Fisheries Scientific Committee

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FINAL DETERMINATION

The Murray crayfish – *Euastacus armatus* as a Vulnerable Species

The Fisheries Scientific Committee, established under Part 7A of the *Fisheries Management Act 1994* (the Act), has made a final determination to list the Murray crayfish, *Euastacus armatus* as a VULNERABLE SPECIES in Part 1 of Schedule 5 of the Act.

The listing of Vulnerable Species is provided for by Part 7A, Division 2 of the Act.

The Fisheries Scientific Committee, with reference to the criteria relevant to this species, prescribed by Part 16, Division 1 of the *Fisheries Management (General) Regulation 2010* (the Regulation) has found that:

Background

1) Murray crayfish, *Euastacus armatus* (von Martens 1866), is a valid recognised taxon and is a species as defined in the Act. The species is endemic to lotic waters of the southern Murray-Darling Basin. In NSW this includes the Murray and Murrumbidgee catchments below ~700m ASL with the natural range possibly also extending into the headwaters of the Macquarie and Lachlan catchments (Gilligan *et al*. 2007). Its distribution extends into the ACT, Victoria and South Australia, but the majority of the population exists within NSW.

2) The maximum documented size of Murray crayfish is 174 mm OCL (occipital-carapace length) and 2.5 kg (Gilligan *et al*. 2007), although weights of up to 3 kg (Geddes 1990) and 50 cm total length have been reported (Horwitz 1990). It is the largest species of *Euastacus* and the second largest freshwater crayfish in the world. Murray crayfish is slow growing, with 50% of females reaching sexual maturity at 8 years and 100% at 10 years of age. The majority of males are sexually mature at 4 years and the estimated age of the largest measured individual is 20 - 28 years (Gilligan *et al.* 2007).

3) O’Connor (1986) hypothesised that mating is cued by a rapid decline in water temperature. In the mid-Murrumbidgee River, mating is highly synchronised during a brief period in early to mid May at temperatures of 12 – 15^{o}C. Fecundity is size-dependent, ranging from around 150 eggs per female at onset of sexual maturity and increasing to around 1,500 at maximum size (Gilligan *et al.* 2007). Females care for the eggs under their abdomen for the 20 week incubation period. Hatchlings remain in the mothers care for a further month (depending on temperature) (Geddes *et al.* 1993) before dispersing. Mortality between fertilisation and dispersal is 65% under captive conditions (Gilligan *et al.* 2007). Mortality then declines to 31 - 46 % for larger size classes up to 18 months of age (O’Connor 1986, Geddes *et al.* 1993).

4) Given its widespread distribution in habitats ranging from pasture-lands to sclerophyll forest, its existence in both large and small streams (Morgan 1986, Horwitz 1990), and particularly its broad altitudinal range, it appears that the species is tolerant of a variety of in-stream habitat conditions (Gilligan *et al.* 2007). At a microhabitat scale, deep flowing water habitats proximal to clay banks for burrowing, wood or rock cover are characteristic of occupied areas (Gilligan *et al.* 2007). However, there is evidence of size-dependent habitat segregation, with smaller individuals utilising smaller order tributary streams and shallow riparian habitats (Gilligan *et al.* 2007).

5) Adult Murray crayfish have very low dispersal abilities and occupy small home-ranges. In a large three year tag-recapture study, 87% of tagged individuals were recaptured within a few metres of their initial capture sites (O'Connor 1986). Of those that did move, the average movement was only 3.5 ± 0.61(SE) km (maximum = 14 km) (O'Connor, 1986). Ryan (2005) documented an average home range size of 1,800 – 2,000 m^2, but the average core activity area was only 370 m^2.

6) Commercial fisheries for Murray crayfish formerly existed in South Australia and New South Wales, but not in Victoria or the Australian Capital Territory. McCoy (1867) reported that Murray crayfish were sent to markets in Melbourne and Sydney in "great numbers" following the arrival of the railway at Echuca in 1865 and in the Riverina in the late 1870s. By 1942, however, the Murray crayfish was considered to have little economic value (uncited information source in O'Connor 1986). The NSW commercial fishery dataset is unable to provide an assessment of trends in catch-per-unit-effort through time, as fishing effort was not constant in each year. The Murray fishery peaked at over 15 tonnes in 1955 and reached this level again in 1975 (Gilligan *et al*. 2007). The Murrumbidgee fishery was an order of magnitude smaller and peaked at only ~ 1.2 tonnes in 1974 (Gilligan *et al*. 2007). By 1982, professional fishermen in New South Wales rarely marketed Murray crayfish. The New South Wales commercial harvest of Murray crayfish ended in 1987.

8) Recreational fisheries for Murray crayfish are totally closed in both South Australia and the Australian Capital Territory. However, a popular recreational fishery for Murray crayfish currently exists in some waterways of New South Wales and Victoria. In New South Wales, Murray crayfish are one of the four most prominent recreationally fished species in the lower Murray and Murrumbidgee (Sanger and King 2002). A number of waterways within NSW and Victoria are totally closed to recreational fishing for Murray crayfish. These include a number of short reaches immediately upstream and downstream of weirs, a number of lowland river reaches and in all notified trout waters in upland areas (NSW DPI 2012). In total, ~1,400 km of stream within the range of Murray crayfish are closed to crayfishing in New South Wales (streams less than 700 m ASL with greater then 5 ML day^{-1} average flow).

9) Murray crayfish are protected under the *Fisheries Act 1982* in South Australia, are listed as vulnerable in the Australian Capital Territory under Section 21 of the *Nature Conservation Act 1980* (Protected Invertebrate - schedule 1 of the *Nature Conservation Act 1980*, Gazette No. S85, 28 Aug 1991) and as threatened in Victoria under the *Flora & Fauna Guarantee Act 1988*. Nationally, Horwitz (1990) defined the conservation status of Murray crayfish as 'indeterminate', due to the lack of knowledge regarding the species at that time. Similarly, Murray crayfish were listed as internationally 'indeterminate' following a review of their status in 1994 by the IUCN (Groombridge 1994). Horwitz (1995) subsequently suggested the national conservation status be raised to threatened and following re-assessment in 1996 the IUCN listed Murray crayfish as Vulnerable on the *IUCN Red List of Threatened Species* (Crandall 1996). However, a review of the IUCN categorisation for the species using the *Ramas Red List* software program (Akçakaya and Ferson 1999) suggested a listing category of 'Data Deficient' (Clarke and Spier 2003). The species was subsequently downgraded to that category in 2010 (Alves *et al.* 2010).

Criteria – reduction in abundance, geographic distribution or genetic diversity (Regulation clause 271)

1) *Reduction in abundance:* In the 1800s, during his explorations of the lower Murray River in South Australia, Eyre (1845) observed that Aborigines could spear 10 to 16, two to four pound (~ 1 - 1.5 kg) Murray crayfish (~ 130 – 160 mm OCL based on the length-weight relationship of Johnson and Barlow (1982)) from a bark canoe in an hour or two. In 1880, the

Royal Commission into the 'Prospects of Fisheries in New South Wales' reported that Murray crayfish were "very numerous" in the Murrumbidgee River. Broughton (1966) reported that workers constructing weirs on the lower Murray River between 1922 and 1935, regularly harvested Murray crayfish, which were said to "swarm" in the river. In 1949/50, Langtry (in Cadwallader 1977) observed that the numbers of Murray crayfish were increasing dramatically throughout the whole Murray system (referring to the New South Wales portion and inclusive of the Murrumbidgee River), and that a catch of 60 crayfish per 'regulation sized' cray-pot was not unusual. In the 1940s and 1950s in South Australia, commercial fishermen considered that catches were good, consisting of crayfish ranging in size from 0.5 kg (~105 mm OCL) to 2.5 kg (~175 mm OCL), with most about 1 kg (~ 130 mm OCL) (Geddes *et al.* 1993).

Around the 1940s to 1950s, Murray crayfish populations reportedly began to decline (Johnson and Barlow 1982, O'Connor 1986; Walker 1982; Geddes 1990; Horwitz 1990, Geddes *et al.* 1993, Horwitz 1995). Between the 1960s and 1980s anglers increasingly reported declining catches in the mid reaches of both the Murray and Murrumbidgee Rivers, with anglers catching fewer and smaller crayfish each year (Pollard *et al.* 1980; Johnson and Barlow, 1982; O'Connor 1986; Barker 1990; Geddes 1990; Sanger and King 2002).

Multi-decadal time series data on catch per unit effort (CPUE) are available from the mid Murrumbidgee River near Narrandera from the early 80s and from the upper Murrumbidgee River within the ACT from the late 80s. O'Connor (1986) produced a temperature-dependant CPUE model for the mid-Murrumbidgee River that predicted a maximum CPUE of 0.50 per hoop net lift (at between 15 – 17 ^{o}C) and an expected range of 0.11 - 0.41 per hoop net lift during the winter sampling period. Concurrent recreational logbook data collated by O'Connor (1986) suggested an average CPUE of 0.51 crayfish per net lift in the Wagga Wagga to Narrandera reach. Given the statements above, this level of abundance represents the outcome following over three decades of perceived decline. In 1992, Gehrke (1992) re-sampled two of O'Connor's monitoring sites and reported a CPUE of 0.69 ± 0.10 (SE) and 0.29 ± 0.06 (SE) per hoop net lift. Asmus (1999 and unpublished data) quantified a CPUE of 0.99 ± 0.13 (SE) in July 1997, 0.83 ± 0.16 (SE) in July 1998, 0.85 ± 0.16 (SE) in November 2003 and 1.31 ± 0.19 (SE) in August 2004 and McCarthy (2005) reported CPUE for hoop nets at Narrandera of 0.73 Murray crayfish per net lift in 2004, suggesting that the decline had been arrested and that abundance was increasing. However, information provided by Fisheries NSW staff (compliance officers and others) and recreational crayfishers suggested a rapid and substantial population decline in recent years. At Narrandera, the decline can be pin-pointed to having occurred between September 2007 and April 2008 (Leslie Rava, Narrandera Fisheries Centre, pers comm.). Unpublished data collected by Fisheries NSW in 2011 represented an average CPUE of 0.11 ± 0.03 (SE) Murray crayfish per hoop net lift at Narrandera (Asmus, unpublished data). Therefore, the 2007-2008 decline in the mid-Murrumbidgee River represented a rapid > 90% decline in CPUE (relative to 2004 abundance) from what was already a greatly reduced abundance relative to populations pre-1950. In addition to the declining abundance, reproductive failure has also been reported, with observations of fewer sexually mature females 'berried', and those that were carrying reduced numbers of eggs (Leslie Rava, Narrandera Fisheries Centre, pers comm.).

In the upper Murrumbidgee River, Lintermans and Rutzou (1991) reported a very low average CPUE of 0.017 ± 0.009 (SE) (maximum = 0.13) Murray crayfish per hoop net lift across 13 sites in 1988-1989. Dramatically increased capture of Murray crayfish in gill nets in the mid 1990s prompted Lintermans to re-sample 10 of these sites with hoop nets in 1998 and he reported an increase in abundance to an average CPUE of 0.038 ± 0.021 per hoop net lift (maximum = 0.22) (Lintermans 2000), attributing the increase to closure of the fishery in the ACT 1991. However, Ryan (2005) sampled 7 sites in the upper Murrumbidgee in 2005 and reported a CPUE of 0.011 ± 0.007 crayfish per hoop net lift and most recently, Fulton *et al.* (2010) sampled 11 sites in 2008 and 3 sites in 2009 and reported an average CPUE of 0.016 ± 0.007 crayfish per hoop net lift.

There is little evidence that the abundance, average size or sex ratio of Murray crayfish populations had recovered over a seven year total fishing closure of the Victorian fishery (Morison 1988; Barker 1992), or a nine year fishing closure along a ~70 km reach of the mid Murrumbidgee River (Asmus 1999). Despite an initial increase in abundance after the closure was first implemented (Lintermans 2000), the 17 year total closure of the ACT fishery has not resulted in an increase in Murray crayfish abundance in the upper Murrumbidgee River (Fulton *et al.* 2010). These instances suggest that either recreational fishing is not the dominant process limiting population recovery, or that compliance was/is insufficient to prevent illegal harvest.

No similar quantitative time-series of data (spanning decades) is available for populations in the Murray River. However, annual Munyama trap surveys in the mid-Murray River in the vicinity of the Barmah-Millewa Forest between 2007 and 2011 indicate that CPUE has remained relatively stable since 2007, with only minor fluctuations between an average ± SE of 0.04 ± 0.01 crayfish per trap hour in 2007, 0.12 ± 0.05 in 2008, 0.19 ± 0.15 in 2009, 0.12 ± 0.04 in 2010 and 0.07 ± 0.08 in 2011 (Rourke and Tonkin 1999). Further upstream near Albury, Edney (unpublished data) reported an average CPUE of 0.26 crayfish per hoop net lift in 2005 while Zukowski *et al.* (2011*b*) report winter CPUE of 0.61 - 0.67 crayfish per hoop net lift in 2009. Data from both Murray River locations suggest that the Murray River population did not collapse during the same period the Murrumbidgee population had declined by 85%. However, Zukowski *et al.* (2011*a*) summarised local ecological knowledge through surveys of fishers in the Albury to Corowa reach of the Murray River in 2009 and quoted statements such as "*The numbers of crays has dropped heaps over the last 20 years* (i.e., since 1989) *and now we can't even catch one legally sized one*" and "*All been fished out. Now nothing but small males and large females*" suggesting longer-term declines in the status of the population and the fishery. As reported in the mid-Murrumbidgee River, both Rourke and Tonkin (2009) and Zukowski *et al.* (2011*b*) present evidence of reproductive failure in the mid-Murray River, with a substantial proportion of sexually mature females not 'berried' (43% and 42% respectively) and 17% of those that are only carrying < 30 eggs (Rourke and Tonkin, unpublished data). In addition to these data from the mid-Murray River, Zukowski (Ph.D. student: Charles Sturt University) has sampled 29 equidistant sites in the Murray River between Euston and Jingellic annually between 2007 and 2010, but the results are not yet available.

Several point estimates of abundance are available for other regions:

- Logbook data collected from the Murray and Murrumbidgee Rivers by recreational anglers between 1982 and 1984 (concurrent with the fishery independent sampling of O'Connor) report an average of 0.32 per hoop net lift in the Murray River and 0.30 per hoop net lift in the Murrumbidgee (O'Connor, 1986). However, abundance varied spatially, with the minimum and maximum average crayfish per hoop net lift in the Murray River being 0.09 and 0.53 in the Euston to Mildura and the Yarrawonga to Barmah reaches respectively, the minimum and maximum in the Murrumbidgee River being 0.10 and 0.51 in the Darlington Point to Hay and the Wagga Wagga to Narrandera reaches respectively (O'Connor, 1986).
- In 2004, McCarthy (2005) reported a catch rate of 0.008 Murray crayfish per net hour for Munyana traps in the Murray River downstream of Swan Hill.
- No Murray crayfish were collected during annual Munyama and Opera House trap

sampling (10 net hours per method per site) at between 24 and 37 sites within the Edward-Wakool-Niemur anabranch system in 2010, 2011 and 2012 (Wooden, unpublished data).

- Fulton et al. (2010) report average CPUE of 0.125 ± 0.079 (SE) crayfish per hoop net lift from the Goobarragandra River (a tributary of the Murrumbidgee catchment near Tumut) in 2009.

2) *Reduction in geographic distribution:* Murray crayfish are believed to have disappeared entirely from the Murray River downstream of the head of the Mildura weir pool at around 34^{o} 30’ S (McCarthy 2005). Similarly, they were not collected in the Edward-Wakool-Niemur anabranch system despite recent sampling by Wooden (unpublished data), however large numbers of crayfish were reported to emerge from the Edward River at Moulamein during the 2010-2011 blackwater event (Whitworth *et al.* 2011). They are considered to be absent in the Murrumbidgee River downstream of around Hay, however no surveys have been undertaken in the lower part of the Murrumbidgee River to confirm this.

Criteria – threatening processes (Regulation clause 272)

Several threatening processes have been proposed as the cause of the reduced distribution, abundance, average size and reduced reproductive output of Murray crayfish populations since the 1950s. Although no single theory adequately explains the declines observed throughout the entire range of Murray crayfish, particular threatening processes are likely to have been principally responsible for population declines in different areas. Some threatening processes that may have resulted in declines in the past are no longer impacting Murray crayfish populations, while others continue to impact populations, either resulting in continuing declines or preventing or limiting the recovery of Murray crayfish populations that declined historically.

1) Walker (1982) and Walker (2001) attributed the disappearance of Murray crayfish from the lower Murray River to the construction of weirs and subsequent river regulation in the 1920s and 30s, which transformed the lower Murray River into a continuous series of weir-pools. The hydrology, hydraulics, sedimentation rates and bio-film composition are all altered from the natural riverine state (Walker and Thoms 1993; McCarthy *et al.* 2004). Data collected by McCarthy (2005) demonstrating the avoidance of weir pool environments by Murray crayfish in the Mallee region of the Murray River support the proposal that river regulation, by creating low flow environments that are unsuitable for Murray crayfish, is an important threatening process in the lower Murray River. Further, sedimentation may impact upon crayfish by filling deep holes within the river channel, smothering snags or other cover, or smothering clay banks required for burrowing. Walker (1982) reported that sedimentation in the lower Murray River was severe in the years following weir construction. Sedimentation was exacerbated during the 1956 floods when a huge silt burden was deposited and completely filled parts of the channel (Walker 1982). This silt burden has remained in the river because of the absence or reduced frequency of flushing flows. As in the lower Murray, anglers in the lower Murrumbidgee report that Murray crayfish declined following the construction of Maude and Redbank Weirs (O’Connor, 1986).

2) River regulation may also act as a threatening process through seasonal flow reversal, where flows during the May – August active period are considerably lower than natural flows. Further, reduced river levels during winter expose burrows and burrowing sites. If brooding females use burrows during autumn-winter, limited or reduced access to burrows may limit localised recruitment of Murray crayfish. Although river regulation provides a reasonable explanation for the local extinction and reduced abundance of Murray crayfish in heavily regulated reaches, it does not provide an adequate explanation for declines in unregulated or minimally regulated reaches and tributaries. Further, river regulation does not provide an

adequate explanation for the decline in average size reported throughout the remainder of the species range.

3) Walker (1982), O'Connor (1986), Geddes (1990), Horwitz (1990) and Geddes *et al.* (1993) referred to threats posed by pesticides and pollution. O'Connor (1986) noted that the areas of major decline in crayfish numbers were downstream of major irrigation systems, where synthetic organochlorine pesticides such as DDT were applied liberally in the late 1940s and 1950s (Radcliffe 2002). Run-off from irrigation is one of the most important contributors to the transport of pesticides into waterways and their subsequent accumulation in sediments and aquatic organisms (Nowell *et al.* 1999). Spray-drift also results in the input of pesticides to waterways (Raupach and Briggs 1998). Given the sensitivity of crayfish to pesticides and pollution (Geddes 1990; France and Collins 1993; Davies *et al.* 1994; ANZECC and ARMCANZ 2000), the persistence of some pesticides in aquatic sediments (Radcliffe 2002) and ecosystems, and the bio-accumulative and bio-magnifying nature of the some toxins (Radcliffe 2002), it is highly likely that this may have been a critical factor in the decline of Murray crayfish in the 1950s. The impacts of pesticide residues and agricultural pollution increase in a downstream direction (Muschal and Warne 2001) and the spatial and temporal patterns in the disappearance of Murray crayfish from the lower Murray and Edwards, Wakool and Niemur Rivers are more closely associated with the advent and proliferation of use of pesticides than any other threatening process (O'Connor 1986). However, the most persistent of the organo-chlorine family of pesticides, such as DDT, were banned from use in Australia in 1987 (Radcliffe 2002) and the environment has now had time to purge accumulated residues in aquatic sediments. As a consequence, the threats posed by some of the organo-chlorine chemicals have been removed. However, crayfish are sensitive to numerous pesticides and agro-chemicals that remain in use. Further, the quantities of these pesticides used continue to increase (Radcliffe 2002), albeit under reasonably comprehensive regulations governing their use in areas adjacent to waterways. O'Connor (1986) cites L.F. Reynolds as stating that fishermen suggested that spraying of locust plagues in South Australia in the early 1950s left residues in the soil that entered the river during the 1956 flood, and that the demise of crayfish could be associated with this single input of pesticides.

   Lastly, collapse of mine tailings dumps at Captains Flat in the upper Murrumbidgee catchment in 1938 and 1943 released large quantities of heavy metals into the Molonglo River and its floodplain and fish were apparently still absent up to 15 km downstream of the mine fifty years later (ACT Government 1999). Therefore, pollution originating from mining sites is as significant a threat as are agro-chemicals in some locations, but only at localised scales relative to pesticide impacts which may be much more widespread.

4) O'Connor (1986), Geddes (1990), Horwitz (1990), Lintermans and Rutzou (1991), Geddes *et al.* (1993), Horwitz (1995), the ACT Government (1999) and McCarthy (2005) suggested that overfishing was a primary cause of decline of Murray crayfish. Commercial fisheries for Murray crayfish closed in New South Wales in 1987. Therefore, whether commercial fisheries contributed to declines as key threatening process or not, they no longer impact on Murray crayfish populations.

   O'Connor (1986) associated the extensive declines of Murray crayfish in the middle reaches of the Murray River and the Murrumbidgee River with the advent of the caravan, aluminium trailer boat and freezer in the 1950s and 1960s. The implications of these inventions were that fishermen could travel further, travel more regularly and harvest greater numbers of crayfish than had previously been possible. Fishing inspectors working within the range of Murray crayfish during this period recall the extremely large catches that were regularly taken by local and travelling recreational fishers during this period, and that individuals of all sizes were harvested indiscriminately (Peter Angel, pers. comm.: Narrandera Fisheries Centre). Historically, recreational fisheries existed throughout the range of Murray crayfish and most jurisdictions had limited or no recreational fishing regulations up until the 1980s.

Several studies have attempted to assess the impact of recreational fishing on Murray crayfish populations by either documenting the response to total fishing closures (Morison 1988; Barker 1990; Asmus 1999, Lintermans 2000, Fulton *et al.* 2010), or by comparing the characteristics of crayfish populations in areas with easy versus difficult access for recreational fishers (Lintermans and Rutzou 1991; Asmus 1999; McMonigle unpublished; Edney, unpublished). There is little evidence that the abundance, average size or sex ratio of Murray crayfish populations had recovered over a seven year total closure of the Victorian fishery (Morison 1988; Barker 1992), a nine year closure along a ~70 km reach of the mid Murrumbidgee River (Asmus 1999) or a 17 year total closure of the ACT fishery (Fulton *et al.* 2010). This suggests that either recreational fishing is not the dominant process limiting population recovery, or that compliance was/is insufficient to prevent illegal harvest despite the closures. Similarly, studies comparing Murray crayfish populations at sites that are easy and difficult to access have provided mixed results. In the Australian Capital Territory, Lintermans and Rutzou (1991) caught few crayfish (13% of total captures) at easily accessible sites, suggesting that angler accessibility had a significant impact on Murray crayfish abundance. Similarly, Edney (unpublished) recorded a CPUE of only 0.06 crayfish per hoop net lift at an easily accessible reach versus a CPUE of 0.41 crayfish per hoop net lift at a more inaccessible reach. In contrast, Asmus (1999) found no significant differences between sites with easy versus limited recreational fisher access for any of the population variables assessed. Despite these results, there is strong evidence that current fishing regulations result in a substantially biased sex ratio, with a low abundance of sexually mature males > 90 mm OCL in populations exposed to recreational fishing (Gehrke 1992, Asmus 1999, McCarthy 2005, Rourke and Tonkin, 2009, Zukowski *et al.* 2011*a*). The lack of large sexually mature male crayfish may be contributing to reduced reproductive output of populations by making it difficult for large females to find suitable mates (Gilligan *et al.* 2007, Zukowski *et al.* 2011*b)*. Further, fishing pressure clearly leads to substantial truncation of the population size structure at the minimum legal length (Gilligan *et al.* 2007, Zukowski *et al.* 2011*a,b*) and the current minimum size limit only allows 50% of females to reach sexual maturity before being exposed to recreational fishing (Gilligan *et al.* 2007, Zukowski *et al.* 2011*b*). Handling of berried females has also been demonstrated to lead to the loss of eggs (Zukowski *et al.* 2011*b*).

Despite closure of the commercial fishery and the introduction of regulatory controls to the recreational fishery (closed waters, seasonal closures, bag limits, minimum size limits, protection of berried females etc.) in response to the perceived decline, the species has not recovered in any region where time-series abundance data are available.

5) Like other components of aquatic ecosystems, Murray crayfish are threatened by habitat degradation of riverine habitats. Specific examples that are likely to have impacts upon Murray crayfish are the infilling of formerly deep holes and smothering of substrates through sedimentation (Walker 1982; ACT Government 1999), the removal of snags (ACT Government 1999) and the clearing of riparian zones (ACT Government 1999).

6) Thermal pollution by the release of cold water downstream of Burrinjuck, Blowering and Hume Dams significantly alters the natural thermal regimes for hundreds of kilometres downstream (Phillips 2001). As mating, rates of development and activity of Murray crayfish are influenced by temperature (O'Connor, 1986), thermal pollution may detrimentally impact on Murray crayfish populations by increasing development times and altering the

reproductive season. The influence of reduced summer water temperatures on the growth, survival and recruitment of Murray crayfish remains unknown.

7) The impacts of competition with and predation by introduced trout (*Salmo trutta* and O*ncorhynchus mykiss*), redfin (*Perca fluviatilis*) and carp (*Cyprinus carpio*) are unknown. However, it is highly likely that these species impact upon juvenile and immature Murray crayfish (Merrick 1995; ACT Government 1999).

8) Intolerance of low dissolved oxygen concentrations is demonstrated by observations of Murray crayfish leaving the water (crawling onto river banks or snags) when dissolved oxygen concentrations fell to 1.8 mg L^{-1} during a black water event in the Barmah-Millewa Forest in 1992 (McKinnon 1995) and again in 2010-11 (King *et al.* 2012). The later event extended the entire length of the Murray River downstream of the Barmah-Millewa Forest and persisted for 6 months (Whitworth *et al.* 2011). Large numbers of crayfish were observed emerging from the water shortly after blackwater arrived at Barmah, Barham, Swan Hill, Boundary Bend and at and downstream of Euston on the Murray River and at Moulamein on the Edward River (Whitworth *et al.* 2011). King et al. (2012) observed that the crayfish remained at the waters edge in a lethargic state and were frequently observed to re-immerse themselves - presumably to moisten their gills (King *et al.* 2012, Whitworth *et al.* 2011). A maximum of ~750 individuals per km of bank were recorded (King *et al.* 2012). However, despite the hypoxic blackwater persisting at Barmah-Millewa until the end of March 2012, few crayfish were observed on the banks by January and none by February (King *et al.* 2012). It is unknown whether they succumbed to predators (humans or foxes), polyphenolic toxins within the blackwater or stress, or whether they returned to the water and survived despite the continuing low oxygen concentrations. Sampling by Rourke and Tonkins (unpublished data) undertaken seven and 19 months after commencement of the Barmah-Millewa blackwater event suggest that CPUE had declined from an average (± SE) of 0.37 ± 0.27 crayfish per Munyana trap hour before the blackwater, to 0.07 ± 0.06 and 0 ± 0 crayfish per hour seven and 19 months afterward at blackwater affected sites, but increased from 0.08 ± 0.03 crayfish per trap hour to 0.22 ± 0.07 and 0.14 ± 0.14 crayfish per hour at unaffected sites immediately upstream during the same period. Unavoidable natural blackwater events will continue following drought-breaking floods. Both natural floods and environmental watering events designed to inundate dry floodplains have resulted in the creation of blackwater flows and have the potential to significantly impact upon Murray crayfish.

Conclusion pursuant to section 220F(4) of the Act

The Fisheries Scientific Committee takes into consideration the facts that:

1) Murray crayfish abundance has reportedly declined substantially from the 1940s – 50s.
2) Murray crayfish abundance has subsequently declined even further during the past few years in both the mid-Murrumbidgee and mid-Murray Rivers.
3) The species remains at very low abundance in the headwaters and upper reaches of its distribution in the Murrumbidgee catchment.
4) Murray crayfish have disappeared from large areas of their former range in the mid to lower reaches of their distribution.
5) Current recreational fishing regulations and fishing pressure leads to a significantly skewed sex ratio of sexually mature individuals. It is probable that this is impacting on the reproductive capacity of the population.
6) The species is protected from fishing within approximately 1,400 km of waterways.

7) Murray crayfish are sensitive to a number of threatening processes that continue to impact upon their populations.
8) The slow growth rate and relatively low fecundity of the species is likely to limit their ability to recover quickly from population declines.

In the opinion of the Fisheries Scientific Committee:

(a) *Euastacus armatus*, the Murray crayfish is facing a high risk of extinction in New South Wales in the medium-term future, as determined in accordance with the criteria prescribed by the Regulation as discussed above, and

(b) it is not eligible to be listed as an endangered or critically endangered species.

The species is eligible to be listed as a VULNERABLE SPECIES.

Sources and Links

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