1. INTRODUCTION

Fish are the most diverse group of vertebrates with more than 30,000 species world-wide (Maitland 1987; Tudge 1990). Australia (including its surrounding marine waters) has one of the largest fish faunas in the world with an estimated 3,600 species (Paxton *et al*. 1989). However the vast majority of these species are marine, with only a small proportion of freshwater species. The Australian freshwater fish fauna is often referred to as depauperate or impoverished with approximately 200 species described (Wager & Jackson 1993, McDowall 1996), most of which are derived from marine ancestors. For such a large land-mass as Australia, this is a very small number of species with much smaller countries such as Japan (127 species (Okada 1960)) and New Guinea (316 species (Allen 1991)) having freshwater fish faunas of comparable size. The relatively low number of Australian freshwater fish species is related to this country's long isolation, historical climate and aridity (McDowall 1981; Allen 1989). The largest river system in Australia, the Murray-Darling, has only 35 or so native fish species, whereas the Mississippi-Missouri system has 373 native species (Courtenay 1990) and the Amazon Basin some 1300 species described so far (Cadwallader and Lawrence 1990).

The Australian freshwater fish fauna is also notable in that it has a significant proportion of alien species. There are approximately 25 species of alien fish (McDowall 1996), with many introduced for recreational fishing purposes in the 1800s. Such fish include the trouts and salmons, Redfin Perch, Carp, Tench and Roach. A more recent wave of introductions has seen a number of ornamental and aquarium species establish such as Oriental Weatherloach, Sailfin Molly, Swordtail, Platy and Guppy (Arthington & Blühdorn 1995). Many of these aquarium species are restricted to tropical or sub-tropical waters, but some such as Oriental Weatherloach, are rapidly spreading through the cooler, temperate regions (Lintermans et al. 1990a,b; Lintermans 1993a,b; Lintermans & Burchmore 1996). The Murray-Darling system has a high proportion of alien species with 13 of the 50 or so fish species being alien. The number of alien fish species (~25 species) in Australia is similar to the number of alien mammals (~23 species) and birds (~20 species) but much higher than for the other two vertebrate groups in Australia, with reptiles (2 species) and amphibians (1 species) (Thompson *et al*. 1987) both having a substantially lower alien component. The high alien component of the Australian fish, mammal and bird faunas is largely due to deliberate introductions for hunting or sport, with reptiles and amphibians largely excluded from such pastimes. Recent studies in New South Wales have revealed that alien fish now form up to 70% numerically and 80–90% of the biomass in many rivers (Faragher & Lintermans 1997; Brown 1996). A similar situation exists in the Canberra region where recent studies have found that alien species comprise up to 96% numerically of the total catch in the Murrumbidgee, Molonglo and Queanbeyan rivers (Lintermans 1995, 1997, 1998a,b).

1.1 Fish Declines

Although no Australian freshwater fish species has become extinct since European settlement, approximately 8% of the Australian fish fauna is now considered threatened (Australian Society for Fish Biology 1998), with around 25% of species having either suffered a significant decline in distribution or only found in restricted areas (Wager & Jackson 1993).

The most often cited causes for declines in fish abundance and distribution are habitat destruction or modification (including the effects of dams, weirs), introduction of alien species, and overfishing.

Habitat destruction or modification

Alteration or destruction of fish habitat is widely regarded as one of the most important causes of native fish declines in Australia (Cadwallader 1978; Koehn & O'Connor 1990a,b; Lintermans 1991a; Hancock 1993) and overseas (Moberly 1993; Maitland 1987). Habitat modifications occur in many forms, but the major classes are:

- barriers to fish passage;
- alteration to flow regimes below impoundments;
- alteration to thermal regimes below impoundments;
- reduction in floodplain habitat or access to floodplains;
- reduction of instream habitat; and
- reduction in water quality.

The presence of dams and weirs on rivers prevents fish moving from one section of stream to another. Such movements may be essential for feeding, breeding or other reasons. Dams and weirs also prevent recolonisation of streams by fish after local 'catastrophes' or depletion. An example is the construction of Scrivener Dam to form Lake Burley Griffin in 1963 which effectively isolated the Molonglo and Queanbeyan rivers from the Murrumbidgee River.

The construction of dams also has a severe effect on the quality of fish habitat through the modification of the natural flow regimes and water quality of rivers below impoundments. Several native fish species use increasing water temperature associated with late spring/early summer flows as cues to commence spawning (McDowall 1996a; Cadwallader & Backhouse 1983). The effect of some impoundments on downstream river flows is to partially reverse the seasonal nature of flows as water from spring and autumn rains are collected and stored for release in summer. The quality of water released is also a problem in that it may be released from the lower levels of the reservoir and be much colder than the surface waters. The release of a cold slug of water during the breeding season can inhibit the upstream spawning migrations of native fish, and if these releases of cold water are regular and persistent, breeding of native fish may not occur. Studies have shown that the lowered water temperatures may extend for several hundred kilometres downstream.

The regulation of streams by dams and weirs has reduced the incidence of flooding in many drainage systems. Many rainfall events which would have previously caused local flooding are now captured and stored in large impoundments. Access by fish to floodplain habitats has also been reduced as a result of the construction of levee banks and regulators on flood-runners.

Instream habitat has been reduced, particularly in the lower reaches of the Murray-Darling Basin, as extensive de-snagging programs were carried out up until the 1980s. The clearing of riparian zones throughout the inland, as well as the spread of exotic willows, means that the opportunity for natural replenishment of hardwood into streams is much reduced. Erosion and sedimentation of streams has also reduced instream habitat through filling deep holes, smothering riffles and other complex habitats.

Water quality has declined dramatically as levels of nutrients, pesticides, and other chemicals have increased over the years. Evidence is emerging of another significant water quality threat, the addition of endocrine disrupting chemicals to waterways. These chemicals either disrupt normal hormone function, or mimic hormones

to give an unnatural response. One group of endocrine disruptors is the environmental oestrogens which can mimic the female hormone, oestrogen. Major sources of environmental oestrogens are pesticides, detergents and prescription drugs such as antibiotics. These chemicals enter waterways either via runoff from agriculture, or discharge of treated sewage effluent. In Europe and America there is growing evidence of the changed sex ratios or feminisation of many aquatic species, particularly fish, which have been exposed to environmental oestrogens. This can have severe impacts on the ability of the species to successfully reproduce. Little research has been conducted in Australia on this problem, but it represents a real threat to Australia's streams, and further investigation is urgently required.

Introduction of alien species

The establishment of alien fish species is often cited as a cause of native fish declines in Australia although much of the evidence is anecdotal. This is because the majority of alien species became established in the mid to late 1800s when the distribution and abundance of native fish were poorly known or documented. However, there is convincing evidence of the Galaxiidae being adversely affected by the presence of both Brown Trout and Rainbow Trout (Tilzey 1976; Frankenberg 1966; Fletcher 1979; Cadwallader 1979b; Cadwallader & Backhouse 1983; Jackson 1981; Jackson & Williams 1980; Lintermans & Rutzou 1990). The main interactions between trout and native species are thought to be predation and competition for feeding, spawning or territorial requirements. Brown Trout were first introduced into the Canberra region in 1888, being one of the first areas of New South Wales to be stocked (National Trust of Australia 1980). Rainbow Trout were first introduced into Australia and New South Wales in 1894 (Faragher 1986), so both trout species have been established in south-eastern New South Wales for a century or more. In the Canberra region both Brown Trout and Rainbow Trout are known to prey on Mountain Galaxias and Two-spined Blackfish (Sanger 1990; Lintermans 1991b, 1998d), with Brown Trout also known to prey on Macquarie Perch and Trout Cod (NSW Fisheries unpublished data). Similarly, in the Upper Murrumbidgee catchment Redfin Perch are known to prey on Western Carp Gudgeon and Murray Cod and are suspected to prey on Macquarie Perch.

Another potentially serious impact of alien species is their ability to introduce or spread foreign diseases and parasites to native fish species (Stewart 1991; Dove 1998). Carp or Redfin Perch are considered to be the source of the Australian populations of the parasitic copepod *Lernaea sp.* (Langdon 1989a). This copepod has been recorded on introduced trout species and Goldfish as well as a number of native fish species in the Murray Darling Basin including Murray Cod, Golden Perch, Silver Perch, River Blackfish (Langdon 1989a), Macquarie Perch, and Mountain Galaxias (Lintermans unpublished data). This parasite has recently also been recorded on a native frog species, Perons Tree Frog *Litoria peronii* in the Cotter River in the ACT (Lintermans unpublished data).

Carp or Eastern Gambusia are also considered the source of the Asian fish tapeworm *Bothriocephalus acheilognathi* which has recently been recorded from the native fish species Western Carp Gudgeon in the Canberra region (Dove *et al*. 1997). This is the first record of this parasite in Australia which is known to cause high levels of mortality in juvenile fish overseas, and may have similar effects on local native species. This species has a low host-specificity at both stages of its life cycle with the adult stage recorded from at least 50 species of fish in five taxonomic orders (Dove *et al*. 1997).

Of more concern is the recent identification in Australia of the disease Epizootic Haematopoietic Necrosis Virus (EHNV). This virus, unique to Australia, was first isolated in 1985 on the alien fish species Redfin Perch (Langdon *et al*. 1986). It is characterised by sudden high mortalities of fish displaying necrosis of the renal haematopoietic tissue, liver spleen and pancreas (Langdon & Humphrey 1987). The disease also affects trout species which can act as vectors. Experimental work by Langdon (1989a,b) has demonstrated that a number of native fish species were extremely susceptible to the disease.

EHNV was first recorded from the Canberra region in 1986 when an outbreak occurred in Blowering Reservoir near Tumut (Langdon & Humphrey 1987). Subsequent outbreaks have occurred in Lake Burrinjuck in late 1990, Lake Burley Griffin in 1991 and 1994, Lake Ginninderra and Googong Reservoir in 1994. The spread of EHNV has been aided by its relatively resistant characteristics and ease of transmission from one geographical location to another on nets, fishing lines, boats and other equipment. Langdon (1989b) found that the virus retained its infectivity after being stored dry for 113 days. Once EHNV has been recorded from a water body it is considered impossible to eradicate the virus.

OVERFISHING

Overfishing has been shown to be important in the decline of several freshwater native fish species such as Trout Cod (Douglas *et al*. 1994), Macquarie Perch (Cadwallader 1978), Murray Cod (Rowland 1989; Jackson *et al*. 1993) and blackfish (Lewis 1917; Roughley 1953). Within the Murray-Darling Basin, commercial fishing for native freshwater fish species has been declining in recent decades, and ceased in New South Wales in 2001. There is still a substantial recreational native freshwater fishery in the Murray-Darling Basin, and recreational fishing has the potential to impact on species which have already been depleted through habitat destruction and the other threats mentioned previously. Overfishing is generally not involved in the decline of smaller species, although the harvesting of some small species as bait fish may lead to localised declines.

1.2 Purpose of this Review

An essential step in the conservation and sound management of fish populations is ensuring that the general community is informed and aware of the presence, distribution, diversity and value of healthy fisheries and the individual species which comprise them. Knowledge of the threats facing fish populations also empowers communities to make informed choices between different management actions which may effect aquatic ecosystems. Much of the existing information on the distribution and abundance of freshwater fish in the Upper Murrumbidgee catchment is anecdotal or has been collected on an ad-hoc basis. Consequently, good baseline datum does not exist for some species and/or localities. For other species and/or river systems, baseline surveys have been carried out over the last 10–20 years.

This report draws together both published and unpublished data on the freshwater fish fauna of the Upper Murrumbidgee catchment. This report also includes information on the Murray River Crayfish which whilst taxonomically is a crustacean, for the purposes of this report is considered a native fish.