EPBC Act referral guidelines for the vulnerable Murray cod (*Maccullochella peelii*)

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Important notice

Please note that these guidelines are general in nature and do not remove your obligation to consider whether you need to make a referral to the Minister for the Environment (the Minister) under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). While these guidelines provide information to help you decide whether to refer your action, the possible impacts of your proposal will depend on the particular circumstances of the action. These circumstances may include issues such as the proximity of the action to habitat, indirect impacts and impact-mitigation measures.

These guidelines were developed on the basis of the best information available at the time of writing. However, the impacts of proposals will be assessed by the Australian Government Department of the Environment (the Department) on the basis of the best information available at that point in time, which may differ from the information on which these guidelines are based.

These guidelines do not provide guidance on requirements under state and local government laws. Information on state, territory and local government laws pertaining to the area in which your proposed project is likely to have an impact can be obtained from:

- the Queensland Department of Agriculture and Fisheries (www.daf.qld.gov.au/fisheries)
- the Queensland Department of Environment and Heritage Protection (www.ehp.qld.gov.au/)
- the New South Wales (NSW) Department of Primary Industries (Fishing and Aquaculture) (www.dpi.nsw.gov.au/fisheries)
- the NSW Office of Environment and Heritage (www.environment.nsw.gov.au/)
- the Australian Capital Territory (ACT) Environment and Planning Directorate – Environment website (www.environment.act.gov.au)
- the Victorian Department of Environment, Land, Water and Planning (www.delwp.vic.gov.au/)
- Primary Industries and Regions South Australia (www.pir.sa.gov.au/), and
- the South Australian Department of Environment, Water and Natural Resources (www.environment.sa.gov.au/managing-natural-resources/water-use/water-planning/water-licences-and-permits/water-meter-self-reads).

How to use these guidelines

These guidelines are intended to assist you in determining whether your action needs to be referred to the Department. These guidelines should be read in conjunction with the Department's policy statement, Significant impact guidelines 1.1 – Matters of National Environmental Significance, which is available on the Department's website at www.environment.gov.au/epbc/publications/significant-impact-guidelines-11-matters-national-environmental-significance.

The Murray cod (*Maccullochella peelii*) is listed as a vulnerable species under the EPBC Act. Listed threatened species and ecological communities are matters of national environmental significance under the EPBC Act. These guidelines primarily apply to the assessment of impacts on the species within its natural distribution in

Australia (refer to Section 2 of these guidelines). However, for the purposes of protecting the Murray cod and promoting its recovery, adverse impacts that are likely to occur on translocated Murray cod populations that occur outside of the species' natural distribution may be assessed under the EPBC Act as to whether they are likely to be significant impacts on the species.

A person or incorporated body planning to undertake an action that has, will have or is likely to have a significant impact on the Murray cod within its natural distribution, must refer the proposal to the Minister before commencing. The Minister will then decide within 20 business days whether assessment is required under the EPBC Act. The potential significance of each action is judged on a case-by-case basis. Substantial penalties apply for undertaking an action, to which the EPBC Act applies, without approval (civil penalties up to $8.5 million or criminal penalties including up to seven years imprisonment). More information on referral, assessment and compliance is available on the Department's website at www.environment.gov.au/epbc/.

There is a national recovery plan in place for the Murray cod, which is available on the Department's website at www.environment.gov.au/biodiversity/threatened/publications/recovery/murray-cod.html. The Minister must not make a decision which is inconsistent with a national recovery plan.

The decision tree in Figure 1 and the rest of these guidelines are designed to assist you in determining whether your proposed action needs to be referred. You may also refer your proposed action if you are uncertain about the need to refer or contact the Department by emailing epbc.referrals@environment.gov.au.

Possible exceptions to the need to refer

Certain actions are exempt from the requirement of assessment and approval under the EPBC Act. These include lawful continuations of land use that started before 16 July 2000, or actions that were legally authorised before 16 July 2000. There are a number of criteria that must be satisfied to rely on any such exemptions. More information on exemptions under the EPBC Act is available on the Department's website at www.environment.gov.au/resource/prior-authorisation-and-continuing-use-exemptions-sections-43a-and-43b.

Where to get more information

The SPRAT profile for the Murray cod provides the biological and ecological context for significant impact guidance and impact-mitigation measures. It can be accessed on the Department's website at www.environment.gov.au/cgi-bin/sprat/public/sprat.pl.

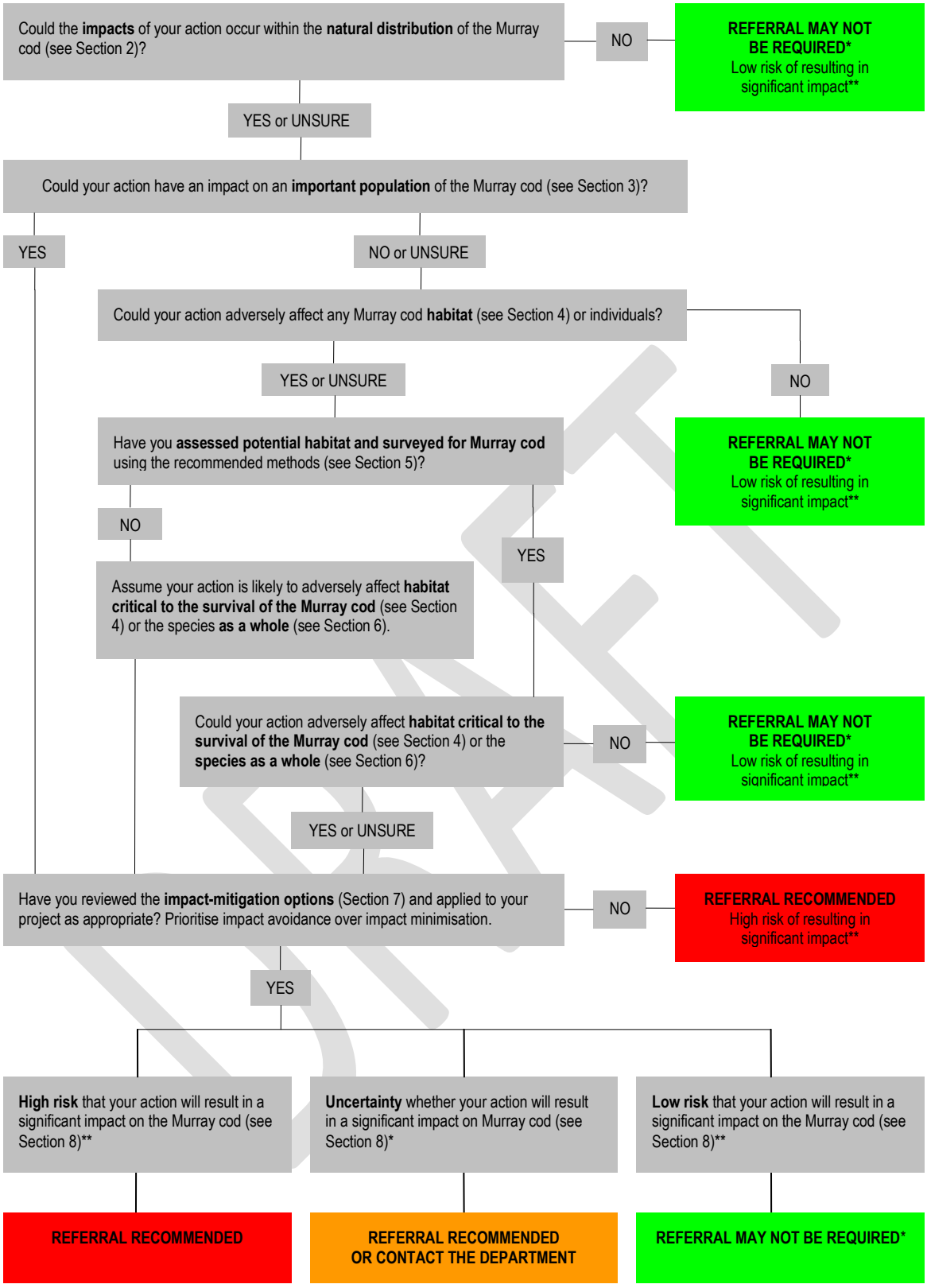
The *Survey guidelines for Australia's threatened fish* are available on the Department's website at www.environment.gov.au/resource/survey-guidelines-australias-threatened-fish-guidelines-detecting-fish-listed-threatened.

Other EPBC Act policy statements are available on the Department's website at www.environment.gov.au/epbc/policy-statements. These documents may help you to understand the EPBC Act and your obligations. The Department can provide assistance in ensuring your action complies with the EPBC Act, especially when contacted early in the planning process.

The Protected Matters Search Tool, available on the Department's website at www.environment.gov.au/epbc/pmst/index.html, can provide a good starting point for

determining the likelihood of matters of national environmental significance occurring in the area to be affected by your proposed action. State and territory government agencies may also hold relevant information including habitat and species distribution information.

Figure 1: Decision making



* Although it may appear that there is a low risk of a significant impact, and that a referral may not be required, you may still choose to refer your proposed action. If you are uncertain about the need to refer then you can contact the Department to discuss your action by emailing epbc.referrals@environment.gov.au.

** Risk is the chance of something happening that will have a [significant] impact on objectives [e.g. protecting matters of national environmental significance] (adapted from Australian/New Zealand Risk Management Standard ISO 31000:2009).

1. What is known about the Murray cod?

The Murray cod is the largest freshwater fish found in Australia. It can grow up to 1.8 m in length and weigh over 100 kg, although most adult fish recorded today are between 3 and 10 kg. The species is light olive to dark green in colour with mottled patterning across the back and sides, cream to white undersides, large rounded pectoral (side) fins, and the soft dorsal (lower back) fin, anal fin and caudal (tail) fin usually have distinct white edges.

The Murray cod generally reaches sexual maturity at five years of age. Having a slow maturation rate and relatively low fecundity means that Murray cod populations are vulnerable to continued declines or local extinctions even though the original cause of habitat or resource loss or degradation may have ceased.

The species has a distinct annual reproductive cycle. Egg production in females commences in winter and continues throughout the species' breeding season from late August to mid-December. Breeding activity, including migrations of breeding adults to suitable breeding habitats, is triggered by increasing day length and rising water temperatures (above approximately 15 °C). The species' reproductive cycle culminates in a four to five-week spawning period. Given that spawning is dependent on day length and temperature, the timing of this relatively short spawning period is expected to vary depending on the climatic region in which the population is located and annual variations in climatic conditions within regions. Migrations, spawning and development of larvae tend to occur later in the temperate southern region of the species' distribution than in the north.

Releases of substantial volumes of cold water from impoundments have been known to reduce natural water temperatures by up to 15 °C several hundred kilometres downstream. Such reductions in water temperature severely degrade local Murray cod habitats, slow the growth of fish, inhibit the breeding cycles and cause larval mortality when they coincide with the breeding season.

Natural flow regimes in the waterways of the Murray-Darling Basin (the Basin) are important to the ecology of the Murray cod. They enable the migration of breeding adults upstream and the dispersal of larvae downstream to habitats suitable for sheltering and foraging. Adults tend to move 40–50 kilometres upstream to spawn, however some have been tracked several hundred kilometres. Flows in the northern parts of the Basin are typically higher in summer and lower in winter, whereas flows in the southern parts of the Basin are generally high in winter and spring and low in summer and autumn. Research suggests that the reduced frequency, extent and duration of flooding in the Basin resulting from river regulation adversely affect Murray cod larval recruitment (successful addition of juveniles to populations through the survival and development of newborn young).

Murray cod form breeding pairs once upstream movement is complete. Females deposit eggs in mats (flat dense clusters) on hard, bare substrates. The male guards and fans the eggs during the incubation period. After hatching, the larvae remain clustered at the nest site for up to 11 days – with the male fish continuing to guard them – before dispersing downstream. Larvae disperse from nest sites actively drifting in currents, usually at night. After 3–7 days of drifting, larvae tend to settle where they find suitable sheltered habitats, typically along the margins of main-channel waterways.

Sudden releases of large volumes of water from large impoundments resulting in fast flows of water can be detrimental to the recruitment of Murray cod larvae in populations

downstream if they coincide with spawning events. Depending on the proximity of breeding habitat downstream of large impoundments, strong flows can dislodge eggs from spawning sites or flush larvae from nests before they are mature enough to drift downstream. Larvae can also be flushed into waterways outside of the main-channel waterway, such as anabranches, billabongs and irrigation channels, where habitat necessary for their survival, especially during periods of drought, is less likely to be found.

Adult Murray cod are known to be territorial and show homing behaviours. After upstream migration and breeding, they often return downstream to the same snag (piece of large submerged woody debris) that they originally departed from. This unique behaviour emphasises the significance of snags to Murray cod as they may be important location markers of an adult's usual home range.

More information on the biology and ecology of the Murray cod is provided in the Department's Species Profile and Threats (SPRAT) database.

2. Could the impacts of your action[1] occur within the natural distribution of the Murray cod?

The Murray cod has a broad natural distribution within the waterways of the Murray-Darling Basin. It is found in New South Wales, Victoria, Queensland, South Australia and the Australian Capital Territory up to about 1000 m above sea level, particularly in the northern parts of the basin. Stocking with hatchery-bred Murray cod fingerlings has occurred in waterways and artificial impoundments (dams, reservoirs or weirs) within and outside the species' natural distribution (the species' distribution).

The Murray cod's current distribution remains patchy and is localised to areas where habitat for the species' sheltering, foraging, breeding and upstream migration is abundant and habitat modification and disturbance is minimal. Map 1 shows the species' distribution: the river catchments in which the species naturally occurs.

The Murray cod population in NSW has experienced large historic declines but the species is still found in the majority of its distribution. Stocking with hatchery-bred Murray cod fingerlings has occurred in many waterways, reservoirs and farm dams within the species' distribution in NSW and the ACT. This has maintained the species' distribution where the species would otherwise have been rare or locally extinct.

The Murray cod population in Victoria has experienced large historic declines, both in size and in extent of distribution. The species has been successfully stocked into a number of waters within its distribution in Victoria, but there are few tributaries of the Murray River where it could be considered common.

The Murray cod population in Queensland has also experienced a decline in size and in extent of distribution. Historically, Murray cod have been translocated (including the stocking of hatchery-bred fingerlings) into numerous waterways outside of their distribution, including the Mary and Dawson Rivers. However, most of these translocated populations have failed to persist.

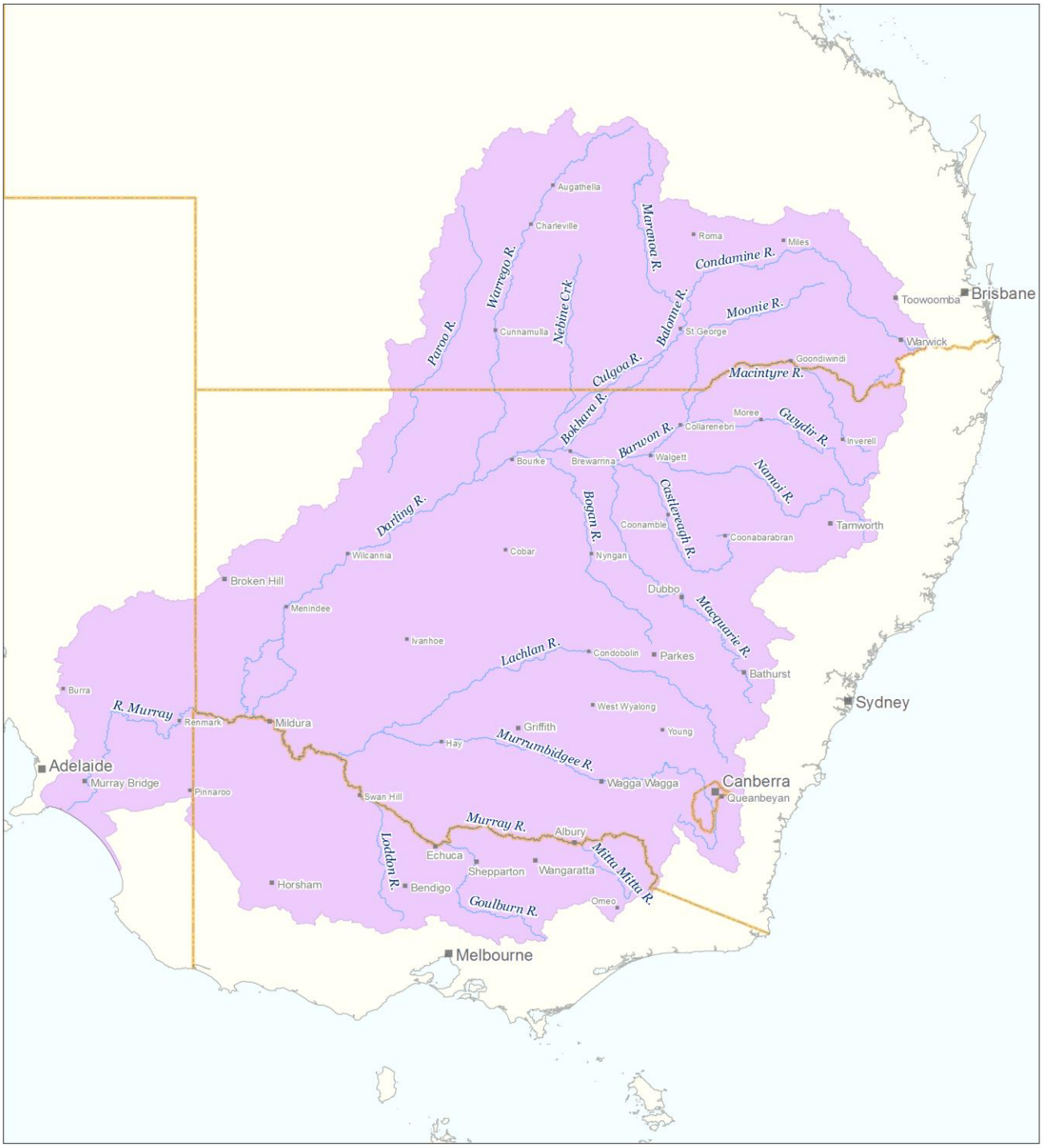
[1] When considering whether or not your action will have a significant impact on the Murray cod, it is relevant to consider all adverse impacts from the action, including direct, indirect and offsite impacts such as downstream or downwind impacts, upstream impacts and facilitated impacts (impacts that result from further actions, which are made possible or facilitated by the action).

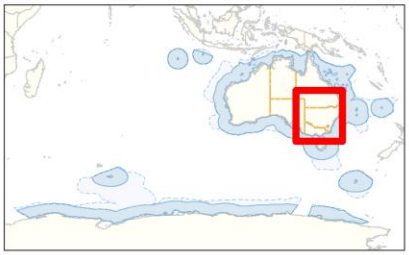
In South Australia, the Murray cod was once common along the main channel and anabranches of the River Murray, the lower lakes and some sections of streams draining from the Mount Lofty Ranges. Since the early 1900s, there have been large declines in the abundance and potentially the distribution of Murray cod. Current research indicates that key areas, such as flowing anabranches (e.g. Chowilla), are important for recruitment of Murray cod, particularly during years of sustained low flows in the River Murray.

The species' indicative distribution is shown in Map 1 and is based on the best available information at the time of publication. For the most up-to-date report of whether the Murray cod may occur in your study area[2], use the Department's Protected Matters Search Tool.

[2] For the purposes of these guidelines, 'study area' refers to the geographical area in which your proposed action is likely to directly or indirectly affect a potentially occurring Murray cod population or habitat for the species' sheltering, foraging, breeding or dispersal. This area should extend as far downstream and upstream from the boundary of the project footprint as necessary to assess all potential negative impacts.

Map 1: Indicative distribution of the Murray cod (*Maccullochella peelii*)





0 50 100 200 300 400 km

Legend

- River catchments in which the species may occur
- Cities & Towns
- State Border
- MajorRivers

12/01/2016

Caveat: The information presented in this map has been provided by a range of groups and agencies. While every effort has been made to ensure accuracy and completeness, no guarantee is given, nor responsibility taken by the Commonwealth for errors or omissions, and the Commonwealth does not accept responsibility in respect of any information or advice given in relation to, or as a consequence of, anything containing herein.

Contextual data sources:
Dept. of the Environment (2015), *Species of National Environmental Significance Database*
Dept. of the Environment (2012), *Collaborative Aust. Protected Areas Database*
Geoscience Australia (2006), *GEODATA TOPO 250K Series 3*
Geoscience Australia (2006), *Aust. Maritime Boundaries*

3. Could your action have an impact on an important population of the Murray cod?

Important populations are necessary for a species' long-term survival and recovery because they support and maintain breeding and recruitment, dispersal and genetic diversity across the species' distribution. Therefore, important populations are an essential consideration when assessing impacts on a vulnerable species.

At the time that the National Recovery Plan was finalised, a number of waterways in which important populations of the Murray cod occur were identified according to a variety of criteria, most notably geographic representation (upland, lowland), separate genetic units, and population size or integrity to support breeding stocks. Additional populations have since been identified and the list of waterways in which important populations occur updated in consultation with the National Murray Cod Recovery Team and other experts.

Important populations of the Murray cod occur in the following sections of waterway:

Queensland

- Condamine River upstream of Warwick
- Border rivers (see also populations listed for NSW):
  - the Macintyre-Dumaresq Rivers to approximately 50 km downstream of Goondiwindi
  - Weir River
  - Macintyre Brook downstream of Inglewood
  - Severn River, and
  - Pike Creek downstream of Glenlyon Dam
- Warrego River between Charleville and Cunnamulla

NSW

- Border rivers:
  - Macintyre River downstream from the Elsmore area
  - Dumaresq River
  - Severn River upstream and downstream of Pindari Dam, and
  - Mole River
- Gwydir River from Copeton Dam to Moree (including the Horton River)
- Namoi River upstream of Lake Keepit and between Boggabri and Pilliga
- Lachlan River between Brewster Weir and Booligal
- Murray River upstream of Lake Hume to Jingellic
- Murray River, tributaries and anabranches downstream of Lake Mulwala
- Edward River including major tributaries
- Murrumbidgee River from Wagga to Hay
- Darling River downstream of Menindee

ACT

- Murrumbidgee River

Victoria

- Kiewa River downstream of Dederang
- King River downstream of Edi
- Ovens River
- Broken Creek downstream of Nathalia
- Broken River downstream of Benalla
- Goulburn River downstream of Lake Nagambie
- Ulupna Creek (an anabranch of the Murray River)
- Mullaroo Creek/ Lindsay River/ Wallpolla Creek (anabranches of the Murray River)
- Other sections of the Murray River (see populations listed for NSW)

South Australia

- Chowilla anabranch system (extends into NSW on the northern side of the Murray River)
- Pike River - Mundic Creek system
- Kattarapko anabranch system
- Lower River Murray (floodplain and gorge reaches – i.e. from the NSW border to Lake Alexandrina)
- Lakes Alexandrina and Albert

4. Could your action adversely affect any Murray cod habitat?

The Murray cod is found in a wide range of warm and temperate water habitats which range from clear, rocky, fast-flowing upland streams (as found in the upper western slopes of NSW and in the ACT) to turbid, slow-flowing to standing waters in lowland rivers, tributaries, anabranches (including larger billabongs) and lakes. The species prefers waterways with ample structural features providing shelter and deep pools and waterholes up to 5 metres in depth. The Murray cod is also found in a range of impoundments (dams, reservoirs or weirs). In large impoundments, the species may be found at depths below 5 metres where temperatures or the amount dissolved oxygen in the water are not too low.

All life history stages of the Murray cod depend on structural features in waterways, such as snags in lowland streams and boulders and bedrock features in upland streams, to slow the flow of water during periods of high or fast flows and to provide shelter. Juvenile fish, in particular, require shelter from fast-flowing water and larger fish require structural features as ambush points for foraging. Overhanging stream banks and vegetation, trailing bank vegetation, tree stumps, logs and branches in stream habitats also provide shelter for all life-history stages[3] of the species.

[3] For the purposes of these guidelines, 'life-history stage' refers to a distinct stage of development during the life of an individual Murray cod from inside the egg to hatchling or 'larvae" to swimming juvenile to adult at sexual maturity.

Breeding occurs where snags or hard clay banks are present in lowland waterways and where large rock boulders or bedrock features are present in upland waterways. The removal of snags or other structural habitat, or riparian vegetation from which snags originate, will reduce the carrying capacity of the population in that area of habitat. When flooding occurs in seasonal wetlands, the Murray cod is known to shelter under shrub species, such as tangled lignum (*Duma florulenta*).

Any section of a waterway that comprises a connected system of habitats suitable for sustained use by a Murray cod population for sheltering, foraging, breeding and upstream and downstream movement is considered by the Department to be **habitat critical to the survival of the species**[4].

Further information on the habitat types in which the Murray cod occurs is provided in the SPRAT database.

5. Have you assessed potential habitat and surveyed for the Murray cod using the recommended methods?

If the environmental impact of your proposed action does not occur in an area where important populations of the Murray cod occur, as listed above, the Department recommends that you conduct a desktop assessment, habitat assessment and a targeted survey for Murray cod using the most appropriate methods.

Desktop assessment

With regard to the nature and extent of your proposed action and its potential environmental impacts, determine the extent of your study area.

Assess the distribution of Murray cod records in relation to your study area by:

- contacting the relevant state or territory fisheries authorities and local angling associations
- reviewing all location and stocking records, and
- reviewing the relevant peer-reviewed literature on the species.

Murray cod populations that are likely to be affected by your proposed action should be identified by clearly indicating on a map of the study area where and when specimens have been recorded.

Habitat assessment

An assessment of potential in-stream and riparian habitat features in the study area should indicate how various life history stages of the species may use the habitat. Assess the quality of potential habitats for the species' sheltering, foraging, breeding and movements, in particular the presence of the habitat features described above.

A habitat assessment should include an assessment of the characteristics and extent of vegetation and other environmental features adjacent to potential aquatic habitats in the study area. The distribution of habitat for sheltering, foraging, breeding and movement of Murray cod populations in the study area should be shown clearly on a map.

[4] This definition is distinct from declared 'critical habitats' in NSW which are protected under sections 53–55 of the *Threatened Species Conservation Act 1995*.

Targeted survey

A guide to conducting targeted surveys for the Murray cod in areas of suitable habitat is outlined below. Surveys should:

- be conducted by a suitably qualified person with demonstrated skill in Murray cod surveys
- maximise the chance of detecting the species, and
- account for uncertainty and error (e.g. false absences).

There are a range of survey methods which are suitable for detecting the Murray cod in potential habitat. Selection of the most appropriate survey methods that are also the least disruptive for the species in a given area of potential habitat will depend on the characteristics of the site, the time of year and the life history stages that may be present. For example, the most effective methods of surveying a lowland river habitat on an autumn day , such as electrofishing, would be unsuitable for surveying a narrow rocky upland river between September and mid-December when adults may be engaged in breeding activity or recently hatched larvae may be present.

Optimal timing

The optimal period in which to survey for Murray Cod is from March to May. Survey methods that involve the direct physical disturbance of Murray Cod adults or juveniles, for example catch-and-release fishing or electrofishing, are not recommended to be used during the period from June to mid-December. Such methods are likely to cause stress to adult females leading to egg resorption during winter, and disrupt breeding activity from late-winter to early summer. These methods can also be harmful to adults or juveniles when they are used during the warmer months of the year, particularly when water and air temperatures are high. Less disruptive survey methods may be used at any time.

Survey methods

Table 1 provides general guidance on the suitability of recommended Murray cod survey methods for lowland and upland habitat types and the appropriate time of year in which to use those methods. Where it is not possible to conduct surveys in the recommended manner, or to use equivalent, alternative methods, failure to detect the Murray cod should not be considered indicative of its absence.

While the Survey guidelines for Australia's threatened fish provides general guidance on survey methods for listed threatened fish species including the Murray cod, it is recommended that you apply the survey approach and use the survey methods outlined in these guidelines.

Table 1: Survey guidelines for detecting the Murray cod

Survey method	Habitat suitability	Timing
Electrofishing	Use boat-mounted units in waterways of sufficient size. Use backpacks or shore-mounted units in small flowing upland waterways.	Generally March to May. However, from mid-December onwards (after breeding season), these methods could be used during cool periods, for example during the early morning
Skilled catch-and-release fishing using suitably strong tackle and lures with single barbless hooks, or baits on barbless hooks, and careful 'best-practice' handling methods[5]	All habitat types	
Daytime snorkelling	Clear waters in any part of the species distribution	Any time of year – these methods are especially useful during the breeding season and hot weather
Spot-lighting at night		
The use of underwater cameras mounted on poles and probed into snags, undercuts, etc.		
The use of Doppler imaging equipment mounted on poles and probed into snags, undercuts and other shelter habitats.	Turbid waters in any part of the species distribution	
The use of fine meshed fyke nets to detect small juvenile fish	A range of stream structures, billabongs, swamps, farm ponds, dams and irrigation channels	Early September to early January depending on the regional spawning period (refer to Section 1)
The use of larval drift nets to detect larvae	Downstream of breeding habitat	

6. Could your action have an impact on the species as a whole?

In addition to impacts on important populations of the Murray cod, you need to consider the potential for your action to have a significant impact on the species in other ways, for example facilitating the introduction of disease, invasive or predatory species, or modifying or destroying currently unoccupied habitat that meets the description of habitat critical to the survival of the species above. For further information on significant impact criteria, refer to page 11 of Significant impact guidelines 1.1. Section 8 of these guidelines provides some guidance on how these criteria may be applicable to the impacts of your proposed action.

7. Options for mitigating impacts

When designing your proposed action, avoiding impacts on the Murray cod should be your principal aim. This can be achieved by retaining habitat and preserving populations of the Murray cod. If you believe you have no options to retain habitat or conserve populations, you should mitigate the impacts of your proposed action. Table 2 outlines the main threats to the Murray cod within its distribution, the associated impacts and measures to mitigate or reduce the level of impact. It is not intended to be exhaustive or prescriptive. Impact-mitigation should be monitored to ensure that it is effective and to allow for adaptive management responses.

[5] Murray cod are extremely susceptible to high water and air temperatures and stress from excessive/prolonged handling. They are also very susceptible to damage to their scales and mucus lining, which often results in oomycete (*Saprolegnia* species) infections. Murray cod should never be handled with dry hands or placed on hot, dry or rough surfaces.

Table 2: Primary threats, impacts and mitigation

Threat	Impact	Mitigation
Habitat removal, modification or degradation (through actions such as the clearing of riparian vegetation, removal of snags, stream diversions, bridge and channel constructions or upgrades, the introduction of livestock to the riparian environment, or any action resulting in the substantial sedimentation or alteration of the hyrdochemistry of the aquatic habitat)	• Loss of in-stream shelter habitat (structure and diversity) and the resultant alteration of flow regimes in waterways • Loss of habitat through the reduction or alteration of groundwater flows • Loss of in-stream habitat through infilling of refuge pools or the sedimentation of potential spawning sites • Collapse and loss of stream bank habitat as a result of stock movements • Deterioration of water quality leading • Murray cod eggs and larvae and other freshwater biota are particularly susceptible to increased salinity, especially above 0.34g/L. • Direct mortality of Murray cod (considering all life-history stages of the species)	• Devise and implement alternatives to the removal of snags or other habitat features from waterways. It is preferable to relocate snags in the waterway rather than removing them. Refer to relevant state or territory guidelines during planning phases. • Minimise the removal of the native vegetation from the riparian zone, especially within 30 m of the waterway, in order to maintain shelter for the species and to provide an ongoing source of woody debris, especially snags. Maintain it as a buffer to minimise soil erosion and protect habitat from sedimentation. • Implement a plan to maintain water quality to the *Australian and New Zealand guidelines for fresh and marine water quality*: *Volume 1 (2000)* (ANZECC guidelines) (www.environment.gov.au/resource/australian-and-new-zealand-guidelines-fresh-and-marine-water-quality-volume-1-guidelines) through appropriate, regular monitoring of key water quality indicators and response to significant changes in water quality. • Develop and implement a detailed spill and contamination prevention plan for pollutants and biocides. • Design, maintain and operate projects appropriately to minimise the risk of sedimentation, or chemical or thermal pollution. • Maintain water flows to limit the deposition of sediments in the waterway.
Creation of barriers in habitat (through actions such as the construction or upgrading of water impoundments or road crossings, or the discharge of cold water or pollutants into streams)	• Obstructs the movement of adult or juvenile Murray cod and may limit the success of recruitment • Reduced ability to recolonise areas during or after adverse environmental events, such as droughts or bushfires in the surrounding landscape • Fragmentation and isolation of populations generally leads to genetic drift over successive generations and a reduction in genetic diversity in those isolated populations. • Undershot weirs are known to be lethal to most Murray cod larvae that pass through them.	• Where alternatives to the construction of physical barriers in habitat are unavoidable, they must be designed, constructed and maintained to best-practice standards. Consider the downstream drifting of Murray cod larvae when designing barriers. • Design road crossings and fishways to allow upstream and downstream movement of native fish species, including the Murray cod. Confirm that fishway designs are fit-for-purpose by consulting fishway experts. For example, refer to Fairful and Witheridge (2003). • Design and maintain barriers to avoid the creation of thermal and chemical barriers as a result of in-stream stratification. • Implement barrier monitoring, maintenance and remediation strategies to repair, replace or remove damaged or ineffective weirs or fishways. • Where there are no alternatives to installing a weir, install an overshot weir. Undershot weirs are not recommended.

Threat	Impact	Mitigation
Alteration of natural flow regimes (including flood pulses) and the alteration of thermal regimes of waterways (through river regulation: the construction of water impoundments and the extraction or release of water from storages)	• Entrapment or water-flow entrainment of Murray cod in impoundments or irrigation channels resulting in the an increased mortality rate in the local population • Altering the environmental factors that stimulate spawning migrations of the species • Reduction in flow velocity and depth needed for the movement of breeding adults upstream or larvae downstream and, therefore, the species' breeding or distribution potential • Large sudden releases of water from storages may cause: ○ immature Murray cod larvae to be flushed from breeding habitat before they are ready to drift downstream ○ thermal pollution of downstream habitats ○ the flushing of planktonic food resources for drifting larvae ○ the erosion and slumping of stream bank habitat, and ○ water-quality problems that can kill fish.	• Maintain environmental flows, to meet the requirements of the species, as much as possible. Where releases of environmental flows from impoundments are proposed, conduct scientific research of the downstream aquatic ecosystem to gather evidence about the most appropriate times of year and rates at which water should be released to maximise the benefit to, and avoid adverse effects on, the various life history stages of the species and its habitat. Develop and implement a plan for releases of environmental flows based on the evidence gathered. Monitor and make reports available to the public on the effectiveness of such water releases. • Minimise the drawdown of impoundments for irrigation purposes, particularly during the breeding season (September to mid-December). • Incorporate ramping up/down protocols in the commencement and cessation of water flows. • Implement measures to maintain water temperatures within 1.5˚C of the monthly median temperature of the waterway. Use an appropriate impoundment design (multi-level take-offs and remixing of thermally stratified water in the storage) to manage the thermal regime of the waterway. • Where there are no alternatives to the installation of irrigation channels, pipes or water pumping systems, design and install with devices to avoid the entrapment or water-flow entrainment of Murray cod in such systems. Use screening systems of an appropriate/approved design. Maintain and clean screens regularly, monitor their effectiveness and replace when necessary.

Threat	Impact	Mitigation
Release of hatchery-bred Murray cod with a limited genetic base in waterways where populations naturally occur (through inappropriately controlled selective breeding/stocking programmes and aquaculture operations)	• Selection of broodstock from genetically separate populations or distant geographic regions, where members of the species are specially adapted to different environmental conditions, for use in a stocking programme can alter the genetic identity of a stocked population and cause a reduction in its biological fitness (regardless of whether it has been previously stocked). This effect is known as outbreeding depression. • Stocking a Murray cod population (regardless of whether it has been previously stocked) with fingerlings that are the product of inbreeding in a hatchery or small wild population can cause a reduction in the genetic diversity and biological fitness of the stocked population. • The lower the genetic variation or the smaller the number of genetically effective breeders in a wild population, the greater the effect that inappropriate broodstock selection and stocking is likely to have on that receiving population	• Apply the guidance outlined in the FAO *Technical Guidelines for Responsible Fisheries - Precautionary Approach to Capture Fisheries and Species Introductions – 2* (1996), available on the FAO's website at www.fao.org/fishery/topic/13302/en#container, during the early planning and risk assessment of a breeding/stocking programme. • Principal requirements to maintain genetic integrity or diversity in a wild population that is proposed to be stocked with hatchery-bred fish are: ○ obtaining broodstock from the local wild population ,which the stocking programme is intended to enhance, and not from genetically separate populations or distant geographic regions ○ avoiding the use of hatchery-bred fish [either those produced within the same hatchery or individuals collected in a waterway that are identifiable (see dot point below) as having originated from former breeding/stocking programmes] as broodstock. Implement broodstock rotation at appropriate time intervals. ○ maximising the number of effective breeders in a breeding program by increasing the total number and equalising the sex ratio of the broodstock in ponds, and using artificial spawning methods to increase control of matings, eliminate polygamous spawnings and repeat spawning between individuals ○ maintaining records of broodstock collection methods, hatchery and stocking operations, the genetics and geographical locations of all broodstock collected and fingelings to be stocked, and ○ monitoring the effect of stockings on the genetic structure of receiving populations, their contribution to relevant state fisheries and the conservation of the species in the region. The most effective method to assist in the future identification of stocked Murray cod is to record the genetics of released fingerlings. Fingerlings may also be marked physically or chemically in a manner which identifies the genetics or parentage of those fish. • Design and implement a breeding/stocking programme in accordance with best-practice procedures to maintain genetic diversity and prevent the introduction of harmful pathogens and invasive species in a stocked population. For example, refer to the NSW DPI *Hatchery Quality Assurance Programme* available on the NSW DPI website at www.dpi.nsw.gov.au/__data/assets/pdf_file/0019/223534/Hatchery-Quality-Assurance-Program.pdf.

Threat	Impact	Mitigation
Introduction or increased release of native or non-native fish, or diseases or parasites, in waterways where populations naturally occur (including through actions such as stocking programmes, fish aquaculture or ornamental outdoor pond operations, or through the movement of recreational anglers between fishing sites)	• Reduction in habitat and food resources as a result of competition with introduced fish, particularly exotic species such as European carp (*Cyprinus carpio*), redfin perch (*Perca fluviatilis*), brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykiss*), goldfish (*Carassius auratus*) and mosquitofish (*Gambusia holbrooki*) • Predation by introduced fish species, particularly the brown trout, rainbow trout and redfin perch • Disease, injury or mortality of Murray cod as a result of parasitism or infection with pathogens	• Implement appropriate hatchery and aquaculture operation controls. • Implement and maintain biosecurity in hatcheries with currently accepted aquaculture protocols. • Devise and implement a biosecurity plan that identifies all potential pathways for the introduction and spread of infectious diseases, and establishes protocols to minimise the risks of disease transmission to Murray cod populations. The plan should include an auditing component. • Restrict all water flows and fish transfers between areas of suspected fish virus sources and previously unaffected ecosystems. • Devise and implement an invasive species management plan/alien fish strategy. • Devise and implement invasive species barriers/traps. • Devise and implement a campaign to educate recreational anglers about the threats (i.e. predation, competition and spread of harmful pathogens) that specific introduced fish species pose to the local Murray cod population. Install and maintain signage at popular fishing locations about best-practice methods to prevent the translocation of introduced fish or the pathogens they may carry to other waterways within the Murray cod's distribution. • Restrict fishing in high risk areas where translocation of introduced fish, diseases and parasites could become an issue. • Recreational anglers should take precautionary steps to minimise the risk of transferring introduced fish, diseases and parasites between sites. It is recommended that anglers use a separate set of fishing equipment in areas known to be free of the pathogen rather than attempting to disinfect potentially contaminated equipment.
Overfishing (through organised recreational fishing operations or events involving multiple anglers taking Murray cod from within the species' distribution)	• Reductions in breeding populations • Angling can disrupt the breeding cycle of a population. Disturbance caused by angling may cause egg resorption in females during winter and may be disrupt breeding activity during the period from late August to mid-December.	• Practice catch-and-release angling using suitably strong tackle and lures with single barbless hooks, or baits on barbless hooks, and careful 'best-practice' handling methods[4]. • Follow state and territory regulations on size and bag limits and closed seasons[6].

[6] Recreational fishing activities undertaken by individual anglers in accordance with relevant state or ACT laws would not require referral for assessment and approval under the EPBC Act. However, an action proposed to be undertaken by a person or incorporated body, which involves the removal of a substantial number of Murray cod from within the species' natural range over a given timeframe, has the potential to have a significant impact on the species. An estimation of what is a "substantial number" of fish removed from the Murray cod population within a state's or the ACT's jurisdiction must take into account how that action may affect the cumulative take by all recreational anglers relative to the sustainable yield determined for the species for a given timeframe by the fisheries authority in that jurisdiction.

8. Could your action require a referral to the Minister for a significant impact on the Murray cod?

It is your responsibility to decide whether or not to refer your action to the Minister. If you believe your action is likely to have a significant impact on the Murray cod, you should refer your action to the Department. If you are uncertain whether your action will have a significant impact on the Murray cod, you may still refer or contact the Department.

Table 3 provides guidance on what may be at high to low risk of requiring a referral to the Department, and where uncertainty may exist. This guidance is not intended to be comprehensive. Other types of actions or impacts may constitute varying degrees of risk.

Table 3: Referral guidelines

High risk of significant impacts on the Murray cod: referral recommended
• An action that is likely to adversely affect habitat critical to the survival of the species by: ○ removing, modifying or degrading the structural elements of a significant proportion of the habitat ○ causing the sedimentation of a significant proportion of the habitat causing a divergence of greater than 1.5 °C from the monthly median water temperature of a waterway[7] in which the habitat occurs ○ reducing the water quality (especially relating to temperature, dissolved oxygen, acidity, salinity, chemical pollutants) of a significant proportion of the habitat outside the applicable minimum or maximum thresholds presented in *the Australian and New Zealand guidelines for fresh and marine water quality: Volume 1 (2000)* (ANZECC guidelines) (www.environment.gov.au/resource/australian-and-new-zealand-guidelines-fresh-and-marine-water-quality-volume-1-guidelines) ○ creating a barrier which fragments habitat or alters the existing flow regime or hydrology of the habitat, for example eliminating flood pulse flows, creating weir pool effects or degrading spawning sites with low-flow accumulations of algal/periphytic growth or silt • An action that is likely to adversely affect an important population of the species (see Section 3) in any of the above-mentioned ways, or by: ○ removing, modifying or degrading the structural elements of a significant proportion of habitat which the population may rely on for sheltering, foraging or breeding ○ fragmenting the population or substantially inhibiting the population's breeding cycle, larval recruitment or the exchange of genetic material by restricting the upstream or downstream movement of the population, including freely drifting larvae ○ disrupting the activity of a breeding population in a manner which is likely to substantially diminish recruitment of larvae into the local population during a single breeding season ○ reducing its genetic diversity ○ decreasing the size of the population or of any given life-history cohort of that population over the long-term ○ substantially decreasing the size of the population, or of any given life-history cohort of that population, to the extent that its reproductive capacity is likely to be substantially

[7] Where the monthly median water temperature of the waterway is not available, gather relevant data available for all comparable waterways in the catchment and apply the most appropriate values.

diminished in the succeeding one or more breeding seasons

- introducing a predatory or competitive native or alien fish species or pathogen that is likely to be detrimental to the population

Uncertainty: referral recommended or contact the Department

- An action that may adversely affect a habitat critical to the survival of the species or important population in any manner as mentioned in the 'High-risk' section of this table
- An action that is likely to adversely affect a large area of habitat, which does not meet the description in these guidelines of habitat critical to the survival of the species, by:
  - substantially reducing the water quality (especially relating to temperature, dissolved oxygen, acidity, salinity, chemical pollutants) outside the applicable minimum or maximum thresholds presented in the ANZECC guidelines
  - substantially altering the existing flow regime or hydrology of the aquatic system
- An action that is likely to adversely affect a population, which is not considered an important population as indicated in these guidelines, by:
  - causing a long-term or substantial short-term decrease in the size of the population or of any given life-history cohort of that population, for example through an organised recreational fishing operation or event involving multiple anglers taking multiple Murray cod from an important population over a relatively short time period
  - causing a large reduction in the area of occupancy of the population
  - fragmenting the population or preventing the upstream or downstream movement of the population and the flow of genetic material
  - disrupting the activity of the breeding population in a manner which is likely to substantially diminish recruitment of larvae into the local population during a single breeding season
  - reducing the genetic diversity of the population
  - introducing a predatory or competitive native or alien fish species or pathogen that is likely to be detrimental to the population (such an impact could result from the action of an individual angler)

Low risk of significant impacts on the Murray cod: referral may not be required but you may refer for legal certainty

- An action affecting a Murray cod population occurring outside the species' distribution
- Temporary impacts on a population outside of breeding season
- Individual recreational fishing activities following relevant state or territory regulations on fishing equipment, size and bag limits and closed seasons