

**Background and Implementation Information for
the
Murray Hardyhead *Craterocephalus fluviatilis*
National Recovery Plan**

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Australian Government

**Department of
Sustainability and
Environment**



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Species Information

Description

The Murray Hardyhead *Craterocephalus fluviatilis* McCulloch, 1913 belongs to the family Atherinidae, the hardyheads or silversides, which contains about 160 species occurring in freshwater, estuaries and coastal seas throughout the tropic and temperate zones around the world. Australia has about 26 species of hardyheads, of which 14 are primarily freshwater.

Hardyheads are small, silvery, translucent fish with two widely-separated dorsal fins, the first composed of slender spines, the second having a single spine and numerous soft rays. There is usually a longitudinal silvery, golden, reddish or black stripe running mid-laterally along the body. The lateral line is rudimentary or absent, although most species have a series of pores along the mid-lateral scales.

Hardyheads are generally omnivorous, taking small aquatic invertebrates and some plant material. Most hardyheads form schools, sometimes in very large numbers. They are probably important in the diet of larger fish and waterbirds. Australian freshwater hardyheads spawn in pairs, laying demersal eggs amongst aquatic vegetation, the eggs attaching to plants by means of adhesive threads (Allen *et al.* 2003).

The Murray Hardyhead is a typical hardyhead, growing to about 75 mm in length, with a translucent silvery body. The dorsal surface sometimes has a golden sheen, there is a bright silver mid-lateral stripe, and the head and snout are sometimes dusky. There are two separate, small dorsal fins, the first with 4–7 spines, the second with one spine and 5–8 rays. The anal fin is small, opposite the second dorsal fin and has one spine and 6–9 rays. The pectoral fins are inserted high on the sides, near the top of the operculum opening, and have one spine and 11–13 rays. The pelvic fins are small, abdominal and have one spine and 5–6 rays. Fins are translucent, but apparently turn orange at spawning. The mouth is small and protrusible, and has a labial ligament restricting the gape. There is a single row of small teeth in both jaws. The Murray Hardyhead has relatively small, thin scales, with a mid-lateral scale count of 31–35, and 10–12 scales in transverse series, including 4–8 above the mid-lateral band. Head scales are relatively large, with a single large interorbital scale reaching as far as the anterior margin of the orbit (description based on Ivanstovff & Crowley 1996, and ARI data).

Very little is known about the Murray Hardyhead, but its biology and ecology is presumed to be similar to other Australian inland (freshwater) hardyheads. A study of the spawning and development of *C. fluviatilis* (Llewellyn 1979) was actually of *C. s. fulvus* (Crowley & Ivanstovff 1990). The Murray Hardyhead is a mobile, schooling species. Spawning apparently occurs in late spring and summer, and the adhesive eggs are laid amongst aquatic vegetation (Ivanstovff & Crowley 1996). In Victoria, adults in spawning condition have been collected in stands of *Ruppia* species in saline lakes (Raadik & Fairbrother 1999) and it is presumed the species spawns amongst this vegetation. Adults with mature gonads have been collected in November (Raadik & O'Connor 1996; Raadik & Fairbrother 1999) and February (J. Lyon DSE-ARI unpubl. data), and newly hatched larvae as small as 5 mm in length have been collected in mid summer (B. Ebner, unpubl. data). Diet consists primarily of microcrustaceans (Hardie 2000; B. Ebner, unpubl. data).

Taxonomic status

Historically, the Murray Hardyhead has been confused with several other hardyheads (Crowley & Ivanstovff 1990), including the Darling River Hardyhead *Craterocephalus amniculus*, the Lake Eyre Hardyhead *Craterocephalus eyresii* and the Unspecked (or Fly-specked, or Freshwater) Hardyhead *Craterocephalus stercusmuscarum fulvus* (eg. Cadwallader & Backhouse 1983). Morphologically, the Murray Hardyhead is virtually identical to the Lake Eyre Hardyhead, which is endemic to the Lake Eyre basin in South Australia, so there is no range overlap (Ivanstovff & Crowley 1996). The Unspecked Hardyhead, which is widespread in the Murray-Darling River system, overlaps in range with the Murray Hardyhead (Ivanstovff & Crowley 1996). However, the two species are rarely sympatric, with the Murray Hardyhead often occurring in slightly to moderately saline waters and the Unspecked Hardyhead occurring in freshwater (Ebner & Raadik 2001). There are some locations where both species occur together, such as the

Cardross Lakes (Vic) (T. Raadik DSE-ARI pers. com.), and the lower lakes of the Murray River in South Australia (where both occur along with the marine/estuarine species, the Small-mouthed Hardyhead *Atherinasoma microstoma*) (B. Zampatti SA SARDI pers. comm.). The Murray Hardyhead and the Unspecked Hardyhead can be most readily distinguished by scale size and count: the Murray Hardyhead has 10–12 scales in transverse series, including 4–8 above the mid-lateral band, while the Unspecked Hardyhead has larger scales, with eight or fewer scales in transverse series, including three above the mid-lateral band (Ivanstoff & Crowley 1996). However, there is some doubt as to the accuracy of published keys, and additional genetic and morphometric analyses are required to confidently distinguish between these two species.

Conservation status

The Murray Hardyhead was formerly widespread and common in the mid to lower Murray-Darling River system. It has suffered a substantial decline in range and abundance, especially in the upstream part of its range, although it is still locally common in some parts of its range at the downstream limits in South Australia. Some remaining populations are now isolated and small, and subject to threats such as rising salinity, declining water levels and declining water quality.

National conservation status

Listed as **Vulnerable** under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act).

Considered **Endangered** by the Australian Society for Fish Biology (ASFB 2001).

Assessed as **Endangered** on the IUCN Red List of Threatened Species (IUCN 2003) (criteria A1c; B1+2ab – version 2.3, 1994)

Conservation status in range states

New South Wales

Listed as **Endangered** under the *Fisheries Management Act* 1994.

Victoria

Listed as **Threatened** under the *Flora and Fauna Guarantee Act* 1988 (FFG Act).

Considered **Critically Endangered** (DSE 2007).

South Australia

Listed as **Endangered** under the National Parks and Wildlife Act 1972 *Draft Threatened Species Schedules* (IUCN criteria B1ab(i,ii,iv))

Current Conservation Status Assessment

An assessment of the conservation status of the Murray Hardyhead against the IUCN 2001 Categories and Criteria, using current population and threat information, results in a classification of: **Critically Endangered**: Criteria A3bc (IUCN 2001; version 3.1): population size reduction of $\geq 80\%$, projected or suspected to be met within the next 10 years or three generations (whichever is the longer), based on an expected loss of at least ten of thirteen remaining populations and their habitats within the next two years

Distribution

The Murray Hardyhead is endemic to the lowland floodplains of the Murray-Darling River system in south-eastern Australia (New South Wales, Victoria and South Australia) (Lloyd & Walker 1986; Ivanstoff & Crowley 1996). Current distribution includes the mid to lower reaches of the Murray River, with confirmed records from wetlands near Swan Hill and Mildura (Victoria) (Chessman & Williams 1974; McGuckin 1999; Raadik & Fairbrother 1999; Hardie 2000; DSE Aquatic Fauna Database), and in the Murray River and its tributaries near Renmark, Swan Reach and the lower lakes near the mouth of the Murray River (South Australia) (Lloyd & Walker 1986; Hammer *et al.* 2002; Wedderburn & Hammer 2003). The species has been reported to occur as far upstream as Yarrowonga (Murray River) and Narrandera (Murrumbidgee River). In NSW, there has only been one record in the last 20 years, and there are no recent confirmed records from the Murrumbidgee River and none from the Darling River (J. Pursey DPI NSW Fisheries pers. comm.). However, the exact distribution of the Murray

Hardyhead is unclear due to confusion in identification with other hardyheads, including the Darling River Hardyhead, Lake Eyre Hardyhead and Unspecked Hardyhead (Crowley & Ivanstoff 1990).

In Victoria, the species has been recorded from several locations over the past 40 years, including Cullen, Elizabeth, Golf Course, Long, Tuchewop, Wandella and Yando Lakes (Chessman & Williams 1974; Fleming 1990; McGuckin 1999; Hardie 2000; DSE Aquatic Fauna Database). However, due to the confusion in taxonomy of *Craterocephalus* species, at least some of the early identifications may be incorrect. More recent surveys have confirmed the presence of Murray Hardyhead in Round Lake (McGuckin 1999; Hardie 2000; Lyon *et al.* 2002), Woorinen North Lake (McGuckin 1999; Hardie 2000; Lyon *et al.* 2002), Cardross Lakes and Lake Hawthorn (Raadik & Fairbrother 1999). In South Australia, the species has been recorded from several locations from near Renmark downstream to near the mouth of the Murray River, including the Murray River and tributaries Finniss River, Angas River, Marne River and Dishers Creek (Lloyd & Walker 1986). There are historical records from Lake Alexandrina (1886), Finniss River (1961 and 1963), near Mannum (1968), Coorong (1984) and Black Swamp (junction of Finniss River and Tookayerta Creek) (1984). Current distribution indicates several discrete, apparently isolated populations along the Murray River, including Scotts Creek (1998), Berri and Dishers Creek Evaporation Basin (2000), Lake Littra (2000), Lake Albert (2003), Lake Alexandrina (2003) and Hindmarsh Island (2002) (B. Zampatti SARDI SA pers. comm).

Recovery Information

Existing Conservation Measures

A number of specific and general initiatives for conservation of the Murray Hardyhead are underway or have been completed, including:

- Several studies looking at taxonomy, distribution, biology and conservation status (eg. Crowley & Ivanstoff 1990; Ebner & Raadik 2001; Hardie 2000; Ivantsoff & Crowley 1996; Raadik & Fairbrother 1999; Raadik & O'Connor 1996).
- Listing as a threatened species under Australian, NSW, Victorian and South Australian Government legislation.
- A review of conservation status, threats and recovery actions for Murray Hardyhead is included in *The Action Plan for Australian Freshwater Fishes* (Wager & Jackson 1993).
- Information on the Murray Hardyhead, including threats, protected status and management actions required for conservation of the species, is available in publications such as listing statements and threatened species brochures.
- Management plans prepared for some waters (eg. Cardross Lakes) where Murray Hardyheads occur.
- In Victoria, provisions for 'top-up' environmental flows are already being made for Cardross, Round and Woorinen North Lakes to dilute the increasingly saline water in these lakes, for conservation of the native fish fauna, especially Murray Hardyhead.

Recovery Objectives

The **overall objective** for recovery of the Murray Hardyhead is to minimise the probability of extinction of the Murray Hardyhead in the wild, and to increase the probability of important populations becoming self-sustaining in the long term.

Within the life span of this Recovery Plan, the **Specific Objectives** for recovery of the Murray Hardyhead are to:

1. Investigate and manage threats to populations and habitats.
2. Determine population persistence and trends.
3. Determine habitat preferences.
4. Investigate important life history attributes.

5. Establish and maintain the Murray Hardyhead in captivity.
6. Establish new populations of Murray Hardyhead in the wild.
7. Increase community awareness of Murray Hardyhead conservation.

Objective 1. Investigate and manage threats to populations and habitats.

Recovery Criterion:

At least two current wild populations are surviving and breeding after five years.

Action 1.1 Identify current/potential threats for all extant populations, including changing water management regimes, salinity levels, presence and impact of acid sulphate soils, and impact of introduced species.

Threat assessments need to be undertaken for all extant populations of Murray Hardyheads. The recent losses of perhaps four populations since 2000, and the impending loss of most of the remaining populations, makes this process imperative. The work will involve collating recent water and habitat quality data, collecting and analysing new water and soil samples, and undertaking surveys for threat assessments. Threat identification is a necessary first step to subsequent management and control.

Responsibility: DSE, DEH, SARDI

Action 1.2 Supply environmental water to Round and Woorinen North Lakes annually as required to maintain water quality conditions to ensure long-term sustainability of populations.

Woorinen North Lake and Round Lake are key sites for conservation of Murray Hardyhead, and require a top-up environmental water allocation periodically to maintain suitable water quality conditions for the species. These fresh water top-ups will be continued as required, based on monitoring of water quality conditions and fish populations there, and management requirements in any relevant management plans for the lakes.

Responsibility: GWW, DSE

Action 1.3 Supply environmental water to Cardross Lakes for at least one season to ensure short-term persistence of the population there.

Water level is dropping to critically low levels in one basin in Cardross Lakes where Murray Hardyhead occurs, and some of the environmental water allocation will be used to maintain the population for at least another summer. Part of this population will be taken into captivity to provide some insurance in the event that the environmental water allocation is insufficient to maintain suitable habitat conditions and the wild population is lost. Some fish from this population will be taken into captivity (see Objective 5) in the event that the population is ultimately lost.

Responsibility: DSE, GMW

Action 1.4 Develop and implement water quality and habitat monitoring programs at Cardross, Hawthorn, Round and Woorinen North Lakes.

Environmental water allocations will be made for Cardross, Round and Woorinen North Lakes, and it is important to monitor water quality and habitat to determine if the added water is benefiting the Murray Hardyhead. This will provide important information for future management of the sites. While no environmental water will be available for Lake Hawthorn, it is also important to monitor conditions over the coming summer as an adjunct to monitoring the fate of the hardyhead population there.

Responsibility: MCMA, DPI, GMW, DSE

Action 1.5 Investigate reasons for the recent extinction of Murray Hardyhead in Lake Elizabeth.

Until very recently, Lake Elizabeth held a large population of Murray Hardyheads. However, the species has not been detected in the lake since 2004, and is now presumed extinct there. Precise causes of decline/extinction are not clear, as there is still a considerable amount of water in the lake. Causes need to be identified and a remediation plan prepared and implemented as the site could be a vital reintroduction site (see Objective 6) to establish new populations to safeguard against extinction.

Responsibility: DSE

Action 1.6 Undertake a cost-benefit analysis of maintaining or restoring habitat conditions at five locations for Murray Hardyhead in Victoria.

The long-term strategy for Murray Hardyhead conservation is to have at least five sustainable populations at secure locations in Victoria. This will necessarily mean examining the feasibility, including costs/benefits, of restoring habitat conditions (including installation or upgrading of water supply infrastructure) and reintroduction to sites from which the species is now absent. None of the sites where the species occurs is maintained without cost, and the investigation needs to identify the costs of maintaining current sites as well as rehabilitation of previous sites or proposed new translocation sites.

Responsibility: DSE

Objective 2. Determine population persistence and trends.

Recovery Criterion:

All remaining populations monitored at least annually to determine area, extent, size, structure, estimation of population change and habitat quality.

Action 2.1 Undertake a genetic assessment of population structure throughout range to determine presence and limits of Evolutionarily Significant Limits.

Preliminary evidence indicates some genetic differentiation among populations, although whether this is an artefact of the isolation caused by changed flooding and water management regimes is not known. Determination of species identification and population structure will be important in accurately determining the distribution of Murray Hardyhead and determining appropriate units for management such as translocations. As the similarity in appearance of Murray and Unspecked Hardyheads has led to some confusion in the accurate identification of populations, genetic assessment will also be important in determining species limits.

Responsibility: DSE, SARDI

Action 2.2 Develop and implement population monitoring programs at Cardross, Hawthorn, Round and Woorinen North Lakes to determine population trends and responses against recovery actions, especially environmental water allocations to maintain water quality.

Environmental water allocations are being made to three lakes in Victoria where the species currently occurs. However, the response of populations to these initiatives is generally not known. This action aims to commence long-term monitoring to determine population and species trends, especially where management actions are occurring. Ongoing monitoring needs to be undertaken to obtain data to gain an understanding of population distribution and changes, and will gather data to determine area, extent, size and structure of populations, estimation of population change and habitat quality. The results will be used to gain an indication of the impact of environmental management programs on Murray Hardyhead and to provide information to enhance programs where appropriate.

Responsibility: DSE, MCMA, FRC

Action 2.3 Survey all current populations in South Australia at least once annually to determine presence and persistence.

South Australia currently constitutes the stronghold of the Murray Hardyhead, although deteriorating water quality conditions mean the likely extinction of most, if not all, populations in that State. Therefore, it is imperative to survey all current populations at least once per year to determine persistence.

Responsibility: SARDI

Objective 3. Determine habitat preferences.

Recovery Criterion:

Habitat features and preferences identified and incorporated into relevant management processes.

Action 3.1 Survey known habitat, collect habitat and environmental information and determine habitat preferences for lake and riverine dwelling populations.

As the Murray Hardyhead is found in both lakes and rivers, it is likely to occur in areas with different habitat characteristics. This action aims to identify those characters that could provide important habitat, especially breeding habitat. This information is important for subsequent use in environmental restoration programs such as provision of environmental water allocations and riparian revegetation projects, and needs to be provided to land/water managers in a form that can easily be integrated into relevant management processes such as site management plans.

Responsibility: DSE, SARDI

Action 3.2 Prepare management plans for Round and Woorinen North Lakes incorporating habitat requirements for Murray Hardyhead.

Round Lake and Woorinen North Lake are vitally important sites for the long-term survival of the Murray Hardyhead, and are receiving environmental water allocations to maintain habitat conditions for the Murray Hardyhead. However, management arrangements need to be formalised in a written management plan prepared for each lake, incorporating current uses as well as Murray Hardyhead conservation requirements.

Responsibility: DSE, NCCMA, GMW

Objective 4. Investigate important life history attributes.

Recovery Criterion:

Key life history attributes are identified and information incorporated into site management for population and habitat protection.

Action 4.1 Evaluate current reproductive status, fecundity, recruitment levels and longevity.

Key biological information on the Murray Hardyhead, such as breeding biology and recruitment, age and structure of populations is either rudimentary, inferred from other similar species, or lacking. Obtaining this information is key to determining population trends and ultimately sustainability of populations, and will be important in determining management responses for the conservation of the species. The research should be carried out on both riverine and lake-dwelling populations.

Responsibility: DSE

Action 4.2 Determine stimuli for reproduction/spawning.

Precise requirements for spawning of Murray Hardyhead are not known, although the species apparently does not need flooding, unlike some other Murray-Darling fish species. Determining the spawning requirements is necessary to ensure suitable conditions are available (or can be

created) in lakes supporting isolated populations, and especially at reintroduction sites, to maximise chances of successful population establishment and recruitment. This will also assist managing existing populations to maximise successful recruitment. The project should cover both lake and riverine populations, to ensure the full range of environmental conditions likely to trigger spawning are covered.

Responsibility: DSE, FRC

Action 4.3 Investigate salinity tolerance at critical life history stages.

While the Murray Hardyhead can tolerate conditions ranging from low to quite high salinity, adults may be relatively salt-tolerant but the early life stages, particular eggs and fry, may be more sensitive to high salinity levels. Tolerance levels need to be determined to be able to develop management recommendations for managing salinity levels in isolated waterbodies where the species occurs. The action will involve laboratory-based studies of eggs, larvae and juveniles to determine salinity tolerances as the basis for preparing relevant management recommendations.

Responsibility: DSE

Objective 5. Establish and maintain the Murray Hardyhead in captivity.

Recovery Criterion:

A captive population of at least 100 adult fish is established and successfully breeding, and resulting offspring raised through to adults.

Action 5.1 Establish a facility in Victoria to maintain and breed the Murray Hardyhead in captivity.

With the likely impending extinction of the Murray Hardyhead population in Lake Hawthorn and the probable loss of the Cardross population in the next few years, a captive facility will be established to hold fish salvaged from both populations and eventually breed these for reintroduction. The captive facility will be established at the Murray Darling Freshwater Research Centre Lower Basin Laboratory at Mildura, with capacity to hold at least 100 adult fish in breeding tanks and several thousand larval/juvenile fish in larger raising tanks. Holding facilities will comprise replicate, isolated units for maintaining genetic integrity of separate stocks of fish, and for hygiene and disease control. The facility will be established in an enclosed, temperature and light-controlled building, and experienced care will be provided seven days per week.

Responsibility: M&NCCMAs, FRC, DSE

Action 5.2 Take at least 50 fish from Cardross Lakes and 50 fish from Lake Hawthorn to establish the captive population.

When suitable facilities are established, at least 50 fish from Cardross Lakes and 50 fish from Lake Hawthorn (the two most at risk populations in Victoria) will be collected as the founders for the captive population. If lake conditions deteriorate quickly, more adults will be taken into captivity. If breeding occurs in the lakes, then subsequent capture will be delayed until juveniles (which have potentially much longer longevity than adults) enter the wild population, and these will be captured in early 2008.

Responsibility: FRC

Once suitable captive facilities are established, at least 50 fish from Cardross Lakes and 50 fish from Lake Hawthorn will be collected as the founders for the captive population, to ensure that at least 90% of the source population genetic variability is represented in the founders. Adults and any subsequent juveniles from both populations will be maintained in separate facilities to prevent mixing of stocks.

Responsibility: FRC

Action 5.3 Maintain fish for first year and attempt to breed in captivity.

The Murray Hardyhead is only a short-lived species, with most adults having only a single breeding season before dying. Maintaining sufficient numbers in captivity over several generations to preserve founder genetic variability and for eventual translocation to the wild presents some unique challenges. Breeding in captivity will be essential to maintaining a captive population for several years or until suitable translocation sites are available (Objective 6). Collected fish will need to be maintained until at least late 2008, with feeding, health and reproductive condition monitoring, and preparing suitable facilities for breeding and raising fish.

Responsibility: FRC

Action 5.4 If breeding is successful, attempt to raise young through to adults.

If the species does reproduce successfully in captivity in late 2008, then suitable facilities will need to be in place to hold potentially large numbers of larval fish and ongrow these to juveniles and adults. This will be a challenging situation, especially providing suitable food for the tiny, newly hatched larvae. This will essentially extend the captive management component of the recovery program well into a second year.

Responsibility: FRC

Action 5.5 Investigate the feasibility of establishing a captive population in South Australia.

Murray Hardyhead populations still surviving in South Australia are the most abundant and genetically diverse, but potentially could all be lost if current dry conditions continue into 2008. Establishing a captive population from some of these fish would attempt to preserve some of the genetic variability to be represented in Victorian populations.

Responsibility: DEH, SARDI

Objective 6. Establish new populations of Murray Hardyhead in the wild.

Recovery Criterion:

At least one new population is established at a secure location in the wild.

Action 6.1 Evaluate and select suitable translocation sites that are ecologically and biologically suitable, have security of tenure, are managed appropriately and have stakeholder support.

The Murray Hardyhead has disappeared from several locations within its former range in recent years, including several lakes, for reasons including rising salinity and water bodies drying out. Reduced flooding means that chances of natural recolonisation are extremely low. However, isolated waterbodies offer the opportunity for reintroduction, where threats are known and controlled. Also, the creation of new habitats through wetland rehabilitation within the range of the species also offers potential translocation sites. These need to be investigated to ensure suitable habitat is available and threats are controlled or have ceased. Consultation with local stakeholder (eg. land owners/managers, CMA, water authority, Landcare group etc.) would also be required to gain their support for the proposal.

Responsibility: DSE

Action 6.2 Prepare and implement site management plan (if none available) to ensure site is suitable for establishment of new population.

Once a suitable site has been selected, there may be some further site preparation required, such as negotiating or obtaining a water allocation to manage salinity levels within appropriate limits, managing water levels, protecting habitat, sampling for acid sulphate soils etc. These

issues need addressing prior to any release of fish. Once site selection and management are complete, the translocation plan can then be implemented.

Responsibility: DSE

Action 6.3 Prepare and implement translocation plan taking account of national and State policies and guidelines for translocation of aquatic organisms.

If a reintroduction is contemplated, a translocation plan needs to be prepared, specifying information such as source population, number of fish to be translocated, when and how many releases there will be, monitoring protocol and defining evaluation criteria. The plan needs to comply with the 'National Policy for the Translocation of Live Aquatic Organisms' (Ministerial Council on Forestry, Fisheries and Agriculture MCFFA 1999), plus any relevant State requirements (eg. DPI 2003), including appropriate permits.

Responsibility: DSE

Action 6.4 Maintain and monitor translocated populations.

Once the reintroduction occurs, there will be an ongoing requirement to monitor the outcome, and perhaps maintain habitat requirements within specified levels (eg. salinity levels through water management). The monitoring protocol needs to be sufficient to detect survival and dispersal of released fish, reproduction and recruitment to the adult population.

Responsibility: DSE

Objective 7. Increase community awareness of Murray Hardyhead conservation.

Recovery Criterion:

Knowledge of Murray Hardyhead increases with managers and the public, and conservation requirements included in NRM plans and projects.

Action 7.1 Publicise results of Murray Hardyhead investigations and incorporate into catchment management, river health and wetlands programs where appropriate.

Publishing research and other information on Murray Hardyhead and conservation efforts is an important aspect of the recovery program. This information needs to be made available not only in scientific journals, but also in more accessible forms such as technical reports for land/water managers to be able to adapt and use the information. Relevant information could also be published in the popular literature such as magazines and media articles, to keep the community informed and build support for Murray Hardyhead conservation and management.

Responsibility: DSE, FRC, CMAs, DEH

Action 7.2 Promote community awareness of and identify opportunities for involvement in the conservation of the Murray Hardyhead.

Community support for Murray Hardyhead conservation, especially from landowners and managers adjacent to waters where the species occurs, is important in ensuring the successful outcome of conservation efforts. Opportunities for promoting conservation of the species include field days demonstrating wetland protection and rehabilitation, information brochures and assistance in field surveys for the species.

Responsibility: M&NCCMAs, DSE, DEH

Abbreviations: DEH = Dept. for Environment & Heritage (SA); DPI = Dept. of Primary Industries (Vic); DSE = Dept of Sustainability and Environment (Vic); FRC = Murray Darling Freshwater Research Centre Lower Basin Laboratory, Mildura; GMW = Goulburn-Murray Water; MCMA = Mallee Catchment

Management Authority; NCCMA = North Central Catchment Management Authority; SARDI = Sth
Australian Research & Development Institute

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Priority, Feasibility and Estimated Costs of Recovery Actions

Action	Description	Priority	Responsibility	Feasibility	Cost estimate					Total
					Year 1	Year 2	Year 3	Year 4	Year 5	
1	Threat management									
1.1	Threat identification	1	DSE, DEH, SARDI	100%	\$25,000	\$25,000	\$25,000	\$0	\$0	\$75,000
1.2	Environmental water supply	1	GMW, DSE	100%	\$50,000	\$50,000	\$50,000	\$50,000	\$50,000	\$250,000
1.3	Emergency water supply	1	DSE, GMW	100%	\$50,000	\$50,000	\$50,000	\$50,000	\$50,000	\$250,000
1.4	Water quality, habitat monitoring	1	DSE, GMW, DPI, MCMA	100%	\$250,000	\$100,000	\$0	\$0	\$0	\$350,000
1.5	Lake Elizabeth extinction	2	DSE	50%	\$0	\$30,000	\$0	\$0	\$0	\$30,000
1.6	Cost-benefit analysis	2	DSE	100%	\$0	\$50,000	\$50,000	\$0	\$0	\$100,000
2	Population trends									
2.1	Genetic assessment	2	DSE	75%	\$0	\$10,000	\$10,000	\$0	\$0	\$20,000
2.2	Population monitoring	1	DSE, MCMA, FRC	75%	\$75,000	\$75,000	\$75,000	\$75,000	\$75,000	\$375,000
2.3	Population survey	1	SARDI	75%	\$25,000	\$25,000	\$25,000	\$25,000	\$25,000	\$125,000
3	Habitat preferences									
3.1	Habitat surveys	1	DSE, SARDI	100%	\$0	\$25,000	\$25,000	\$25,000	\$0	\$75,000
3.2	Management plans	1	DSE, NCCMA, GMW	100%	\$0	\$10,000	\$0	\$0	\$0	\$10,000
4	Life history attributes									
4.1	Reproduction, recruitment	1	DSE	100%	\$30,000	\$30,000	\$30,000	\$0	\$0	\$90,000
4.2	Spawning stimuli	1	DSE, FRC	100%	\$0	\$0	\$30,000	\$30,000	\$0	\$60,000
4.3	Salinity tolerance	1	DSE	100%	\$0	\$0	\$20,000	\$20,000	\$20,000	\$60,000
5	Captive management									
5.1	Captive facility establishment	1	DSE, M&NCCMAs, FRC	100%	\$50,000	\$0	\$0	\$0	\$0	\$50,000
5.2	Fish capture	1	FRC	75%	\$20,000	\$0	\$0	\$0	\$0	\$20,000
5.3	Fish maintenance and breeding	1	FRC	75%	\$95,000	\$0	\$0	\$0	\$0	\$95,000
5.4	Ongrowing larvae	1	FRC	50%	\$0	\$95,000	\$95,000	\$95,000	\$95,000	\$380,000
5.5	Captive management in SA	1	DEH, SARDI	75%	\$10,000	\$0	\$0	\$0	\$0	\$10,000
6	Reintroductions									
6.1	Select, evaluate sites	1	DSE	75%	\$35,000	\$35,000	\$0	\$0	\$0	\$70,000
6.2	Site preparation	1	DSE	75%	\$0	\$0	\$50,000	\$100,000	\$100,000	\$250,000
6.3	Translocation plan	1	DSE	75%	\$0	\$0	\$10,000	\$5,000	\$0	\$15,000
6.4	Translocation and monitoring	1	DSE	75%	\$0	\$0	\$0	\$0	\$50,000	\$50,000
7	Information and awareness									
7.1	Information provision	1	DSE, FRC, M&NCCMAs	100%	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$10,000
7.2	Awareness, participation	1	M&NCCMAs, DSE, DEH	50%	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$10,000
Totals					\$719,000	\$614,000	\$549,000	\$479,000	\$469,000	\$2,830,000

