept fish less than a year. The length of time a person had owned fish was positively correlated with their self-rated knowledge of fish care and biology (Spearman’s rho p < 0.001, r = 0.428).

The overall mean for knowledge was 2.7 with a median of three (‘I am moderately knowledgeable about fish’). People who currently own fish (n = 386, Md = 3) rated themselves as more knowledgeable than people who had previously kept fish (n = 147, Md = 2, Mann-Whitney U test p < 0.001, U = 9743.5, z = 12.2, r = 0.53). More knowledgeable owners were more likely to have over 30 fish (Figure 2.1), provide real aquarium plants (p < 0.001, U = 22515, z = 5.065, r = 0.21), supply live food (p < 0.001, U = 20580, z = 7.965, r = 0.35), and utilise veterinary care (p < 0.001, U = 5091, z = 4.3, r = 0.19). Less knowledgeable owners were more likely to own just a single fish (Figure 2.2), have artificial plants (p < 0.001, U = 19708, z = 7.597, r = 0.33) and keep goldfish (Figure 2.2, Mann-Whitney U p < 0.001, z = 0.32). However, knowledge did not differ with the size of the smallest tank kept (p = 0.757, Mann-Whitney U test), or whether substrates (p = 0.489) and shelters (p = 0.848) were provided.
Figure 2.1. Respondents’ knowledge of fish biology according to the number of individual fish kept.
Bars represent quartiles. The bold line is the median.

Figure 2.2. Differences in knowledge of fish biology between respondents who keep different types of fish.
Bars represent quartiles. The bold line is the median.
2.4 Discussion

There is a lack of information on the environmental conditions and level of care provided to privately owned ornamental fish (Etscheidt & Manz 1992; Huntingford et al. 2006). This online survey of a representative sample of reasonably experienced Australian fish owners provides a useful overview of current pet fish welfare and identifies gaps in our knowledge.

Amongst our respondents, nearly 60% of respondents reported losing fish to disease or illness but only 7% reported that they would contact a vet if their fish became ill. Although fish commonly carry parasites both in the wild (Van Oosterhout et al. 2003) and at pet stores (Wickins et al. 2011), fish owners can minimize deaths from disease by providing optimal water quality, stocking density, implementing quarantine procedures (Schelkle et al. 2011) and becoming familiar with symptoms and treatments of common diseases or utilizing professional veterinary care (Loh & Landos 2011). While it would have been interesting to determine a more specific cause of death than ‘disease and illness’ this was not possible due to the difficulty of accurately determining the cause of illness in fish (Johansen et al. 2006); often specialist techniques such as bacterial cultures, histopathology, microscopy and haematological tests are needed for diagnosis (Loh & Landos 2011). There is a dearth of scientific research into disease in ornamental species. Whittington and Chong (2007) highlighted that between 2000 and 2006 there were 265 publications about ‘farmed fish disease’ in the PubMed database compared to just 17 publications on ‘ornamental fish disease’.

Poor water quality is likely to be the ultimate cause of death underlying most deaths reported as ‘illness’ and ‘old age’. Environmental conditions and health are closely linked in fish and most fish can withstand disease if environmental conditions are good (Almeida et al. 2008; Johansen et al. 2006). Only one fifth of our respondents reported experiencing fish deaths due to poor water quality, but Etscheidt and Manz (1992) found unacceptably high levels of nitrite in 94% of the aquaria they tested.

The second most commonly reported cause of death in fish was ‘old age’, cited by nearly half of the survey’s respondents. Aging is a probable cause of death for small species, such as guppies and tetra, which are thought to live less than two years (O'Sullivan et al. 2008). Many other aquarium species are extremely long lived (Weber
such as goldfish, who survive for 5-7 years in the wild (Morgan & Beatty 2007) and up to 41 years in captivity (BBC News 1999). Anecdotal evidence from fish owners shows that many common species including discus, cichlids and barbs can live over ten years (Gay 2011). This would suggest that fish owners might be over-attributing age as a cause of death. Since captive bred animals normally live longer than their wild counterparts, this gives further evidence that many aquarists are failing to provide an optimal environment for their pets (Mason 2010).

Environmental stressors may also help to explain why over a third of participants had owned fish that jumped out of the tank. Although there has been no specific research into why fish might jump from aquaria, jumping has been observed as a response to ectoparasites (Nguenga 1987), introduction to a new aquarium (Magid 1966), exposure to some anaesthetics (Munday & Wilson 1997), aggression from other fish (Berti et al. 1982), to escape from predators (Saidel et al. 2004), as a natural behaviour in the wild to move between pools (Aronson 1971), and to escape extreme temperatures (Debnath et al. 2006).

Temperature is an important environmental parameter, with incorrect temperatures and heater failures responsible for deaths reported by 13% of respondents. Even when not lethal, temperature can influence the spread and mortality of disease (Gilad et al. 2003). Due to the broad nature of the survey and the limited knowledge of some participants, there were no specific questions in this survey about the provision of heaters or temperatures at which fish were kept, but this could be an interesting line of inquiry for future studies.

Inappropriate species assemblages seem to be a far more serious problem than has previously been assumed. Nearly half of participants reported that they had fish eaten or attacked by another animal, even though Etscheidt & Manz (1992) reported that only 19% of aquariums in their study contained a mixture of small and predatory species. There is very little scientific research on how ornamental fish species interact (Sloman et al. 2011) and aggressive behaviour is often linked to stocking density (Saxby et al. 2010), making it difficult for even knowledgeable aquarists to assemble a peaceful community tank. The most popular species kept by the respondents matched sales data presented by O’Sullivan (2008). The exception was catfish, which were kept by over 40% of respondents but account for less than 3% of sales. This could be attributable to several factors, including a biased response from catfish fanciers, unregulated trade between aquarists reducing official sale figures, the relatively long lifespan of catfish,
most aquarists keeping just a single catfish rather than a school as with most other common fish, catfish being more tolerant to poor conditions and therefore having a higher survival rate or catfish being valued by owners as potential contributors to tank ecosystem health.

Most respondents kept aquaria, with only 10% owning fish bowls. Fish bowls are a threat to both fish health and behaviour. As well as limiting movement, fish bowls are too small to maintain constant water parameters and are normally without filters, aeration and heaters (Walster 2008). A third of respondents kept small (7 – 55L) tanks, which could cause welfare problems if they are overstocked.

Basic structural enrichment was widespread, with less than 4% of respondents maintaining a completely bare tank. Many respondents probably provide structures for ornamental purposes rather than out of concern for the fish, but the reason for provision does not change the welfare outcomes. The most common form of enrichment was substrates, such as gravel or sand, provided by 90% of respondents. Substrate is known to be important for the welfare of several ornamental fish species (Galhardo et al. 2008; Smith & Gray 2011), unlike shelters (68% respondents) and live plants (69% respondents), which can have positive (Oldfield 2011), neutral (Brydges & Braithwaite 2009) or even negative impacts (Barreto et al. 2011) depending on the species and density. Different forms of structural enrichment will vary in their value between species, but given that two-thirds of owners keep a mixed assemblage of species a variety of enrichment types is likely to be beneficial.

Use of behavioural enrichment, such as live food and training regimes, was less commonly reported. Live food is known to improve foraging skills in farmed fish (Brown et al. 2003), but is yet to be studied in ornamental species. Live food is thought to encourage active behaviour, provide chemosensory stimuli and may improve nutritional balance (Williams et al. 2009). Although live food is thought to be a risk for introducing pathogens (Williams et al. 2009), this has been poorly studied and it is unlikely to be a problem for all fish (Maynard et al. 1996), especially if the feeder animals are purchased from a reputable source. Behavioural training is used with other captive animals to reduce stress, improve handling procedures and provide enrichment (Laule et al. 2003), but with fish has only been applied to improving survival rates for hatchery-reared species (Brown & Laland 2001) and zebra sharks in a public aquarium (Marranzino 2013).
Fish kept by most respondents had access to social interaction, with less than 5% of respondents keeping a single fish. Social interaction is highly valued by fish (e.g. Brown & Laland 2003; Croft et al. 2006), even amongst species traditionally considered solitary, such as Siamese fighting fish (Snekser et al. 2006). However, keeping fish in groups, especially in inappropriate densities, can cause problems such as disrupted mating systems and aggression (Etscheidt & Manz 1992; Hutter et al. 2010; Saxby et al. 2010). There is a lack of scientific data on appropriate shoal sizes for most domestic fish (Saxby et al. 2010), forcing aquarists to rely on anecdotal reports and guesswork when stocking a tank.

Increased experience and self-reported knowledge of fish biology correlated with better fish husbandry practices. We found that more knowledgeable owners provided more enrichment, were more likely to keep groups of fish rather than a single fish and were slightly more likely to use veterinary services. Education programs, better dissemination of scientific data and sharing experiences could help fish owners to improve their level of care. However, education is unlikely to influence all behaviours. For example, fish owners with different levels of knowledge were equally likely to provide shelters.

The present results help to identify which areas of fish welfare should be targeted by future research. Contrary to the popular media image of lonely goldfish in small bowls (e.g. ABC News 2004, Hudderfields Daily Examiner 2011), relatively few fish were kept either singly or in bowls. A more productive line of inquiry would be in-depth investigations into mortality rate, disease and lifespan for ornamental fish, particularly with regards to water quality. More research is also needed on aggression and compatibility between species, although some recent research is beginning to address this gap (e.g. Saxby 2010; Oldfield 2011; Sloman et al. 2011). Since enrichment is also frequently provided by fish owners, more data should be gathered on how enrichment items influence stress and welfare in pet fish. Galhardo et al. (2008) and Smith & Gray (2011) provide some insight into the importance of substrate for some species, but there are still large gaps in our knowledge, particularly with regards to common ornamental fish species, live food and the value of plants and shelters.

Compared to cats and dogs, pet fish appear to be better provided for in some areas but much worse off in others. In Australia, veterinary care is much more prevalent for both cats and dogs, with 77% of dogs and 52% of cats visiting a vet yearly (Heady 2006). Only 3% of these owners had never taken their pet to a vet (Heady 2006), compared to the 93% of fish owners who have never considered using a vet. Disease is also the most
commonly reported cause of death for dogs (64%) by owners, but with cancer and cardiovascular disease topping the list there is more evidence for age-related deaths (Michell 1999). Dogs also get more behavioural enrichment, with 79% provided with toys and 64% receiving training (Korbelt et al. 2003), compared to 39% of fish receiving live food and only 9% training. However, fish receive more social enrichment—only 5% of people keep a single fish compared to approximately three-quarters of cat (Toribio et al. 2009) and dog owners (Kobelt et al. 2003) who keep just the one. Overall, it appears that pet owners are less solicitous of health and behaviour in fish compared to other pets.

2.5 Conclusion

Keeping fish in aquaria potentially provides serious challenges to their health, comfort and ability to express natural behaviours. In particular, it seems likely that fish owners in our study may overestimate the role of old age in causing fish deaths and underestimate the impact of long term stressors such as suboptimal water quality and aggressive interactions with other fish. More knowledgeable owners were found to be more likely to provide enrichment and slightly more likely to use veterinary care, so education and sharing experiences may improve welfare more generally for captive fish. However, the current dearth of scientific data on ornamental fish behaviour and welfare needs to be addressed before reliable educational material or legislative guidelines can be developed. Factors associated with being a more knowledgeable owner should be identified, so that educational attempts can be targeted to meet aquarists’ needs.
3 Are you gill-ty of pet neglect: What owner attributes are associated with knowledgeable care of pet fish?

3.1 Introduction

Maximising welfare is a difficult task for most fish owners because the welfare of fish depends on a number of factors such as the fish tank environment, diet, stocking density and species composition (Huntingford et al. 2006; Saxby et al. 2010). In one study 81% of fish in private fish tanks were kept at an unsuitable pH and 19% had an inappropriate mixture of species (Etscheidt & Manz 1992). Moreover, high turnover of stock is considered normal by fish owners (Etscheidt & Manz 1992; Panaquatic Health Solution Pty Ltd 2006) and over half of fish owners surveyed in Chapter 2 stated that the most common cause of death is disease and illness. These examples suggest that fish owners have limited knowledge and skill to care for their animals, both of which are considered prerequisites to providing good welfare (Hemsworth et al. 2009).

Although a direct link between education of pet owners and an improvement in care has not been shown (Edgar & Mullan 2011), fish keepers who rated themselves as having a higher knowledge of fish care and biology were more likely to provide enrichment and health care to their pet fish (see Chapter 2). Likewise, knowledge of rabbit biology was associated with planning to undertake important husbandry measures like neutering and vet checks (Edgar & Mullan 2011).

There are many attributes that are thought to correlate with people’s knowledge about animals, including attitudes (Ajzen 1991; Ajzen & Fishbein 2000; Ellingsen et al 2010), emotions (Pooley & O'Connor 2000), beliefs (Knight et al. 2004), social norms (Rohlf et al. 2010) and gender (Herzog 2007).

Attitudes towards the way animals are treated are linked to the belief that animals are sentient and can feel pain (Ellingsen et al 2010; Knight et al. 2009). This is unfortunate for fish, as public opinion rates their intelligence as being far below that of other vertebrates (Driscoll 1995; Knight et al. 2009; Kupsala et al. 2013). The myth that fish have a ‘three-second memory’ is still prominent in the public consciousness (e.g. Hipsley 2008; Mythbusters 2004), despite a growing body of research that shows fish have good memories and display a range of complex behaviour (reviewed in Brown et al. 2006; Manteifel & Karelina 1996). Only 59% of the Finnish public knew that
Atlantic salmon could feel pain (Kupsala et al. 2013), although scientific evidence shows they have a similar nervous system to other vertebrates (Braithwaite 2010).

Pooley and O’Connor (2000) argue that emotions may be more important in forming attitudes than knowledge. For example, the quality of the emotional attachment to pet dogs may influence owners’ provision of care (Shore et al. 2005). Again, fish are at a disadvantage here as they are not as seen to be as interactive or responsive as other pets (Driscoll 1995; Langfield & James 2009).

The importance of societal pressure had received little attention amongst pet researchers, although being part of a social network can be an important part of pet ownership (Serpell 2003; Wood et al. 2005). For example, the strongest predictor of behaviour for dog owners was their normative beliefs about what their family and friends think is important for pet care (Rohlf et al. 2010).

There are small but consistent differences between men and women in their behaviour towards animals (Herzog 2007). Both genders are equally likely to own pets (Marx et al. 1988; Parslow et al. 2005) and display a similar level of attachment towards their pets (Herzog 2007). However, women are more likely to empathise with animals (Ellingsen et al 2010; Knight et al. 2004) and be sympathetic towards animal welfare (Herzog 2007), while men are less likely to believe in animal cognition (Knight et al. 2004).

This study aimed to identify which of these factors are associated with aquarists’ information seeking behaviour and level of knowledge about fish biology.

### 3.2 Methods

Data were gathered using an online survey (design and distribution of the survey are described in Chapter 2.2). The data analysed in this chapter relate to knowledge and factors thought to be important in influencing knowledge. Participants were asked to rate their knowledge of fish care and biology on a six-point ordinal scale from zero (“I know nothing about fish”) to five (“I am an expert on fish”). Seventeen other items relating to emotional attachment, social capital, beliefs, attitudes and source of information were measured using binary variables (Table 3.1, the full survey is provided in Appendix C). In addition,
Table 3.1. Survey questions grouped by factors that may be relevant to participants’ knowledge of fish care.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Question</th>
<th>Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics</td>
<td>Gender</td>
<td>Male, Female, N/A</td>
</tr>
<tr>
<td></td>
<td>What is your age?</td>
<td>Open answer</td>
</tr>
<tr>
<td></td>
<td>Do you currently own or care for any pet fish? / Have you previously owned pet fish?</td>
<td>Yes, No</td>
</tr>
<tr>
<td></td>
<td>How knowledgeable about fish care and biology are you?</td>
<td>0 (I know nothing about fish) - 5 (I am an expert on fish)</td>
</tr>
<tr>
<td>Emotions</td>
<td>Do you talk to your fish?</td>
<td>Yes, No</td>
</tr>
<tr>
<td></td>
<td>Do you name your fish?</td>
<td>Yes, No</td>
</tr>
<tr>
<td></td>
<td>Do you feel sad if your fish dies?</td>
<td>Yes, No</td>
</tr>
<tr>
<td></td>
<td>Do you bury your fish if it dies?</td>
<td>Yes, No</td>
</tr>
<tr>
<td>Social</td>
<td>Do you talk to other people about your fish?</td>
<td>Yes, No</td>
</tr>
<tr>
<td></td>
<td>Do you participate in fish shows or clubs?</td>
<td>Yes, No</td>
</tr>
<tr>
<td></td>
<td>Do you discuss fish or aquariums online (e.g. in blogs, forums, discussion groups, etc.)</td>
<td>Yes, No</td>
</tr>
<tr>
<td>Beliefs</td>
<td>Fish have a three second memory</td>
<td>True, False, Unsure</td>
</tr>
<tr>
<td></td>
<td>Fish do not feel pain</td>
<td>True, False, Unsure</td>
</tr>
<tr>
<td></td>
<td>Fish are capable of learning</td>
<td>True, False, Unsure</td>
</tr>
<tr>
<td></td>
<td>On a scale of one to five, how would you rate [the intelligence of] fish?</td>
<td>1 (unintelligent) - 5 (Extremely intelligent)</td>
</tr>
<tr>
<td>Welfare</td>
<td>Do you support the formation of marine parks and reserves?</td>
<td>Yes, No, Sometimes, Unsure</td>
</tr>
<tr>
<td></td>
<td>Do you think the RSPCA and other organisations should be responsible for the welfare of pet fish?</td>
<td>Yes, No, Unsure, Other</td>
</tr>
<tr>
<td></td>
<td>In 2005, the city council of Rome, Italy banned small, round goldfish bowls under animal cruelty by-laws. If your local government considered similar regulations, what would your reaction be?</td>
<td>1 - Strongly against, 3 - Neutral, 5 - Strongly supportive</td>
</tr>
<tr>
<td>Involvement</td>
<td>Do you eat fish?</td>
<td>Yes, No</td>
</tr>
<tr>
<td></td>
<td>Do you go fishing for enjoyment or recreation?</td>
<td>Yes, No</td>
</tr>
<tr>
<td></td>
<td>Do you snorkel?</td>
<td>Yes, No</td>
</tr>
</tbody>
</table>
respondents were asked where they acquired their pet fish and what sources they gathered information from before acquiring the fish.

Data analysis

Mann-Whitney U tests were used to compare behaviours with differences in owner self-rated knowledge of fish, as this test is more robust and better suited to ordinal data compared to t-tests (Pallant 2011). Effect size (Cohen 1988) was calculated for all tests, as recommended by Herzog (2007). The effect size is considered weak if it is below 0.2, moderate from 0.2 - 0.5 and strong if it is over 0.5 (Pallant 2011). Data were analysed in SPSS v.20.

The respondents were segmented using a two-step cluster analysis because it can cope with large data sets, determines the optimal number of clusters and is one of the few modelling techniques able to combine both continuous and categorical data (Norusis 2011; Schiopu 2010). Two-step cluster analysis is a descriptive, non-inferential technique and identification of clusters is strongly influenced by the input variables and analysis choices (Chan 2005). Ideally, all variables should be completely independent and continuous variables normally distributed, but the analysis is reasonably robust to violations of these assumptions (Norusis 2011). An exploratory approach was used, where all variables (n = 31) were initially included then the number of variables was progressively narrowed down based on their importance to the model. The appropriateness of the model was determined using the silhouette measure, which measures cohesiveness within clusters and distance between clusters (Schiopu 2010, p397). The log-likelihood distance measure was used to account for categorical measures and Schwarz’s Bayesian Criterion was set as the clustering criterion. Noise handling was set to 1% to allow for statistical tree growth while minimizing the exclusion of outliers. However, the final model was found to be robust to changes in clustering criterion, noise handling, pruning options and the order of variables.

Over 100 combinations of variables were tested to determine the final clusters. Of the original 533 respondents, 477 were included in the final cluster analysis. Fifteen respondents were excluded for having returned incomplete questionnaires, as the two-step method is unable to process missing data. The analysis also excluded 41 ‘outlier’ respondents that it could not fit into the model. Unfortunately, SPSS does not currently provide the option of viewing these outliers, so it difficult to determine exactly how they differed to the average respondent. The overall silhouette measure was 0.5, which
is considered a clear cluster result (Kaufman & Rousseeuw 1990). The silhouette measure could have been improved to 0.6 by reducing the number of variables to fewer than seven, or by increasing the number of respondents classified as outliers. However, as the most important predictors remained unchanged I felt this was an unnecessary reduction of useful data.

3.3 Results

Overall, 533 people answered the survey, 386 who currently kept fish and 147 that had previously owned fish but no longer do. (One participant fewer than Chapter Two as a current fish owner was excluded from analysis because they did not state their knowledge of fish biology). Age was normally distributed (5% <17 years old; 29% 18-25; 31% 26-35; 27% 36-55; 6% 56+; 3% declined to answer) and showed no association with knowledge ($p = 0.102$). There was a gender bias amongst participants, with more males (60%) than females (38%) and 3% declined to identify their gender. Males tended to have higher knowledge scores than females ($p < 0.001$, $z = 7.516$, $r = 0.33$).

Nearly half (46%) of fish owners talk to their fish and a similar proportion (49%) name their fish. Most participants (73%) agreed they would feel sad if their fish died, but only 29% agreed that they would bury their fish. Less knowledgeable participants were more likely to name fish ($p < 0.001$, $z = 4.5$, $r = 0.19$) and feel sad when a fish died ($p = 0.005$, $z = 3.04$, $r = 0.12$), but knowledge was unrelated to talking to fish ($p = 0.751$) and burying dead fish ($p = 0.946$).

Nearly all (93%) respondents supported the formation of marine parks. Those who were unsure or unsupportive of marine parks ($n = 38$) were less knowledgeable about fish ($p < 0.001$, $z = 3.53$, $r = 0.15$). Knowledgeable fish owners were more likely to take part in recreational fishing ($p < 0.001$, $z = 0.2226$, $r = 0.27$). There was no difference in knowledge ($p = 0.287$) between fish owners who supported banning fishbowls (63%) and those who were opposed (10%, with the remaining 27% were neutral or unsure). Half of the participants supported the suggestion that non-governmental animal welfare organisations should take more responsibility for fish welfare, but this showed no relationship with knowledge ($p = 0.063$).
Most respondents knew that fish could feel pain (86%) and can learn (87%). Slightly fewer respondents (75%) correctly identified that fish do not have a three-second memory. Knowledge of fish care had a weak correlation with knowing that fish could learn ($p < 0.001$, $z = 5.604$, $r = 0.24$) and feel pain ($p = 0.019$, $z = 2.341$, $r = 0.1$), and a moderate association with correctly identifying that the three-second memory myth is false ($p < 0.01$, $z = 10.345$, $r = 0.448$). Most (72%) respondents rated fish intelligence as a two or three out of five, with 13% scoring fish as just a one (very unintelligent) and only 4% scored fish as a five (very intelligent). Knowledge of fish biology was positively correlated with the belief that fish are more intelligent (Spearman’s rho $p = 0.000$, $r = 0.18$).

Most aquarists had acquired fish from local pet stores (61%) or specialist fish stores (53%) (Table 3.2). Acquiring a fish from a local pet store ($p = 0.057$), as a gift ($p = 0.581$) or as a prize ($p = 0.763$) were not associated with the owner’s knowledge of fish biology. However, more knowledgeable owners were more likely to use all other methods of acquiring fish (specialist fish pet store $p < 0.001$, $z = 7.993$, $r = 0.35$; private sale $p < 0.001$, $z = 10.68$, $r = 0.46$; wild capture $p < 0.001$, $z = 7.622$, $r = 0.33$).

Over half of participants used a general Internet search to gather information when purchasing a new fish, although 16% gathered no information at all (Table 3.3). People who gathered no information had a significantly lower knowledge of fish biology ($p = 0.001$, $z = 3.375$, $r = 0.15$).

**Table 3.2. Sources utilised for obtaining pet fish.**

Respondents ($n = 533$) could nominate more than one source.

<table>
<thead>
<tr>
<th>Source of Fish</th>
<th>Respondents (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local pet stores</td>
<td>60.6</td>
</tr>
<tr>
<td>Specialist fish stores</td>
<td>52.9</td>
</tr>
<tr>
<td>Private sale</td>
<td>36.8</td>
</tr>
<tr>
<td>Internet sale</td>
<td>27.2</td>
</tr>
<tr>
<td>Wild capture</td>
<td>16.7</td>
</tr>
<tr>
<td>Giveaway</td>
<td>12.9</td>
</tr>
<tr>
<td>Gift</td>
<td>9.0</td>
</tr>
<tr>
<td>Carnival prize</td>
<td>4.5</td>
</tr>
</tbody>
</table>
Table 3.3. Informational sources used by respondents when they were planning to purchase new fish.

Respondents could nominate all sources that they utilised.

<table>
<thead>
<tr>
<th>Source of Information</th>
<th>Respondents (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General internet search</td>
<td>51.1</td>
</tr>
<tr>
<td>Place of purchase</td>
<td>46.2</td>
</tr>
<tr>
<td>Books</td>
<td>43.2</td>
</tr>
<tr>
<td>Asked in an online forum</td>
<td>41.8</td>
</tr>
<tr>
<td>Asked friends</td>
<td>31.1</td>
</tr>
<tr>
<td>No information</td>
<td>16.1</td>
</tr>
</tbody>
</table>

All other sources of information were associated with higher knowledge (online search $p < 0.001, z = 7.67, r = 0.33$; books $p < 0.001, z = 9.345, r = 0.4$; asked online $p < 0.001, z = 9.855, r = 0.43$; asked friends $p < 0.001, z = 7.679, r = 0.33$), except for obtaining information at the place of purchase ($p = 0.329$).

Most fish owners discussed their fish with other people (71%) or participated in online discussion boards about fish (57%). A quarter of respondents (26%) had participated in fish clubs or shows. All three measures of social capital were strongly associated with knowledge (discuss fish $p < 0.001, z = 11.523, r = 0.5$; participate online $p < 0.000, z = 15.232, r = 0.66$; shows or clubs $p < 0.001, z = 9.587; r = 0.42$).

There are two main clusters of fish owners (Table 3.4). The first cluster, termed committed owners, accounted for the majority (73%) of respondents and was characterized by their higher knowledge of fish biology, information seeking, social sharing of information and use of specialist aquarium stores. This cluster was predominantly male (75%). The second cluster, named casual owners, described 27% of the respondents and was characterized by low knowledge about fish, belief in the three-second myth and little or no information seeking behaviour. There were more females (60%) than males in this cluster and most had stopped keeping fish. Emotional relationships with fish (e.g. talking to fish, naming fish, mourning fish) and support for animal welfare were not important for the formation of the clusters.
Table 3.4. Characteristics of the two groups of fish owners determined using a two-step cluster analysis.

Variables are listed in order of decreasing importance.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cluster 1 Committed (n = 347)</th>
<th>Cluster 2 Casual (n = 130)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge of fish biology [1 – 5 scale]</td>
<td>4.3</td>
<td>2.6</td>
</tr>
<tr>
<td>Participated in online discussions about fish</td>
<td>87%</td>
<td>0%</td>
</tr>
<tr>
<td>Previously kept fish, but no longer do (as opposed to currently keeping fish)</td>
<td>5%</td>
<td>74%</td>
</tr>
<tr>
<td>Has talked to others about their fish</td>
<td>92%</td>
<td>20%</td>
</tr>
<tr>
<td>Sought information on fish using a general internet search</td>
<td>70%</td>
<td>0%</td>
</tr>
<tr>
<td>Sought information on fish in books</td>
<td>59%</td>
<td>0%</td>
</tr>
<tr>
<td>Knows that fish do not have a three-second memory</td>
<td>89%</td>
<td>41%</td>
</tr>
<tr>
<td>Purchased fish at specialist aquarium stores</td>
<td>67%</td>
<td>23%</td>
</tr>
<tr>
<td>Sought information on fish from their friends</td>
<td>42%</td>
<td>6%</td>
</tr>
<tr>
<td>Male</td>
<td>75%</td>
<td>39%</td>
</tr>
</tbody>
</table>

3.4 Discussion

This study aimed to identify factors that were associated with aquarist’s level of knowledge about fish biology. Respondents to this survey could be classified as two main types of aquarist—committed owners and casual owners. Committed owners, who make up 73% of the sample, report a greater knowledge of fish biology, discuss fish more with others, seek more information and buy fish at specialist aquarium stores. Casual owners report having less knowledge of fish biology, are likely to have ceased owning fish, rarely discussed their pets or sought information when they did own fish and were more likely to believe the myth that fish have a three-second memory. These data suggest that social norms and beliefs were more strongly associated with knowledge and information seeking by aquarists than attitudes and emotions.
Having experience with animals has been associated with increased knowledge, positive attitudes towards animal welfare and negative attitudes towards using and hunting animals (Paul & Serpell 1993; Prokop & Tunnicliffe 2010; Serpell 2004; Tomazic 2011). However, an increased knowledge of fish biology showed no association with support for either banning fishbowls or animal welfare groups taking action on fish welfare. Similarly, bird owners are less likely to consider that keeping birds in cages is cruel (Prokop et al. 2008). Instead, participants who had a greater knowledge of fish biology were actually more likely to participate in recreational fishing. Fishers often have a high level of knowledge and interest in fish (Li et al. 2010) — they go fishing because they like fish, not in spite of it (Braithwaite 2010). Muir et al. (2013) found that, compared to non-fishers, anglers assigned equal importance to using harm-minimising fishing practices, but rated fish as less able to feel pain. This shows that experience and positive attitudes towards animals are not automatically associated with an increase in welfare, as people may rationalize their use of animals in order to spend more time in the company of animals (Serpell 2009).

Emotional attachment seemed to have a relatively unimportant association with knowledge, possibly because of the bias towards knowledgeable male respondents. On average, men are less emotionally involved with animals than women (Herzog 2007). Although naming pet fish and feeling sadness when they died both showed a weak association with knowledge, talking to fish and burying dead fish were unrelated. None of these measures were strongly associated with whether people were committed or casual fish owners. Similarly, Ramon et al (2010) found no link between emotional attachment and knowledge of pet care behaviour in cat owners.

Women were slightly more likely to show emotional attachment to their fish. This is consistent with the literature for other animals (Ellingsen et al. 2010; Herzog 2007; Knight et al. 2004) and a New Zealand study that showed women were more concerned about fish welfare than men (Muir et al. 2013). In spite of this, men were more likely to be classified as committed owners than women. This is related to the gender imbalance in this survey: more of the current owners who replied were male, while female respondents were more likely to be prior fish owners. This is unusual as women are normally overrepresented in surveys of pet owners (Rohlf et al. 2010), although both genders are equally likely to keep pets (Marx et al. 1988; Parslow et al. 2005). There are differences in gender balance according to the type of pet kept — for example, women are more likely to keep horses (Gorecka-Bruzda et al. 2011) — but this has not
been previously observed in fishkeeping. It may simply be that fish appeal more to men than women. Alternatively, equal numbers of men and women may take up fish keeping, but women are more likely to drop out while men continue on to become experienced owners. It is possible that males simply self-rate themselves as being more knowledgeable than females, but several other lines of data — such as a reduced belief in the three-second myth and increased information seeking behaviours — supporting the conclusion that the male respondents tended to be genuinely more committed fish owners.

The perception of fish by the general public is that they are far less intelligent than other vertebrates (Knight et al. 2004). This is shown by the belief among casual owners that fish have a three-second memory. Myths such as the ‘three-second memory’ are particularly resistant to conventional educational methods (Kupsala et al. 2013; Prokop et al. 2009). Sexton and Stewart (2007) found that people who believed myths about bats had a lower knowledge of their biology and more negative attitudes towards them, while New et al. (2000) found that people who relinquish their pets to shelters are more likely to believe in common myths such as ‘female cats should have one litter before being desexed’. Improving the public image of fish may help to improve care giving by casual fish keepers. Fish owners with a higher level of knowledge were less likely to believe that fish had a three second memory and more likely to recognise that fish are able to learn, feel pain and are intelligent.

The Internet is the most important source of information for fish owners and varies in quality and accuracy (Walster 2008). Less than half of the respondents were provided with information about fish at their place of purchase. Pet shops are considered to have a responsibility to provide information to new pet owners (Edgar & Mullan 2011) and the Pet Industry Association of Australia’s voluntary code of practice for aquarium stores specifically encourages stores to provide literature on fish care to purchasers (Panaquatic Health Solution Pty Ltd 2006). Realistically, given the difficulty of finding trained staff, the time pressure on staff, and the ‘come-and-go’ nature of aquarium stores (Miller-Morgan 2010; O'Sullivan et al. 2008), it is difficult to educate every customer about fish care. A more pragmatic solution may be to encourage the manufacturers of fish products to promote good welfare practices, particularly on labels for ongoing purchases such as fish food and water conditioner. Ultimately, however, the responsibility lies with the pet owner to ensure they are adequately informed about pet care.
The majority of fish owners (73%), labelled committed owners, actively seek out information each time they purchase a new fish and appear to be knowledgeable about fish biology. Although it is likely that they already provide a high standard of living conditions for their fish, our scientific understanding of fish welfare is rapidly improving and there is often new information that should be shared with fish owners. Information can be efficiently provided to this cluster through online discussion boards and specialist fish stores. Committed owners have high social connectivity and are likely to discuss their fish both online and with friends, so new information should spread fairly rapidly. Fish clubs and discussion boards should not be dismissed as anecdotal or amateur. Given that there is a dearth of professional research on ornamental fish (Walster 2008), information sharing between aquarists is important for building the body of knowledge. For example, the Australia New Guinea Fishes Association was instrumental in preventing the extinction of Lake Eacham rainbow fish (Leggett & Merrick 1997) and hobbyists enthusiastically embrace scientific research when it is openly available (Rhyne 2010).

It would be far more difficult to disseminate information within the casual cluster of fish owners (27% of participants). These aquarists have a low existing level of knowledge and are not actively searching for information on fish or discussing fish care with others. There is room to improve information provision at the point-of-sale, as less than half of respondents received any information when they bought their last fish. However, simply increasing the provision of information to fish owners will not help to solve the problem of unbalanced uptake of that information between committed and casual owners (Li et al. 2010). Casual fish owners may even actively avoid information if it causes them cognitive dissonance (Coleman 2010).

Rather than simply trying to educate people, pet fish owners should be encouraged to seek out information of their own accord. This can be done by increasing societal pressure to be a good fish owner, just as we feel social pressure to be responsible dog owners (Rohlf et al. 2010). This is particularly difficult because fish tend to suffer from passive neglect (Chapter 2) and people tend to judge passive neglect of animals less harshly than active abuse of animals (Henry 2009).

It is important to note that this study does not establish cause and effect between the attributes measured and fish owner behaviour. As with other surveys of pet owners, a direct, causal link between information provision and improved care is yet to be established (Edgar & Mullan 2011). However, studies of this kind are valuable because
they allow us to profile different groups of owners and target communication and welfare intervention strategies appropriately (Visser & Van Wijk-Jansen 2012).

The majority of participants appear to be knowledgeable and capable fish owners. However, many casual owners appear to have given up fish ownership, suggesting that there is high turnover in their group of owners. This suggests that sales of new fish and aquaria from non-specialist pet stores may be disproportionately going to homes where the owner has less knowledge about fish biology. Since less than half of owners report receiving information about their fish at the place of purchase, pet stores are an obvious target for disseminating information to casual owners. Further information could be opportunistically provided along with ongoing purchases such as fish food.

3.5 Conclusion

Fish owners with a better knowledge of their pets’ needs and biology are more likely to provide better care and seek out more information on fish. However, information provision alone is not enough to improve owner knowledge, as a quarter of fish owners in this study were not actively seeking information at all. Since information seeking behaviour is strongly associated with social norms and beliefs about fish, it would be more appropriate to use targeted communication strategies, such as increasing information delivery at the point-of-sale, on fish care products, through mass media and social advertising. Although the majority of fish owners appear to have a good knowledge of their pet fish, there is a significant proportion (27%) who appear to have limited knowledge about their pets. Information delivery methods should be carefully evaluated to ensure that they are reaching the targeted group of fish owners.
4 Reeling them in: Can short films improve knowledge, attitudes and behaviour towards pet fish care?

4.1 Background

Fish in captivity are often exposed to stressors such as handling, parasites, high-density stocking and poor water quality (Etscheidt & Manz 1992; Loh & Landos 2011). Most fish owners appear to be committed to ensuring good welfare for their pets. However, approximately a quarter of fish owners surveyed reported a low level of knowledge about their pet’s biology and an increased belief in myths about fish (Chapter 2).

It is difficult to correct misconceptions amongst casual fish owners, as they rarely deliberately seek out any information on how they should be caring for their fish (Chapter 3). Instead, in order to educate casual fish owners about welfare requirements, information should be channelled through media that are efficient at reaching people in their everyday lives, such as mass media (Coleman 2010). After completing their formal education the majority of people rely on the media, especially television, for their scientific information (Dhingra 2006; Hwang & Southwell 2009).

If used correctly, film and television can have dramatic impacts on awareness and audience behaviour. For example, the End of the Line documentary on overfishing proved to be so powerful that sales of sustainable fish rose by 15% in Waitrose supermarkets in the UK following its release (Britdoc Productions n.d.). Unfortunately, film can also have unintended negative effects on behaviour, such as Finding Nemo (Stanton & Unkrich 2003), which increased demand for pet clownfish in spite of having a strong conservation message (Plate 2007; Yong et al. 2011).

Animal welfare groups often use film media such as television advertisements or YouTube films to spread their message (Loader 2008), but it is unknown how successful this has been in driving behavioural change. Currently, animal welfare promotions often frame their appeals using negative emotions, such as guilt and shock (Jones 1997). There is some evidence to support this choice. University students were more willing to donate time and money when shown negative, depressing images of dogs compared to warm, positive dogs (Haynes et al. 2004). However, negative frames
have been shown to overwhelm and disempower the audience when used to campaign for environmental (O'Neill & Nicholson-Cole 2009) and humanitarian causes (Seu 2010). Negatively framed advertisements used in animal welfare campaigns appear to have an immediate adverse reaction and can actually reduce immediate support amongst non-activists (Mika 2006), although it is not clear what the longer-term influence on behaviour might be.

This study explores how short films negative and positive framing can influence people’s attitudes, knowledge and behaviour towards their pet fish.

Since interventions to change behaviour are generally more effective if they provide targeted, personalized messages based on specific behaviours (Webb & Sheeran 2006), our study focussed on encouraging people to clean their aquaria every week. Tank cleaning is a discrete and measurable behaviour that is important to maintain good water quality, which is one of the most important parameters for fish health and welfare (Johansen et al. 2006; Loh & Landos 2011; Snieszko 1974). In particular, cleaning the tank involved a water change, which removes any excess nitrate that hasn’t been taken up by aquaria plants. Nitrates, a by-product of fish excretion, slow fish growth and reduce their resistance to disease (Loh & Landos 2011). It is probable that many owners attribute fish deaths caused by poor water quality to illness or old age (Weber 2010); (Chapter 3). A lack of regulations protecting fish welfare (O'Sullivan et al. 2008) means that the level of care is left to the individual pet owner, so there are few barriers to behavioural change. Animal welfare organisations have paid very little attention to aquarium fish welfare to date, so there are no compounding effects from previous campaigns that participants could have been exposed to.

It is hypothesised that the films will have a greater impact on attitudes, intentions and behaviour, in accordance with the Theory of Planned Behaviour (Ajzen 1991). The Theory states that behaviour is best predicted by intentions, which in turn are influenced by attitudes, social norms and behavioural control (Armitage & Conner 2001). If the films positively change behaviour, there are three potential outcomes—shaping, reinforcing and changing (Miller 1980). Shaping occurs when participants acquire new beliefs or attitudes. Response reinforcing works on exiting attitudes, to strengthen them and make them more resistant to change. Response changing involves a shift from an existing position to a new position.
4.2 Methods

I created two short (50 second) films for use in the study. One film was positively framed, drawing on joyful emotions and comedy, while the second was negatively framing, inducing guilt. Both films featured goldfish, as these are one of the most common fish species kept as pets (Chapter 2; O'Sullivan et al. 2008).

The positive film showed fish defecating (Figure 4.1A) and eating food in time to music, followed by the message, ‘Your fish poop where they eat.’ The negative film consisted of still shots of a ‘dead’ cat, dog and goldfish (Figure 4.1B), with voiceover from three speakers discussing how long the animals lived. The message, ‘Goldfish should live 10-15 years’ appeared. Both films then finished with the same clip of a tank being cleaned and a final message, ‘Keep your fish (healthy/happy). Clean your tank weekly.’ Half of the respondents in each treatment were assigned to the ‘Keep your fish happy’ concluding message and half to ‘Keep your fish healthy.’

Both films were intended to address common misconceptions that fish owners might have, as incorrect beliefs were shown to be associated with lower knowledge of fish biology in Chapter 2. The positive film was concerned with the misconception that fish are low-maintenance pets, while the negative film focuses on the myth that fish are short lived. The difference in topic between the two films does introduce confounding factors into the analysis as, although the main message is the same for both films, they address different underlying beliefs.

A. A goldfish defecating in the positive film.

B. A ‘dead’ goldfish floats on the surface of the tank in the negative film.

Figure 4.1. Screenshots from the two short films used in the experiment.

Full films can be watched at www.youtube.com/user/FishWelfare

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Since it is not clear which misconception is more important in influencing behaviour, it was decided to test both. However, it must be recognised that this does limit ability to directly compare the positive and negative films.

Both films used classical music for background. The positive film used Strauss’ The Blue Danube (1866) and the negative film had Beethoven’s Moonlight Sonata (1801). These pieces were selected because they are from a similar time period, well known and free of lyrics or singing that could distract the audience. Ideally, both pieces would have come from the same composer, but it was difficult to find a composer that had produced both negative and upbeat music with an otherwise similar style. From a practical perspective, the songs were also chosen because they are both publically available and free of copyright restrictions.

The films were embedded in the survey, although a link to the YouTube site was also provided as a back-up in case of browser problems. During the research, the YouTube site was hidden from search engines and only available to those who had the link. Now that the study is complete the films have now been made publically available at www.youtube.com/user/FishWelfare

Participants were recruited internationally through advertisements on social websites, including Facebook, Reddit, fish related discussion boards and student forums. In order to participate, respondents had to be over 18 and currently own fish. The surveys were hosted at SurveyGizmo (Widgix 2005-2011) and were approved by The University of Australia Human Research Ethics Committee (RA/4/1/5511). No animals were harmed during the making of the films.

To begin, respondents answered a short survey (5 - 10 min) and were randomly assigned to one of five treatments by the survey software. The five treatments were control (no film); positive film- healthy message; positive film- positive message; negative film-healthy message; and negative film- positive message. Thirty days after the initial survey, respondents were contacted by email and asked to complete the follow-up survey. A reminder email about the follow-up survey was sent a week later if they had not responded. Questions for both the initial survey and the follow up are shown in
Statistical Analysis

Non-parametric statistics were used, as many data were binary and were not normally distributed. Mann-Whitney U tests and Kruskal-Wallis tests were used for comparing groups within one survey and the Wilcoxon Signed Rank Test were used for comparing results across the pre- and post-surveys (Table 4.1). Spearman’s rho was used for correlations between continuous data. The effect size (r) is also shown, where r < 0.2 indicates a weak effect, r = 0.2 - 0.5 a moderate effect and r > 0.5 a strong effect (Cohen 1988; Pallant 2011). Chi-square tests with Fischer’s exact test were used to compare frequency data (i.e. For key message recall).
Table 4.1. Question alignment between the pre- and post- surveys.

Attitude, behaviour, knowledge and intention questions are indicated in square brackets. Questions marked with an asterisk were not displayed to the control group. The full survey is provided in Appendix D.

<table>
<thead>
<tr>
<th>Original Question</th>
<th>Follow-up Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Where do you live?</td>
<td>-</td>
</tr>
<tr>
<td>What gender are you?</td>
<td>-</td>
</tr>
<tr>
<td>How often did you clean your tank in the last month?</td>
<td>How often did you clean your tank in the last month? (If you own more than one tank, please consider your smallest tank).</td>
</tr>
<tr>
<td>[Behaviour]</td>
<td></td>
</tr>
<tr>
<td>Do you own goldfish?</td>
<td>-</td>
</tr>
<tr>
<td>Does your tank contain plants?</td>
<td>-</td>
</tr>
<tr>
<td>How knowledgeable about fish care and biology are you?</td>
<td>How knowledgeable about fish care and biology are you?</td>
</tr>
<tr>
<td>[Knowledge]</td>
<td></td>
</tr>
<tr>
<td>Fish deserve the same level of care as cats and dogs.</td>
<td>Fish deserve the same level of care as cats and dogs.</td>
</tr>
<tr>
<td>[Attitude]</td>
<td></td>
</tr>
<tr>
<td>Split to Films*</td>
<td>-</td>
</tr>
<tr>
<td>How many times did you watch the film?*</td>
<td>Do you remember watching a short film in the earlier survey? What was the main message of the film you watched?*</td>
</tr>
<tr>
<td>[Intentions]</td>
<td></td>
</tr>
<tr>
<td>Do you intend to do any of the following?</td>
<td>Did you improve the way you cared for your fish over the last month? Why/why not?</td>
</tr>
<tr>
<td>Clean your tank more often</td>
<td>-</td>
</tr>
<tr>
<td>Find out more about fish care</td>
<td>Over the last month, have you sought out any information on fish or fish care?</td>
</tr>
<tr>
<td>Talk to others about your fish</td>
<td>Have you talked to other people about fish in the last month?</td>
</tr>
</tbody>
</table>
4.3 Results

The initial call for participants generated 340 responses, of which 195 (57%) provided complete responses to the follow-up survey a month later. Respondents who were assigned to a film treatment but said they were not able to watch the film were moved to the control group for analysis (n = 14). Roughly equal numbers were exposed to the control, positive film and negative film and there were no significant initial differences between the groups in any of the key variables (Table 4.2).

No significant differences were found between the ‘healthy’ and ‘happy’ messages at the end of the films for any variable, so data were combined into three (positive, negative and control) treatment groups for all further analysis.

There was no overall change in respondents’ knowledge (p = 0.81), attitude towards fish care (p = 0.51) or tank cleaning behaviour (p = 0.89) over the month (Figure 4.2). However, respondents did seek out more information on fish care (p < 0.000, z = 7.879, r = 0.56) and talk about fish (p < 0.000, z = 9.519, r = 0.682) significantly more often than they had initially said they would (Figure 4.3). These patterns remained the same regardless of film treatment (p > 0.05 for all groups).

![Figure 4.2](image)

**Figure 4.2.** Change in the knowledge, attitudes and behaviour of fish owners a month after they watched a short educational film (p > 0.05).
Table 4.2. Study demographics and tank variables.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Control (no film)</th>
<th>Positive film</th>
<th>Negative film</th>
<th>Total sample</th>
<th>p-value for difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size</td>
<td>65</td>
<td>68</td>
<td>62</td>
<td>195</td>
<td></td>
</tr>
<tr>
<td>Gender (Male:Female)</td>
<td>40 (61.5%): 25 (38.5%)</td>
<td>29 (42.6%): 39 (57.4%)</td>
<td>28 (45.2%): 34 (54.8%)</td>
<td>97 (49.7%): 98 (50.3%)</td>
<td>0.064</td>
</tr>
<tr>
<td>Location (Australia: Other)</td>
<td>39 (61.9%): 24 (38.1%)</td>
<td>36 (53.7%): 31 (46.3%)</td>
<td>29 (47.5%): 32 (52.5%)</td>
<td>104 (54.5%): (87 (45.5%)</td>
<td>0.273</td>
</tr>
<tr>
<td>Knowledge of fish biology (mean and SD)</td>
<td>3.26 (1.08)</td>
<td>2.99 (1)</td>
<td>3.19 (1.07)</td>
<td>3.14 (1.05)</td>
<td>0.393</td>
</tr>
<tr>
<td>Tank cleans/month (mean and SD)</td>
<td>2.32 (1.52)</td>
<td>2.4 (1.73)</td>
<td>2.65 (1.63)</td>
<td>2.45 (1.63)</td>
<td>0.529</td>
</tr>
<tr>
<td>Plants</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>12 (18.5%)</td>
<td>8 (11.8%)</td>
<td>9 (14.5%)</td>
<td>29 (14.9%)</td>
<td>0.433</td>
</tr>
<tr>
<td>Fake</td>
<td>10 (15.4%)</td>
<td>17 (25%)</td>
<td>9 (14.5%)</td>
<td>36 (18.5%)</td>
<td></td>
</tr>
<tr>
<td>Real</td>
<td>37 (56.9%)</td>
<td>32 (47.1%)</td>
<td>33 (53.2%)</td>
<td>102 (52.3%)</td>
<td></td>
</tr>
<tr>
<td>Both real and fake</td>
<td>6 (9.2%)</td>
<td>11 (16.2%)</td>
<td>11 (17.7%)</td>
<td>28 (14.4%)</td>
<td>0.534</td>
</tr>
<tr>
<td>Goldfish</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never owned</td>
<td>24 (36.9%)</td>
<td>25 (36.8%)</td>
<td>22 (35.5%)</td>
<td>71 (36.4%)</td>
<td></td>
</tr>
<tr>
<td>Previously owned</td>
<td>26 (40%)</td>
<td>19 (27.9%)</td>
<td>21 (33.9%)</td>
<td>58 (29.7%)</td>
<td></td>
</tr>
<tr>
<td>Currently own</td>
<td>15 (23.1%)</td>
<td>25 (35.3%)</td>
<td>19 (30.6%)</td>
<td>66 (33.8%)</td>
<td></td>
</tr>
</tbody>
</table>
Figure 4.3. Fish owners intentions to act vs. actual behaviour in the month after they watched a short educational film.

Although self-assessed knowledge of fish biology did not change across the entire group, there was regression towards the mean between the two surveys. People who scored themselves 0-2 in knowledge improved across the month (n = 44, p > 0.000, z = -4.082), while those scoring 4-5 decreased (n = 68, p = 0.001, z = 3.26) and those scoring a three remained the same (n = 83, p = 0.637).

Participants who sought out information did not report an increase in their knowledge of fish biology (p = 0.538) but respondents with a greater initial knowledge of fish biology were more likely to acquire further information (p = 0.013, U = 3319, z = 2.484, r = 0.18, acquired information \( \bar{x} = 3.28 \), no information \( \bar{x} = 2.86 \)). Most (67%) participants sought out information on fish during the course of the survey. Online sources of information (53%) were more popular than offline (35%), while only 9% referred to the website provided with the survey.

About a quarter (24%) of participants stated that they intended to clean their aquarium more frequently over the following month. This group rated themselves as significantly less knowledgeable about fish biology (\( \bar{x} = 2.7 \)) than those who did not intend to clean their tank more often (\( \bar{x} = 3.3 \), U = 2398, z = 3.374, p = 0.001, r = 0.24).

The participants who stated that they intended to clean their aquarium more often showed a significant improvement in the frequency of tank cleaning in the follow-up survey (n = 47, z = 2.559, p = 0.011, r = 0.26). This was strongly influenced by treatment group. Frequency of tank cleaning increased in both the negative film (n = 15, z = 1.992, p = 0.046, r = 0.36) and positive film groups (n = 20, z = 3.416, p = 0.001, r
while the control group showed a significant decrease \( (n = 12, z = 2.271, p = 0.023, r = 0.46) \) (Figure 4.4). There was no difference between goldfish owners and owners of other fish species \( (p > 0.05 \text{ for all treatments}) \) and treatment did not influence the proportion of people who agreed that they improved their care over the month \( (p = 0.092) \).

More participants who watched the positive film remembered that the key message was that fish tanks should be cleaned \( (Table 4.3, \text{Chi-sq } p < 0.0001) \), although only two people mentioned that cleaning should be done weekly. Respondents who watched the negative film were more likely to fail to identify any message \( (\text{Chi-sq } p = 0.01) \) or remembered more secondary messages \( (Table 4.3) \). Nearly all \( (n = 190) \) participants watched the film just once, so the frequency of exposure could not be correlated with message recall.

Cleaning out the tank had a weak positive correlation with greater self-assessed knowledge of fish biology \( \text{(Spearman’s rho } p = 0.054, r = 0.138) \) and believing that fish deserved equal care to other pets \( (p < 0.000, r = 0.248) \). Tank cleaning was also associated with location \( (p < 0.000, U = 2956.5, z = 4.243, r = 0.3, \text{Australian residents } \bar{x} = 1.9, \text{other countries } \bar{x} = 3) \), whether participants acquired information \( (p < 0.000, U = 4667.5, z = 4.46, r = 0.32, \text{no information } n = 64, \bar{x} = 1.2, \text{got information } n = 131, \bar{x} = 2.8) \) and whether they talked about their fish \( (p < 0.000, U = 1179.5, z = 4.312, r = 0.31, \text{talked about fish } \bar{x} = 2.65, \text{did not discuss fish } \bar{x} = 1.25) \). Respondents who had artificial plants also cleaned out their aquarium less often \( (Figure 4.5, p = 0.004, \text{Chi-sq } 1.259, df = 2) \).
Table 4.3. Messages that respondents remembered a month after watching the film.

Optional open answer question, one response could mention several messages.

<table>
<thead>
<tr>
<th>Message</th>
<th>Examples</th>
<th>Positive Film (n = 68)</th>
<th>Negative film (n = 62)</th>
<th>Total % (n = 130)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary Message</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tank should be cleaned</td>
<td>‘Clean your tank’, ‘positive water = positive fish’, ‘water changes’</td>
<td>45 (66%)</td>
<td>8 (13%)</td>
<td>41</td>
</tr>
<tr>
<td>Specified that tanks should be cleaned ‘regularly’ or ‘often’</td>
<td></td>
<td>22 (32%)</td>
<td>3 (5%)</td>
<td>19</td>
</tr>
<tr>
<td>Specified that tanks should be cleaned ‘weekly’</td>
<td></td>
<td>2 (3%)</td>
<td>0</td>
<td>1.5</td>
</tr>
<tr>
<td><strong>Secondary Message</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fish waste is a problem</td>
<td>‘Fish poo where they play’, ‘fish live in their own waste’</td>
<td>15 (22%)</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>All pets should be treated with respect</td>
<td>‘Pets require care regardless of species; fish often seen as ‘disposable’ pets’, ‘fish do not get the same chance at life as other furry pets’</td>
<td>4 (6%)</td>
<td>17 (27%)</td>
<td>16</td>
</tr>
<tr>
<td>General care and maintenance is important (without specific reference to water quality)</td>
<td>‘look after your fish’, ‘fish welfare’, ‘fish need proper care’</td>
<td>8 (12%)</td>
<td>17 (27%)</td>
<td>19</td>
</tr>
<tr>
<td>Mortality or lifespan</td>
<td>‘fish live a long time’, ‘fish live longer than most people think’</td>
<td>1 (1.5%)</td>
<td>7 (11%)</td>
<td>6</td>
</tr>
<tr>
<td><strong>No message</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-specific fish</td>
<td>‘fish are pretty’, ‘all I can remember is the image of fish swimming’</td>
<td>4 (6%)</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Don’t remember / left blank / incomprehensible</td>
<td></td>
<td>8 (12%)</td>
<td>24 (39%)</td>
<td>25</td>
</tr>
</tbody>
</table>
Of the participants who agreed that they did not improve their fish care over the month of the survey (n = 148), 112 explicitly stated in an open answer question that their current level of care was already sufficient. Only 8.9% of people who considered that their care was already good had intended to clean out their tank more often, compared to 44.6% of people who did not explicitly state their current level of care was good (Chi-sq 33.12, p < 0.000). Respondents who stated that their care was already good did clean out their tank more often than respondents who did not state this (Figure 4.6, Mann-Whitney U 3454, z = 2.915, p = 0.004) and had a greater self-rated knowledge of fish biology (X̄ = 3.33 compared to X̄ = 2.88 for those who did not state their care was already good, p = 0.004, U = 3577, z = 2.894, r = 0.21). Three people stated that they had not improved their care because their fish had died before the second survey. These respondents had rated their level of knowledge about fish as very little or basic.

There were small gender differences in knowledge (p = 0.021, U = 3887.5, z = 2.313, r = 0.17, males X̄ = 3.3, females X̄ = 2.95), keeping goldfish (p = 0.021, phi = 0.2, 39% females keep goldfish vs. 21% men), keeping artificial plants (p = 0.056, phi = 0.2, 24% females vs. 12% males) and seeking information online (p = 0.052, phi = 0.015, 61% males vs. 46% females).

![Figure 4.5. Relationship between the type of plants kept in the tank and the number of times that the tank was cleaned over a month.](image-url)
Figure 4.6. The proportion of respondents who stated that their fish husbandry was already good compared to the number of times respondents cleaned out their tank in the month prior to the first survey.

4.4 Discussion

The results of the experiment partially supported the hypothesis that the films would affect attitudes and behaviour, in accordance with the Theory of Planned Behaviour. Both positively and negatively framed films increased the likelihood that participants would clean their tank more frequently the following month compared to the control, but only if the participant already consciously intended to improve this behaviour. This fits in well with the Theory of Planned Behaviour as intentions are expected to be the best predictor of behaviour (Ajzen 1991).

The films did not appear to initiate the intention to clean aquaria more often, but rather strengthened pre-existing intentions. They could have done this in several possible ways.

Firstly, the section of the film showing a tank being cleaned may have lowered perceptual barriers to tank cleaning. Fish owners have a high level of actual behavioural control over their pet care, but they may have been reluctant to improve care if they perceived it as difficult or time consuming.
Secondly, the film may have strengthened participants’ attitudes towards the importance of aquarium cleaning. Although there was no change in attitudes towards the relative importance of fish as pets compared to dogs and cats, this measure may not have been specific enough to detect a change. General attitudes often correlate poorly with situational behaviours (Ajzen 1991; Ajzen & Fishbein 1977; Ajzen & Fishbein 2000; also see section 1.1) and it would have been better to directly ask about attitudes toward tank cleaning in relation to fish health and effort required.

Lastly, it is possible that the result was a statistical error due to the limited sample size or self-reporting bias. The overall study gathered a moderate number of respondents (n = 195), but only a quarter displayed an intention to clean their tank more frequently, limiting the sample size for observing behavioural change. Considering that other studies suggest actual behavioural change is lower than self-reported behavioural change (Webb & Sheeran 2006), it is possible that the results reflect a sampling bias. However, given that effect sizes were found to be medium to large, it would be pre-emptive to dismiss the results entirely— they provide a promising starting point to encourage larger, more comprehensive studies into how short films can influence behaviour.

There was some evidence to suggest that the positive film was slightly more effective than the negative. More participants who intended to clean their tank did so after watching the positive film (70%) compared to the negative (40%). People who watched the positive film were also more likely to identify that the key message of the film was that the tank should be cleaned. This could be due to the different focus of the films, as respondents in the negative treatment identified general maintenance of fish more often. However, people in the negative treatment were four times more likely to forget the key message than the positive treatment group. This is consistent with the idea that frames that target negative emotions could cause people to ignore or repress their reaction (Duncan 2008; Mika 2006). Despite this, very few people reported that they felt guilty for either the negative (n = 4) or positive (n = 6) treatments. An alternative explanation is that showing the cause of dirty water (i.e. fish excretion) is cognitively easier to associate with the action of cleaning than demonstrating the outcome (i.e. longer lifespan for fish). There was no difference between the textual framing (happy vs. healthy) groups, even though other studies have found that the choice of text can be quite important (Nabi 1998). In this case, the overall frame appears to have had a stronger influence.
The intervention only appeared to effectively produce change in participants with existing positive intentions, suggesting that films are most useful as a response reinforcer. Response reinforcing is the most common type of behavioural change targeted by media (Miller 1980), so it is not surprising that it is the outcome of a short, advertisement-style film. Response changing might be more desirable, but also tends to be more gradual and require longer-term communication strategies (Simons & Jones 2011). The film was most effective as a reinforcer for aquarists who cared about their fish but had room to improve their husbandry. Ideally, an intervention would also reach those aquarium owners who have poor attitudes towards fish care, but this group is less likely to access online information on fish (Chapter 3).

Behavioural change in tank cleaning was only monitored for one-month after the intervention. Since tank cleaning is a frequently performed behaviour, it may have become habit over the month and therefore be maintained (Webb & Sheeran 2006). However, given that the films were very short (one minute long) it is impressive that they had any impact at all, and a longer-term effect is not necessarily likely. A similar example of a popular short YouTube video about safety at railway crossings showed that the impact was only short term (Carey & Butt, 2013). Ongoing long-term communication strategies are likely to be needed to create long-term change (Simons & Jones 2011).

There was a strong ceiling effect in the respondent group, where no change was observed because the targeted behaviour was already prevalent (Cramer & Howitt 2005). Three-quarters of participants did not improve the care of the fish over the month of the survey, mainly because they considered that their current level of care was already sufficient. On average, this group did clean out their aquaria more often and self-rated their knowledge as being greater than respondents who did not explicitly state that their care was already at a high level, providing evidence that many respondents are likely to be responsible and capable fish keepers. However, 54% of fish owners who stated that their level of care was good had only cleaned out their aquaria twice in the month preceding the survey, including four people who had not cleaned their aquaria at all. Infrequent cleaning does not necessarily mean that these respondents are not adequately caring for their tank. The recommendation to clean tanks weekly is based on average requirements (Loh & Landos 2011). Large, lightly stocked or heavily planted tanks may not need cleaning as frequently, while small or densely stocked aquaria may need cleaning more than once a week. Due to the differences in stocking density, plants,
Fish species and aquarium size between fish owners it is difficult to establish exactly how much fish welfare will improve with weekly cleaning. Nevertheless, it is also possible that some respondents may believe they are caring for their fish adequately and do not have enough knowledge to recognize that they need to further improve (the "Dunning-Kruger effect", Kruger & Dunning 1999). Some participants may also hold beliefs that conflict with the films, for example, participants who stated that, “I am concerned that cleaning too regularly removes essential bacteria in the tank” and “I only clean the tank when it needs done as this can be a stressful experience for fish”. Such beliefs can form perceptual barriers for behaviour change (Ajzen 1991). Future interventions focusing specifically on perceived barriers to aquarium maintenance (e.g. time, difficulty, belief that too much cleaning harms fish) would be helpful.

All groups, including the control, were more likely to talk about fish and gather information than was predicted by their intentions. This is somewhat contradictory to the Theory of Planned Behaviour, which states that intentions are the strongest predictor of behaviour (Ajzen 1991). However, there are circumstances where behaviours can be activated without the participant consciously holding the behavioural goal (Webb & Sheeran 2006). For example, self-reporting of participant intentions often under-detects the influence of social norms (Nolan et al. 2008). Simply taking part in a research survey, especially one promoted through social media, may have increased the normative social value of discussing fish. The increase in discussion and information gathering may also be an artificial artefact of the experiment—respondents may unconsciously change their behaviour in response to being studied, rather than in response to the intervention (the 'Hawthorne Effect', Diaper 1990). Alternatively, it may be that respondents may not have realized how often they were already taking part in these behaviours until they were asked to consciously monitor them in the post-survey.

The greatest concern for fish welfare arising from this study is that respondents who kept only artificial plants cleaned out their tanks less frequently. Artificial plants do not remove nitrogenous waste from the water like real plants, so without regular cleaning the nitrates will build up. High nitrate can compromise the fish immune system, stunt growth and even kill fish (Johansen et al. 2006; Loh & Landos 2011). Since less frequent cleaning was not observed when both real and artificial plants were kept, it seems that artificial plants are a symptom of poor care rather than the cause. Aquarists are likely to buy artificial plants because they want to dedicate less time to their pets and believe artificial plants will be easier to keep.
Respondents with a greater knowledge of fish biology were more likely to seek out information on fish care, clean out their aquaria more frequently and state that their current level of care was good. The pattern of knowledge being associated with better animal care has been observed in many other studies. Rabbit owners with a greater knowledge of their pet’s biology were more likely to neuter and provide companionship (Edgar & Mullan 2011) and children who kept goldfish had more accurate knowledge of animal biology compared to non-fish owners (Hatano & Inagaki 1993). However, it has not yet been convincingly demonstrated whether information provision alone can improve care-giving behaviours in pet owners (Edgar & Mullan 2011; Prokop et al. 2008).

Our study suggests that information provision will be most effective for pet owners who already recognise that they need to improve their behaviour. It is possible that increasing knowledge shows a threshold effect, where more information significantly improves welfare provision to a certain point but then plateaus. This would help to explain why most respondents in this study did not report an improvement in overall knowledge even when they had been seeking out information on fish care.

Some small effects of gender were observed, with female respondents having a slightly lower average knowledge of fish biology, being less likely to seek information online and more likely to keep goldfish and artificial plants. Gender differences are common in the human-animal interaction literature (Herzog 2007) and similar differences were reported in Chapter Three.

### 4.5 Conclusion

Short, online films can be a powerful tool to communicate the science behind animal welfare issues. A simple survey was enough to prompt participants to discuss fish welfare and seek out information, and the film acted as a response reinforcer to help people act on pre-existing intentions to improve their pet care. Positive framing appeared to be more effective than negative framing, especially in prompting message recall after a month. However, more research is needed with larger sample sizes and different disciplines to confirm how long behavioural change responses are maintained for and the long-term influence of negative message framing.
Many respondents indicated that they did not change their behaviour in response to the film because they already cleaned out their tank frequently and took good care of their fish. These owners are likely to be similar to the ‘committed owners’ identified in Chapter Two. Advertising campaigns that target basic husbandry behaviours are unlikely to help this group. However, most committed owners are active in the online aquarist community (Chapter Two) and may show an interest or become involved with new scientific research on ornamental fish (Rhyne 2010). However, there is a dearth of scientific interest in ornamental species and there are few data on how husbandry practices impact on fish welfare.
5 Why did the fish cross the tank: How can we objectively measure the value of enrichment for captive fish?

5.1 Introduction

More fish are kept as pets in Western households than any other animal (APPA 2012; O'Sullivan et al. 2008; TNS 2012). Aquarium keeping is a 1000-year-old tradition, but there is limited scientific understanding of how to best keep ornamental species (Walster 2008). As with any animal in captivity, the welfare of ornamental fish is dependent upon the fulfilment of the five freedoms—freedom from hunger and thirst; freedom from discomfort; freedom from pain; freedom from distress; and freedom to express natural behaviour (Farm Animal Welfare Council 2009). Environmental enrichment is an important husbandry technique for meeting these freedoms.

Environmental enrichment consists of any structures provided to a captive animal that help to improve health and the expression of natural behaviours (Williams et al. 2009; Young 2003). However, the relationship between environmental enrichment and fish welfare is not always clear because the benefits for fish vary and there are few data on the best type of enrichment to provide (Barreto et al. 2011; Brydges & Braithwaite 2009; Kistler et al. 2011). For example, enrichment reduces aggression in many fish species (Basquill & Grant 1998; Hojesjo et al. 2004; Kadry & Barreto 2010; Oldfield 2011), but Nile tilapia provided with stones and artificial plants actually showed increased intensity of fighting, perhaps because enriched territory is valued more highly (Barreto et al. 2011).

Shelter is thought to be a highly valued type of enrichment for several fish species (Delaney et al. 2002; Hixon & Beets 1989; Slavik et al. 2012). For example, checker barbs and zebra fish prefer to spend time in a compartment containing plants and clay pots compared to an empty compartment (Kistler et al. 2011). Atlantic salmon do not even have to be using the shelter to benefit—just the presence of shelter nearby lowers their metabolic rate (Millidine et al. 2006). However, once again the value of the enrichment appears to be variable. White cloud minnows, goldfish and tetra make use of plastic shelters and plants when they are kept in small shoals (< 5 fish), but not when
they are kept in larger, natural sized shoals (Pitcher & Magurran 1983; Sloman et al. 2011). Several studies suggest that fish value shelters and plants as protection from predators (Ingrum et al. 2010; Millidine et al. 2006; Sloman et al. 2011), even if no predators are visible and the fish have been raised in a predator-free environment. This suggests that shelter is a behavioural need, not just a preference, for some species (Jensen & Pedersen 2008).

Simple artificial shelters are easier to maintain and clean compared to natural sources of shelter (Williams et al. 2009), but there is some doubt as to whether they are equally effective. The provision of a complex environment of glass rods did not change zebra fish behaviour or cortisol levels (Wilkes et al. 2012). By contrast, zebra fish choose to spend 99% of their time close to artificial plants when in a large tank (Delaney et al. 2002). This suggests that artificial plants are an acceptable facsimile of natural complexity but glass rods are not (Wilkes et al. 2012). The shape of the shelter may also be important—goldfish prefer to shelter near structurally complex artificial plants and avoid simpler, obstructive cover such as plastic blocks that could disrupt the line of sight for predator monitoring (Ingrum et al. 2010).

The 87% of hobbyists who provide plants for their ornamental fish (Chapter 2) are either doing so for decorative purposes or acting on the assumption that plants are beneficial. There are little or no scientific data to show that fish need plants, or that fish prefer to have access to real plants rather than artificial ones. To determine the need and the type of plant, it is necessary to ask the animals themselves which enrichment they wish to utilise (Dawkins 2006).

Multiple methods have been developed to investigate preference and motivation for an animal to access a given resource (Fraser & Nichol 2011). Preference tests, where an animal is asked to choose between resources, are used to assess what animals want and to order their preferences for different resources. Motivational tests, where an animal is required to pay a cost to access resources, are generally considered more revealing than preference tests because they measure how much an animal wants the resource (Kirkden & Pajor 2006). To gain access to the resource the animal must perform a task that gradually increases in difficulty (Jensen & Pedersen 2008; Kirkden & Pajor 2006). The level of difficulty at which the animal stops responding provides a measure of willingness to work for access that can be quantitatively compared between resources (Veissier & Forkman 2008).
Motivational tests are yet to be applied widely in fish. Galhardo et al (2011) tested the motivation of Mozambique tilapia to access a social partner or food over a bare control compartment. Tilapia are mouth-orientated fish and carry pebbles to build nests, so Galhardo et al (2011) chose door presses as a biologically relevant measure of motivation. However, operant conditioning is a time consuming process and door pressing may be a difficult task for other species to associate with the reward (Kirkden & Pajor 2006). In this chapter, a novel method is used to manipulate the cost by changing the level of swimming effort that the fish must exert in order to access the resource.

Preference and motivational tests were used to determine whether fish value plants as enrichment and, if so, whether they discriminate between real and artificial plants. Goldfish (Carassius auratus) were chosen as the case study species as they are one of the most popular species sold, accounting for approximately a quarter of ornamental fish sales in Australia (O’Sullivan et al. 2008) and are one of the more common laboratory species (Ostrander 2000). Goldfish are substrate feeders, foraging for microbenthic organisms (Smith & Gray 2011). As such, plants are a form of structural enrichment rather than food. The hypothesis is therefore that goldfish will prefer planted areas but will show a similar level of motivation to access both real and artificial plants.

It is difficult to make assumptions about the natural behaviour of goldfish as they have been domesticated since the 12th century (Rylkova et al. 2010). Domestication has reduced the swimming ability of many goldfish varieties (Blake et al. 2009) and they are generally considered to be a slow water species (Davidson & Goldspink 1978). Goldfish oxygen consumption increases linearly as water velocity increases (Blake et al. 2009). Therefore, asking fish to swim against a water current would be a suitable measure of work to test motivation. Water flow is also a relatively natural stimulus for fish, so it should not require specific training.

5.2 Methods

The research was approved by the UWA Animal Ethics Committee (RA/3/100/1028). Twenty comet goldfish were obtained from a local, private supplier (Woodvale, Western Australia). The fish were approximately six months old, unsexed and ranged
from 4 - 7cm in length. They were bred and raised in an outdoor plastic pond containing live plants (*Vallisneria* sp.) for shelter. The fish were inspected by a qualified fish veterinarian (R. Loh) and found to be healthy with very low numbers of gill parasites (*Dactylogyrus* sp.) that were treated with three doses of formalin at 0.025ml/L at seven-day intervals prior to the commencement of the experiment. *Dactylogyrus* spp. can cause lethargy, respiratory problems and death in higher numbers, but do not have a significant effect on health at low numbers in good water conditions (Reed et al. 1996).

Laboratory conditions were kept at 21°C under natural light. The fish were kept in a single aquarium 152cm long x 42cm tall x 34cm wide, filled with 180L of water and a 1cm layer of coarse white sand substrate. Fish were fed daily on sinking pellets and 40L water changes were conducted twice weekly. Water quality (including ammonia, nitrite, nitrate and pH) was monitored regularly using commercial API brand kits and maintained at appropriate levels. (Full monitoring procedures are outlined in Appendix E).

Many common water plant species do not have convincing artificial imitations, and many of the artificial plants available are not sold as live species in Australia. Therefore, the plants selected for this experiment were *Bacopa* sp. and *Ambulia* sp., as these species were readily available as both plastic and live plants from local suppliers. The artificial plants (WaterWonders brand Ambulia and Green Bacopa) were trimmed to match the live plants in size and leaf cover (Figure 5.1). All plants were kept in green pots (7cm high) to facilitate ease of movement between experiments. In between experiments both live and artificial plants were housed in a separate aquarium to the fish.

![Figure 5.1. Real and artificial plants used in the preference and motivational tests. From left to right: artificial Ambulia, real Ambulia, artificial Bacopa, real Bacopa.](image)
Figure 5.2. Experimental design for preference tests, viewed from above.

Fish were randomly assigned to be tested with real plants on the (a) right or (b) left.

The testing tank was identical to and shelved directly above the holding aquarium. In all experiments, I left the room as soon as fish were placed in the experimental set up and behaviour was recorded using film camera for later analysis. Fish were individually identified by their appearance, including differences in colour, tail shape, small scars and size.

Preference tests

The preference test aimed to determine the preference of the fish for real and/or artificial plants when no cost is imposed for access. The preference test was free choice, with no barriers between any of the three compartments (real plants, artificial plants and empty control) (Figure 5.2).

Thin lines delineating the three compartments of equal length (50.7cm) were painted on the outside of the aquarium to assist with film analysis. Fish were initially placed in the central (control) compartment and timed for forty minutes, beginning from when they crossed into another area. Each fish ($n = 20$) was tested once. Half the fish were randomly assigned to have real plants in the left compartment and artificial plants in the right compartment, which was then reversed for the other fish to rule out lateral bias. The total time spent in each compartment was recorded, as well as the choice of compartment entered. Three fish were excluded from the analysis because they appeared unresponsive during the tests and did not enter all of the compartments. All
the other fish were active during the test and entered each of the compartments at least once.

**Motivational tests**

The aim of the motivational test was to determine the amount of effort that goldfish are willing to exert to access enrichment. Fish (*n* = 19) were introduced individually to the test tank, which was divided in half by a 9cm long tunnel with a 5cm diameter entrance through the centre of a mesh barrier (Figure 5.3). An identical tunnel was used to separate the holding tank into two compartments for a fortnight before the experiment began, so that fish could habituate to the apparatus, but they received no special training. All fish were observed to pass through the tunnel in the holding aquarium, except one who was excluded from the experiment. A pump (PondMax PP3000, 3000L/hour) was used to create a water current through the tunnel in the experimental tank. Water current was measured using the FP211 Global Water Flow Probe. On the first day of each treatment the current was turned off, then was strengthened to 0.05m/s on the first day, 0.1m/s on the second day and by 0.1m/s increments each following day until the treatment was complete. Ascending costs were used because they are thought

**Figure 5.3. Set up for motivational tests, viewed from above.**

Fish were tested with real plants (a), artificial plants (b) and control (c) in a random order.

![Figure 5.3](image-url)
to give a more complete demand curve compared to random order of cost strengths (Asher et al. 2009). A fish was considered to have finished when it failed to pass through a current on two consecutive days or when it reached the strongest current (0.7m/s). Fish were given two days to rest in between treatments and received the three treatments (control, real plants and artificial plants) in random orders.

**Controlling for cost**

A final experiment was conducted to test the behaviour of fish that entered the control compartment during the motivational test. The aim was to determine whether the fish value the additional space or are motivated to swim against the current itself. The design of this experiment is based on Sherwin and Nicol (1997), where the animal has two entrances to choose from—one with a cost, and one without.

In this experiment, the fish were placed in the test tank set up identically to the control motivation test, but with two tunnels, one on the left and one on the right side, rather than a single central tunnel. The dual tunnel divider was placed in the holding tank for two days before the experiment started—as all fish passed through the divider within half an hour of its introduction a longer habituation period was considered unnecessary.

![Experimental design in control for cost tests, viewed from above.](image)

Fish were tested with the right hand condition (a), left hand condition (b), and control in a random order (c).
To control for lateral biases, the fish underwent three treatments: no current, current on the right hand side and current on the left hand side (Figure 5.4). The trial ran for ten minutes (as most fish in the motivational tests had made their first entry in the first ten minutes of the trial) and the number of entries through each side of the tank was recorded. No plants, real or artificial, were present in this test.

Only fish that completed the highest current (0.7m/s) in the motivational test were included in the control experiment (n = 11), in order to exclude fish that did not show motivation to access empty space. One fish did not pass through the tunnel in any of the three control treatments—although it was observed to use the tunnels in the holding tank—so it was excluded from the analysis.

Data analysis

Films were analysed using CowLog (Hanninen & Pastell 2009) and the statistical analysis was conducted in SPSS (IBM 2011). Means and standard deviations are provided in seconds. Standard deviation is used for most graphs as it is more relevant for repeated measures than confidence intervals or standard error (Cumming et al. 2007).

For the preference test data, a one-way repeated measures ANOVA was used to compare time spent in each of the three areas followed by a pairwise comparisons using a Bonferroni adjustment. For the motivational test data we used a one-way MANOVA, with significance determine using Wilk’s Lambda (Wilk’s Λ) test. Both ANOVA and MANOVA are used for comparing the variance between groups, with the MANOVA applying when there are multiple dependant variables (Pallant 2011).

To analyse the test that controlled for cost, we used a non-parametric Wilcoxon-signed rank test because the Kolmogorov-Smirnov test showed that the number of entries to the compartment did not conform to assumptions of normality.

5.3 Results

Preference test

There was an overall effect of enrichment on the time spent in each compartment (Figure 5.5, Wilks’ Λ = 0.124, F (2, 15) = 53.04, p < 0.001, multivariate partial eta squared = 0.876). Fish spent significantly more time in the enriched compartments than
the bare one (p < 0.001). However, there was no difference between the amount of time spent in areas with real and artificial plants (p = 1). Eight fish entered the artificial plant compartment first and nine fish initially entered the real plants compartment.

**Motivational test**

Fish showed relatively inelastic demand for access in all three treatments (Figure 5.6), with eleven of the nineteen fish completing the 0.7m/s test for all of the treatments. Of the remaining eight fish, two preferred the control, three preferred real plants and three showed equal motivation to access artificial plants and either real or control. The latency to enter the test area, number of entries to the test area and time spent in the test area showed no difference as the current increased (Table 5.1) or between treatments (Table 5.2).

**Control for cost**

There was no consistent difference in the number of entries to the right and left hand tunnels when there was no current (Figure 5.7, z = 0.848, p = 0.396, r = 0.19), with three fish preferring the right hand tunnel, four the left and three tied. In both the right and left side test conditions, nine out of ten fish showed a bias towards the tunnel without a current (Figure 5.7, right hand test z = -2.668, p = 0.008, r = 0.597, left hand test z = -2.52, p = 0.012, r = 0.564).

![Graph showing mean amount of time spent near plants](image)

**Figure 5.5. Mean amount of time that goldfish spent near plants during a 40-minute preference test.**

(n=17, error bars represent standard deviation).
Figure 5.6. Inelastic demand for access to plants and empty space in goldfish (n=19).

Table 5.1. Measures of motivation in experimental treatments as the water current increased in strength.
Values given as p-value (Wilks' Lambda). No significant differences found.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Control</th>
<th>Artificial</th>
<th>Real</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latency to enter the test area</td>
<td>0.55 (0.084)</td>
<td>0.297 (0.35)</td>
<td>0.304 (0.36)</td>
</tr>
<tr>
<td>Entries to the test area</td>
<td>0.728 (0.272)</td>
<td>0.678 (0.32)</td>
<td>0.196 (0.34)</td>
</tr>
<tr>
<td>Time spent in the test area</td>
<td>0.604 (0.4)</td>
<td>0.731 (0.62)</td>
<td>0.94 (0.72)</td>
</tr>
</tbody>
</table>

Table 5.2. Measures of motivation compared between treatments.
Values are given as seconds (mean ± SD). No significant differences found.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Control</th>
<th>Artificial</th>
<th>Real</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latency to enter the test area</td>
<td>280 ± 279</td>
<td>310 ± 275</td>
<td>251 ± 246</td>
</tr>
<tr>
<td>Entries to the test area</td>
<td>2.4 ± 1.7</td>
<td>2.3 ± 1.7</td>
<td>2.4 ± 1.7</td>
</tr>
<tr>
<td>Time spent in the test area</td>
<td>563 ± 352</td>
<td>563 ± 328</td>
<td>518 ± 325</td>
</tr>
</tbody>
</table>
Figure 5.7. Tunnel used by fish for gaining access to an empty compartment. (n=10, error bars represent standard deviation).

5.4 Discussion

The hypothesis was confirmed for the experiment: preference testing showed that goldfish prefer to spend their time in planted areas of the aquarium, but do not discriminate between real and artificial plants. However, it was unexpectedly found that goldfish will also work hard to access extra space, even in the absence of plants.

Goldfish do not appear to differentiate between real and artificial plants. Since goldfish do not actively feed on plants, it is likely that the plants are valued as shelter from predators. Plants could also provide shelter from aggressive conspecifics, but this is probably of less value to goldfish as they are known to spend less time near shelter and more time foraging as shoal size increases (Magurran & Pitcher 1983).

Plants, both artificial and real, provide complex habitat that is likely to be perceived as better shelter from predators than alternative enrichment such as obstacles (Ingrum et al. 2010) or glass rods (Wilkes et al. 2012). Ingrum et al. (2010) found that providing plants did not influence the position or orientation of foraging goldfish, but those fish were tested in shoals and limited to foraging within 27cm of cover. Our experimental tank was much longer (152cm), providing a greater distance over which to measure
preference, and goldfish were tested individually, which is likely to increase the perceived predation risk (Magurran & Pitcher 1983).

In spite of deliberate artificial selection and domestication since at least 1848 (Balon 2004), comet goldfish appear to have retained some anti-predator behaviours even when raised in captivity (Ingrum et al. 2010). By contrast, more recently domesticated species such as Atlantic salmon or brown trout that often show reduced anti-predator behaviours compared to wild fish (Huntingford 2004). It has been suggested that high-growth rates are evolutionarily linked to a phenotypic acceptance of risk while foraging (Biro et al. 2004). Since goldfish have been selected for colour and shape rather than high-growth rates, they may have maintained normal risk-reducing behaviours.

Since goldfish do not seem to discriminate between real and artificial plants, aquarists should choose the type that best suits their needs. Artificial plants are easier to clean, can be trimmed so as not to obstruct monitoring, and are less likely to introduce foreign organisms or absorb chemicals (Williams et al. 2009). Artificial plants are also much easier to maintain with goldfish, as they have a reputation for uprooting real plants (Skomal 2008). Real plants also remove more oxygen than they produce during the night, which can lead to oxygen depletion and fish kills if insufficient aeration is provided (Francis-Floyd 1992). The main benefit of real plants is that they supplement biological filtration by removing nitrogenous compounds from the water (Williams et al. 2009). Unfortunately, aquarists who keep artificial plants also tend to clean their aquarium less often (Chapter 4).

The goldfish showed inelastic demand for entry to an empty compartment. It is sometimes suggested that animals access empty compartments because the operant behaviours used in motivational tests may be self-rewarding for animals (Sherwin & Nichol 1997). That is, the animals may be motivated to perform the cost behaviour (i.e. swimming against a current) rather than being motivated to achieve the reward (i.e. access to the other compartment). The fish in this trial did not undergo operant training and preferred to avoid the water current when another choice was made available, suggesting that they valued the additional space itself rather than being motivated to swim against a current.

Fish are known to extensively explore a new environment, even after they have encountered suitable habitat (Gill & Andrews 2001). However, this does not fully account for the results, as fish behaviour did not change over time as they became more
familiar with the test aquarium. It is more probable that fish do actually show an inelastic demand for additional space, as seen in mice (Sherwin & Nichol 1997). Swimming and exercise are known to improve growth rates, muscle development, osmoregulation, and disease resistance; while simultaneously decreasing aggression, cortisol levels and anxiety (reviewed in Davidson 1997; Huntingford & Kadri 2013). It is not known if this is also true of goldfish, but it is possible that adequate swimming space meets important physiological needs.

Rabbits will also pay to access empty compartments, but not as much as they are willing to pay for access to resource compartments (Seaman et al. 2008). It is possible that the goldfish may have differentiated between planted and empty compartments if the cost of access was higher. It was not anticipated that the fish would be so successful at negotiating the current given that they are generally considered to be slow water fish. Goldfish do not adapt to water flow (Davidson & Goldspink 1978) and Bainbridge (1960) found that 6.7cm goldfish could swim at ~75cm/s for just one second before they became exhausted. Blake et al. (2009) suggested that although domestication has altered the swimming ability of goldfish, the comet strain is closer to the wild type. We propose that using a water current is still a valid method of testing motivation, but that the cost needs to be increased for comet goldfish by using a much stronger flow. Lengthening the tunnel could also increase the cost paid in motivational tests, but the tunnel would need to be carefully designed to limit the risk of fish sustaining injuries against the tunnel wall while fighting the current.

The value of plants for goldfish still needs to be clarified under different circumstances, since this study was limited to young, individually tested goldfish. The value of shelter is thought to differ depending on the shoal density (Hossain et al. 1998; Sloman et al. 2011), the size of the fish (Brown & Braithwaite 2004) and is likely to be species specific (Kistler et al. 2011), meaning that results may have limited applicability to other species and possibly even to other goldfish varieties. It is therefore important that we continually test and improve enrichment to ensure we are providing the most appropriate and practical options (Williams et al. 2009). Preference tests, although considered flawed by many, may provide similar results far more easily under most circumstances (Studnitz et al. 2007). Using both techniques allows triangulation of enrichment, reducing the impact of confounding variables. At the very least, motivation to obtain additional space should also be measured.
5.5 Conclusion

Preference and motivational testing was successfully used in this study to determine that
goldfish do not discriminate between artificial and real plants, but prefer any plants over
empty space. Nevertheless, in the absence of plants goldfish are still highly motivated to
obtain empty space.

Motivational tests have rarely been applied in fisheries research to date (Galhardo et al.
2011) and could still prove a useful tool if the cost required is matched to the species.
Using increasingly strong water currents in motivational tests for goldfish proved to be
a practical measure of cost, but did not adequately discriminate between preferences.
Water currents provide a natural stimulus for fish and required no training time, as
opposed to conventional operant conditioning techniques. Researchers will need an
accurate idea of the swimming ability of the species to set the cost correctly at a level
where fish will discriminate between preferences, but the method shows great potential
for increasing our understanding of fish welfare.
6 Fin-ishing Up: General Discussion & Recommendations

The aim of this thesis has been to develop pathways for improving the welfare of pet fish. This was achieved through developing a model of factors that contribute to fish welfare and then testing the validity and importance of those factors. The main outcomes of the thesis are the identification of common problems for pet fish welfare, recognition that there are different types of fish owner, the development of strategies for influencing owner behaviour toward pet welfare and improved methods for critically analysing the effect of enrichment on fish welfare. Figure 6.1 shows how these original findings contribute to the understanding of the thesis model. This discussion briefly summarises the significance of the key findings and provides recommendations for care and future research for each of the main stakeholders—aquarists, communicators and researchers.

6.1 Identification of current problems for pet fish welfare

Until now, the only information available about conditions in home aquaria came from Etscheidt and Manz’s (1992) study of 103 aquaria in Germany. They found that water quality was a major issue, but the study was limited to aquaria that owners were willing to have inspected and fishkeeping technology has significantly advanced over the last two decades. Chapter Two attempted to address this gap in our knowledge by using a large online survey of aquarists.

In this thesis, the greatest threat to pet fish welfare perceived by owners to be disease. Over half of fish owners surveyed reported fish deaths from disease, even though deaths from disease should be minimal under optimum environmental conditions. Water quality in home aquaria is likely to be the main contributing factor. Poor environmental conditions will not kill the fish outright, but can stunt growth, shorten lifespan and make fish more susceptible to disease. Because the ultimate cause of death is not obvious, fish owners are likely to overestimate the number of fish that die from ‘old age’, although this is difficult to verify since there is a lack of data regarding lifespan and mortality data for ornamental species.
Figure 6.1. Original findings of the thesis in relation to the theoretical concept of fish welfare.

Findings are numbered by chapter.
However, fish deaths from disease cannot be solely attributed to owner neglect. The Australian Quarantine and Inspection Service enforces stringent inspections and holding periods for all imported ornamental fish (Whittington & Chong 2007), but in spite of this over 70% of commercially available fish in Australia suffer from some form of disease, mainly parasites and bacterial infections (Evans & Lester 2001; Wickins et al. 2011). Many will have been imported from overseas and possibly kept for days in crowded, hypoxic plastic bags (McCollum 2007). Under these conditions, it is not surprising if even experienced aquarists lose fish to disease shortly after purchase.

Even so, deaths could be minimized by veterinary treatment and inspection before or immediately after purchase. However, most fish are available so cheaply that the industry and fish owners typically place little value on specialist veterinary services for individual animals (Miller-Morgan 2010). This issue could be addressed in part by encouraging general practice vets to obtain the skills needed to treat fish.

Another major problem for pet fish was keeping them in unsuitable species assemblages or inappropriate shoal sizes. Etscheidt and Manz (1992) estimated that 19% of people kept a mixture of aggressive and peaceful species. My study suggests that the prevalence of inappropriate species mixtures may be even higher, as half of aquarists had experienced fish dying from being eaten and attacked by another animal. A third had also experienced deaths from fish jumping from the tank, which can be a symptom of aggressive interaction between fish (Berti et al. 1982; Saidel et al. 2004).

Fish owners are restricted in their ability to choose appropriate social and habitat environments for their pets by the limits of our scientific knowledge. Fish often have species-specific requirements, and there are over 3500 species of ornamental fish that are traded (O'Sullivan et al. 2008). This makes it difficult to provide guidelines for every species and it is only recently that social parameters have begun to be investigated for even the most common species (Saxby et al. 2010; Sloman et al. 2011).

In conclusion, the biggest threats to welfare for pet fish are disease, aggressive interactions with other animals and limited knowledge of fish needs. Fish owners are likely to be underestimating the influence of water quality on welfare. These problems are exacerbated by a shortage of qualified fish veterinarians and the scarcity of scientific studies on ornamental fish species.
6.2 Different types of aquarists

Several studies have shown that people have varying approaches to pet ownership (Blouin 2013; Visser & Van Wijk-Jansen 2012), but to date this had not been researched in aquarists. Results from Chapter 2 suggested that fish owners who are more knowledgeable about fish biology provide more types of enrichment for their pets. This thesis has identified two different types of aquarists based on their level of knowledge. These types display different approaches to care and are best targeted through different communication channels.

The Committed Aquarist

Committed owners made up approximately three-quarters of all aquarists surveyed in this study. Committed aquarists have a high level of knowledge about fish biology. They recognise that fish are intelligent and deserve the same level of care as other pets. These aquarists clean out their tank regularly, keep numerous fish (often maintaining multiple tanks), and are more likely to provide live food and real plants to their pets. Due to the high level of turnover of casual owners entering and leaving the aquarium hobby, the majority of people keeping fish at any one point in time are expected to be the committed aquarists.

Committed owners are always on the lookout for ways to further improve their care and are mostly limited by the lack of our scientific knowledge about ornamental fish. Therefore, it will be relatively easy to disseminate results of new research to this group, as they have strong online social networks.

Providing more information to this group will not necessarily measurably increase their knowledge of fish biology, as they will show a ceiling effect. Behavioural interventions and welfare campaigns are unlikely to show any obvious effect on this group, but are likely to provide positive reinforcement and encourage the continuation of information seeking and sharing. Committed aquarists should be encouraged to actively share their knowledge with friends who are casual fish owners without being asked, as casual owners are unlikely to request information (Chapter 3).

The Casual Owner

Casual fish owners have little or no knowledge of fish biology. This study showed that they are more likely to believe in common myths about fish, such as that fish have a
three-second memory. These owners clean out their aquaria less often, keep fewer fish and provide less enrichment. They made up approximately a quarter of aquarists in the study.

Casual owners tend to be short-term fish owners. Because they lack the prerequisite knowledge to care for their fish, their pets generally die quickly; then discouraged, they may not buy new fish. The high turnover of casual fish owners presents a barrier to communicating with this group effectively.

Despite being difficult to contact, casual owners represent the most important target for behavioural interventions. As seen in Chapter Three, there are casual owners who intend to improve and can follow-through on those intentions is provided with key information. Any intervention should be ongoing to reach casual owners when they purchase their first fish.

There are two possible interventions suggested by the data presented in this thesis. Firstly, information provision at the point of sale. By targeting owners at the source, this avoids the problem that casual owners do not search for information. Currently, only 50% of fish owners are receiving advice when they buy their fish, which could be improved. There is also potential to include more information with fish-related purchases, such as labelling on fish food.

Secondly, since casual owners do not actively search for information about fish, information should be presented through sources that they encounter everyday. These sources could include YouTube and other online social media, television news and radio, and talking to friends who are committed fish owners. Interventions such of these could also help to change broader social norms about fish keeping.

Legislation protecting fish does need to be improved (Section 1.3), but this is unlikely to happen until there is widespread social support for fish care. Currently, only a marginal majority of fish owners would support moves to ban small fish bowls or have animal welfare organisations police fishkeeping (Section 3.3).

**Contribution of owner knowledge, beliefs and gender to fish welfare**

The main difference between the three types of fish owners is their level of commitment and amount of knowledge about fish. Normally, knowledge is considered to be a contributor to attitudes, but a relatively minor component in shaping behaviours (Ajzen 2011). However, because keeping fish involves a foreign environment, specialist
knowledge, and high level of investment, it may be that knowledge plays a greater role in shaping behaviour.

Emotional attachment is normally considered to be one of the key features of a pet ownership (Endenburg 1995; Wrye 2009; Zasloff 1996). I hypothesized that pet owners who show greater levels of attachment to their pet fish would also provide better welfare. However, this was not found to be the case. Again, knowledge of fish biology appears to be a more important driver of behaviour. In most other animal species being kept as a pet reduces exploitative use for food, hunting or research (Serpell 2004). The opposite appears to be true for fish. People who keep pet fish are more likely to go fishing for recreation. This suggests that people relate to fish on a pragmatic level, rather than an emotional one.

This may also help to explain the small, but consistent, gender differences that were observed in this thesis. Women were more likely to be less knowledgeable about fish and are more likely to be casual, while men tended to be committed owners. Small gender differences are commonly found in anthrozoological research (Herzog 2007), so it is not unexpected that men and women should relate to fish differently, although the mechanisms behind this behaviour remain unclear.

### 6.3 Developing strategies to change fish owner behaviour

The three types of fish owners are likely to be reflected in other animal welfare issues: there are people who are uninterested, people who are already very interested, and a small percentage of people who can be moved from casual to committed with appropriate intervention. Animal welfare and rights campaigning strategies have been critiqued in the literature to some extent (Jasper & Poulsen 1995; Jones 1997; Mika 2006; Seu 2010), but to the best of my knowledge this thesis is the first attempt to experimentally test the effectiveness of welfare advertising on changing behaviour. It was found that even very short films can positively change behaviour for people who have been intending to improve.

Most animal welfare issues are promoted using negative frames that attempt to shock the viewer (Jasper & Poulsen 1995; Mika 2006). Chapter 4 suggested that although a negative frame can still be effective, it might not be as powerful as a positive frame.
However, due to the small sample size and confounding variables in this study more research needs to be done to confirm this finding. These strategies are likely to be especially applicable to other small animals that tend to be misunderstood by pet owners, such as birds and rabbits.

6.4 Improved methods for critically analysing the value of enrichment for fish welfare

Behavioural enrichment is often used to compensate for confined space in other captive animals (Young 2003). Most fish owners provide some form of enrichment, particularly substrates and plants. However, the value of enrichment can vary and may actually decrease welfare under some conditions (Williams et al. 2009). It is therefore important to quantitatively establish the effect of providing enrichment on animal welfare. To date, no studies have directly compared the value of real and artificial plants for fish welfare and only two other studies have used motivational testing with fish (Galhardo et al. 2011; Garcia 2011). In both of these studies the fish were trained to perform a specific task to gain access to a desirable resource. Chapter 5 describes a motivational test in which a water current was used as an alternative cost, because it is more biologically relevant to fish and removes the need for lengthy operant training.

Goldfish in our study preferentially spent their time near plants rather than in an un-enriched area. The goldfish did not differentiate between real and artificial plants. This is advantageous for aquarists, as artificial plants are easier to maintain and are less likely to introduce pathogens or toxins to the tank (Williams et al. 2009) and do not seem to influence fish welfare.

Artificial plants therefore may not impair fish welfare when used by a capable aquarist. However, results from Chapter 5 showed that less knowledgeable fish owners are both more likely to use artificial plants and less likely to clean out their tank regularly. Live plants take up some of the excess nutrients from fish waste, reducing the need for regular water changes (Williams et al. 2009). When artificial plants are kept, aquarists need to change water more frequently to compensate for the build up of nitrates, but this is the exact opposite of what was observed in the study. It seems that skilful fish owners
maximize water quality by combining both regular water changes and live plants, whereas poor fish owners do neither.

This study also found that goldfish showed a high level of motivation to obtain additional empty space. This was unexpected considering that goldfish are generally considered to be a slow-water species with poor swimming abilities that can survive in small aquaria (Blake et al. 2009; Davidson & Goldspink 1978). It is not clear if goldfish appreciate the space itself or the ability to swim further. Swimming has been implicated in maintaining fish health (Huntingford & Kadri 2013). It is therefore imperative to establish whether swimming is a behavioural need or simply a preference (Jensen & Pedersen 2008).

6.5 Recommendations and future research

This thesis has advanced our knowledge of fish welfare in several ways (Figure 6.1). It is now possible to identify the most common welfare problems for pet fish and recognise some of the owner attitudes that are associated with them. This study has identified the different types of fish owners and suggested how best to communicate with them. It has established that film media are an effective intervention for some fish owners. Lastly, an improved method for investigating the value of enrichment has been developed by making the experimental design more biologically relevant. These advances can be used to make practical recommendations to improve pet fish welfare.

Recommendations for Fish Owners

1. Talk to people about your fish.

One of the key differences between committed fish owners and casual owners in this study is that committed owners talk about their fish—both online and offline. Communities of aquarists may help to construct positive social norms toward fish care and help to diffuse new scientific information efficiently.

2. Consider getting professional veterinary care.

Only 5% of fish owners would consider getting veterinary care for a sick fish, even though fish are as intelligent and capable of feeling pain as other pets, such as cats and
dogs, and deserve an equal level of care. Most small animal veterinarians have minimal training in fish health and a shortage of professional fish veterinarians further exacerbate this problem.

3. Keep your fish in the largest tank possible.

Most aquarists already know that keeping a larger tank helps to maintain good water quality. However, this thesis found that goldfish place a high value on access to additional space. Swimming is thought to improve growth, development and disease resistance and to reduce anxiety and stress (Huntingford & Kadri 2013).

Recommendations for Communicators

1. Target experienced owners online and casual owners offline.

Committed fish owners are more likely to discuss fish with other aquarists and participate in online discussion boards. Any new information about fish care can be easily disseminated through these strong social networks.

Casual fish owners are harder to reach. Since they are less likely to be actively looking for information on fish, they need to be targeted through other channels. These could include providing information at the place of purchase with new fish or fish-related products, mass media campaigns, Facebook or other social media. However, before committing substantial resources to any of these options, pilot tests should be conducted to ensure that providing information through these channels actually influences behaviour. Although we found that providing an informational film did change behaviour for some people, more research needs to be done to clarify the strength and directionality of the knowledge-behaviour relationship.

2. Use positive framing

It appears that positive framing of animal welfare messages may increase the uptake and retention of information more than negative framing. However, further research with larger sample sizes is important to establish the strength of the effect, particularly with regards to the duration of behavioural change.

3. Focus research on social norms.

The importance of social norms appeared several times in the research, but was not fully investigated. To our knowledge, only one study has examined the influence of social
norms on pet welfare (Rohlf et al. 2010). Social norms are likely to be an important
driver of attitudes and behaviours and should be investigated further by
anthrozoological researchers.

**Recommendations for Animal Welfare Researchers**

1. **Better data collection.**

   The literature review highlighted how little is known about the ornamental fish trade. In
   order to create accurate guidelines and legislation, basic data collection needs to be
   standardised. For example, importers and retailers should collect data on the number of
   individual fish sold (rather than kilograms of fish) and scientific researchers should be
   required to report the type of species used (rather than just ‘fish’).

2. **Focus further research on the value of enrichment.**

   Basic knowledge of the influence of enrichment is well established for some
   aquaculture species, but severely neglected for ornamental fish. Preference and
   motivational testing methodologies are well established in animal welfare science and
   should be more widely applied in fish. For example, it is not known how the value of
   structural enrichment differs between fish species and varieties, whether behavioural
   enrichment (such as training) is beneficial, or what the ideal shoal assemblages are for
   most species.

3. **Conduct more research on ornamental fish health.**

   Most research into fish welfare has focused on commercially significant aquaculture
   species rather than ornamental fish. More research needs to be done on the impact of
   owner care behaviours on fish health so that these behaviours can be targeted by
   interventions. Most importantly, it needs to be established whether swimming is as
   important for small, freshwater ornamental species, as it appears to be for larger free-
   swimming aquacultured species. It is especially important to find out whether the
   goldfish motivations for obtaining additional space are driven by a behavioural need or
   another variable. If keeping goldfish in small aquaria conflicts with essential
   behavioural needs then guidelines for keeping this species will need to change
   significantly.
6.6 Conclusion

There is now sufficient research into fish behaviour to conclude that fish are intelligent animals and can suffer, making them a priority for welfare protection. The main barrier to providing good welfare for ornamental fish is a lack of knowledge. For the one-quarter of fish owners in this study who were not committed to the welfare of their pets, this barrier may be overcome by targeted provision of information. However, for the majority of fish owners the barrier is created not through negligence in their ownership, but by the limits of scientific knowledge about ornamental fish species. While ornamental fish may not be a particularly charismatic or economically important animal to study, increased scientific research in this area could make a significant difference to practical welfare outcomes for billions of captive animals and their owners.
7 Glossary

**Anthropomorphism**: the attribution of human emotion or intention to non-human animals or objects.

**Anthrozoology / Anthrozoological**: an interdisciplinary field of study that is concerned with the interactions between humans and animals.

**Aquarists**: in this thesis, the term ‘aquarist’ is used to describe any person who owns or cares for pet fish.

**Aquarium**: a container of water in which fish are kept. In this thesis, aquarium is used interchangeably with ‘tank’.

**Angler**: a person who catches fish for recreational purposes.

**Artificial plants**: any sort of artificial aquarium plant, including plants made of silk, plastic and other materials.

**Attitude**: a mental evaluation of a subject along a continuum of like/dislike or positive/negative attributes.

**Behavioural enrichment**: a type of enrichment that aims to stimulate an animal to perform a diversity of behaviour. Examples of behavioural enrichment for fish include training, access to live food, provision of toys and mirrors, etc.

**Cerebellum**: a region of the brain implicated in spatial, relational and emotional learning.

**Cognition** and **Cognitive abilities**: poorly defined in the scientific literature, but generally used to refer to executive mental functions. ‘Cognitive abilities’ is therefore used to describe a wide range of behaviours related perception, attention, memory and learning (Brown *et al.* 2006, p1). Also see **intelligence**.

**Cognitive dissonance**: a psychological state of discomfort caused by simultaneously holding two ideas that conflict with each other.

**Consciousness**: the subjective mental experience of existence. Consciousness is poorly defined as a scientific term and it is therefore difficult to prove or disprove whether any animals are conscious (see Dawkins 2012 for a review).

**Conspecifics**: individuals belonging to the same species.

**Disease**: an overarching term to describe any impairment of normal bodily functioning. Also see subclinical disease.
Ectothermic: An animal whose body temperature is the same as the surrounding environmental temperature, sometimes called ‘cold-blooded’.

Elastic demand: when an animal uses a resource less as the cost of obtaining that resource increases. Elastic demand indicates that the resource is non-essential for the animal (see Fig 1.4).

Emotion: a brain state that assigns a positive or negative value to a stimulus or event. An emotional response requires recognition of the stimulus (i.e. it is not a reflex response) but does not necessarily require self-awareness.

Enrichment: any change made to the captive living conditions of an animal that improves its health and ability to perform natural behaviours while decreasing unnatural behaviours.

Environmental enrichment (also known as structural enrichment): enrichment that aims to provide a stimulating physical environment for the animal. Examples of structural enrichment for fish include shelters, substrates, water flow, plants, etc.

Fitness: describes the ability of an organism to successfully survive and reproduce.

Framing: the choice of a particular viewpoint, or way of constructing an issue, with the aim of influencing an audience.

Fry: young fish.

Husbandry: the practice of caring for a captive animal.

Inelastic demand: the use of a resource to the same extent regardless of the cost of obtaining that resource. Inelastic demand indicates that a resource is highly valuable, or even essential, to the animal (see Fig 1.4).

Intelligence: a broad term for describing an animal’s capacity for flexible behaviour and mental problem solving (Roth & Dicke 2005). Intelligence describes overall behavioural flexibility rather than specific cognitive abilities.

Intervention: a resource that aims to change people’s behaviour. (e.g. workshops, brochures, films, pledges, etc.).

Intraspecific: individuals belonging to different species.

Lateral bias: A behavioural asymmetry where an animal preferentially chooses one side or direction over another. E.g. Being right handed or left handed is a lateral bias.
Operant training: a training method in which an animal is taught to associate a particular behaviour with a certain outcome (e.g. a food reward).

Pain: an aversive sensory experience that is caused by tissue damage and elicits protective physiological and behavioural reactions.

Pet: an animal kept by people for pleasure, rather than for work or monetary gain.

Meme: an idea or practice that spreads from person to person within a culture.

Meta-analysis: an analysis that combines datasets from many individual studies to produce a synthesis of research to date.

Motivational Test: an experimental method in which animals are required to pay a cost (e.g. pressing a lever) each time they want to access a desired resource (e.g. food). The perceived value of the resource to the animal is determined by gradually raising the cost until the animal is no longer willing to pay for access.

Neocortex: a part of the brain. The neocortex is the familiar wrinkly top layer that covers the two hemispheres. It is often associated with higher brain function such as sensory perception and conscious thought.

Nitrate: a nitrogen compound that is a secondary product produced in the breakdown of fish wastes. Nitrate is toxic to fish in sufficiently high amounts.

Nociceptor: a type of sensory neuron that detects and responds to pain.

Norm: a belief held by society or a group of people that informs what behaviours are considered socially acceptable.

Physiological: physical functioning of living organisms.

Preference test: an experimental method in which animals are given access to different resources. The way in which the animal chooses to use the different resources reveals information about their preferences.

Stress: an emotional and physiological response to an aversive stimulus (stressor).

Subclinical disease: a disease that does not display any visible symptoms or clinical signs, making it very difficult to detect. Subclinical diseases can persist for a long time with no change or detectable problem, only becoming visible when the animal is stressed. Also known as asymptomatic diseases.

Substrate: the material at the bottom of the habitat or aquarium, such as mud, sand, gravel, stones, etc.

Theory of mind: the ability of one individual to think about the thoughts of another individual.
Theory of Planned Behaviour (TPB): a predictive theory of behaviour created by Azjen (1991). The TPB states that behaviour is predicted by behavioural intentions, which are informed by attitudes, norms and barriers.

Welfare: the condition of an animal in relation to how well it is coping with its environment.
8 References


Cheng, H. W. (2007). Animal welfare: should we change the housing to better accommodate the animal, or change the animal to accommodate the housing? *CAB Reviews* **2** (47): 1-6.


Francis-Floyd, R. (1992). *Dissolved oxygen for fish production*. Fisheries and Aquatic Sciences Department, University of Florida, FA27 Available at: http://edis.ifas.ufl.edu/fa002


Government of Western Australia (2002). Animal Welfare Act. 033. State Law Publisher. Available at:


IBM (2011) IBM SPSS Statistics, 20.0.0.


9 Appendices
Appendix A  Scientific names of the fish species referred to in the thesis.

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
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</thead>
<tbody>
<tr>
<td>Angelfish</td>
<td><em>Pterophyllum scalare</em></td>
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<tr>
<td>Atlantic mollies</td>
<td><em>Poecilia mexicana</em></td>
</tr>
<tr>
<td>Burbot</td>
<td><em>Lota lota</em></td>
</tr>
<tr>
<td>Butterfly fish</td>
<td>Family Chaetodontidae</td>
</tr>
<tr>
<td>Cardinalfish</td>
<td><em>Apogon notatus</em></td>
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<tr>
<td>Catfish</td>
<td><em>Corydora</em> spp.</td>
</tr>
<tr>
<td>Cichlids</td>
<td>Family Cichlidae</td>
</tr>
<tr>
<td>Cichlid, Burton's</td>
<td><em>Astatotilapia burtoni</em></td>
</tr>
<tr>
<td>Cichlid, Malawi</td>
<td><em>Pseudotropheus</em> spp.</td>
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<td>Cichlid, midas</td>
<td><em>Amphiliophus citrinellus</em></td>
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<td>Cichlid, pearl</td>
<td><em>Geophagus brasiliensis</em></td>
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<tr>
<td>Cichlid, zebra</td>
<td><em>Metriaclima zebra</em></td>
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<tr>
<td>Checker barbs</td>
<td><em>Puntius</em> oligioepis</td>
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<tr>
<td>Cleaner fish</td>
<td><em>Labroides</em> bicolor</td>
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<tr>
<td>Cleaner wrasse</td>
<td><em>Labroides</em> dimidiatus</td>
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<tr>
<td>Clownfish</td>
<td>Amphirioninae (Nemo is an <em>Amphirion ocellaris</em> )</td>
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<td>Cod</td>
<td><em>Gardus</em> morhua</td>
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<tr>
<td>Comets</td>
<td>Variety of 'Goldfish'</td>
</tr>
<tr>
<td>Coral trout</td>
<td><em>Plectropomus</em> leopardus</td>
</tr>
<tr>
<td>Goatfish</td>
<td><em>Parupeneus</em> cyclostomus</td>
</tr>
<tr>
<td>Gobies</td>
<td><em>Bathygobius</em> hoplitis</td>
</tr>
<tr>
<td>Goldfish</td>
<td><em>Carassius</em> auratus</td>
</tr>
<tr>
<td>Groupers</td>
<td><em>Plectropomus</em> pessuliferus</td>
</tr>
<tr>
<td>Guppies</td>
<td><em>Poecilia</em> reticulata</td>
</tr>
<tr>
<td>Lake Eacham Rainbowfish</td>
<td><em>Melanotaenia</em> eachmensis</td>
</tr>
<tr>
<td>Minnows, European</td>
<td><em>Phoxinus</em> phoxinus</td>
</tr>
<tr>
<td>Minnows, white cloud</td>
<td><em>Tanichthys</em> albonubes</td>
</tr>
<tr>
<td>Moorish idol</td>
<td><em>Zanclus</em> cornutus</td>
</tr>
<tr>
<td>Moray eels</td>
<td><em>Gymnathorax</em> javanicus</td>
</tr>
<tr>
<td>Mosquito fish</td>
<td><em>Gambusia</em> holbrooki</td>
</tr>
<tr>
<td>Salmon</td>
<td>Family Salmonidae. See Atlantic salmon, chinook salmon and rainbow trout.</td>
</tr>
<tr>
<td>Salmon, Atlantic</td>
<td><em>Salmo</em> salar</td>
</tr>
<tr>
<td>Salmon, chinook</td>
<td><em>Oncorhynchus</em> tshawytscha</td>
</tr>
<tr>
<td>Siamese fighting fish</td>
<td><em>Betta</em> splendens</td>
</tr>
<tr>
<td>Sticklebacks, three-spined</td>
<td><em>Pungitius</em> pungitius</td>
</tr>
<tr>
<td>Sticklebacks, nine-spined</td>
<td><em>Gasterosteus</em> aculeatus</td>
</tr>
<tr>
<td>Stingrays</td>
<td><em>Potamotrygon</em> castexi</td>
</tr>
<tr>
<td>Tiger barbs</td>
<td><em>Barbus</em> tetrazona</td>
</tr>
<tr>
<td>Trout, brown</td>
<td><em>Salmo</em> trutta</td>
</tr>
<tr>
<td>Common Name</td>
<td>Scientific Name</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>----------------------------</td>
</tr>
<tr>
<td>Trout, rainbow</td>
<td><em>Oncorhynchus mykiss</em></td>
</tr>
<tr>
<td>Tetra</td>
<td><em>Paracheirodon innesi</em></td>
</tr>
<tr>
<td>Tilapia, Nile</td>
<td><em>Oreochromis niloticus</em></td>
</tr>
<tr>
<td>Tilapia, Mozambique</td>
<td><em>Oreochromis mossambicus</em></td>
</tr>
<tr>
<td>Wrasse</td>
<td>Family Labridae</td>
</tr>
<tr>
<td>Yellowtail</td>
<td><em>Seriola lalandei</em></td>
</tr>
<tr>
<td>Zebra fish</td>
<td><em>Danio rerio</em></td>
</tr>
<tr>
<td>Zebra shark</td>
<td><em>Stegostoma fasciatum</em></td>
</tr>
</tbody>
</table>
Appendix B  Notes on reading the survey materials

- [ ] indicates that checkboxes were used, which allow participants to select multiple options from the list.
- ( ) indicates that radio buttons were used, which limit participants to selecting just one option from the list.
- * indicates that the question was mandatory.
- _______ a dotted black line indicated a text field, for open answer questions.
- ____ ____ a solid grey line indicates a page break.
- *Italics* are used to describe long responses and explain hidden survey features, such as piping respondents to different questions.
- ‘Piped’ or ‘piping’ is when the survey program automatically directs respondents to the next question based on their answer to the previous question. This is done so that participants are not exposed to irrelevant questions, saving them time and avoiding response bias.
Appendix C  Survey: Importance of knowledge, attitudes and point of sale on the welfare of aquarium fish.

See Appendix B for notes on reading this survey.

Thank you for your interest! The survey takes just 10-15 minutes to complete. It consists of simple questions about fish and your aquarium.

You will not be asked to supply your name or any other identifying information and all data will remain confidential. If at any time you wish to withdraw from the study you may do so by simply closing the browser window.

The survey is part of a research project being undertaken by Miriam Sullivan towards her PhD in the School of Animal Biology at The University of Western Australia. The information gathered will help us form a better understanding of why people keep fish and what factors can influence the welfare of aquarium fish.

If you wish to know more about the study, please email Miriam Sullivan at msullivan@admin.uwa.edu.au or call (+61 8) 6488 4559. You may also contact the chief investigator, Associate Professor Nancy Longnecker at nancy.longnecker@uwa.edu.au or (+61 8) 6488 3926

1. Find out more...
   ( ) Show terms and conditions

The following information appears only when the respondents check the yes box, and disappears if they uncheck the box.

The survey is part of a research project being undertaken by Miriam Sullivan towards her PhD in the School of Animal Biology at The University of Western Australia. The information gathered will help us form a better understanding of why people keep fish and what factors can influence the welfare of aquarium fish.

You will not be asked to supply your name or any other identifying information and all data will remain confidential. There are no risks or discomforts anticipated for participants, however, if at any time you wish to withdraw from the study you may do so by simply closing the browser window. All information entered up to that point will be discarded. Your participation in this study does not prejudice any right to compensation, which you may have under statute or common law.

I (the participant) have read the information provided and any questions I have asked have been answered to my satisfaction. I agree to participate in this activity, realising that I may withdraw at any time without reason and without prejudice.

I understand that all information provided is treated as strictly confidential and will not be released by the investigator. The only exception to this principle of confidentiality is if documents are required by law. I have been advised as to what data is being collected, what the purpose is, and what will be done with the data upon completion of the research.
I agree that research data gathered for the study may be published provided my name or other identifying information is not used.

If you are under 18 years of age, please have your parents read the above terms and give their consent before you check the box to continue.

If you wish to know more about the study, please email Miriam Sullivan at msullivan@admin.uwa.edu.au or call (+61 8) 6488 4559. You may also contact the chief investigator, Associate Professor Nancy Longnecker at nancy.longnecker@uwa.edu.au or (+61 8) 6488 3926

2. Do you agree to participate?*

( ) Yes

Thank you for your participation in this study. Please answer the following questions to the best of your ability. Remember, there are no right or wrong answers- we are interested in your opinion.

3. Do you currently own or care for any fish?

( ) Yes **Piped to question 9.**
( ) No **Piped to question 4.**

4. Do any of the following reasons prevent you from owning fish?

( ) I find fish uninteresting
( ) I don’t know enough about fish care
( ) I cannot afford to own fish
( ) I cannot own fish due to personal circumstances (e.g. rental agreement or household rules forbid pets)
( ) I do not have the time to take care of fish
( ) Other (Please specify) ________________________________
( ) N/A

5. Have you previously owned pet fish?

( ) Yes **Piped to question 6.**
( ) No **Piped to question 23.**

6. How long has it been since you last owned fish?

______________________________

7. What species/types of fish have you owned? (Check all that apply)

( ) Goldfish
( ) Siamese fighting fish (betta)
( ) Tetras
8. How knowledgeable about fish care and biology are you?
( ) I know nothing about fish
( ) I know very little about fish
( ) I know basic information about fish
( ) I am moderately knowledgeable about fish
( ) I am very knowledgeable about fish
( ) I am an expert on fish
( ) N/A

Past owners are now piped to question 16, except that all the questions from 11-22 are now in past tense (e.g. ‘Why do you keep pet fish?’ becomes ‘Why did you keep pet fish?’)

9. How many fish do you own?
( ) 1
( ) 2-5
( ) 6-10
( ) 10-30
( ) 30+

10. What species/types of fish do you own? (Check all that apply)
( ) Goldfish
( ) Siamese fighting fish (betta)
( ) Tetras
( ) Livebearers (mollies, guppies, platys and swordtails)
( ) Cichlids (includes angelfish, discus, oscars and convicts)
( ) Cyprinids (barbs and danios)
( ) Catfish
( ) Clownfish
( ) Wrasse
( ) Blennies
( ) Marine Angelfish
( ) Other (Please specify) ____________________________
( ) Unsure of species
11. How many different tanks do you have?

12. What size is your smallest tank? (Need help? Try this aquarium calculator.)

Embedded link to http://animal-world.com/encyclo/information/calculate.htm#Aquarium%20Volume%20Calculator

( ) Fishbowl (under 7L / 2Gal)
( ) Small (7-55L / 2-15Gal, dimensions less than 30x15x20cm)
( ) Medium (56-150L / 15-40Gal, dimensions larger than 30x15x20cm)
( ) Large (151+L / 40+Gal, dimensions greater than 120x30x40)
( ) Unsure of tank size
( ) Small pond (Bathtub size or smaller)
( ) Large pond (Larger than a bathtub)

13. How long have you owned aquarium fish?

( ) Less than six months
( ) More than six months, but less than a year
( ) Between one and five years
( ) Between six and ten years
( ) Eleven years or longer
( ) Unsure

14. How knowledgeable about fish care and biology are you?

( ) I know nothing about fish
( ) I know very little about fish
( ) I know basic information about fish
( ) I am moderately knowledgeable about fish
( ) I am very knowledgeable about fish
( ) I am an expert on fish
( ) N/A

15. How much time do you spend caring for and interacting with your fish on an ordinary day?

( ) Less than five minutes
( ) Five to ten minutes
( ) Between ten minutes and half an hour
( ) Half an hour to an hour
( ) More than an hour
( ) Unsure

16. Why do you keep pet fish? (Check all that apply)

( ) They are relaxing to watch
( ) I find fish interesting
( ) I am unable to keep other pets (e.g. due to time, expense, etc.)
( ) I was given a pet fish as a present
( ) Unsure
( ) Other (Please specify) ____________________________

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17. Do you provide any items to make your tank more natural or interesting? (Check all that apply)
( ) No, it is a bare tank
( ) Gravel, sand or similar covering for the tank floor
( ) Shelters (e.g. dead coral, pipes, castles)
( ) Live aquarium plants
( ) Fake aquarium plants
( ) Live food (e.g. mosquito larvae)
( ) Other types of animal (e.g. anemones, snails)
( ) Other (Please specify) ____________________________

18. Do you... (Check all that apply)
( ) ...talk to your fish?
( ) ...name your fish?
( ) ...train your fish to do tricks?
( ) ...feel sad if your fish dies?
( ) ...take your fish to the vet if it is ill?
( ) ...bury your fish if it dies?
( ) ...talk to other people about your fish?
( ) ...participate in fish shows or clubs?
( ) ...discuss fish or aquariums online? (e.g. in blogs, forums, discussion groups, etc.)

19. Where did you get your fish from? (Check all that apply)
( ) Local pet store
( ) Specialist fish pet store
( ) As a gift
( ) Private sale
( ) Over the internet
( ) Wild caught
( ) At a public fete or show
( ) Private giveaway
( ) Other (please specify) ____________________________

20. When you first get a fish, or when you buy a new fish, did you get any information about fish care? (Check all that apply)
( ) I didn't get any information on fish care
( ) I got information on fish care from the person/store where I bought the fish
( ) I did a general internet search for information
( ) I asked for information on online forums and discussion boards
( ) I read books about fish and fish care
( ) I asked friends about their experiences
( ) Other (Please specify) ____________________________

21. Have you had any pet fish which died?
( ) Yes Piped to question 22.
( ) No Piped to question 23.
( ) N/A Piped to question 23.
22. What do you think may have caused the fish to die? (Check all that apply)
( ) Old age
( ) Disease or illness
( ) Jumped out of the tank
( ) Poor water quality
( ) Incorrect feeding practices or the fish stopped eating
( ) Eaten or attacked by another fish or other animal
( ) Just vanished from the tank
( ) Inappropriate temperature (e.g. power failure to heaters)
( ) Unsure about the cause
( ) Other (please specify)

23. Please rate the following statements as true or false:

<table>
<thead>
<tr>
<th>Statement</th>
<th>True</th>
<th>False</th>
<th>Unsure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish have a three second memory</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>Fish do not feel pain</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>Fish are capable of learning</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
</tbody>
</table>

24. On a scale from one to five, how would you rate the following animals:

<table>
<thead>
<tr>
<th>Animal</th>
<th>1 (Unintelligent)</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5 (Extremely intelligent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>Dog</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>Octopus</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>Human</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>Lizard</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>Dolphin</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
</tbody>
</table>

25. Do your fish...
(Not displayed to people who have never owned fish)

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>Unsure</th>
</tr>
</thead>
<tbody>
<tr>
<td>..respond to humans?</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>..recognise you as an individual?</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
<tr>
<td>..know when feeding time is?</td>
<td>( )</td>
<td>( )</td>
<td>( )</td>
</tr>
</tbody>
</table>

26. Do you have any stories or examples of fish displaying either intelligence or complex behaviours?

---
27. Do you support the formation of marine parks and reserves?
( ) Yes
( ) No
( ) Sometimes
( ) Unsure

28. Do you think that the RSPCA and other organisations should be responsible for the welfare of pet fish?
( ) Yes
( ) No
( ) Unsure
( ) Other

29. In 2005, the city council of Rome, Italy banned small, round goldfish bowls under animal cruelty by-laws. If your local government considered introducing similar regulations, what would your reaction be?

30. Are you:
( ) Male
( ) Female
( ) N/A

31. What is your age?

32. Do you:

......eat fish? ( ) Yes ( ) No
.....go fishing for enjoyment or recreation? ( ) Yes ( ) No
.....go fishing for commercial purposes? ( ) Yes ( ) No
.....work in aquaculture? ( ) Yes ( ) No
.....breed or sell pet fish? ( ) Yes ( ) No
.....scuba dive? ( ) Yes ( ) No
.....snorkel? ( ) Yes ( ) No
.....spearfish? ( ) Yes ( ) No

33. Do you own any other pets? (Check all that apply)
( ) No other pets
( ) Cat/s
( ) Dog/s
( ) Small mammals (e.g. guinea pigs, mice, rats, hamsters)
( ) Horse/s
( ) Other livestock (e.g. cows, sheep, pigs)
( ) Poultry (e.g. chickens, ducks)
( ) Other bird/s
( ) Reptile/s
( ) Amphibian/s
( ) Land Invertebrate/s (e.g. insects, ant farms, worm farms)
( ) Aquatic Invertebrates (e.g. yabbies, starfish, squid, anemones)
( ) Other (Please specify) __________________________________________

34. Do you have any other comments or thoughts regarding fish or this survey?

________________________________________

Thank you for participating in this study. Your answers are much appreciated! If you have any further concerns, questions or feedback about this survey, please contact Miriam Sullivan at sullim01@student.uwa.edu.au
Appendix D  Survey: Influence of short films on aquarist behaviour

See Appendix B for notes on reading this survey.

Keeping Aquarium Fish

Thank you for your interest in participating in this research project. We are exploring whether short films about fish care can be useful for fish owners. It involves a short survey and should take no more than five minutes to complete.

You will be asked to supply your email address so that we can send you a short follow-up survey in one month's time. Your email address will be kept completely confidential and will not be used for any purposes outside of this research project.

In order to participate in the research, you must be over the age of 18 and currently keep fish. Participation is completely voluntary.

You may withdraw at any time by simply closing your browser window. You do not need to provide a reason for withdrawing and all the data you have provided up until that point will be destroyed.

This research project forms part of a PhD being undertaken by Miriam Sullivan at the University of Western Australia. If you have any questions or concerns, please do not hesitate to contact Miriam at Miriam.sullivan@uwa.edu.au or call (+618) 6488 1612.

1) Show more information on research ethics

[ ] Yes

The following information appears only when the respondents check the yes box, and disappears if they uncheck the box.

You may also contact the Chief Investigator Associate Professor Nancy Longnecker at nancy.longnecker@uwa.edu.au

Your participation in this study does not prejudice any right to compensation, which you may have under statute or common law. Approval to conduct this research has been provided by The University of Western Australia (RA/4/1/5511), in accordance with its ethics review and approval procedures. Any person considering participation in this research project, or agreeing to participate, may raise any questions or issues with the researchers at any time.

In addition, any person not satisfied with the response of researchers may raise ethics issues or concerns, and may make any complaints about this research project by contacting the Human Research Ethics Office at The University of Western Australia on (08) 6488 3703 or by emailing hreo-research@uwa.edu.au

All research participants are entitled to retain a copy of any Participant Information Form and/or Participant Consent Form relating to this research project.
2) I (the participant) have read the information provided and any questions I have asked have been answered to my satisfaction. I agree to participate in this activity, realising that I may withdraw at any time without reason and without prejudice.*

( ) I agree to take part in this study
( ) I do not wish to take part

3) Are you over 18 years old?*

( ) Yes
( ) No

4) Do you currently own aquarium fish?*

( ) Yes
( ) No

5) To continue and take part in the research, please enter your email address. We will use this to send you the follow-up survey in one month's time. (Your email address will be kept secure and will not be used for any other purpose.)*

6) Where do you live?
( ) Australia
( ) United Kingdom
( ) United States
( ) Drop-down list of all other countries

7) Are you:*
( ) Male
( ) Female

8) How often did you clean your fish tank in the last month? (If you own more than one tank, consider your smallest tank.)*

( ) Not at all
( ) Once
( ) Twice
( ) Three times
( ) Four times
( ) Five times
( ) Six or more times

9) Do you own goldfish?*

( ) No
( ) No, but I have before
( ) Yes
10) Does your tank contain plants? (If you own more than one tank, consider the smallest tank.)*
( ) No
( ) Yes, fake plants
( ) Yes, real plants
( ) Yes, both fake and real plants

11) How knowledgeable about fish care and biology are you?*
( ) I know nothing about fish
( ) I know very little about fish
( ) I know basic information about fish
( ) I am moderately knowledgeable about fish
( ) I am very knowledgeable about fish
( ) I am an expert on fish

12) Do you talk to other people about your fish?*
( ) Yes
( ) No

13) Fish deserve the same level of care as dogs and cats.*
( ) Strongly disagree
( ) Disagree
( ) Neutral
( ) Agree
( ) Strongly agree
( ) Unsure

After this question, survey respondents are randomly shown one of five treatment films on the following page.

Please watch this film.

Film is embedded in the survey here, with the caption:
(Make sure your volume is turned on! Film still not working? Watch on Youtube at hyperlink to the assigned film, opens in a new window.)

14) How many times did you watch the film?*
( ) None
( ) Once
( ) More than once

15) Do you intend to do any of the following: (Please choose all that apply)*
[ ] Clean your tank more often
[ ] Find out more about fish care
[ ] Talk to others about your fish
[ ] Tell others about this survey
[ ] Other (please specify):
[ ] None of the above
16) Please add any comments you would like to make about fish care or the survey.

Thank You!
Thank you for taking our survey. Your response is very valuable to us. If you would like to find out more about fish care, please visit
http://tanksforallthefish.wordpress.com/
Fishkeeping Follow-up Survey

Keeping Aquarium Fish: Follow-up Survey

Thank you for participating in this research project. This survey is a follow-up to the one you participated in a month ago and should take no more than five minutes to complete.
Please answer honestly. All your answers will remain anonymous.

You may withdraw at any time by simply closing your browser window. You do not need to provide a reason for withdrawing and all the data you have provided up until that point will be destroyed.

This research project forms part of a PhD being undertaken by Miriam Sullivan at the University of Western Australia. If you have any questions or concerns, please do not hesitate to contact Miriam at Miriam.sullivan@uwa.edu.au or call (+618) 6488 1612.

1) Show more information on research ethics
[ ] Yes

The following information appears only when the respondents check the yes box, and disappears if they uncheck the box.

You may also contact the Chief Investigator Associate Professor Nancy Longnecker at nancy.longnecker@uwa.edu.au

Your participation in this study does not prejudice any right to compensation, which you may have under statute or common law. Approval to conduct this research has been provided by The University of Western Australia (RA/4/1/5511), in accordance with its ethics review and approval procedures. Any person considering participation in this research project, or agreeing to participate, may raise any questions or issues with the researchers at any time.

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All research participants are entitled to retain a copy of this information.

2) I (the participant) have read the information provided and any questions I have asked have been answered to my satisfaction. I agree to participate in this activity, realising that I may withdraw at any time without reason and without prejudice.*
( ) I agree to take part in this study
( ) I do not wish to take part

3) To continue and take part in the research, please enter the same email address you used to complete the first survey. (This will allow us to match your answers with the first part of the survey. Once your
answers have been matched up, your email will be discarded to preserve your anonymity during analysis.)*

4) **Are you:**
( ) Male
( ) Female

5) **How often did you clean your fish tank in the last month? (If you own more than one tank, consider your smallest tank.)**
( ) Not at all
( ) Once
( ) Twice
( ) Three times
( ) Four times
( ) Five times
( ) Six or more times

6) **How knowledgeable about fish care and biology are you?**
( ) I know nothing about fish
( ) I know very little about fish
( ) I know basic information about fish
( ) I am moderately knowledgeable about fish
( ) I am very knowledgeable about fish
( ) I am an expert on fish

7) **Have you talked to other people about your fish in the last month?**
( ) Yes
( ) No

8) **Over the last month, have you sought out any information on fish or fish care?**
[ ] No
[ ] Yes, from the website provided at the end of the last survey
[ ] Yes, from other online resources
[ ] Yes, from sources other than the internet

9) **Fish deserve the same level of care as dogs and cats.**
( ) Strongly disagree
( ) Disagree
( ) Neutral
( ) Agree
( ) Strongly agree
( ) Unsure
10) **Do you remember watching a short film in the earlier survey?** *This question did not appear on the survey for the control group.*

( ) Yes  
( ) No  
( ) The film did not work

What did you think was the main message of the short film you watched?

________________________________________________________________________

11) **Did you improve the way you cared for your fish over the last month?**

( ) Yes  
( ) No

12) **Why/Why not?**

________________________________________________________________________

In what way(s) did you improve fish care?

________________________________________________________________________

13) **Please add any comments you would like to make about fish care or the survey.**

________________________________________________________________________

Thank You!  
Thank you for taking our survey.  
We are still collecting data from other survey respondents, but the results will be sent to you once the research is finalised. If you would like to find out more about fish care, please visit [http://tanksforallthefish.wordpress.com/](http://tanksforallthefish.wordpress.com/)
Appendix E  Developing monitoring guidelines for fish welfare

Abstract

NHMRC guidelines for wellbeing of animals used in scientific research aspire to treat all vertebrates equally. In practice, however, the welfare monitoring templates provided as examples have far lower standards for fish compared to mammals. Mice, for example, require individual monitoring and action is taken when a score of 1 is recorded. By comparison, fish are monitored in schools and no action is required until a score of 4 is reached. We propose an improved monitoring sheet for fish with additional measures of health and earlier intervention. In particular, this monitoring schedule is more sensitive to species-specific problems such as parasite and disease outbreaks that can cause large losses of fish if not detected early.

Background

The code of practice set out by the Australian National Health and Medical Research Centre (NHMRC) of Australia requires all researchers to routinely monitor animal health and wellbeing (National Health and Medical Research Council 2004). Researchers need to justify how they will do this: how will monitoring be done? How often will monitoring occur? When you will intervene if there is a problem? What action will you take? Who is responsible? (Section 2.2.16).

All of these questions can be addressed by using score sheets for animal monitoring. Score sheets are a form of marking rubric used to quantitatively score the animal’s health, with set scores triggering specific interventions by the researcher. First suggested by Morton and Griffiths (1985), score sheets help to standardize the process of measuring animal health, increase objectiveness of monitoring, minimize differences in judgment between researchers, help to measure the impact of procedures and can be tailored to species, strain and procedure specific needs (Hawkins et al. 2011; Van der Meer et al. 2001). For example, the template provided by Deakin University (Figure 1) lists 15 health measures on which mice should be scored daily. A normal mouse is scored at zero; action is taken when a mouse receives a score of one; and a mouse that scores three is humanely killed. In the UK, most researchers use subjective ‘clinical observation sheets’, while score sheets are used by just 32% of laboratories (Hawkins 2002).

For model species such as mice, which have a long history of being used in research, there are many templates available to help researchers create their monitoring rubrics. Comparatively, templates for fish monitoring are far less detailed and normally look at observations of the entire school, rather than individual fish. Even when more detailed criteria are provided, the scores to initiate action may be set too high. For example, in the best example we found, mortality of >1% per day scores a three, within the range for ‘normal’ health of 0-4. In this case, all the fish could die before the researcher was required to take any action at all.
There is an urgent need of adequate monitoring sheet for fish used in research because 1) under NHMRC guidelines fish are accorded that same respect as any other vertebrate (National Health and Medical Research Council 2004), but in practice both researchers and Animal Ethics Committees need to pay greater attention to fish welfare and 2) fish are becoming increasingly popular as an experimental animal. In 2009, over 1.5 million fish were used for teaching and research in Australia, the most popular of any laboratory animal (Humane Research Australia 2009). This paper describes the development of a new monitoring sheet (provided at the end of the paper) as part of a project on welfare of aquarium fish. We aimed to produce a monitoring sheet that was:

1. Used for monitoring individuals;
2. Uses noninvasive indicators that are sensitive to fish health;
3. Specific to the needs of the species;
4. Could be used as a template for other researchers.

### 1. Used for monitoring individuals

The monitoring sheet prescribes weekly monitoring for individual fish, temporarily increasing to daily morning following stressful procedures. This is a very achievable level of monitoring for our study, in which only 20 fish are used. Since monitoring takes less than two minutes per fish (providing no problems are identified), it is easy to check four different fish each weekday while they are being fed. Fish can be individually identified by sight, if they have different patterns, or by the implantation of elastomer tags (Astorga et al. 2005; Northwest Marine Technologies 2010).

### 2. Non-invasive indicators that are sensitive to small changes in fish health.

Handling can be extremely stressful for fish (Brydges et al. 2009), so it is important that the indicators used can be determined by visual observation. All of the indicators chosen are behavioural or physical and are easy to recognise and monitor.
All of the indicators are based on known signs of distress in fish. For example, a reduced response to stimuli is associated with pain (Sneddon et al. 2003); increased breathing and loss of equilibrium with stress (Newby & Stevens 2008; Sneddon et al. 2003); and social isolation with parasitic infections (Croft et al. 2011). Three of the indicators (colour, fins and skin) relate to the skin of the fish as this is one of the most sensitive markers of health—stress alone can cause skin liaisons in some fish (Johansen et al. 2006; Noga et al. 1998). These monitoring indicators include both behavioural and physical measures used by specialist fish vets (Loh & Landos 2011).

Diagnosing illness in fish can be difficult—often by the time a problem is obvious it may be too late to save the fish (Johansen et al. 2006). It is therefore important to detect and take action on problems as early as possible. The monitoring sheet has an extremely low score threshold (2) to prompt an increase to daily monitoring and implementing treatment. It also requires the researcher to contact an expert for treatment of any fish scoring four or above.

Obtaining expert advice is important, as the specific cause of a problem is often complicated. Subclinical issues, such as poor water quality, may not kill the fish, but do make it susceptible to more obvious diseases and infections (Johansen et al. 2006; Loh & Landos 2011). If the underlying stressor isn’t treated then opportunistic diseases will continue to effect more fish.

3. Specific to the needs of the species

This monitoring sheet is specifically designed for goldfish (Carassius auratus). For example, goldfish monitoring looks closely at the colour, skin and fin condition of the fish. This is specifically to pick up early indicators of common goldfish parasites such as whitespot (Ichtyopthirius spp.) and flukes (Gyrodactylus and Dactylogyrus species) (Loh & Landos 2011). There are over 20,000 species of fish and, although animal ethics reports do not distinguish between them (Johansen et al. 2006), they can have vastly different needs.

4. Could be used as a template for other researchers.

The monitoring sheet should be useful for most scientific research that follows the three R’s of animals ethics (replacement, refinement and reduction) (Russell & Burch 1959): scientists should already be using a minimal numbers of animals in a controlled environment. It is relatively easy for scientists to adapt the guidelines for other species, for example, including ‘erratic swimming’ under the movement section would help to detect herpes virus in koi (Matsu et al. 2008).

Limitations

One of the main problems with score sheets is that they are time consuming to implement, especially with large number of animals. One solution is to make daily visual observations of animals, but only fill out individual scoring sheets when a problem is noted. Van der Meer et al. (2001) argues that this system is more subjective and less formal, meaning that some problems could be overlooked. However, it may be a useful system for monitoring large numbers of shoaling fish where it is impractical to tag individuals. Another option is to use a representative sample of the population (Johansen et al. 2006). For example, large, opaque tanks used in aquaculture research make visual observations difficult, but 1-5% of the shoal could be captured regularly for detailed monitoring.
Another limitation is that many of the indicators used are ‘iceberg indicators’. These are indicators that could be indicative of multiple causes (Hawkins et al. 2011). For example, a fish breathing at the surface could be suffering from a lack of dissolved oxygen, high nitrogen levels or parasitic infection of the gills. These indicators are still important for monitoring because they are sensitive to welfare, but should be interpreted with caution. The intervention point for a score of 2-3 states that researchers should increase monitoring and implement treatment, allowing animal technicians to use their own judgment and experience to address iceberg indicators.

Johansen et al. (2006) offers a good overview of important environmental parameters to monitor, as well as other options for measuring fish welfare. Our monitoring sheet does not provide room to record the temperature, pH and water quality. These environmental factors are extremely important determinants of fish welfare, however, they should be monitored on a daily basis and recorded separately to observations of individual fish health.

**Conclusions**

The health and welfare of individual fish used in research is often overlooked. We have presented a monitoring sheet that is easy, non-invasive and quick to implement. Although this form of monitoring will not be suitable for all fish research, we encourage other researchers to use our score sheet as a template to improve fish welfare.

**Acknowledgements**

Dr Richmond Loh, for veterinary advice and aid concerning goldfish disease and treatments.
## Monitoring Sheet

<table>
<thead>
<tr>
<th>AEC Project No:</th>
<th>Investigator Name and Contact:</th>
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<tbody>
<tr>
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<table>
<thead>
<tr>
<th>Animal ID:</th>
<th>Species: Goldfish</th>
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<tr>
<td></td>
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</table>

### Signs | Clinical Observation (N or A)

<table>
<thead>
<tr>
<th>Date</th>
<th>Activity</th>
<th>Behaviour</th>
<th>Buoyancy</th>
<th>Breathing</th>
<th>Colour</th>
<th>Eating</th>
<th>Fins</th>
<th>Movement</th>
<th>Skin</th>
<th>Other (Specify)</th>
<th>Total and Comments</th>
<th>Initials</th>
</tr>
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</table>

- Examine each animal for abnormalities and record observations in the table
- Observations to be made **weekly** EXCEPT-
- Daily monitoring for three days following introduction to tank and experimental procedures
- Normal clinical signs recorded as ‘N’
- Abnormalities recorded as ‘A’ and severity indicated in brackets e.g. Skin A(2)
- Record comments concerning abnormalities in the comments section

**Contact Details of Researchers**
**CLINICAL SIGNS SEVERITY SCORES**

<table>
<thead>
<tr>
<th>SIGNS</th>
<th>0</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity</td>
<td>Normal</td>
<td>Dull or slow OR overactive</td>
<td>Little response to stimuli OR overreacts. <strong>Lethargic and non-responsive.</strong></td>
</tr>
<tr>
<td>Behaviour</td>
<td>Normal</td>
<td>Keeping slightly apart from other fish</td>
<td>Isolated from other fish</td>
</tr>
<tr>
<td>Buoyancy</td>
<td>Normal</td>
<td>Swimming is a little off-balance</td>
<td>Loses equilibrium when not swimming</td>
</tr>
<tr>
<td>Breathing</td>
<td>Normal</td>
<td>Gill beat rate is a little faster or slower than normal</td>
<td>Breathing heavily or <strong>breathing excessively at the surface.</strong></td>
</tr>
<tr>
<td>Colour</td>
<td>Normal</td>
<td>Slightly dulled or <strong>with black or white spots.</strong></td>
<td>Dull or <strong>extensive black or white patches.</strong></td>
</tr>
<tr>
<td>Eating</td>
<td>Normal</td>
<td>Increased OR decreased over 24 hours</td>
<td>Increased or decreased over 48 hours</td>
</tr>
<tr>
<td>Fins</td>
<td>Normal</td>
<td>A little frayed at the edges</td>
<td>Split or ragged fins</td>
</tr>
<tr>
<td>Movement</td>
<td>Normal</td>
<td>Rubbing against ground</td>
<td>Keeping still near the bottom of the pond</td>
</tr>
<tr>
<td>Skin</td>
<td>Normal</td>
<td>Thickened mucous or small spots</td>
<td>Trailing mucous, spotting or swelling; <strong>skin lesions.</strong></td>
</tr>
</tbody>
</table>

**Intervention Criteria**

<table>
<thead>
<tr>
<th>Total Score</th>
<th>Health</th>
<th>Action Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1</td>
<td>Good</td>
<td>Continue routine monitoring</td>
</tr>
<tr>
<td>2-3</td>
<td>Fair</td>
<td>Increase to daily monitoring. Implement treatment if practical.</td>
</tr>
<tr>
<td>4-8</td>
<td>Poor</td>
<td>Contact expert, treat immediately. Consider pain relief or euthanasia.</td>
</tr>
<tr>
<td>9+</td>
<td>Very Poor</td>
<td>Euthanise</td>
</tr>
</tbody>
</table>

**Contact Details of Researchers**
References


10 Tanks A Lot: Acknowledgements

My Supervisors

**Dominique Blache**, for being incredibly patient and giving wonderful advice on my papers. They were painful to re-write sometimes, but are a billion times more readable for your input.

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Lastly, I’d like to apologise for the terrible fish puns. I just couldn’t miss such a good oppor-tuna-ty.