Threats to Murray cod

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Abstract

Many of the threats to Murray cod are well documented, although not necessarily quantified in a scientific manner. Most have previously been covered in a range of forums, (e.g. previous MDBC workshops) and publications (including the *Native Fish Strategy*), often with suggested solutions. Such threats include: habitat loss, sedimentation, changes to flows, barriers to movement, interactions with alien species, fishing (commercial, recreational and illegal), changes to water quality (temperature, salinity, suspended sediment, oxygen), loss to irrigation systems and stocking of hatchery fish, including potential genetic impacts.

Other threats have not been so widely recognised, have less direct effects, and are difficult to quantify or have not been widely considered. These include: incremental changes to habitats, reductions in riparian vegetation, isolation of the river from the floodplain, ecosystem changes, low population numbers, deviations from sustainable population structures and diseases. Some of these threats are direct, others indirect, and some operate at a regional scale while others are Basin-wide. Other management issues such as the philosophy of waterway and fisheries managers, a lack of ownership and effective legal responsibility by the public agencies, and a lack of recognition and understanding of the life history traits of Murray cod, all indirectly threaten the species.

This paper examines all threats to Murray cod and concludes that the greatest overall threat is that there is currently no effective management for this species. This is highlighted by our lack of knowledge of population sizes, recruitment patterns and angler take from populations, inaction in regulating non-natural mortality, a lack of ability to address known threats, and poor responses to recent major fish kills.

Introduction

Most of the threats to Murray-Darling Basin fish species have long been recognised and well documented (e.g. Cadwallader 1978), although their impacts have not necessarily been quantified or mitigated. Many of these threats have been discussed in detail at previous Murray-Darling Basin Commission forums with a range of management recommendations suggested in the subsequent publications (Blanch 2001; Phillips 2001, 2003; Murray-Darling Basin Commission 2004; Lintermans & Phillips 2004; Lintermans *et al*. 2005). Murray cod *Maccullochella peelii peelii* are also threatened by many of the issues that are impacting native fish in general (Kearney & Kildea 2001), and indeed, undertaking the recommendations made in previous Murray-Darling Basin Commission workshops would greatly assist Murray cod populations. There are however, less direct and less well-known threats that ultimately also impact on Murray cod. These include non-ecological issues and our approaches to management. This paper examines all threats to Murray cod, provides information for the basis of workshop discussions and management outcomes, and provides recommendations for immediate actions to restore populations of this icon species.

Recognised threats to Murray cod

Changes to flows

Most debate regarding the importance of floods and a natural flow regime for native fish involves the contribution flow makes to conditions that enhance recruitment. While the applicability of the Flood Pulse Concept (Junk *et al*. 1989) to Australian fishes has recently been questioned (Humphries *et al*. 1999), it has been suggested that strong Murray cod recruitment follows years with high flow levels (Ye *et al*. 2000; Rowland 1998). Murray cod have been categorised as a main channel specialist (Humphries *et al*. 2002) that will utilise floodplain channels when they are flowing (Koehn 1996), but they do not appear to utilise the flood plain proper (King 2002). Changes to flows can alter downstream larval travel times and hence distances (Koehn *et al*. 2004), and can therefore affect population distributions. Variations in flow, often removed with the delivery of irrigation water, can stimulate fish movements (Mallen-Cooper *et al*. 1996) and assist in recolonisation.

Loss to irrigation systems

Losses of native fish, including Murray cod, into irrigation systems has recently been recognised for larvae, juveniles and adult fish (Koehn & Nicol 1998; Koehn *et al*. 2004), with presumed high mortalities when the channels are drawn down at the end of the irrigation season. There is a need for quantification of this risk and improved management of irrigation systems to reduce its impacts.

Changes to water quality

Suspended sediment, low oxygen levels, herbicides and altered water temperatures have all been suggested as possible causes of recent fish kills involving Murray cod (Koehn 2005; Sinclair 2005). These kills however, have probably been the result of a number of factors, exacerbated by a lack of flow, and have highlighted the fact that water quality problems remain a threat to this species. While such fish kills provide a graphic reminder of the critical impact of water quality changes, non-critical changes are more common and may have greater overall impacts. Cold-water pollution from low-level dam releases (see Phillips 2001) has been estimated to impact on at least 2800 km of stream in the Murray-Darling Basin (Ryan *et al*. 2003). This may affect spawning, egg and larval survival, swimming speeds, feeding and growth rates. For example, juvenile Murray cod held at 24.2 °C grew almost twice as long and 3.5 times as heavy as Murray cod held at 12.6 °C over a 3-month period (Ryan *et al*. 2003). High turbidities and salinities may also have adverse physiological or behavioural effects. Stratification may occur in pools due to temperature or salinity gradients and result in de-oxygenated, saline bottom layers (Anderson & Morison 1990).

Barriers to movement

There are more than 3600 structures that can impede fish movements in the Murray-Darling Basin. Recent research has increased our understanding of the movements of Murray cod, both for adults and larvae (Koehn 1996; Koehn & Nicol 1998; Humphries *et al*. 2002; King 2002), both in upstream and downstream directions. Movements of adult fish in both upstream and downstream directions provides challenges to ensure that large adult, pre-spawning fish can negotiate fishways, then return downstream safely. The downstream drift of larvae then provides a recolonisation and redistribution process for these young fish. Agencies that manage Murray cod need to recognise the mobility of various life stages and provide for adequate fish passage (Koehn *et al*. 2005).

Habitat loss

The removal of structural woody habitat has been widespread in Murray-Darling Basin rivers, particularly in lowland reaches over a large number of years (Mudie 1961; Phillips 1972; Gippel *et al*. 1992; Treadwell *et al*. 1999). We now have a better understanding of the importance of this habitat to adult and juvenile Murray cod (Koehn 1996). Reinstatement of woody habitat is now recommended as a priority action for river restoration (Murray-Darling Basin Commission 2004), and our understanding of its effects and fish-habitat relationships is increasing (Nicol *et al*. 2002). In general, more habitat can mean more fish, and suitable habitats are needed for all life stages. The infilling of undulations and holes by sedimentation may also impact on cod habitats and could blanket spawning substrates.

Interactions with alien species

Eleven introduced fish species are also present in the Murray-Darling Basin (Murray-Darling Basin Commission 2004). Of these carp *Cyprinus carpio,* redfin *Perca fluviatilis* and Gambusia *Gambusia holbrooki* are the most widespread. Carp receive the most public attention and are often blamed for many of the ills of the river. Recent reviews (Koehn *et al.* 2000; Koehn 2004) indicate that they are a typical invasive species, which is tough and well adapted to making the most of already degraded riverine environments. Carp now comprise a majority of the fish biomass in the Murray-Darling Basin (Harris & Gehrke 1997) and may compete in some way with Murray cod for habitat space. There is no evidence for any other form of competition between Murray cod and carp, although Murray cod are known to prey on juvenile carp (Koehn *et al.* 2000). In contrast, redfin are likely to have caused predation pressure on young Murray cod, and so may a range of other invasive species that may enter the Murray-Darling Basin e.g. banded grunter *Amniataba percoides* and *Tilapia*. Effects of other species such as Gambusia and oriental weatherloach *Misgurnus anguillicaudatus* that may nip fins or eat eggs are unknown.

Life history strategy

Understanding of Murray cod life history traits and population dynamics must be adequate to support scientifically based management and can help protect populations from perturbations. Long-lived marine animals generally have low fecundity, slow growth, infrequent recruitment, low von Bertlanffy growth coefficients (K<0.10) and are particularly vulnerable to extinction (Musick 1999). While Murray cod fecundity could only be classified as moderately low, average K values of 0.108 have been reported by Anderson *et al.* (1992), with rates as low as 0.06 for some river reaches (Rowland 1985). This is a warning sign for this species, as such animals tend to be particularly susceptible to excessive mortality and stock collapse, and resource mangers must be aware of the critical management requirements of such long-lived species (Musick 1999).

Diseases

Our understanding of the impacts of fish diseases on Murray cod is poor. A range of diseases including ectoparasitic protozoans such as *Chilodonella*, *Trichodina* and *Ichthyophthirius* are widespread and can be problematic in fish culture conditions (Langdon 1988; Rowland & Ingram 1991), but their occurrence or impact in the wild is unknown. Redfin virus, epizootic haematopoietic necrosis (EHN) (Langdon *et al.* 1986) has been shown to be lethal to some native species, and Murray cod is susceptible and could be a carrier (Langdon 1988). Outbreak of a new iridovirus infection in cultured Murray cod in Victoria remains unconfirmed for wild fish (Prof. Richard Whittington unpubl. data). Potential impact of Barramundi Encephalitis Virus (BEV) is also unknown.

Fishing

Past commercial catches of Murray cod have obviously impacted on populations (Reid *et al.* 1997), although these fisheries are now closed. The loss of commercial fisheries however, also means the loss of the most comprehensive population data available on this species. To date, this data collection has not been replaced by any other method. Past commercial take has largely been replaced by increased take by recreational anglers, and this has not been quantified. Over-fishing is recognised as a problem for some populations and targeting of legal-size fish may have severe impacts on population structures and may not be sustainable for many populations (see Nicol *et al.* 2005).

Take by illegal methods is indiscriminate and difficult to quantify but needs to be considered for population management. Illegal, unreported and unregulated fishing has been described as the theft of public resource and is a significant threat to the sustainable utilization of freshwater fish resources (DPI 2003). Illegal take of Murray cod may be exacerbated by the premium price paid for wild fish over cultured product ($28 versus $14 per kg) (DPI 2003). The use of set-lines targets large fish that are unlikely to be effectively harvested by rod and line anglers and has impacts on population viability by removing large, reproducing adults (Nicol *et al.* 2005). For Atlantic cod, older, larger fish have been shown to contribute the largest number of eggs and also produce the largest number of recruits likely to produce offspring with higher rates of survival (Cardinale & Arrhenius 2000 cited in Juanes 2003). Murray cod is a species that is particularly susceptible to angling in the months prior to the spawning season and the closed season instigated during this period is an

appropriate measure, although its timing may be questioned in some areas. Similarly, closures during lake draw-downs and drought events where populations are particularly susceptible may be necessary to limit mortality.

Hatchery stocking and genetic implications

Stocking is an option often suggested to remedy reduced fish populations and has been adopted as a management tool by both well-meaning angler organisations and fisheries agencies. The greatest threat posed by the 'stocking paradigm', is that it provides and easy management option that can be used as an excuse to defer more difficult and expensive, but more effective management options. Other impacts of stocking have been reviewed in Phillips (2003).

The effectiveness of native fish stocking has not been quantified and while its success appears evident in impoundments, it is river fish populations that are under threat. There is no evidence of the success of river stocking and indeed, most of Victoria and all of New South Wales Murray cod stockings occur into impoundments. Total number of Murray cod stocked by government for all of New South Wales in 2002/03 was 426 000 fingerlings, all of which went into impoundments (www.fisheries.nsw.gov.au). Additional stocking by anglers brings the total number of Murray cod stocked across the entire state of NSW in this season to about 1 million fry. 'Recruitment' from stocking may remain limited compared to the number of recruits that can be produced by natural populations in many areas. The most valuable aspect of stocking is to re-establish populations in areas where there are very low population numbers or the species is locally extinct. Most stocking of Murray cod is however, undertaken to provide put-and-take fisheries rather than to re-establish wild populations. Stocking can in fact mask real natural population recruitment levels, and its necessity highlights the fact that populations are not sustainable under current exploitation rates.

Genetic diversity of wild populations may be adversely impacted by the addition of genetically limited hatchery-produced fish. Study of the genetic diversity of Murray cod released from Victorian hatchery stocking in 2001/2 were found not to be representative of natural populations with only 6 of 11 haplotypes present (Bearlin & Tikel 2003). Such genetic restriction may be more severe in non-government hatcheries, and would be further exacerbated by line breeding for aquaculture for human consumption. There is currently no monitoring of the genetic stocks of hatchery fish.

Less obvious threats

Less direct and obvious threats to Murray cod populations may include:

- Reductions in riparian vegetation that result in reduced organic inputs including woody habitat.
- Incremental changes to habitats can have gradual effects on fish populations that are not obvious in the short-term.
- Ecosystem changes such as changes in overall river productivity (perhaps caused by a change in water temperature), or the 'removal' of large amounts of carbon 'locked away' in the biomass of carp, can indirectly affect fish populations.
- Low population numbers can result in the 'Allee' effect and consequent difficulty in finding mates at low population densities (Allee 1931).
- Population fragmentation and incremental population loss decreases the chance of being able to recolonise after catastrophic events.
- Deviations from sustainable population structures through the loss of an over-proportion of breeding adults, for example, can add risk to long-term population viability.

The philosophy and responsibility of waterway managers with a priority to provide water for agricultural and domestic use, means that the protection of fish populations has a much lower priority, despite any environmental assurances under their charter. The philosophy of fishery managers must change with the formal listing of Murray cod as a threatened species, and appropriate management changes must be made to balance exploitation and conservation goals. Lack of 'ownership', understanding and responsibility by both the public and a variety of waterway management agencies and their staff needs to be addressed. Current angler input into Murray cod management to date largely only involves stocking and fishing regulations. General support for Murray cod as a species must be adequate to ensure it receives appropriate management attention and resources. The importance of this icon species

to river health needs to be emphasised to both management agencies and the public.

The real threat

After consideration of the threats above, it became obvious that the greatest threat to Murray cod populations in Australia is the fact that there is currently NO effective management for this species. Murray cod live in highly managed environments, yet specific management to protect this icon species is minimal and ineffective, as indicated by reduced populations and recent fish kills (Koehn 2005; Sinclair 2005). Murray cod has been listed as a threatened species under the Flora and Fauna Guarantee Act in Victoria since 1992, but no Action Statement outlining management action has yet been produced.

At the most basic level there is no management of populations. This can be most easily explained as population change being the difference between recruitment and mortality. In general, there is no targeted monitoring or assessment of Murray cod population sizes. There is certainly no monitoring or assessment of recruitment, and there are no real figures available for mortalities of different age-classes or the take of 'adult' Murray cod from these populations. Angling regulations remain the main management action for Murray cod. These however, are often largely based on instinct rather than science, sometimes just maintain the 'status quo', rather than aiming for population rehabilitation, are uniform across large portions of the species' range and are difficult to adequately enforce. Size and bag limits do not necessarily protect the components of the population intended (see Nicol *et al.* 2005) and do not necessarily govern take. The effectiveness of such regulations on Murray cod populations have not been quantified and there is no quantification of angler take (= adult mortality) or other forms of mortality from populations.

While many threats to Murray cod have been recognised and management recommendations made, most of these threats are still operating. There are currently no protected Murray cod populations, nor critical habitats declared, despite provisions in Commonwealth and State threatened species legislation (Environment Protection and Biodiversity Conservation Act and Flora and Fauna Guarantee Act).

Discussion

Murray cod is an icon species of the Murray-Darling Basin that has recently been listed as a threatened species under Federal legislation. There is an urgent need for a change in management philosophy from one of exploitation to that of protection of a threatened species, to reflect this current status. This change of status also needs to be conveyed to the public. The lack of active, targeted management for this icon species is quite concerning. More detailed management that involves public ownership may be modeled from the management of fish species with similar biology elsewhere, such as sturgeon in North America. There are numerous species and stocks of sturgeon, with intense efforts to manage and protect them. These species have many similarities to Murray cod in that they are large and long-lived, have relatively low fecundity, have been reduced by many threats including harvest, and can be classed as an icon species (van Winkle *et al.* 2002). There are a range of community/government agency/research partnerships that have formed to protect and manage different sturgeon populations. These have resulted in public workshops and the development of management plans that cover many issues similar to those raised for Murray cod in this workshop (e.g. Wisconson Lake sturgeon management plan (DNR 2004), Alberta's lake sturgeon management plan (Gov.ab 2004; www.sturgeonfortomorrow.org)).

The listing of Murray cod nationally as a vulnerable species is a wake-up call for us all to increase the intensity of our management efforts toward this species. It is only with a greater recognition of the threats to Murray cod populations, and the dedicated implementation of targeted management actions to address them, that we can resurrect this icon species of the Murray-Darling Basin.

Management recommendations

There is the need for:

1. Overarching national management and recovery plans for Murray cod
2. An ongoing understanding of Murray cod population dynamics and consequent active management and responsive regulations
3. Establishment of a Murray-Darling Basin Murray cod assessment group
4. Addressing of all key threats
5. Information on biological responses of Murray cod to threats and threat abatement
6. Determining legal 'ownership' and definition of agency responsibility and accountability for Murray cod populations
7. Protection of some Murray cod populations and determination, declaration and protection of critical habitat areas
8. Enhancement of public 'ownership' of Murray cod and the status of Murray cod as an icon species
9. Banning of the use of set lines
10. Determination of the effectiveness of stocking and a move away from the 'stocking paradigm'

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