NSW GOVERNMENT | Department of Primary Industries

Recreational fishing for Murray Crayfish *(Euastacus armatus)*

Species Impact Statement

Recreational fishing for Murray Crayfish *(Euastacus armatus)* – Species Impact Statement

Published by the NSW Department of Primary Industries, a part of the Department of Trade and Investment

Aquaculture, Conservation and Marine Parks

First published April 2014

ISBN 978 1 74256 603 0

More information and updates to this publication, check www.dpi.nsw.gov.au/ fisheries

Acknowledgments: The primary authors of this document, Emily Messer and John Pursey, are grateful for the assistance of a number of DPI staff, in particular Dean Gilligan, Martin Asmus, Peter Tilbrook, Cameron Westerway and Lee Baumgartner.

Murray crayfish cover image: Prue McGuffie

INT13/76292

Jobtrack 12750

Executive Summary

Proposed Ministerial Order

The Fisheries Scientific Committee added *Euastacus armatus* (Murray crayfish) to the vulnerable species list under the *Fisheries Management Act 1994* (FMA) in 2013. This means Murray crayfish is fully protected as a threatened species.

There is currently an Interim Order allowing the continuation of recreational fishing for Murray crayfish to reduce the social and economic impacts pending the development of this Species Impact Statement (SIS) and the making of a permanent Order.

The Minister for the Department of Primary Industries proposes to make a permanent Order under section 221IA of the FMA, to permit recreational fishing activities targeting the vulnerable species Murray crayfish. If the proposed Order is permitted it will be subject to applicable fishing regulations and should result in minimal social and economic impacts.

The Ministerial order will replace the Interim Order discussed previously.

This document is the SIS that has been prepared to assess the impact of the proposed Ministerial Order to permit recreational fishing for Murray crayfish in areas currently open for fishing.

Legal status of Murray crayfish

Murray crayfish are now listed under the NSW *Fisheries Management Act 1994* as a vulnerable species. In Victoria under the *Flora and Fauna Guarantee Act 1988* they are listed as threatened. In South Australia the Murray crayfish are listed as protected under the *Fisheries Act 1982.* Under the *Nature Conservation Act 1980* they have a listing as vulnerable in the Australian Capital Territory. Nationally the status of Murray crayfish is Indeterminate *Threatened* and internationally the species is classified as vulnerable.

Why is Murray crayfish threatened?

Murray crayfish once existed throughout the Murray and Murrumbidgee rivers, and many of their tributaries. Murray crayfish have totally disappeared from some parts of their natural range, particularly in the Murray River downstream of Mildura, and are often very rare or absent in many other areas where they were once abundant.

Murray crayfish is a large, long lived and low fecundity species. Their life history characteristics make Murray crayfish slow to recover from decline and compound the effects of threatening processes. There are a number of processes which may threaten the survival of Murray crayfish and impact their populations in NSW waterways. These include:

- Removal of woody debris (de-snagging) in rivers and streams
- Thermal pollution from dams
- River regulation (installation and operation of structures that alter natural flow regimes)
- Water quality decline
- Degradation/ loss of habitat
- Recreational fishing activities

Purpose of the Species Impact Statement

The object of this SIS is to assess the potential impact of the proposed Ministerial Order on Murray crayfish. The findings of the SIS, together with advice from the Fisheries Scientific Committee (FSC), other relevant advisory councils and public submissions must be taken into account by the Minister before an Order is made.

During the preparation of the SIS the Minister must provide the public with an opportunity to make written submissions regarding the Order. Prior to making the Order a copy of the proposed Order must be provided to the FSC and other relevant advisory councils for their advice. The Aboriginal Fishing Advisory Council and the Advisory Council of Recreational Fishing are the relevant advisory councils for the purposes of this specific Order. A copy of the finalised SIS will also be provided to these advisory councils.

Subject to the outcomes of this SIS, a Ministerial Order may be implemented to continue recreational fishing under the current regulations.

Species Impact Statement's findings in regard to recreational fishing

There is very limited data available on recreational fishing catch rates for Murray crayfish in Australia and specifically NSW. Accurate estimates of recreational catch are needed to fully assess the potential impact that continued recreational fishing in NSW has on Murray crayfish populations.

Despite closures of the commercial fishery and recreational fishery in ACT, SA and VIC there has been no significant recovery of the species in these regions, and population declines have continued in NSW in both closed and open fishing areas. The cause(s) of these declines have not been objectively determined.

The role of recreational fishing in the decline and/or prevention of recovery of Murray crayfish populations is unclear. Several life history characteristics, such as slow growth, late maturity, low fecundity and limited dispersal capability make Murray crayfish vulnerable to over-exploitation and slow to recover from decline. From an ecological perspective, continued removal of mature adults is likely to have some negative impact on population numbers. This concern is offset by recent changes to fishing regulations which reduced allowable take and possession of Murray crayfish in terms of size, number, season and area permitted to be fished.

There is a recognised social value in the Murray crayfish recreational fishery, and this factor has strongly influenced the recommendation of this SIS to continue the fishery in its current form, while undertaking further research on the impact of recreational fishing. There is also a relatively small economic value in the fishery, largely related to transport, camping and fishing gear expenditure.

Further monitoring and assessment of the species status, and relevant fishing regulations is recommended if the Ministerial Order is implemented.

Conclusions of the Species Impact Statement

With limited scientific evidence on the direct impact of recreational fishing, and recognising the important social value of the fishery, **this SIS recommends the proposed Ministerial Order be made to permit the continuation of the Murray crayfish recreational fishery under the applicable regulatory controls**, provided a comprehensive and scientifically rigorous program is implemented to assess the impact of recreational fishing activity and the status of the Murray crayfish population. The fishery regulations must be reviewed at five year intervals and modifications made in light of information from the research and monitoring program to ensure that efforts to rebuild Murray crayfish stocks are successful and Murray crayfish are conserved for future generations. The SIS also recommends the implementation of a targeted angler education program to educate fishers about concerns for Murray crayfish populations and encourage strict compliance with regulations, and maintenance of a strong enforcement program to ensure high levels of compliance with regulations relating to Murray crayfish.

Your views are important!

NSW DPI is interested in your comments on the conclusions of this SIS and on the proposed Order to permit recreational fishing for Murray crayfish in specified areas.

A copy of the SIS and proposed Ministerial Order are available on the internet at www.dpi.nsw.gov.au/fisheries. For further information or to receive a copy of the proposed order and SIS please call (02) 4916 3811

You can make a written submission to express your views. Please send your submission to:

Murray crayfish Order

C/- Fisheries NSW

Locked Bay 1

NELSON BAY NSW 2315

You can also make your submission via email to:

Fisheries.Threatenedspecies@dpi.nsw.gov.au

If you wish your submission to remain confidential please mark your response accordingly.

Table of Contents

Figures

Tables

1 Introduction

1.1 Background

This Species Impact Statement (SIS) has been prepared to assess the impact of continued recreational fishing in NSW for Murray crayfish subject to the current regulations.

Murray crayfish (*Euastacus armatus)* is a native freshwater species endemic to the Murray- Darling Basin. It is the world's second largest freshwater crayfish. Adults are easily identified by their spiny dark green/brown abdomens and large white claws. Younger crayfish look similar but have yellowish claws.

They were once widespread throughout the Murray and Murrumbidgee River systems, as well as small populations in the upper Lachlan and Macquarie River catchments (although some or all of these northern populations may be the result of unauthorised translocation). Declines in range and distribution have been noted since the early 1950's. Murray crayfish are now considered rare in the lowland reaches of the Murray and Murrumbidgee Rivers and have disappeared entirely downstream of Mildura (McCarthy 2005).

Murray crayfish were traditionally a food source for indigenous Australians (section 9.4). They supported a commercial fishery which peaked at 15 tonnes per year in 1955 and 1975 and closed in 1987 (see section 5.1). Murray crayfish are a highly desirable species for recreational fishers because of their large size (up to 3kg).

In NSW concerns about recent rapid decline of Murray crayfish led to the species being declared as vulnerable by the Fisheries Scientific Committee in 2013 (appendix 6). An Interim order has been in place since the listing to permit the continuation of recreational fishing while the assessment of the proposed permanent Ministerial Order is undertaken.

1.2 Proposed Ministerial Order

Being listed as vulnerable under the *Fisheries Management Act 1994* (FMA) gives Murray crayfish the status and protection of a threatened species. Therefore harming, taking, interfering with or possessing the species within NSW is an offence under the FMA. However the FMA (s.221IA) allows the Minister to make an Order authorising an act (recreational fishing) that may result in harm to this threatened species. This provision is intended to minimise adverse social and economic impacts resulting from a threatened species listing. Before a Ministerial Order can be made an SIS must be prepared to assess the impact of the proposed Order and advice must be sought from the FSC and any relevant advisory council in relation to the proposed Order. For the purposes of this SIS, the relevant advisory councils are the Advisory Council of Recreational Fishing (ACoRF) and the Aboriginal Fishing Advisory Council (AFAC).

The proposed Ministerial Order authorises recreational fishers to carry out fishing for Murray crayfish in certain waters in NSW. The proposal would be subject to the current regulations and would apply to all recreational fishers in NSW regardless of their state of residence.

A copy of the proposed Order is attached at Appendix 1. Copies of the advice received from the FSC and advisory councils are attached at Appendix 2.

There is currently an Interim Order allowing the continuation of recreational fishing for Murray crayfish, pending the making of a permanent Order.

1.3 Content and form of a Species Impact Statement

The requirements of a SIS have been specified in section 221J and 221K of the FMA. The specified contents are as follows:

- a full description of the actions proposed including its nature, extent, location, timing and layout,
- a general description of the threatened species or populations known or likely to be present in the area that is the subject of the action and in any area that is likely to be affected by the action,
- a full assessment of the likely effect of the action on those species and populations including, if possible, the quantitative effect of local populations in the cumulative effect in the region,
- a description of any feasible alternatives to the action that are likely to be of lesser effect and the reasons justifying the carrying out of the action in the manner proposed, having regard to the biophysical, economic and social considerations and the principles of ecologically sustainable development,
- a full description and justification of the measures proposed to mitigate any adverse effect of the action on the species and populations, including a compilation (in a single section of the statement) of those measures,
- a list of any approvals that must be obtained under any other Act or law before the action may be lawfully carried out, including details of the conditions of any existing approvals that are relevant to the species or population.

Matters which have been limited or modified are specified in the Director General's requirements. The limited/or modified requirements as listed by the Director General are listed below

- This SIS is limited to assessing the potential impacts arising from a Ministerial Order authorising the lawful taking of Murray crayfish under current management arrangements. The SIS is not required to assess the impact of recreational fishing outside areas open to fishing, or the general impacts that fishing for Murray crayfish has on other species.
- The SIS does not address effects on the Lower Murray Endangered Ecological Community, as these impacts have been assessed previously in another Species Impact Statement - Fishing in the Lower Murray River Catchment- May 2002, and authorised by the *Fisheries Management Order (Continuation of Activities in Lower Murray River Catchment) 2002.*
- The SIS is not required to address any critical habitat, as under the FMA there is no critical habitat declared for the Murray crayfish, or any other species in the waters affected by the proposal.

A copy of the Director General's requirements is attached at Appendix 3.

1.4 Scope of the Species Impact Statement

This SIS is limited to assessing the potential impacts of recreational fishing under the current regulations on the vulnerable species Murray crayfish. Subject to the outcomes of this SIS, the proposed Ministerial Order may be implemented to continue recreational fishing under the current regulations.

2 Description of the proposed activity

2.1 Persons, activity and limits of the Ministerial Order

The proposed activity is to permit via Ministerial Order, recreational fishers to carry out an activity (recreational fishing) that may result in harm to a threatened species. The persons, activity and limits to which the proposed Order applies are set out below.

Persons- recreational fishers, being those people who have proof of payment of a recreational fishing fee, or are otherwise exempt are authorised to fish for Murray crayfish.

Activity- recreational fishing: meaning to take and possess Murray crayfish from specified bodies of water open to fishing for Murray crayfish in NSW, for any reason other than for sale, subject to the current regulations.

Current fishing regulations- the current fishing regulations relating to Murray crayfish were implemented in April 2013 via a notice under Section 8 of the FMA (see Appendix 4). These regulations are:

- minimum size limit of 10cm (occipital-carapace length),
- maximum size limit of 12cm (occipital-carapace length),
- no taking or harming of berried females,
- bag and possession limits (2 and 4 respectively),
- fishing permitted only in open season: from June 1 to August 31,
- 5 hoop nets per person,
- when using a hoop net the letters “HN” ,the users name and address must be clearly marked on the float, and
- removal of head, tail or claws in, on or adjacent to the waters is prohibited

Specified areas- as well as the above requirements, the Section 8 notification prohibits the take of Murray crayfish at any time from all waters except (also see Figure 1):

- Murrumbidgee River: from the Hume Highway road bridge at Gundagai downstream to 100m upstream of the weir face of Berembed Weir near Ganmain, excluding Old Mans Creek.
- Murray River: from 130m below the weir face at Hume Weir near Albury downstream to the Newell Highway road bridge at Tocumwal.

In this SIS “current regulations” refers to the activity and limits described above.

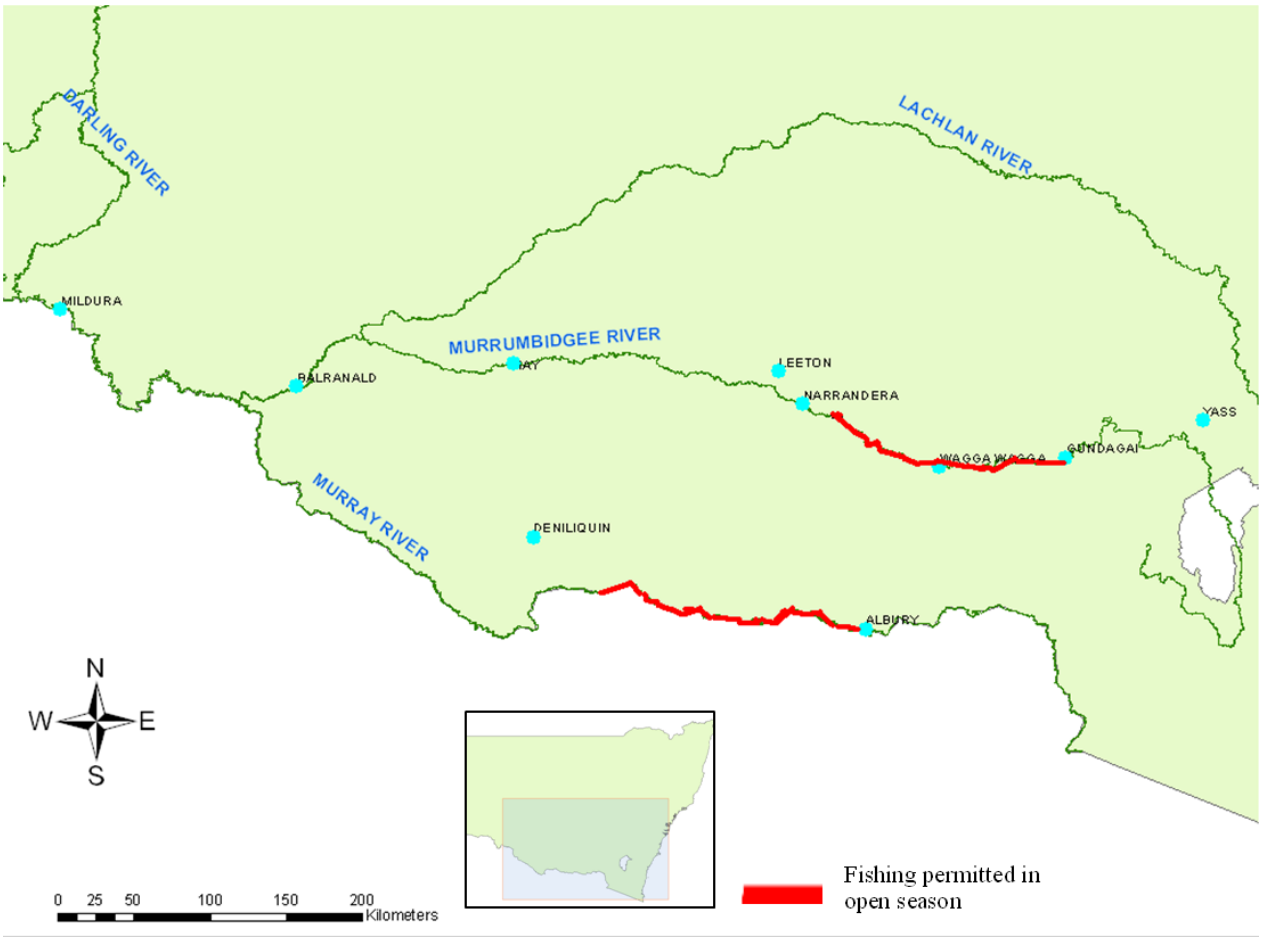

Figure 1. Areas in NSW open to fishing for Murray crayfish during June – August inclusive.

2.2 Recreational fishing methods

The most common method used by recreational fishers is hoop nets which are specifically designed to catch crayfish. The nets are constructed from mesh attached to no more then 2 hoops that form a basket shaped net that is open at the top when suspended (Figure 2). The nets are baited and set on the bottom of a river for a period of time before being lifted by a rope attached to the top hoop. Murray crayfish which are feeding on the bait are trapped as the net is lifted. 5 hoop nets may be used at any one time; all nets must be labelled appropriately.

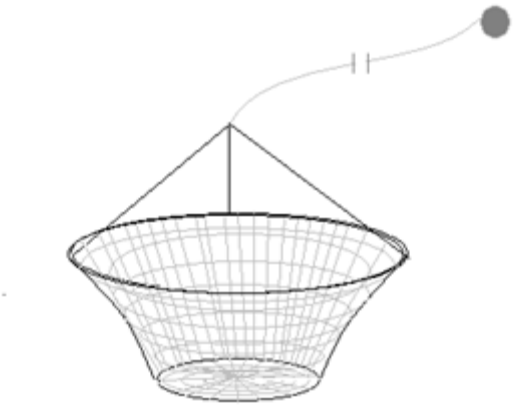

Figure 2. Basic configuration of a hoop net

2.3 Fishing regulations

Fishing regulations are ideally based on specific biological information such as sexual maturity and fecundity; information that drives the applicability of the regulation (see section 5.2). The proposed Ministerial Order for Murray crayfish will require fishers to comply with the most current fishing regulations. These regulations are periodically reviewed and amended, any changes in regulation that are made in relation to Murray crayfish will apply to the Order. All changes are driven by scientific research and aim to sustain Murray crayfish stocks for future generations.

3 Conservation status of Murray crayfish

3.1 Information source

Unless otherwise cited, the information contained in this section is drawn from the publication *Scoping knowledge requirements for Murray crayfish (*Euastacus armatus*)*, Gilligan *et. al.* 2007 available at: http://www.dpi.nsw.gov.au/research/areas/aquatic-ecosystems/outputs/2007/784.

3.2 Legal status

Murray crayfish's high social value and life characteristics combined with other threats makes them vulnerable to decline and slow to recover. This subsequent decline has generated concern about the conservation status of this species and has led to listings as a threatened species by all relevant Australian states (Table 1).

Table 1. Current conservation listings for Murray crayfish in Australia

STATE	STATUS	LEGISLATION
New South Wales	Vulnerable	*Fisheries Management Act 1994*
Victoria	Threatened	*Flora and Fauna Guarantee Act 1988*
South Australia	Protected	*Fisheries Act 1982*
Australian Capital Territory	Vulnerable	*Nature Conservation Act 1980*
Nationally	Threatened	*Environment Protection and Biodiversity Conservation Act 1999*
Internationally	Vulnerable	*ICUN Red List of Threatened Species 2010*

3.3 Distribution of Murray crayfish

Murray crayfish were once widespread throughout the Murray and Murrumbidgee River systems, from South Australia through Victoria, New South Wales and the ACT. Small populations also exist in the upper Lachlan and Macquarie River catchments with records as far north as Kandos and Dunns Swamp (upper Macquarie River catchment) although some or all of these northern populations may be the result of unauthorised translocation. The historical distribution encompassed approximately 12,500km of waterways and up to 700m altitude (fig. 3).

Murray crayfish are now rare in the Edward, Wakool and Niemur rivers in NSW, locally absent from the Murrumbidgee River downstream of Hay and completely absent in the Murray River catchment downstream of Mildura (Appendix 6 & section 4.4). Populations are still present in the Cudgegong River and Abercrombie River.

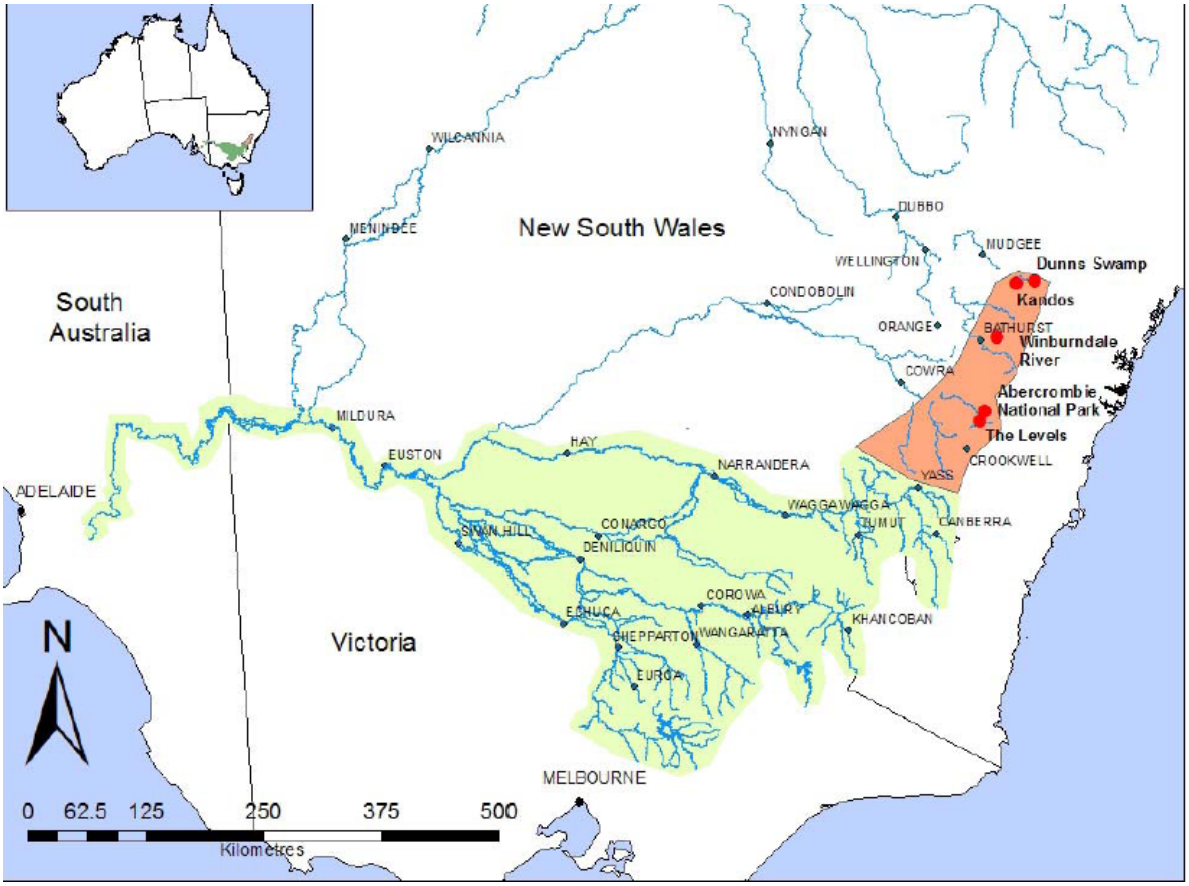

*Figure 3. Historical distribution of Murray crayfish, with the potential extension of the natural range (coloured orange). Image taken from Scoping the knowledge requirements for Murray crayfish (*Euastacus armatus*)* (Gilligan *et. al.* 2007*)*

4 Description of Murray crayfish

4.1 Species description, biology and behaviour

Kingdom: Animalia

Phylum: Arthropoda

Class: Malacostraca

Order: Decapoda

Family: Parastacidea

Genus: *Euastacus*

Species: *armatus*

Murray crayfish is an iconic species in the Lower Murray-Darling Basin. This species is the 2nd largest freshwater crayfish in the world, identified by a dark green/brown spiny abdomen with large white claws. Juvenile crayfish have greenish/yellow coloured claws (McCarthy 2005). They are a slow growing and long lived species. Growth occurs through a series of moults: the frequency of moults is dependant on size. Up to 10 moults occur in the first year of growth, with annual moults common thereafter. On average Murray crayfish reach 200-300mm in length, with a 3kg crayfish the maximum documented (Geddes *et. al.* 1993, ACT Government 1999).

Females become sexually mature between 8 and 10 years of age. Males reach maturity faster at around 4 years. Mating begins in May each year after moulting is complete and is thought to be triggered by a rapid decline in water temperature (O'Connor 1986). Females breed once a year laying 150 eggs at sexual maturity and up to 2000 eggs when they reach maximum size, with low offspring survival (Asmus 1999, unpublished). Once the eggs are fertilized the female holds them under her tail for up to 6 months before they hatch. Once hatched the juveniles remain under the mothers' tail for another 4 weeks feeding on residual yolk in the egg sack. They moult twice before leaving their mother's protection (Clarke & Ascroft 2003).

Adult crayfish are opportunistic omnivores. They consume leaf litter, macro-invertebrates within detrital matter and decomposing carcasses (Nymstom 2002). Through this feeding process they shred and process large amounts of organic matter, whilst burrowing mobilises sediments. These actions are thought to increase the nutrient transformation rates in the immediate and surrounding environment (McCarthy 2005). Furthermore Murray crayfish is an important food resource for native fish such as trout cod, Murray cod and golden perch.

Murray crayfish have low dispersal abilities and occupy small home ranges. The core amount of activity is thought to occur in an approximate 370m² area (Ryan 2005). Social hierarchies exist within populations, where adults restrict the distribution of juvenile individuals to smaller, shallower streams. Scuba observations noted that adult crayfish inhabit deeper holes and juvenile crayfish shelter under rocks in shallow areas (O'Connor 1986).

Genetic and morphological diversity between crayfish from the Murray and Murrumbidgee river systems is not significantly different, suggesting continuous gene flow between populations.

4.2 Habitat Description

Murray crayfish prefer environments with high flow velocity and cool to cold water temperatures. This species is more active in the cooler months when cold flowing water maximises the dissolved oxygen in the water column allowing the crayfish to capitalise energy expenditure. This is done by a reduction in the beating rate of their scaphognathite (a thin leaf like appendage), which maintains water flow through the gill chamber (McCarthy 2005). Compared to other crayfish Murray crayfish have a high tolerance to environmental variables, although high water temperatures and salinity rates are still restricting factors (Geddes *et. al.* 1993).

Murray crayfish require habitats with shelter. Clay banks appropriate for burrowing are preferred. Burrows are usually less then one metre long with up to six entrances. Murray crayfish appear to spend most of summer in burrows, emerging occasionally to feed. They become more active in the winter when water temperatures drop. Burrows have been noted in both large and small streams ranging from sclerophyll forests to pasture lands, below altitudes of 700m. Murray crayfish will shelter in rock crevices, snags and other bank structures when the geomorphology of river banks is not favourable for burrowing.

4.3 Habitat status

Availability of suitable habitat may be a crucial aspect of a population's ability to recover. Recent assessments of biological and environmental conditions in the Murray-Darling Basin have found significant and widespread habitat degradation (Davies *et. al.* 2008). Murray crayfish habitat is under threat from modification through direct and indirect anthropogenic processes including siltation of riverbeds, reduced flow velocity, loss of aquatic plants, increased temperatures, introduction of weed species and a decrease in

dissolved oxygen. Many of these habitat modifications result from industry e.g. farming, forestry, urban development, and dams impacting on the river systems. These changes:

- Reduce burrowing capabilities
- Remove areas of shelter
- Alter water movements and temperature
- Decrease habitat availability
- Limit food availability/ increase competition for food

Natural events also affect crayfish habitat and cause declines in Murray crayfish numbers. Hypoxic black water events are a natural phenomenon which causes a depletion of oxygen levels in the water column. These events can be amplified by poor river management, and consequently result in fish and crustacean mortality. Zukowski *et. al.* (2012a) compared Murray crayfish numbers between unaffected and affected areas before and after a black water event. There were significantly less crayfish found in black water affected sites after the black water event, where crayfish numbers had increased slightly in unaffected areas.

4.4 Decline in Murray crayfish

There have been reported declines in range and distribution of Murray crayfish since early 1950's (Zukowski 2012). The absence of Murray crayfish downstream of Mildura is the most notable reduction in this species distribution. The 1,076 km reach (main channel and anabranches) represents about 8% of the species natural range.

Broader scale population declines have led to closures to 100% of commercial fishing and approximately 16% (1,941km) of waters previously open for recreational fishing (including regions in NSW, SA, ACT and VIC).

The FSC (Appendix 6) found little evidence of recovery in populations where recreational fishing has been closed for several years (see section 4.7). Murray crayfish's slow growth rates and low fecundity are likely to make recovery responses slow.

Monitoring conducted in the mid-Murrumbidgee River shows a major population decline in 2007-2008, with more than 90% reduction in catch per unit effort (CPUE) (Appendix 6). The limited data available for the Murray River suggests that this population did not suffer a similar collapse.

4.5 Current Murray crayfish abundance

Unless otherwise noted, the following is a summary of a Fisheries survey program provided by Fisheries research officers in the Murray and Murrumbidgee areas, especially Mr Martin Asmus, Project Officer for freshwater research.

Fisheries NSW conducted survey programs of Murray crayfish stocks in 2012 and 2013. Murray crayfish populations were sampled at 53 sites each year throughout the species former range in the Murrumbidgee and Murray River systems. At each site the total number of crayfish sampled using 100 hoop net lifts (20 nets x 5 rounds) and 10 munyana traps was recorded. Each 'site' covered approximately 2.5 river kilometres. The results of the 2013 survey are presented in Figure 4. Results for the 2012 survey were generally similar.

Twenty one (21) sites (42%) had a total absence of Murray crayfish. A further 7 sites had a relative abundance of less than 15 crayfish. Sites where crayfish were either absent or in very low abundance were generally in the downstream portion of the study area, but a number of sites in the upstream extent of the study area in the Murrumbidgee River system also showed a total absence of Murray crayfish. Anecdotally, Murray crayfish were

historically abundant across the entire range of this survey.

These data also explain why those areas where current regulations permit fishing for Murray crayfish were chosen: they have the highest relative abundance of Murray crayfish in the study area and hence are the most likely to be able to support fishing pressure. It should be noted however that areas with relatively high abundance are still considered to have only a small proportion of pre-European Murray crayfish populations.

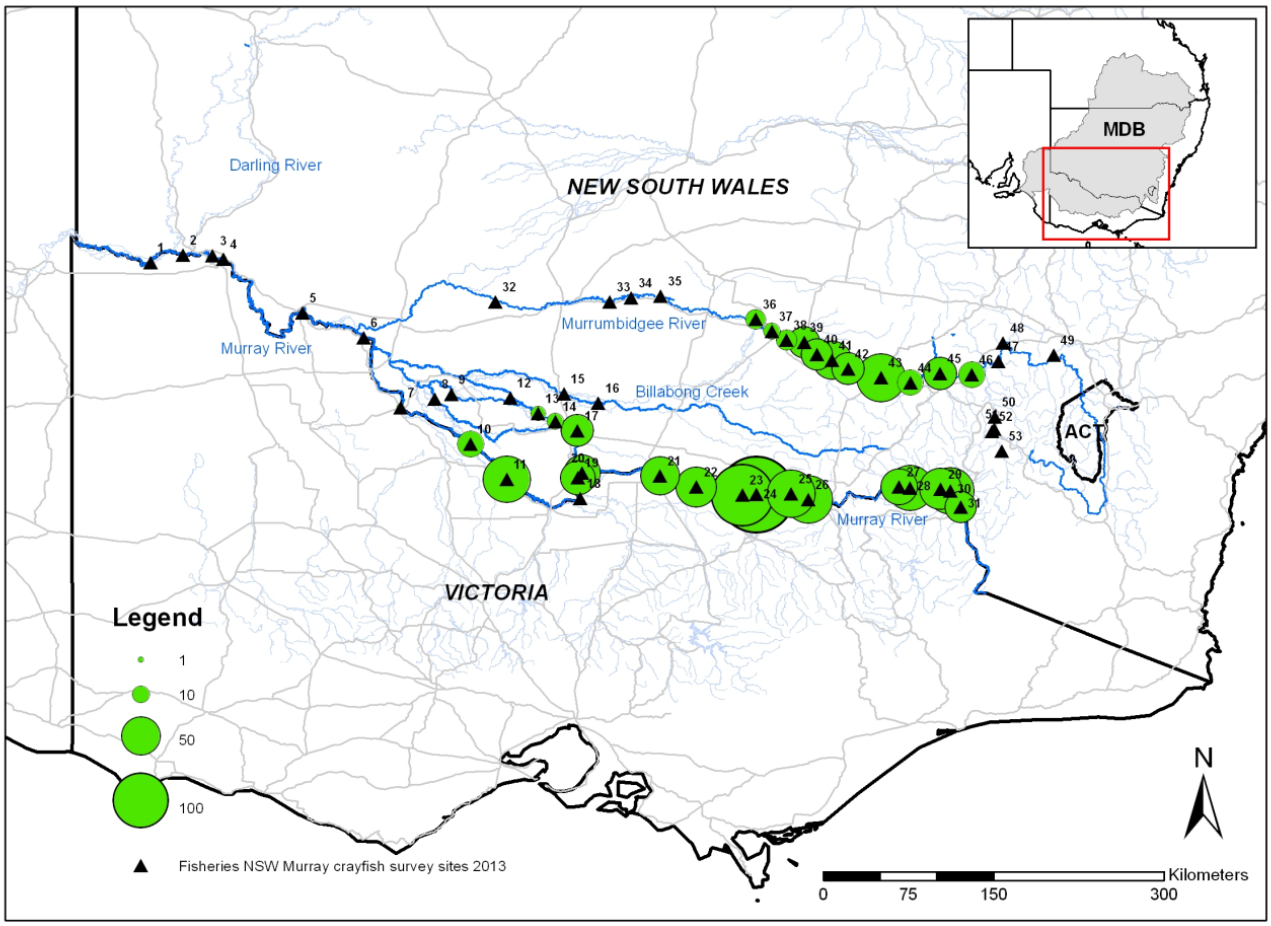

Figure 4. Relative abundance (standardised effort) of Murray crayfish in the Murrumbidgee and Murray Rivers during a 2013 survey. Larger circles represent higher crayfish abundance. Sites with no circles represent zero relative abundance.

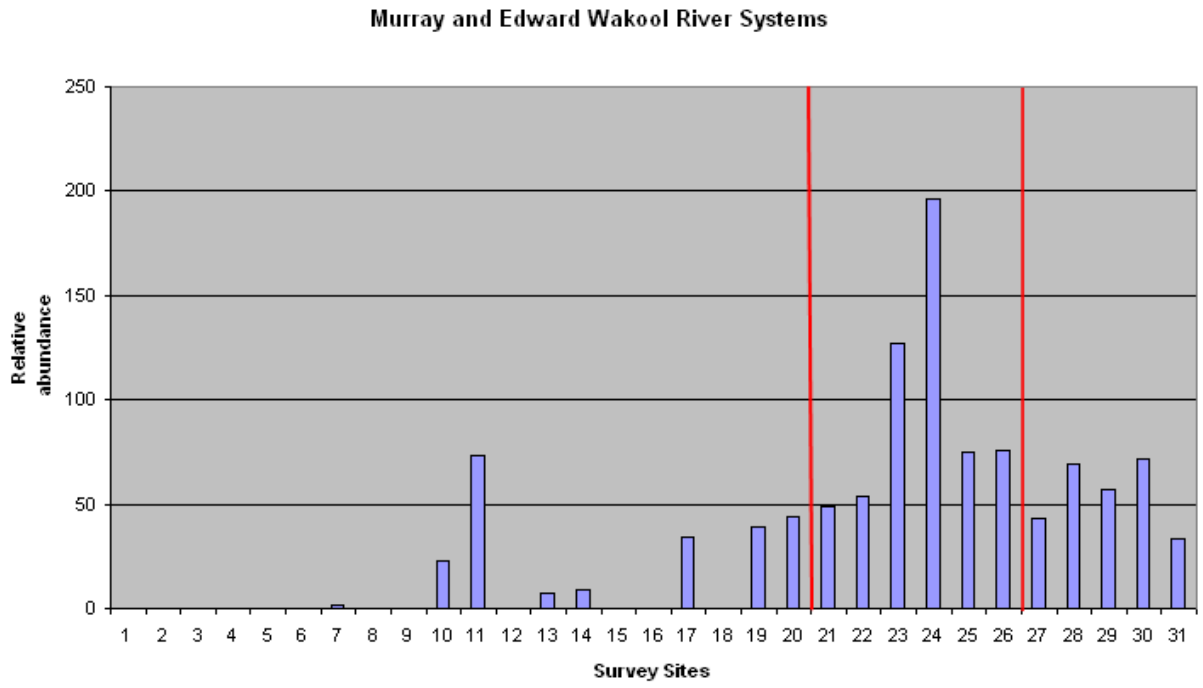

Figure 5. Murray crayfish relative abundance (standardised effort) in the Murray and Edward Wakool River system during a 2013 survey. Site numbers and abundance data correspond to those shown in fig. 4. Area between red lines represents the area currently open to fishing for Murray crayfish.

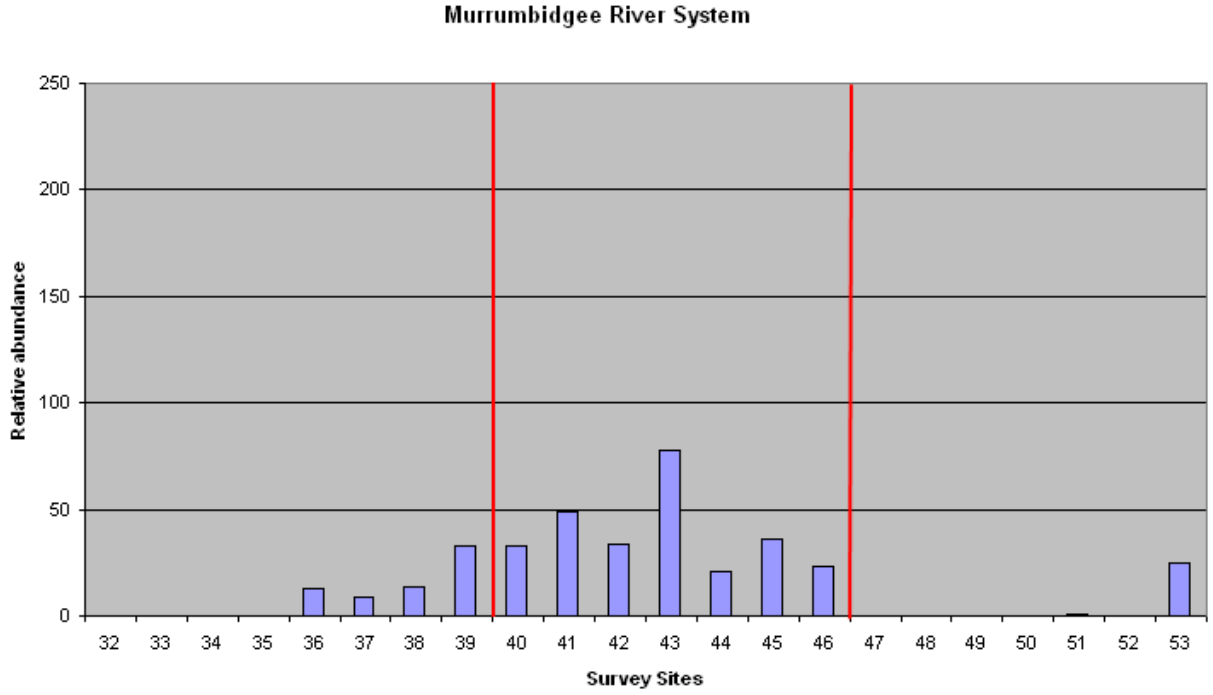

Figure 6. Murray crayfish relative abundance (standardised effort) in the Murrumbidgee River system during a 2013 survey. Site numbers and abundance data correspond to those shown in fig. 4. Area between red lines represents the area currently open to fishing for Murray crayfish.

4.6 Current threats to Murray crayfish

Reductions in distribution, abundance, average size and reproductive output of Murray crayfish populations have been attributed to several threatening processes. No single theory can explain the decline of Murray crayfish across its entire range however particular threatening processes are thought to be responsible for population declines in different areas and at different times (Appendix 6). In its consideration of the listing of Murray crayfish as a vulnerable species the FSC identified the following processes as threats to Murray crayfish.

River degradation- Removal or destruction of vegetation through anthropogenic processes can change flow regimes, cause bank erosion and bank slumping. Increased sedimentation fills formerly deep holes reducing habitat suitability for crayfish.

River regulation- installation and operation of in stream structures (dams and weirs) which alter the natural flow regimes of rivers and streams. These structures physically prevent the re-colonisation of Murray crayfish up or downstream. Weirs create weir pools which are lentic environments not favoured by Murray crayfish. This causes population fragmentation and increased local extinction (McCarthy 2005). River regulation also threatens populations through seasonal flow reversal, where flows during May- August are considerably lower then natural flows; exposing burrows and burrowing sites and limiting localised recruitment of Murray crayfish.

Fishing- Both commercial and recreational fishing have played a role in reducing Murray crayfish populations, however the extent has not been quantified. Fishing may have a greater impact on Murray crayfish abundance when the population size is small and has the potential to prevent the recovery of the population.

Pesticides- There has been major declines of Murray crayfish downstream of major irrigation systems. The use of DDT and other, now banned, highly toxic agricultural chemicals became widespread in the late 1940's coinciding with large Murray crayfish population declines in the early 1950's. There have been suggestions that patterns of Murray crayfish decline are associated with the advent and proliferation of the use of pesticides, including their aerial application.

Hypoxic black water events- Murray crayfish have intolerance to low dissolved oxygen concentrations and black water events cause a depletion of oxygen levels in the water column. Large numbers of crayfish were observed emerging from the water shortly after a black water event. Leaving the water increases vulnerability to predators and environmental stress. Crayfish appeared to be in a lethargic state, indicating their inability to cope well with such an event.

Additional information on these factors is available in the FSC Final Determination (Appendix 6).

4.7 Knowledge Gaps – Species ecology

The extent to which different threats impact current Murray crayfish populations is poorly understood. Research needs to be prioritised to address knowledge gaps to allow threats to be managed appropriately and efficiently.

Gilligan *et. al.* (2007) highlighted a number of high priority research areas relating to Murray crayfish biology and ecology, as follows:

- Current status of Murray crayfish across their range
- Habitats and biology of juvenile crayfish (< 40 mm OCL)
- The effects of habitat modification on Murray crayfish populations

- The effects of pesticides on aquatic ecosystems
- Seasonal use of microhabitats by Murray crayfish
- The effect of land use practices and sedimentation

Addressing the key knowledge gaps identified in this and the following section will aid management initiatives, and ideally encourage population recovery to a sustainable level where recreational fishing has a negligible impact and future generations can continue to partake in the fishery.

4.8 Knowledge Gaps – Fishing impact

To date there has been limited scientific assessment of the impact of recreational fishing on Murray crayfish populations. Forbes (2014 unpublished) completed a creel survey of anglers fishing between Berembed and Yanco Weirs in the Murrumbidgee River, and produced some catch and effort data on Murray crayfish, however this data was a 'snapshot' and accurate estimates of recreational catch and effort for the whole fishery are needed to fully assess the impact that continued recreational fishing for Murray crayfish has in NSW.

The FSC reviewed the available research which has assessed the impact of recreational fishing on Murray crayfish populations. Three studies in particular examined the response of Murray crayfish populations to fishing closures (see Appendix 6):

- over a seven year total closure of the Victorian fishery (Barker 1992),
- a nine year closure along a ~70 km reach of the mid Murrumbidgee River (Asmus 1999),
- a 17 year total closure of the ACT fishery (Fulton *et. al.* 2010).

All three studies found little evidence that the abundance, average size or sex ratio of Murray crayfish populations recovered during the period of closure (despite an initial increase in abundance after the ACT closure was first implemented reported by Lintermans (2000)).

No similar studies have been undertaken to assess fishing impacts in the Murray River.

Overall this research does not specifically or completely assess recreational fishing efforts, nor its direct impacts on Murray crayfish populations. Assessing the impacts (if any) due to recreational fishing is complex and factors such as species biology, illegal fishing and environmental influences will complicate the issue. The relative impact of some threats may vary in different places and with different population sizes. Hence, while the assessments to date have not identified a recovery in closed fisheries, the data is limited and no conclusion can be drawn as to the potential for recreational fishing to prevent recovery or cause further decline in Murray crayfish populations.

More extensive and comprehensive estimates of recreational catch and effort are needed to fully assess the potential impact that continued recreational fishing in NSW has on Murray crayfish populations.

5 Management of Murray crayfish fishery in NSW

5.1 Commercial fishing history

A commercial fishery for Murray crayfish operated in NSW from the mid 1800's. Commercial catches peaked at around 15 tonnes per year in 1955 and 1975, but due to declines in numbers and sustainability concerns the commercial fishery was closed in 1988 (Figure 4).

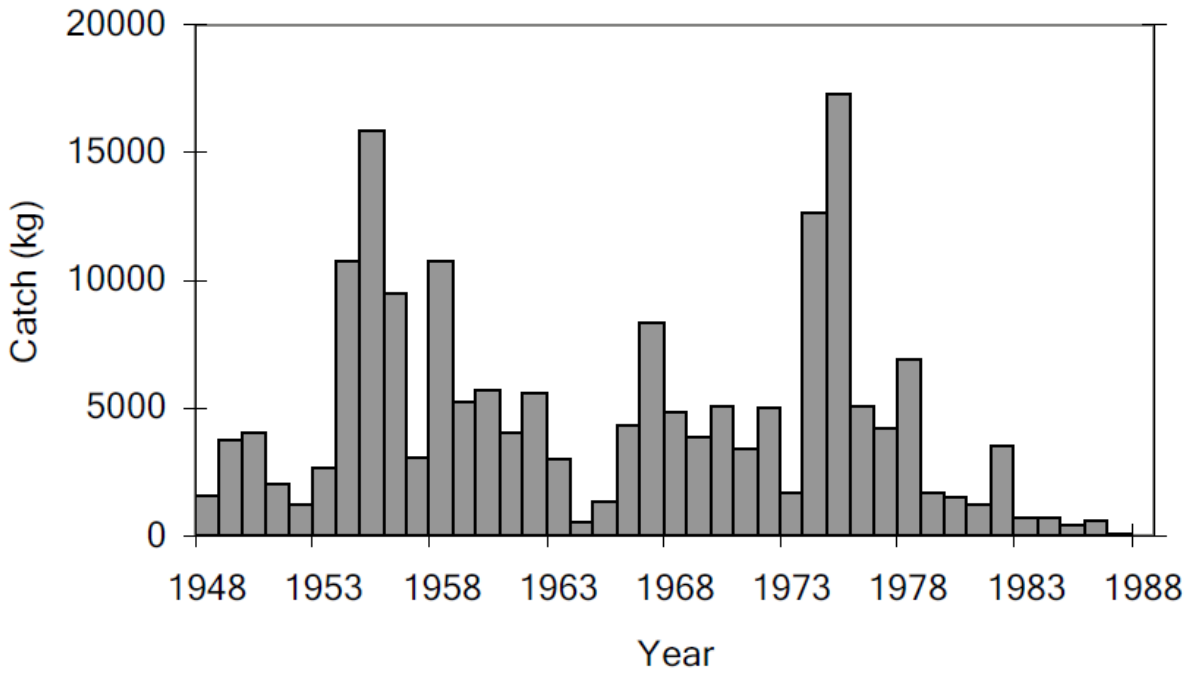

Figure 7. NSW inland commercial catch of Murray crayfish (NSW DPI Comcatch database, unpublished). *These data do not reflect catch per unit effort and cannot be used to infer trends.*

5.2 Recreational fishing regulations

Recreational fishing regulations for Murray crayfish were first introduced in NSW in 1989, consisting of a minimum size limit of 8cm and no take of berried females. Fishing for Murray crayfish has been prohibited in SA and the ACT since 1989. Victoria currently has Murray crayfish regulations similar to NSW including large regions which are totally closed to fishing for Murray crayfish.

Regulations have been revised and updated a number of times in light of new scientific research. A history of recreational fishing regulations for Murray crayfish is provided in appendix 5.

Minimum size regulations are intended to allow stock to reproduce at least once prior to reaching permissible take size. Maximum limits are intended to increase recruitment potential based on the observation that larger females carry more eggs than smaller individuals (Hill 1990). Season restrictions are intended to minimise the take of reproductive females. The open fishing season (June - August inclusive) attempts to ensure that females have the opportunity to mate and produce eggs (become berried) before the season commences, thus preventing them being harvested.

The regulations are also aimed at preventing fishing related disturbance during the main period that Murray crayfish moult. During March and April Murray crayfish have soft exoskeletons as a result of moulting, and handling during this time has an increased risk of damage because there is no protective hard outer shell.

5.3 Current recreational fishing activity

Unless otherwise noted, the following is a summary of observations provided by Fisheries Compliance officers in the Murray and Murrumbidgee areas, especially Mr Peter Tilbrook, Supervising Fisheries Officer, South West zone.

Fishing for Murray crayfish is often undertaken as a social activity, with many fishers camping with friends or family for one or more days. It is a male dominated traditional fishery with many groups visiting annually. It is not uncommon for only a small proportion of a camping group to be active fishers, the rest enjoying other camping activities. Most crayfishing activity takes place on weekends and public holidays during the Murray crayfish open season. During those months crayfishing is by far the most popular fishing activity with 80% - 90% of all fishers targeting Murray crayfish.

Crayfishers generally require the ability to launch boats onto the river; hence most fishing (and camping) takes place in locations near a boat ramp or with reasonable vehicle access to the river bank. No data exists to permit objective assessment of the total number of people who undertake fishing for Murray crayfish, but a subjective estimate has been made of about 50 fishers (potentially 250 hoop nets) within a 100km section of the Murray River with generally good access (Yarrawonga to Tocumwal), on any weekend during the most popular part of the Murray crayfish season. Forbes 2014 (unpublished) assessed fishing effort in a 76km reach of the Murrumbidgee River during the 2012 fishing season (May-August inclusive) and determined a combined boat and shore based fishing of approximately 697 fisher hours of daytime recreational effort were focussed exclusively on crayfish.

More crayfishers target the Murray River than the Murrumbidgee River, with most of the crayfishers on the Murray River coming from Victoria. In general, crayfishers on the Murray River will have travelled longer distances to undertake fishing, with those targeting the Murrumbidgee River are more likely to be from the local area. Numbers of crayfishers travelling to reach the Murrumbidgee have been declining in recent years, with fishers less willing to travel long distances to access a fishery where it is increasingly difficult to catch a legal sized bag limit, and regulations are progressively stricter.

6 Impacts of proposed activity

6.1 Increased relative effort

It is uncertain if recreational fishing has been a significant threat to Murray crayfish populations in the past, however the threat may become considerable in situations of diminished crayfish population density. Factors which threaten populations can be thought of as either population dependent or population independent. Population dependent factors remove a relative proportion (percentage) of a given population so that, as population density declines, fewer individuals are lost. Examples of population dependant factors include disease, adverse environmental conditions and natural predation. Population independent factors remove a fixed number of individuals, regardless of population density. Population independent factors will have a greater relative impact on smaller populations because the percentage of the population removed increases as the population declines.

Recreational fishing is considered a population independent factor because, as the species becomes less abundant (harder to catch) fishers increase their effort by spending more time fishing or fishing more intensely to maintain their usual total catch.

Hence while recreational fishing may not have been a major factor in the historical decline

of Murray crayfish, now that population numbers are much lower recreational fishing may have sufficient impact to hinder recovery. It is also possible that recreational fishers will find the increased effort to land their 'usual' catch excessive and so total fishing effort may decline. Confounding this issue is whether fishers from regions where Murray crayfish can no longer be taken will transfer their effort to the areas which remain open and therefore overall fishing effort could increase (see below).

6.2 Concentration of effort

Murray crayfish life history characteristics such as low fecundity and slow growth make them susceptible to an increased concentration of effort. Distance to fishing grounds, availability of resources and popularity of the fishing activity are factors which influence fishing effort. Other factors include fishers' ability or determination to respond to changes in Murray crayfish availability, shorter fishing seasons and more restricted fishing zones. If fishers travel to catch Murray crayfish in waters open to fishing, they are likely to target crayfish more intensely to make it "worth their while".

As described in section 4.1, Murray crayfish have small home ranges and are thought to have limited dispersal ability. These characteristics make Murray crayfish susceptible to localised overfishing. Fishing for Murray crayfish is a largely social activity, so easily accessible fishing grounds are targeted by fishers. The ACT Action Plan no.14 (ACT Government 1999) observed low catch rates near public parks, roadsides and bridges, which reflect the idea that easily accessible areas will be subject to concentrated fishing effort. Forbes 2014 (unpublished) found that fishing effort for crayfish in a section of the Murrumbidgee River was not uniform, with increased effort in areas considered to have higher crayfish numbers. Fisher effort targeting Murray crayfish upstream of the Old Man Creek confluence, (believed to have greater crayfish abundance) equated to approximately 24 hours per river kilometre, whereas downstream of this area (believed to have poor crayfish abundance) fisher effort averaged only 2 hours per river kilometre. Hence, 92% of fisher effort was concentrated in the upstream area.

6.3 Increased illegal fishing activity

Any change to fishing regulations will inevitably involve a transition period during which compliance may decline while fishers become aware of and familiar with the new requirements.

Fishers targeting Murray crayfish have relatively poor compliance with fishing regulations (see section 7.2). With the 2013 closure of most waters in NSW to Murray crayfish fishing there has been an increase in closed water offences, however most offenders were fishing inadvertently and were cooperative and supportive when advised of the new closures (P. Tilbrook pers. comm).

Also, the use of illegal traps to catch Murray crayfish now appears to be more common, especially on the Murrumbidgee River. This is likely to be a response to the diminished numbers and increasing difficulty of catching Murray crayfish legally. Such traps are often not checked for up to a week meaning many crayfish including under/over size and berried females may perish in the trap and abandoned traps may 'ghost fish' for long periods of time (see section 6.5). Illegal traps also present challenges for compliance officers because they are often submerged, are checked infrequently and are unlabelled (P. Tilbrook pers. comm).

The longer term level of non-compliance is difficult to assess and the level of illegal fishing directly impacting Murray crayfish cannot be assessed. NSW DPI compliance officers will continue to patrol NSW waters including areas open and closed to Murray crayfish fishing and this SIS recommends a strong enforcement program be maintained to ensure high levels of compliance with regulations (see section 7.2).

6.4 Modified population structure

Recreational fishing can impact the sex ratios of Murray crayfish. McCarthy (2005) found sex ratios skewed towards females in two separate fished populations (assuming a 1:1 sex ratio in unfished populations). The current fishing regulations intend to protect actively breeding females and as a result introduce substantial bias towards harvesting male crayfish. The reduction in abundance of large males can shift reproduction competition to smaller, less fecund males which may lead to reduced reproductive success and potential population declines. Lower clutch weights and egg numbers have been correlated with smaller sized males in experiments on spiny lobsters (MacDiarmid & Butler 1999).

6.5 Cryptic impacts

Ghost fishing (by lost or abandoned traps) can potentially lead to unintended impacts by continuing to catch Murray crayfish. Trapped fish or crayfish may not die immediately but once the food supply runs out they will starve, effectively "rebaiting" the ghost trap. Other species also have the potential to become tangled in these traps.

Handling may damage individuals intended for release, and eggs if berried females are caught. This can reduce the fecundity of females (Zukowski 2012; ACT Government 1999; Farrell & Leonard 2000).

6.6 Impacts on other threatened fish species

The entire area of the proposed activity (i.e. the areas where fishing for Murray crayfish may be undertaken) is within the geographic extent of the *aquatic ecological community in the natural drainage system of the Lower Murray Catchment* is listed as an **endangered ecological community** (lower Murray EEC) under the FMA. Impacts of fishing within the lower Murray EEC were assessed in a SIS exhibited in 2002.

Consequently, the Director-General's requirements limit the scope of this SIS to assessing the impacts of recreational fishing on Murray crayfish, and do not require consideration the impact on other threatened species, populations or ecological communities which were assessed in the previous SIS. However, two species which occur in the area which have been listed as threatened since 2002 require individual assessment and are discussed below.

Flathead Galaxias;* Galaxias rostratus *(Critically Endangered; FMA)

Flathead galaxias, also known as Murray jollytail, is endemic to the southern tributaries of the Murray-Darling River System. Flathead galaxias is a small shoaling fish that grows to 150 mm and 22.5 g, but is seldom over 100 mm. It is often seen mid-water, and is found in still and gently flowing waters in small streams, lakes, lagoons, billabongs and backwaters. Its habitats consist of rock or sand bottoms, and aquatic vegetation.

There is a possibility this species may be captured in Murray crayfish hoop nets however the likelihood is considered extremely low because; it is unlikely to occur in the same habitat (high flow velocity), and its small body size and agility will allow it to escape as hoop nets are retrieved. Because it is listed as threatened under the FMA, as well as being a member of the Murray EEC, it must be released with minimal harm. Individual fish which are caught in hoop nets are unlikely to suffer significant injury and so are expected to have a high survival rate.

Eel tailed catfish;* Tandanus tandanus *(western population, Endangered; FMA)

Eel tailed catfish, also known as freshwater catfish, were originally widely distributed throughout the Murray-Darling River System in New South Wales, Queensland, Victoria and South Australia, with the exception of the cooler parts of the southern tributaries.

Eel tailed catfish live in a wide range of habitats including rivers, creeks, lakes, billabongs and lagoons, and although they inhabit flowing streams, are more likely to be found in sluggish or still waters. They can be found in clear to turbid waters, and over substrates ranging from mud to gravel and rock.

Currently, eel tailed catfish are relatively rare in the areas where fishing for Murray crayfish is permitted; hence the likelihood of accidental capture in crayfish nets is small. For similar reasons as flathead galaxias (different habitat and ability to escape as nets are retrieved) eel tailed catfish are unlikely to be captured in Murray crayfish hoop nets and due to their threatened status must also be released with minimal harm. When eel tailed catfish are accidentally lifted in a crayfish net they are unlikely to be entangled so release with minimal handling will be achievable in most cases.

6.7 Habitat impacts

Fishing methods (primarily hoop nets) used for catching Murray crayfish are unlikely to directly alter habitat characteristics however some localised impacts from general fishing activity may occur. For example, activities such as camping, vehicle movements and boat launching can have a localised impact on stream banks and nearby areas. While these impacts are unlikely to be widespread or extensive, there may be some increase of concentration, as discussed in section 6.2. It should also be noted that such impacts are common to a range of fishing activities and the specific contribution of fishing for Murray crayfish is likely to be relatively low.

7 Mitigating measures

7.1 Public education programs

Several sources of information on Murray crayfish are available on the NSW DPI website (www.dpi.nsw.gov.au). The website provides information on the latest regulations such as possession limits, size limits, seasonal closures, and other information relevant to Murray crayfish. Freshwater fishing guides are also publically available free of charge. These are produced annually and contain the latest regulations for recreational fishers.

Public education and distribution of relevant advisory material is aimed at clarifying fisher's understanding of regulations; for example, what waters are open to recreational fishing and what equipment is permitted. There are also signs placed around waterways and Fisheries brochures distributed to fishing tackle shops and tourist information centres. Crayfish measuring devices are also distributed widely. Approximately 400 signs to notify and inform recreational fishers of the changes in Murray crayfish regulations have been or will be erected in key locations such as camp grounds and boat ramps. These signs assist with the identification of threatened species and raise awareness of the protected status of Murray crayfish.

NSW DPI compliance officers from the South West Zone of NSW annually attend the Melbourne 'National 4 x 4, Fishing, Boating and Outdoor Expo'. This event provides an excellent opportunity to advise and educate the Victorian public on NSW fishing rules and regulations, including changes for Murray crayfish. A live Murray crayfish display is usually featured. On average, over 2,000 persons visit the exhibit each year.

The Fishcare Volunteer Program trains and equips volunteers to provide information to anglers about fishing in their local region including relevant regulations, important habitats and how to identify and protect aquatic threatened species.

7.2 Enforcement and compliance of fisheries regulations

The effectiveness of the fishing regulations is largely dependant on the compliance of fishers, the knowledge base behind the regulations and the presence of compliance officers (Zukowski 2012).

NSW DPI compliance officers patrol all NSW waters, including the waters open for Murray crayfish fishing. Fishers targeting Murray crayfish have relatively poor compliance with fishing regulations, with about 20-30 % of those inspected found to be in violation of regulations. The most common non-compliance matters relate to size limits, followed by illegal fishing gear and taking of berried females. Exceeding bag limit offences are now rare (P.Tilbrook Pers. Comm).

A person found to be in breach of fishing regulations relevant to Murray crayfish is considered to be harming a threatened species and cases are managed with regard to departmental enforcement guidelines.

NSW DPI compliance officers can seize any Murray crayfish that are prohibited size, in berry or in excess of maximum permitted numbers. Any live Murray crayfish are returned to the water whilst dead crayfish are either destroyed in the field or stored in freezer facilities. The compliance outcome may be one of the following

- Verbal caution (for most trivial offences),
- Written caution,
- Penalty notice, or
- A court summons.

7.3 Monitoring and Research

The recommendation to permit continued recreational fishing for Murray crayfish via the proposed Ministerial Order is strongly influenced by the perception of a significant social value to the fishery.

Resource assessment surveys undertaken by Fisheries NSW in 2012 & 2013 provide baseline data on the current status of Murray crayfish populations across much of their historical distribution within NSW (see section 4.4 & 4.5). However this SIS has identified considerable knowledge gaps in relation to the impact of recreational fishing on Murray crayfish populations. As discussed in section 6, fishing may adversely affect Murray crayfish recovery if the population has severely declined. The current take of Murray crayfish by recreational fishers is unknown, as is the overall level of fishing effort.

It would be irresponsible to permit the take of a threatened species without putting in place a scientifically robust research and monitoring program which fills knowledge gaps and monitors future population trends, hence the recommendations of this SIS are dependent on a suitable research program being implemented.

Any further monitoring program must have the capacity to identify causes of any observed population changes, including fishing take, and be scientifically robust. As a minimum, the program would be designed to measure:

- spatial & temporal distribution of fishing effort, including transfer of effort from 'closed' areas, catch/harvest rates, methods, potential discard mortality
- Murray crayfish demographics and population trajectory at a range of sites both within and outside permitted harvest areas

An initial goal of the research and monitoring program is the completion of a robust benchmarking survey to set the base line for the ongoing monitoring program. Benchmarking will allow additional monitoring of populations in areas of decline and determine population demographics, viability and genetic diversity in open and closed waterways.

The research and monitoring program must report within five years of the Order being implemented to inform the required management review. If the program requires more time to make confident findings, this should be identified at the five year review stage but the total timeframe for the study should not exceed ten years, however population monitoring must be maintained for an extended period.

8 Alternatives to the proposed Order

8.1 Alternative options

The proposed Ministerial Order will authorise the continuation of recreational fishing for Murray crayfish in NSW subject to the applicable regulatory controls. Other potential options relating to the management of the recreational Murray crayfish fishery are discussed below.

Do not make a Ministerial Order authorising recreational fishing for Murray crayfish- The greatest reduction in mortality of Murray crayfish related to recreational fishing would result from not making a Ministerial Order authorising recreational fishing for this species. Under this alternative, it would be an offence to harm, target or take Murray crayfish anywhere in NSW. This scenario would eliminate any further impacts of recreational fishing on Murray crayfish populations. However closing the fishery is likely to have some degree of economic impact and would prevent recreational fishers from partaking in what is regarded as a largely social activity.

Alternate recreational fishing seasons- Larger reproductive males are thought to make a greater contribution to reproductive success than smaller mature males. Closing the fishery every second or third year would potentially allow more males to pass through the size range where they are a potential fishing target and increase their contribution to reproduction. An increase in fecundity would allow more fished individuals to be replaced through reproduction. This alternative would maintain some of the social value of the fishery, but may result in increased fishing effort and intensity during the seasons that fishing is permitted.

Translocation of Murray crayfish from irrigation channels- There have been suggestions that Murray crayfish exist in considerable numbers in irrigation channels. Translocation of Murray crayfish from irrigation channels into main river channels is a potential short term option to increase population size in rivers as well as recruitment potential. This scenario needs to be further researched before it can become a realistic alternative.

Slow growth rates, high aggression in confined areas and high water quality requirements mean that captive breeding for translocation may be unsuitable.

Catch and release fishery- A catch and release fishery where fishers are not permitted to take, but are allowed to target Murray crayfish would significantly reduce the level of mortality of Murray crayfish due to harvest by recreational fishers. A catch and release fishery would still allow recreational fishers to target Murray crayfish therefore maintaining the social and economic importance of the fishery. This is not an ideal alternative as it is expected to be unpopular with fishers because Murray crayfish are not considered a ‘sport fish’, and the majority of fishers target this species for consumption.

8.2 Summary of alternatives

The proposed Ministerial Order will authorise recreational fishers to take Murray crayfish in NSW subject to the most current regulations. With the limited fishing season for Murray crayfish in NSW (3 month fishing season) and restricted bag/possession limits the recreational fishing impact on Murray crayfish is not considered to be severe. This proposal will allow the social and economic values of the fishery to persist and monitoring of Murray crayfish populations to be undertaken. The current take and possession limits are unlikely to considerably impact angler participation because of the high social aspect of the fishery.

Alternative management arrangements discussed in this section would potentially be more effective at reducing fishing related mortality, but are more likely to increase social and economic effects. Continuation of the limited fishery also provides the opportunity to obtain more accurate data on catch rates and patterns within the recreational sector.

9 Other considerations

9.1 Biophysical considerations

Biophysical impacts are expected to be negligible if recreational fishing for Murray crayfish is to continue under a Ministerial Order. The proposed Order authorises recreational fishers to fish in accordance with current regulations. No changes are expected to be made to current fishing practices. The techniques used are not destructive to the surrounding physical environment and no new impacts are expected to arise. As previously noted, (section 6.7) habitat impacts are not expected to be exacerbated.

Activities associated with fishing such as camping, vehicle movements and boat launching disturb or modify areas adjacent to water bodies. These disturbances are primarily soil compaction, groundcover depletion and pollution and lead to erosion and sedimentation. It is difficult to assess the relative contribution of such disturbance as a direct result of fishing for Murray crayfish. Other recreational fishing activities or general activities such as hunting or recreational four-wheel driving result in similar outcomes.

9.2 Social and Economic considerations

Murray crayfish is an important species for freshwater recreational fishers during the winter season and is considered to have a high level of social importance to those who participate: the experience of catching and eating crayfish goes hand in hand with spending time camping with family and friends.

The social value of the Murray crayfish fishery is difficult to estimate because it involves both tangible (number of jobs sustained, amount of healthy physical activity sustained) and intangible (the value of family bonding and maintenance of tradition values and practices) elements. In general, fishing for Murray crayfish is described as an important social event; bringing families and friends together, allowing them to share the experience of fishing and camping. Zukowski (2012) interviewed fishers to determine their attitudes towards the fishery. Fishers reflected the view of social importance with 47% of fishers commenting that fishing for crayfish was an excuse to go camping with friends and family in the winter time. O'Connor (1986) conducted a similar assessment, issuing log books with questions seeking information on motivation for fishing and attitudes towards regulations. Seventy four percent (74%) of respondents stated fishing for crayfish was undertaken in a social setting on the weekend.

The economic value of the Murray crayfish fishery has not been quantified. There are no specific data relating to Murray crayfish, although estimates on a multi-species fishery are available. The University of Wollongong (2013) assessment of the recreational fishing

sector estimated approximately $251 million annual expenditure can be directly attributed to inland fishing. Expenditure occurs across a range of goods and services including tackle, bait, food, accommodation, fuel, transport and boat hire. The Murray crayfish fishery is a relatively small part of the entire fishing sector in the Murray- Darling Basin (in terms of area, participation rate and seasonality), hence its value is likely to be proportionally small. No other objective estimates are available at this time.

While exact values cannot be determined, it is clear that the recreational fishery for Murray crayfish has a positive social benefit and also provides some degree of economic value to the communities in the Murray and Murrumbidgee River regions. There is a perceived need to balance the social value of the fishery with the ecological imperative of preventing extinction of the species and maintaining a healthy, sustainable fishery which can continue for generations to come.

9.3 Recreational fishing pressure and trends

Very little contemporary data is available on recreational fishing trends in inland waters of NSW and there is no time-series dataset documenting fishing trends for Murray crayfish. As noted in previous sections of this SIS changes to the Murray crayfish management and regulations have taken place, as have fisher's attitudes to sustainable fishing.

Recreational fishing pressure may have become more concentrated with the closure of some regions to fishing for Murray crayfish. The current regulations permit continued fishing for Murray crayfish in relatively small areas.

Whether fishers will travel from the closed areas to open areas to continue fishing for Murray crayfish is unknown. If so, this will increase fishing pressure in those areas that have remained open to recreational fishing. Alternatively, it may be that fishers are not willing to travel long distances to fish for Murray crayfish, or become increasingly disinterested when they are no longer able to fill their bag and possession limits and hence overall fishing effort may be reduced. Research on fishing effort and trends (catch, expenditure, methods and location) is vital for assessments of recreational fishing's impact on Murray crayfish, as well as allowing informed decisions on a range of management issues.

9.4 Aboriginal cultural considerations

This section summarises information from "Scoping the knowledge requirements for Murray crayfish Euastacus armatus*" (Gilligan et al, 2007), chapter 6: "Traditional ecological knowledge, historical use and cultural significance", prepared following a series of consultations with Aboriginal communities throughout the Murray and Murrumbidgee River systems prior to 2007.*

Murray crayfish do not have any significant totemic role within the Aboriginal communities consulted, but they were (and continue to be) utilised as a food resource.

Women harvested Murray crayfish in shallow waters during low river flows or by diving and they were an important food resource during winter. Harvests were considered to be more productive during years with high river flow, or floods (a trend consistent with observations of increases of commercial harvests during times of floods).

Sustainable management of Murray crayfish and other species was and is an imperative part of aboriginal culture. A cyclic pattern of harvest over a number of different sites within the river system ensured that local crayfish populations were not exploited and allowed populations to rejuvenate.

Aboriginal people perceive Murray crayfish to be key indicators of river health and are concerned about the sustainability of the species if high recreational fishing catches are

permitted.

9.5 Ecological Sustainable Development

In common with most other Australian fisheries, NSW inland fisheries management, by necessity, is carried out in an environment where there is a level of scientific uncertainty.

In recognition of this uncertainty, management arrangements for Murray crayfish must be both precautionary and adaptive in nature. The current fishing regulations for Murray crayfish aim to further reduce the risk of serious and irreversible damage to Murray crayfish populations, while meeting the expectations of recreational fishers. The regulations satisfy the current social needs of recreational fishers by allowing fishing for Murray crayfish to continue without compromising the capacity of future generations to experience this activity.

However, further scientific research must be undertaken to address the key knowledge gaps (identified in sections 4.7 & 4.8) that contribute to the level of uncertainty. Further reductions in crayfish populations must trigger a re-evaluation of recreational fishing regulations.

10 Conclusion

10.1 Summary

While the decline of the Murray crayfish population is well documented, its cause(s) have not been objectively determined. The role of recreational fishing in the decline and/or prevention of recovery of Murray crayfish populations is unclear. Several life history characteristics, such as slow growth, late maturity, low fecundity and limited dispersal capability make Murray crayfish vulnerable to over-exploitation and slow to recover from decline. From an ecological perspective, continued removal of mature adults is likely to have some negative impact on population numbers. This concern is offset by recent changes to fishing regulations which reduced allowable take and possession of Murray crayfish in terms of size, number, season and area permitted to be fished.

There is a recognised social value in the Murray crayfish recreational fishery, and this factor has strongly influenced the recommendation of this SIS to continue the fishery in its current form, while undertaking further research on the impact of recreational fishing. There is also a relatively small economic value in the fishery, largely related to transport, camping and fishing gear expenditure. It must be noted however that both the social and economic value of the fishery will be meaningless should the Murray crayfish population decline to extinction.

10.2 Recommendation

On balance, and recognising the value of the Murray crayfish fishery to the community in the Murray and Murrumbidgee regions, **this SIS recommends the proposed Ministerial Order be made to permit the continuation of the Murray crayfish recreational fishery under the applicable regulatory controls**, subject to the following conditions:

- A suitable, targeted angler education program be implemented to educate fishers about concerns for Murray crayfish populations and encourage strict compliance with regulations relating the Murray crayfish,
- A strong enforcement program be maintained to ensure high levels of compliance with regulations relating to Murray crayfish,
- The research and monitoring program described in section 7.3 be fully implemented,
- The impact of fishing on the Murray crayfish population, as informed by the research

and monitoring program, be reviewed at five yearly intervals from the date of the Order (or sooner if further significant declines in Murray crayfish populations are identified),

- If the impact of fishing on the Murray crayfish population, as informed by the research and monitoring program or other appropriate information source is shown to be unsustainable, the relevant fishing regulations must be revised as required to negate the impact.

References:

Personal Communications References:

Dean Gilligan - Senior Research Scientist, Fisheries NSW DPI

Martin Asmus - Project Officer Freshwater Research, Fisheries NSW DPI

Peter Tilbrook - Supervising Fisheries Officer, South West Zone, Fisheries NSW DPI

Literature References:

ACT Government (1999) *Murray River Crayfish* (Euastacus armatus): *A vulnerable species.* Action Plan No. 14. Environment ACT, Canberra.

Alves, N., Coughran, J., Furst, J. & Lawler, S. (2012). *Euastacus armatus* In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iuncredlist.org>.

Asmus, M. (1999) Effects of recreational fishing on populations of Murray crayfish *Euastacus armatus* in the Murrumbidgee River. Unpublished Honours Thesis, Charles Stuart University, Wagga Wagga.

Barker, J. (1992) The spiny freshwater crayfish monitoring program, 1990. Fisheries Management Report no.44, Department of Conservation and Environment, Victoria.

Clarke, G.M. & Ascroft, F.S. (2003) A Review of the Conservation Status of Selected Australian Non-Marine Invertebrates: National Heritage Trust 46 - 51.

Davies P.E., Harris, J.H., Hillman, T.J. & Walker, K.F. (2008) A report on the ecological health of rivers in the Murray-Darling Basin 2004-2007. *Prepared by the Independent Sustainable Rivers Audit Group for the Murray Darling Basin Ministerial Council, Murray-Darling Basin Commission, Canberra.*

Department of Sustainability and Environment (2003), Glenelg Spiny Crayfish *Eustacus bispinosus* Murray Spiny Crayfish *Eustacus armatus*. Action Statement No. 184, Department of Sustainability and Environment, Melbourne.

Ernst & Young (2011) Economic Contribution of Recreational Fishing in the Murray Darling Basin. Department of Primary Industries, Fisheries Victoria.

Farrell, P. & Leonard, B. (2000) Frequent Handling Adversely Affects the Growth of the Australian Freshwater Crayfish *Cherax destructor*, *Journal of Applied Aquaculture*, 10: 29-36.

Fisheries Scientific Committee (2013) Final Determination: Murray Crayfish - *Euastacus armatus* - Appendix 6.

Forbes, J. (2014) Recreational fishing effort, catch, harvest and harvest rates for Murray crayfish *Euastacus armatus* in the Murrumbidgee River, Australia. Draft Manuscript, Department of Primary Industries, NSW Fisheries.

Fulton, C.,J., Starrs, D., Ruibal, M.P. & Ebner, B.C (2012) Counting crayfish: active searching and baited cameras trump conventional hoop netting in detecting *Euastacus armatus*. *Endangered Species Research* 19: 39-45.

Geddes, M.C., Musgrove, R.J. & Campbell, N.J.H (1993) The feasibility of re-establishing the River Murray crayfish, *Euastacus armatus,* in the lower River Murray. *Freshwater Crayfish* 9: 368-379.

Gilligan, D., Rolls, R., Merrick J., Lintermans, M., Duncan, P. & Koehn, J. (2007) Scoping the knowledge requirements for Murray Crayfish *(Euastacus armatus)*. MDBC Project No. 05/1066, Department of Primary Industries.

Henry, G.W & Lyle, J.M (2003) The National Recreational and Indigenous Fishing Survey. FRDC project No 99/158. Australian Government Department of Agriculture, Fisheries and Forestry, Canberra. Australia.

Hill, B.J. (1990) Keynote Address: Minimum legal sizes and their use in Management of Australian Fisheries. In D.A Hancock. Legal sizes and their use in fisheries management. Bureau of Rural Resource Proceedings No. 13*. ' Australian Society for Fish Biology Workshop'.* Lorne pp. 9-18.

Horwitz, P. (1990) The translocation of freshwater crayfish in Australia: Potential Impact, the need for control and global relevance. *Biological Conservation* 54: 297-305.

King, A.J., Tonkin, Z. & Lieshcke, J. (2012) Short-term effects of a prolonged blackwater even on aquatic fauna in the Murray River, Australia: considerations for future events. *Marine and Freshwater Research* 63: 576-586.

Lintermans, M. (2000). Partial recovery of the Murray River Crayfish *Euastacus armatus* in the Australian Capital Territory after the implementation of protective management measures. Draft Technical Report 16, Environmental ACT, Canberra.

Lintermans, M. (2000a). The status of fish in the Australian Capital Territory: A review of the current knowledge and management requirements. Technical report 15, Environmental ACT, Canberra.

Lintermans, M. and Rutzou, T. (1991) The status, distribution and management of the Murray crayfish *Euastacus armatus* in the Australian Capital Territory. ACT Parks and Conservation Service. Canberra, ACT.

MacDiarmid, A.B., & Butler, M.J. (1999) Sperm economy and sperm limitation in spiny lobsters. *Behaviour Ecology Socio-biology* 64: 12-24.

McCarthy, B. (2005) Distribution of Murray Crayfish (*Euastacus armatus)* in the Mallee Region 2004. *Murray-Darling Freshwater Research Centre Mildura.*

Nystrom, O. (2002) Ecology. In: D.M. Holdich (ed.) *Biology of Freshwater Crayfish*. Blackwell Science Ltd*.,* Oxford U.K: 192-235.

O'Connor, P. (1986) The biology of the Murray crayfish, *Euastacus armatus* (Decapoda: Parastacidae) and recommendations for the future management of the Fishery. *Unpublished NSW Department of Agriculture data summary*, NSW Fisheries, Narrandera, NSW.

University of Wollongong (2013) Developing a cost effective state wide expenditure survey method to measure the economic contribution of the recreational fishing sector in NSW. *Final report to the NSW Recreational Fishing Licence Trust* NSW DPI.

Ryan, K. (2005) The home range behaviour of the Murray crayfish, *Euastacus armatus* (Decapoda:Parastacidae) in the Murrumbidgee River, Australian Capital Territory. *Unpublished Thesis*, University of Canberra, ACT.

Walker, K.F. (1982) The plight of the Murray crayfish in South Australia. *Redgum (Conservation Council of South Australia)* 6: 2-6.

Zukowski, S. (2012) Impacts of fishing regulations on the sustainability of Murray Crayfish (*Euastacus armatus),* Australia: Social and biological perspectives. *PhD Thesis,* Charles Stuart University, NSW.

Zukowski, S., Curtis, A. & Watts, R.J. (2011) Using fisher local ecological knowledge to improve management: The Murray crayfish in Australia. *Fisheries Research* 110: 120-127.

Zukowski, S., Watts, R.J. & Curtis, A. (2012) Linking biology to fishing regulations:

Australia's Murray Crayfish (*Eusatacus armatus). Ecological Management and restoration* 13: 183-190.

Zukowski, S., McCarthy, B. & Whiterod, N. (2012a) Effects of a prolonged hypoxic blackwater event on Murray crayfish (*Euastacus armatus)* populations in the River Murray, Australia. Australian Society for Limnology Congress 2012, 26-29 November 2012, Armidale NSW.