Internal use only	
Reference Number	/

Nomination to change the conservation class of a species under the Queensland *Nature Conservation Act 1992*

Complete this form to nominate a species for assessment of its conservation class under the *Nature Conservation Act 1992* (NC Act). Any subspecies, variety, race, hybrid, mutation or geographically separate population (hereafter 'species') can be nominated. The appropriate conservation class will be selected during an expert assessment process and, following approval processes, reflected in the next suitable update of the NC Act.

A species may be nominated to an appropriate conservation class from any other conservation class. The nomination assessment process may result in a species being recommended to the conservation class as nominated, or to a class better supported by scientific data and expert opinion. Assessments and nominations will be shared with the Commonwealth and other Australian jurisdictions within the species' distribution.

All plant and vertebrate species native to Queensland are protected under the NC Act and classified as Least Concern unless found eligible for a different conservation class. Invertebrate species are only protected under the NC Act if specifically named under a conservation class. A species can be nominated for listing or reassignment from any conservation class to:

A national threat category:

- Extinct (EX), Extinct in the Wild (EW), Critically Endangered (CR), Endangered (E) or Vulnerable (V) if it meets at least one of the International Union for Conservation of Nature (IUCN) criteria for species at risk of extinction

A state threat class:

- Near Threatened (NT) if the species meets at least one of the criteria for species at risk of becoming threatened in the future based on concerns relating to population dynamics or threats
- Least Concern (LC) if evidence is provided that no criteria for a higher class have been met, and the species won't become eligible for a higher class in the foreseeable future should conservation actions cease due to reclassification.

The assessment of species against the national threat categories reflected in this form complies with the Memorandum of Understanding for the Common Assessment Method (CAM) between the Commonwealth and Australian states and territories. The objective of the CAM is for partner jurisdictions to adopt each other's national assessments as appropriate. Information about the CAM can be found at https://www.qld.gov.au/environment/plants-animals/wildlife-permits/common-assessment.

To nominate a species with an Australian distribution that is not restricted to Queensland, use the nomination form and guidelines at http://www.environment.gov.au/biodiversity/threatened/nominations/forms-and-guidelines and email the completed form to the Australian Government at EPBC.nominations@environment.gov.au.

Important notes for completing this form

- **To enable a species eligibility for listing to be assessed against the criteria, please complete the form as comprehensively as possible by providing a response in each box with an orange border.**
- Completing a nomination is a demanding task. Nominators are encouraged to seek advice from experts where appropriate to assist in completing the nomination form.
- The opinion of scientific experts may be cited as personal communication with their approval. Please provide the experts names, qualifications and contact details (including employment in a government agency if relevant) in the reference list at the end of the form.
- Include any available information and analysis or state when the required information is not available.
- Figures, tables and maps can be included at the end of the form or provided as separate electronic files or hardcopy documents (referenced as appendices or attachments in your nomination).
- Cross-reference relevant areas of the nomination form where needed.
- **Reference all information sources**, both in the text and in a reference list at the end of the form.
- Identify confidential material and the reason it is sensitive. With the exception of information you have identified as confidential, nominations under the CAM process may be made available by a state, territory or the Commonwealth Government to experts or the public for comment.
- If the species is listed nationally, the Australian Government will publish nomination information on its website. Your details as nominator will not be released and will be treated as confidential information.
- Guidance on interpreting this nomination form can be found in the "*Guidelines for Assessing the Conservation Status of Native Species*" developed by the Australian Government under the EPBC Act here http://www.environment.gov.au/biodiversity/threatened/nominations/forms-and-guidelines. Although not fully relevant under the NC Act, the guidelines provide assistance on several aspects of this form. Please email SpeciesTechnical.Committee@des.qld.gov for further advice on completing the nomination.

Further information on selected questions

INTRODUCTION

Species native to Queensland may be nominated to any conservation class under the NC Act, including to transfer between classes. If the taxon at risk is a population or hybrid, or if you wish to know if it has been unsuccessfully nominated under the NC Act in the past, please contact the Queensland Department of Environment and Science for advice at SpeciesTechnical.Committee@des.qld.gov.au.

To search for a species' conservation class under the NC Act please refer to the *Nature Conservation (Wildlife) Regulation 2006*: https://www.legislation.qld.gov.au/view/html/inforce/current/sl-2006-0206.

You can also search the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) list of threatened species in the Species Profile and Threats Database (SPRAT) at www.environment.gov.au/cgi-bin/sprat/public/sprat.pl.

The full lists of threatened fauna and flora under the EPBC Act are available here:
www.environment.gov.au/cgi-bin/sprat/public/publicthreatenedlist.pl?wanted=fauna
www.environment.gov.au/cgi-bin/sprat/public/publicthreatenedlist.pl?wanted=flora.

You can find a list of nominated species that did not meet the assessment criteria for listing under the EPBC Act at www.environment.gov.au/biodiversity/threatened/unsuccessful-species.html.

A nomination to transfer a species from a threatened conservation class to Least Concern or Near Threatened under the NC Act need not address sections marked with an asterisk (*).

SCIENTIFIC AND COMMON NAMES OF NOMINATED SPECIES

- Provide the currently accepted scientific and common name(s) for the species (including Indigenous names, where known). Note any other scientific names that have been used recently such as superseded names.

TAXONOMY

- Record the species' authority and the taxonomic group to which it belongs (Family name is sufficient for plants; both Order and Family name are required for fauna).
- Is the species known to hybridise with other species? Describe any cross-breeding with other species in the wild, indicating where and how frequently this occurs.

DISTRIBUTION

- In accordance with the CAM, the Commonwealth is the default assessment 'lead' for species occurring across multiple Australian jurisdictions, and the nomination will be subject to the prioritisation and assessment process under the EPBC Act. Download the nomination form here http://www.environment.gov.au/system/files/pages/d72dfd1a-f0d8-4699-8d43-5d95bbb02428/files/nomination-form-species.pdf, and email it to epbc.nominations@environment.gov.au. Further information on the EPBC Act nomination, prioritisation and assessment process is available at http://www.environment.gov.au/biodiversity/threatened/nominations.
  Note: where the relevant jurisdictions agree, a State or Territory (rather than the Commonwealth) may take the lead on assessing a cross-jurisdictional species, in consultation with the Commonwealth and other jurisdictions.
- A nomination for a species endemic to Queensland or with its only Australian distribution in Queensland, for example a species only occurring in Queensland and Papua New Guinea, can be assessed under the NC Act. Please submit your completed nomination form to SpeciesTechnical.Committee@des.qld.gov.au.
- Describe the species' current geographic distribution within Queensland, and where applicable, outside Australia.
- Provide a map, if available, indicating latitude, longitude, map datum and location names
  - Indicate the percentage of the global population that occurs in Queensland, and what is its significance?
  - Is the Queensland population distinct, geographically isolated, or does part or all of the population migrate into/out of the Queensland jurisdiction?
  - Explain the relationship between the Queensland population and the global population.
  - Do global threats affect the Queensland population?
- Give locations of other existing or proposed populations such as populations that are captive, propagated, naturalised outside their range, recently re-introduced to the wild, and planned to be re-introduced. Note if these sites have been identified in recovery plans. Provide latitude, longitude, map datum and location name, where available, in an attached table.
- Give details of fauna species' home ranges/territories including any relevant daily and seasonal or irregular movement patterns, such as arrival/departure dates if migratory.
- Does the species occur within an EPBC Act listed ecological community? You will find a list of EPBC Act listed ecological communities here: www.environment.gov.au/cgi-bin/sprat/public/publiclookupcommunities.pl.

BIOLOGY/ECOLOGY

- **Life cycle**: Provide detail on the age at sexual maturity, average life expectancy, natural mortality rates, and generation length
  - "*Generation length*" is defined as the average age of parents of the current cohort (i.e. newborn individuals in the population), and reflects the turnover rate of breeding individuals in a population. Generation length is greater than the age at first breeding and less than the age of the oldest breeding individual, except in species that breed only once. Where generation length varies under threat, use the more natural pre-disturbance generation length. It is often calculated as = (longevity + age at maturity)/2. Provide details of the method(s) used to calculate the generation length.
- **Reproduction**: Provide detail on the reproductive requirements of this species.
  - **Flora**: When does the species flower and set fruit? What conditions are needed for this? What are the pollinating and seed dispersal mechanisms? If the species reproduces vegetatively, describe when, how and what conditions are needed. Does the species require a disturbance regime (e.g. fire, cleared ground) to reproduce?
  - **Fauna**: provide an overview of the species' breeding system and breeding success, including: when it breeds; what conditions are needed for breeding; whether there are any breeding behaviours that may make it vulnerable to a threatening process.
- **Habitat**
  - Provide information on aspect, topography, substrate, climate, forest type, associated species, sympatric species and anything else that is relevant to the species' habitat.
  - Explain how habitats are used (e.g. breeding, feeding, roosting, dispersing, basking, etc.).
  - Does the species use refuge habitat (e.g. in times of fire, drought or flood)? Describe this habitat.
- **Feeding (fauna):**

- Summarise the feeding behaviours, diet, and the timing/seasonality associated with these. Include any behaviour that may make the species vulnerable to a threatening process.

- **Movement (fauna)**: provide information on daily and seasonal movement patterns.

IDENTIFICATION OF KNOWN THREATS AND IMPACTS OF THE THREATS

- For each threat, describe:
  a. whether it is actual or potential
  b. how and where it impacts on this species
  c. what its effect has been so far (is the threat known or suspected?, does it only affect certain populations?) Present supporting information/research).
  d. its expected effect in the future (is the threat known or suspected?, does it only affect certain populations?, is there supporting research/information?) Present supporting information/research).
  e. its relative importance or the magnitude of the impact on the species.

- Identify and explain any additional biological characteristics particular to the species that are threatening to its survival (e.g. low genetic diversity).
- If subject to natural catastrophic events, i.e. events with a low predictability that are likely to severely affect the species, identify the type of event, its likely impact, and its likelihood of occurrence (e.g. a drought/cyclone in the area every 100 years). If **climate change** is an important threat to the species, provide referenced information on how climate change might significantly increase the species' vulnerability to extinction. Please refer to the *Guidelines for Assessing the Conservation Status of Native Species*: http://www.environment.gov.au/system/files/pages/d72dfd1a-f0d8-4699-8d43-5d95bbb02428/files/tssc-guidelines-assessing-species-2018.pdf.

*CONSERVATION ADVICE: THREAT ABATEMENT AND RECOVERY ACTIONS

- Describe how threats are or could be abated and/or species recovered.
- Identify who is undertaking these activities and how successful the activities have been to date.
- Describe any mitigation measures or approaches that have been developed specifically for the species at identified locations. Identify who is undertaking these activities and how successful the activities have been to date.
- For species nominated as Extinct in the Wild, provide location details for any naturalised or captive populations and the level of human intervention required to sustain the species.

IMPACT OF TRANSFERRING A THREATENED SPECIES TO NEAR THREATENED OR LEAST CONCERN

- Only complete this section if you are nominating a species for transfer to Near Threatened or Least Concern from a class of nationally threatened wildlife (Extinct, Extinct in the Wild, Critically Endangered, Endangered or Vulnerable).
- Provide details of the expected impact on the species if conservation actions ceased following its transfer out of a threatened wildlife class.

CURRENT LISTING CLASS AND CATEGORY

- Note: The term 'class' under the NC Act is equivalent to the term 'category' under the EPBC Act.
- Select the species' current class under the NC Act where applicable. Search the species' NC Act class here: https://www.legislation.qld.gov.au/view/html/inforce/current/sl-2006-0206.
- Select the species' current category under the EPBC Act where applicable. Search the Australian Government SPRAT Database here: www.environment.gov.au/cgi-bin/sprat/public/sprat.pl.

NOMINATED LISTING CLASS

- **After completing the section 'Eligibility against the criteria'** sufficient evidence should be available to determine your response to this section. Please select the NC Act class to which the species is being nominated.

REASONS FOR A NOMINATION TO TRANSFER TO ANOTHER CLASS

Please describe why the species is being nominated to transfer to another conservation class in Queensland:

- *Genuine.* The change in class is the result of a genuine status change that has taken place since the previous assessment. For example, the change is due to an increase in the rate of decline, a decrease in population or range size or habitat, or declines in these for the first time (owing to increasing/new threats).
- *Knowledge.* The change in class is the result of new knowledge, e.g. owing to new or newly synthesised information about the status of the taxon (e.g. better estimates for population size, range size or rate of decline).
- *Taxonomy.* The change in class is due to a taxonomic change adopted during the period since the previous assessment. Such changes include:

- *newly split* (the taxon is newly elevated to species level)
- *newly described* (the taxon is newly described as a species)
- *newly lumped* (the taxon is recognised following lumping of two previously recognised taxa)
- *no longer valid/recognised* (either the taxon is no longer valid, e.g. because it is now considered to be a hybrid, variant form or subspecies of another species, or the previously recognised taxon differs from a currently recognised one as a result of a split or lump).

- *Mistake*. The previous class was applied in error.
- *Other.* The change in class is the result of other reasons not easily covered by the above, and/or requires further explanation. Examples include change in assessor's attitude to risk and uncertainty.

INITIAL LISTING

- The reasons for the initial NC Act listing may be available in the original nomination for the species. This can be obtained by emailing the Department of Environment and Science's Species Technical Committee at SpeciesTechnical.Committee@des.qld.gov.au.
- The reasons for EPBC Act listing may also be available. Search for the species' EPBC Act listing and conservation advice for threatened species in the SPRAT Database www.environment.gov.au/cgi-bin/sprat/public/sprat.pl.
- If there is insufficient information to provide details of the reasons for the original listing, please state this.

CHANGES IN SITUATION LEADING TO THE NOMINATION TO TRANSFER TO ANOTHER CLASS

- Describe the changes that have occurred or are likely to occur to the species' population, range or habitat that influence the nomination to change the species' conservation class.

ELIGIBILITY AGAINST CRITERIA

- For a species to be eligible as Near Threatened or a class of threatened wildlife, it must be assessed as meeting **at least one** of the five 'criteria' on this nomination form. For example, for a species listed as Vulnerable to be transferred to the Endangered class, it must meet the threshold/s for at least one of the five criteria for Endangered.
- A species does not have to be found eligible for the same class under all criteria; however, all questions must be answered. If information is not available for a particular criterion, a statement to this effect is required.
- If you hold unpublished data that support assessment of a criterion, you must provide them with the nomination.
- Standards for assessing a species' conservation status in Australia align with the IUCN Red List Criteria and Categories. Please refer to the IUCN guidelines for explanations of how to address the criteria http://s3.amazonaws.com/iucnredlist-newcms/staging/public/attachments/3151/redlistguidelines.pdf.

DECLARATION

In signing this nomination form, you agree to grant the Queensland Government (as represented by the Department of Environment and Science) a perpetual, non-exclusive, worldwide, royalty-free licence to use, reproduce, publish, communicate and distribute information that you have provided in the nomination form that is not referenced to other sources with the exception of information specifically identified by you as confidential, in websites and publications and to promote those websites and publications in any medium.

As nominator, your details are automatically subject to the provisions of the *Privacy Act 1988* and will not be divulged to third parties. The Commonwealth, State and Territory governments have agreed to collaborate on national threatened species assessments using the CAM. As part of this collaboration, your nomination, including your details as nominator, may be provided to other government jurisdictions, who will also observe these privacy and confidentiality arrangements.

If you subsequently agree to be cited as the author of specific, cited information, you will be acknowledged in all publications and websites in which that information appears, in a manner consistent with the *Style Manual for Authors, Editors and Printers* (latest edition).

Nomination form to change the conservation class of a species in Queensland

Details of the nominated species

SCIENTIFIC NAME OF SPECIES (SUBSPECIES, VARIETY, ETC. TO BE SPECIFIED WHERE RELEVANT)

Cherax robustus Riek, 1951

COMMON NAME(S)

Sand yabby

TAXONOMY

Provide any relevant detail on the species' taxonomy (e.g. authors of taxon or naming authority, year and reference; synonyms; Family and Order).

Crayfish in the Order Decapoda, Family Parastacidae. Formally described by Riek (1951).

*CONVENTIONAL ACCEPTANCE OF TAXONOMY

Is the species' taxonomy conventionally accepted?

☒Yes
☐No

If the species is not conventionally accepted, please provide the following information:

- a taxonomic description of the species in a form suitable for publication in conventional scientific literature

OR

- evidence that a scientific institution has a specimen of the species, and a written statement signed by a person who is a taxonomist and has relevant expertise (has worked with, or is a published author on, the group of species nominated) that the species is considered to be a new species.

Unlike a number of taxonomically problematic species of *Cherax* in Southeast Queensland (e.g. *Cherax dispar* Riek, 1951, *Cherax depressus* Riek, 1951) (Bentley et al. 2010), *Cherax robustus* is distinct morphologically and genetically from other *Cherax* species (Austin et al. 1996; Munasinghe et al. 2004; Bentley 2014), and does not appear to have any major intraspecific taxonomic issues (Rob McCormack pers. comm. 2020).

*DESCRIPTION

Provide a description of the species. Include where relevant its distinguishing features, size and social structure.
How distinct is this species in its appearance from other species? How likely is it to be misidentified?

Cherax robustus is a medium-sized species of the genus and grows to about 120 mm body length (R. McCormack pers. comm. 2020). The body is dark blue to almost black. The upper surfaces of the claws are of similar colour to the body and lack patterning on the palm and orange on the fingertips. The underside of the claws is deep purple (Riek 1951; Davie 2007). In adults, the pincers have a broad patch of long setae on the underside of the fixed finger which continues slightly onto the palm (Davie 2007; McCormack 2012). The inner margin of the palm is longer than the movable finger. The rostrum is broadly triangular and without spines.

Because of the particular habitat of *C. robustus*, it is only sympatric with a small number of other crayfish species. Most notable is *C. dispar* (slender yabby), a smaller (to 75 mm body length), more aquatic species, which is also widely distributed in wallum habitats (Bentley et al. 2010). Unlike *C. robustus*, *C. dispar* has a pair of well-developed spines on the rostrum.

The distribution of *C. robustus* also overlaps *Tenuibranchiurus glypticus* (swamp crayfish) in coastal wallum areas. The distribution of the latter species extends further inland into seasonally inundated, subcoastal areas with clay soils. The swamp crayfish is much smaller (25 mm body length), greyish-brown in colour, and has claws which close vertically rather than horizontally (Davie 2007).

DISTRIBUTION

Provide a succinct overview of the species' known or estimated current and past distribution, including international/national distribution. Provide a map if available.

Is the species' habitat protected within the reserve system (e.g. national parks, Indigenous Protected Areas, or other conservation estates, private land covenants, etc.)? If so, which populations? Which reserves are actively managed for this species? To your knowledge, which reserves are being actively managed in way that provides incidental benefits for this species? Give details.

Cherax robustus is largely restricted to the sandy, lowland coastal areas of Southeast Queensland often referred to as "wallum". Within coastal wallum, the species is primarily found in sedgelands, wet heaths and fens within woodlands/open forests dominated or co-dominated by broad-leafed paperbark. These habitats have low nutrient, siliceous sand soils and low pH ground water (Marshall et al. 2011). Within this area, the species is best known on the large sand islands, namely K'gari (Fraser), Bribie, Moreton, North Stradbroke. However, there have been varying reports on the status of the species on the mainland, where it has been reported extinct, or nearly so (Garvie 1998; Alletson 2000). Davie (2007) suggested it was once distributed in the suburbs of northern Brisbane, but an extensive search of museum and other published records has not confirmed this. Further, there is little appropriate habitat in that area and so this was probably a mistake (J. Short pers. comm. 2020; D. Potter pers. comm. 2020).

Many different publications, reports, and databases were checked for this nomination, and many people who have worked or are working in the relevant areas were interviewed about the distribution of this species. Publications: Riek (1951); Garvie (1998); Cannon & Sewel (2001); Bentley (2007, 2014); Marshall et al. (2011). Databases: Australian Living Atlas (www.ala.org.au), iNaturalist (www.inaturalist.org), OZCAM (ozcam.org.au), Queensland Museum (VERNON Database via P. Davie and D. Potter), WildNet (apps.des.qld.gov.au/species-search). Personal Communications: Glynn Aland (Seqwater), Kieran Aland (Queensland Museum), L. Behrendorff (QPWS), A. Bentley (frc environmental), N. Bignell (The Fauna Catcher), S. Bignell (Feathertail Photography), T. Christensen (QPWS), J. Coe (Jardini International), J. Coughran (Sheridan College), K. Crouch (Kayak), P. Davie (Queensland Museum), J. Esdaile (QPWS), J. Furse (Griffith University), L. Garvie (University of the Sunshine Coast), I. Gynther (DES), R. Hobson (QPWS), T. Howell (Freshwater Ecology Consulting), A. Jensen (QPWS), A. Karklis (QPWS), W. Martin (DES), J. Marshall (DES), R. McCormack (Australian Aquatic Biological), B. McLarty (QPWS), E. Meyer, V. Moscato (Native Foresters), P. Negus (DES), T. Page (DES), D. Potter (Queensland Museum), O. Scully, J. Short (BioAccess Australia), Brendon Yetman (QPWS). Data were cross-checked and validated on Google Earth for any obvious errors and duplications.

Cherax robustus is currently distributed on all four large sand islands (K'gari, Bribie, Moreton, North Stradbroke Islands; Fig. 1), with the fens and swamps of Bribie Island perhaps being its stronghold. On the mainland, it has persisted in a number of isolated pockets. These include (from north to south) the Tin Can Bay area, the Cooloola section of the Great Sandy National Park, and the northern and southern Sunshine Coast (Fig. 1). The Area of Occupancy (AOO) is 212 km^2 and Extent of Occurrence (EOO) is 7701 km^2. These were calculated in GeoCat (available at: geocat.kew.org; Bachman et al. 2011).

Cherax robustus is found in eight locations as defined by the IUCN (IUCN Standards and Petitions Subcommittee 2019) based on distinct areas with common threats (see Criterion B below for more information). These locations are:

1. K'gari
2. Cooloola (mainland section of Great Sandy National Park)
3. Tin Can Bay (mainland)
4. Northern Sunshine Coast (mainland)
5. Southern Sunshine Coast (mainland)
6. Bribie Island
7. Moreton Island
8. North Stradbroke Island.

The distribution records date from 1951 up to 2020. There has been discussion about the range of *Cherax robustus* having contracted in recent years, in particular on the mainland. This is certainly possible and even likely, however 63% of the reported sites date from 2010 or later, and include at least some sites from all locations detailed in Figure 1. It may be that this species was never that abundant on the mainland, although it can be relatively abundant in some ideal conditions (A. Bentley pers. comm. 2020). Inappropriate sampling methods (mainly box traps, but some observations) may also exacerbate its apparent rarity in some places (T. Howell pers. comm. 2020), as it may have a propensity to spend a lot of time in its burrow.

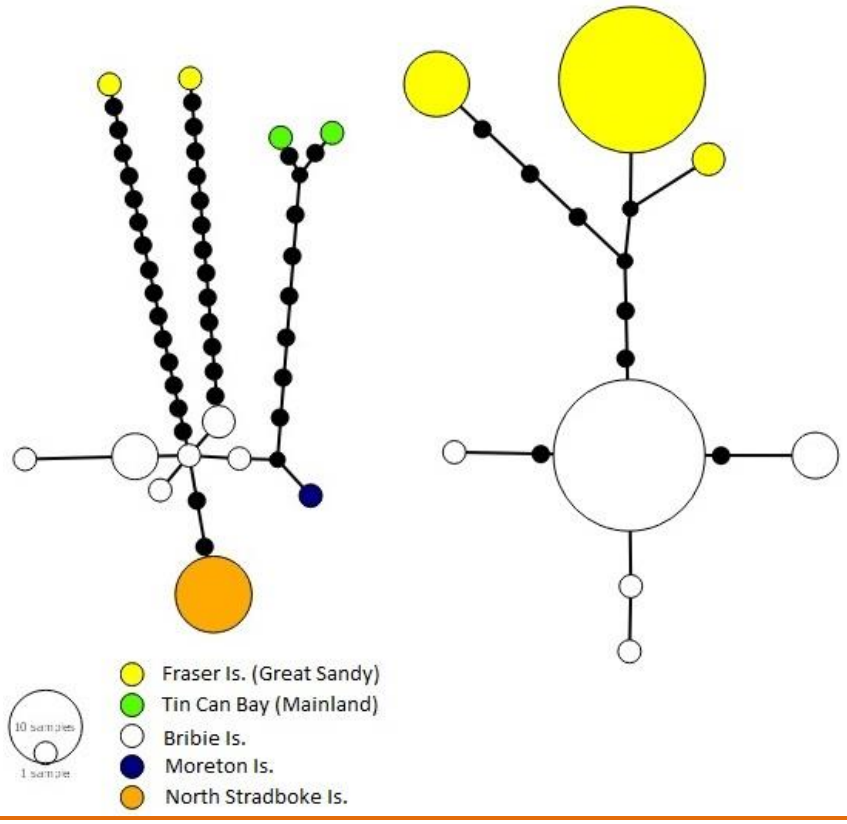
Many of the sites where *Cherax robustus* has been reported are within reserve areas, including the Great Sandy National Park (K'gari and Cooloola sections), Great Sandy Strait Ramsar Wetland Site, K'gari (Fraser

Island) World Heritage Site, Toolara State Forest, Tewantin National Park, Noosa National Park, Mooloolah River National Park, Beerburrum East State Forest, Bribie Island National Park, Bribie Island State Forest, Moreton Island National Park, and Naree Budjong Djara National Park (North Stradbroke Island) (Fig. 2). On the mainland, much of the habitat is on the Sunshine Coast, which is developing quickly. There is a patch of potentially suitable swampy habitat on the mainland directly across from Bribie Island (also identified by Alletson 2000), which is not a protected area and includes some forestry. This area has anecdotal reports of *C. robustus* possibly being present (Alletson 2000; G. Aland pers. comm. 2020).

Of the 64 sites recorded, 39 are in national parks, and 4 in state forests. While it is not the object of active management, it is protected, as any native species is, within a national park. Although not targeted, the species has been incidentally collected and recorded in fish surveys of reserve areas (L. Behrendorff pers. comm. 2020). The species is mentioned in the Bribie Island Management Statement 2013 (QDNPRSR 2013) as a "notable species". It may also have been mentioned in the Noosa National Park Management Plan 1999 (QPWS 1999a) (as "*Cherax* sp.") as worthy of further study, and an identification workshop was held (A. Jensen pers. comm. 2020), although it has not been researched further. Twenty-one of the reported sites for *C. robustus* are outside the reserve system, nearly all of which are on the Sunshine Coast (Fig. 2).

Because *Cherax robustus* is distributed in isolated pockets, spread over a relatively large area that the species is unlikely to be capable of traversing, it is possible that there is significant geographically structured genetic diversity within the species between the different geographic areas. There has been very limited research on this, except for two unpublished undergraduate theses (Garvie 1998, Bentley et al. 2007). These studies were both limited to small sample sizes and specimens sourced almost exclusively from island populations. To compare the two studies, DNA sequences from both were obtained directly from the authors. Both studies used the mitochondrial COI gene, but different portions of it, and so the two datasets could not be combined, but were analysed in parallel in the same manner. Haplotype networks were generated in PopART (Leigh & Bryant 2015) and genetic distances (K2P model) calculated in MEGA X version 10.1.1 (Kumar et al. 2018).

Both datasets had some commonalities, such as no haplotype sharing between areas, Bribie Island having the most haplotypes, and there being two divergent lineages within K'gari (Fig. 3; N.B. the sequences from Garvie 1998 are only half the length of those from Bentley 2007, and so there will be fewer missing haplotypes between lineages in the Garvie 1998 dataset). Bentley et al. (2007) found four lineages overall (1.1 – 2.9% divergent), with two on K'gari, one on the mainland in Tin Can Bay, and a third that encompassed Bribie, Moreton, and North Stradbroke islands. Because of small sample sizes and very few mainland specimens, limited firm conclusions can be drawn. However, 1) the lack of haplotype sharing suggests that there is probably little contemporary population mixing between these areas; 2) the populations from the south (Bribie, Moreton, North Stradbroke Islands) are relatively closely related to each other in an evolutionary sense; 3) the different lineages probably relate to Pleistocene population isolation as also inferred for many other freshwater species on K'gari and other wallum areas (Page et al. 2012).



A) data from Bentley (2007) **B) data from Garvie (1998)**

Fig. 3: *Cherax robustus* genetic haplotype networks of *COI* gene data sourced from two studies. Different colours = sampling locations, small black circle = missing haplotype. A) Bentley (2007): 841 base pairs; B) Garvie (1998): 436 base pairs.

BIOLOGY/ECOLOGY

Provide a summary of biological and ecological information.

Include information on:

- life cycle including age at sexual maturity, life expectancy and natural mortality rates
- specific biological characteristics
- the species' habitat requirements
- for fauna: feeding behaviour and food preference and daily/seasonal movement patterns
- for flora: pollination and seed dispersal patterns

The general biology and life cycle of *Cherax robustus* is very poorly understood, with little data published about it (U.S. Fish and Wildlife Service 2018). Riek (1951) reported that females lay their eggs in August. Davie (2007) reports that *Cherax robustus* grows to about 90 mm overall length, but measurements of specimens from Bribie Island in a private collection (R. McCormack pers. comm. 2020) are larger (largest female = 121 mm head to tail, 30.81 mm occipital carapace length [OCL], 18 g.; largest male = 122 mm head to tail, 30.53 mm OCL, 19 g.). Specimens seen in the wild probably weigh at least 30 – 40 g. (R. McCormack pers. comm. 2020). It is not clear at what size females become sexually mature, but berried females with an OCL of 17.99 – 30.81 mm have been measured (R. McCormack pers. comm. 2020). *Cherax robustus* are known to host a couple of species of ectocommensal temnocephalan flatworms (*Temnosewellia christineae, Temnosewellia dendyi*) (Cannon & Sewell 2001), which is a common feature of parastacid crayfish. The growth rates, population sizes and generation lengths of *Cherax robustus* are not known, although they can be relatively locally common in the very particular areas where the conditions are right (Garvie 1998; Bentley 2007).

Cherax robustus has been observed on Bribie Island making simple burrows (less than 600 mm deep) in moist, sandy soil. It appears that these burrows have one or two entrances and one deep chamber and a few passages running parallel to the surface (McCormack 2012). Active burrows can often be found because of cleared white sand at entrance (K. Aland pers. comm. 2020). *Cherax robustus* seems to spend much of its time in its burrow (R. McCormack pers. comm. 2020). However, this species may also move around the landscape a bit, as anecdotal observations have reported about three quarters of burrows appear to be abandoned (McCormack 2012). *Tenuibranchiurus glypticus* has been found in *C. robustus* burrows, both abandoned and occupied ones (McCormack 2012). On Bribie Island, *Tenuibranchiurus* appears to have a similar preferred habitat to *Cherax robustus* and was found in 76% of the pools that were also inhabited by *Cherax robustus* (Harding & Williamson 2003). Single-gilled eels (*Ophisternon* sp.) have also been collected along with *C. robustus* from burrows on the Sunshine Coast (J. Short pers. comm. 2020). *Cherax robustus* is thought to be highly territorial (Alletson 2000).

Cherax robustus is largely restricted to wallum areas, where it prefers acidic, soft, tannin-stained freshwater marsh, swamps, fens, lakes, and small creeks, often surrounded by *Melaleuca* (paperbark) and dominated by sedges (Davie 2007; Marshall et al. 2011) (Fig. 4). It is also found within the unique patterned fen ecosystem on the west coast of K'gari (Moss et al. 2016).

The soil in much of *Cherax robustus* habitat is sandy and covered with peaty, humic material, as well as some areas of lagoonal tidal mud and silt (Alletson 2000). *Cherax robustus* prefers groundwater-fed, swampy, edge habitat over open, deep or flowing water (Brooks 1987; McCormack 2012; R. Hobson pers. comm. 2020), although juveniles have also been collected from below the water line of shallow creeks (J. Short pers. comm. 2020). *Cherax robustus* appears to be limited to acidic waters (3.3 – 5.3) (Brooks 1987). Alletson (2000) suggests that vegetation influences the water quality, and its decomposition leads to the humic acid, low pH and tannin. *Cherax robustus* is highly adapted to this environment, as it is able to obtain and retain enough calcium carbonate ($CaCO_3$) for its exoskeleton, despite $CaCO_3$ being almost undetectable in the local water or sediments (Bayly 1964).

Cherax robustus is found in a number of different Queensland Regional Ecosystems (REs), with the most common being 12.2.12 (closed heath on seasonally waterlogged sand plains; Queensland Herbarium 2019) at Cooloola, Sunshine Coast, and Bribie Island, and 12.2.15 (*Gahnia sieberiana, Empodisma minus, Gleichenia* spp. closed sedgeland in coastal swamps; Queensland Herbarium 2019) at K'gari, Cooloola, Tin Can Bay, Sunshine Coast, Moreton Island, and North Stradbroke Island. RE 12.2.12 is considered "of concern" under the *Vegetation Management Act 1999* and as "endangered" on the Sunshine Coast south of Noosa, while RE

12.2.5 is “least concern”, except on the Sunshine Coast where it is also “endangered” (Queensland Herbarium 2019).

Bribie Island

North Stradbroke Island

Fig. 4: *Cherax robustus* habitat (photos T. Page)

The feeding patterns of *Cherax robustus* are not known, however it will take dog biscuits and fish in a trap (R. Hobson; I. Gynther pers. comm. 2020). It may well be opportunistic and omnivorous like other *Cherax* spp. that also eat plant and detrital material. It is semi-aquatic and appears to forage out of the water readily (Davie 2007; McCormack 2012; R. Hobson pers. comm. 2020).

Threats

IDENTIFICATION OF KNOWN THREATS AND IMPACT OF THE THREATS

Identify any known threats to the species in the table below. Describe **past, current or future** threats, whether the threats are **actual or potential**, and the **type and level of impact** you believe each threat is having on the species.

Past threats	Impact of threat
Habitat loss due to development	Populations of *Cherax robustus* on island national parks have been largely insulated from the habitat loss and major habitat degradation associated with urban, suburban, and peri-urban development (Fig. 2), except for parts of Bribie Island, where there are extensive housing developments in the south and west of the Island and pine forestry in the centre of the Island. The level and nature of impacts from housing developments on the nearby neighbouring national park is not clear, however there is anecdotal evidence of former *Cherax robustus* sites becoming devoid of animals following the building of subdivisions (G. Aland pers. comm. 2020). A large number of mainland *Cherax robustus* sites and habitat are outside the reserve system on the Sunshine Coast, which has seen a great deal of development. *Cherax robustus* is particularly susceptible to displacement because it is restricted to particular habitat (Alletson 2000). More widely, 41% of *Melaleuca quinquenervia* wetlands remaining in Southeast Queensland were cleared between 1972 and 1990 (Davie 1991). Level of past impact = low (location dependent).
Hydrological modification	One result of urban, suburban and peri-urban development can be a change in hydrological patterns, which can be impactful to a species tied to groundwater-fed wetlands, such as *Cherax robustus.* This modification can be a result of wetland drainage, replacement of groundwater-fed creek beds with concrete storm drains, and lowered water tables (Garvie 1998; A. Bentley pers. comm. 2020; T. Howell pers. comm. 2020). Water tables can be lowered directly by water extraction for drinking water (Bribie Island, Smolders et al. 2011; North Stradbroke Island, Leach 2011), as well as by mining, agriculture, and forestry. For example, the pine forests in the centre of Bribie Island may alter drainage patterns (G. Aland pers. comm. 2020). Level of past impact = low (location dependent).
Drought	Drought is a common feature of the Australian environment, including in Southeast Queensland over a long timescale (Barr et al. 2019). Severe drought is potentially impactful for a species that relies on groundwater-fed wetlands. Anecdotal reports suggest that some *Cherax robustus* sites may have been abandoned on Bribie Island, and this may be associated with the Millennium drought, in combination with changed local groundwater conditions associated with housing developments (G. Aland pers. comm. 2020). Level of past impact = low.
Bushfire	Bushfire is prevalent in wallum areas (Srivastava et al. 2013). For example, K’gari experienced 2-3 unplanned wildfires per year covering 100 hectares or more for the 20 years up to 2008

	(Srivastava et al. 2013). Heath, marsh and swamp wetland areas (i.e. *Cherax robustus* habitat) of K'gari burned the most often of the Island's vegetation types (~4% of the area each year) (Srivastava et al. 2013). Much of this habitat is peat, which burns aggressively when dry (Threatened Species Operations 2020). Bribie Island, which has a large population of *Cherax robustus,* also has had major unplanned fires every 2 or 3 years; for example a fire in 1994 crossed from the mainland and burned most of the Island (QDNPRSR 2013). Complicating matters is the fact that some amount of fire is required for many of these ecosystems to remain intact and healthy, therefore the QPWS has a system of prescribed burns in all of the relevant parks, but these planned fire events are distinct from the unplanned bushfires/wildfires mentioned above (QPWS 1999a). Level of past impact = low.
Feral pigs	The "Predation, habitat degradation, competition and disease transmission by feral pigs (*Sus scrofa*)" was listed by the Federal Government in 2001 as a key threatening process under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (Commonwealth of Australia 2017). Negative impacts can be direct (predation, digging and rooting) and indirect (changing plant species composition, water quality) (Commonwealth of Australia 2017; Negus et al. 2019). Feral pigs are thought to consume crayfish and damage their habitat (McCormack et al. 2010; Commonwealth of Australia 2017). The precise impact on *C. robustus* is not known, however there are reports of about 12 *Cherax robustus* found (in pieces) on Moreton Island in 2011, with feral pig predation a possible cause (J. Esdaile pers. comm. 2020). Level of past impact = low (location dependent).
Unauthorised collecting	All native species within national parks are legally protected from collection, but this is not the case outside the parks, where the *Fisheries Act* 1994 comes into force in Queensland. This act does not specifically protect any species of *Cherax*. There is a general possession limit of 20 for all species not specifically listed, so this would include *Cherax robustus*. However, common bait species, such as *Cherax destructor* have a possession limit of 100 (Queensland Government 2020a). *Cherax robustus* could easily be misidentified as *C. destructor*. The species could also be the object of illegal collecting for the aquarium trade (Coughran & Furse 2012). If it were targeted, there is the possibility that collectors who have handled other crayfish species could introduce new pathogens to the isolated *C. robustus* populations. These activities are more likely to affect mainland populations close to developed areas. Level of past impact = unknown/low.
Current threats	**Impact of threat**
Habitat loss due to development	Mainland and Bribie Island populations of *C. robustus* are imperilled by habitat loss due to development, such as the building of housing estates and highway construction. This can entail complete habitat destruction, or degradation through changed water chemistry and pollution (Garvie 1998; A. Bentley pers. comm. 2020; T. Howell pers. comm. 2020). Southeast Queensland has seen a lot of recent land clearing and human population growth, leading to fragmented remnant vegetation (Neldner et al. 2017). Southeast Queensland is the fastest growing metropolitan region in Australia, with an ensuing boom in housing development, resulting in habitat and biodiversity loss (Field et al. 2012). The human population of Southeast Queensland increased by 2.20% from 2018 to 2019 (.id 2020). Coastal sandy areas favoured by these crayfish are under development pressure, in particular in the Sunshine Coast region. Habitats that host *C. robustus* and a suite of sympatric threatened species (e.g. acid wallum frogs; Shuker et al. 2016) are being cleared for housing estates (Shanna Bignell pers. comm. 2020), retail outlets (J. Coe pers. comm. 2020) and transport infrastructure (Ecosmart 2018), among other things. On the Sunshine Coast, wallum wetlands formed in swale areas between geologically younger fore dunes that are just behind the beach, and older dune systems a little bit further inland (Walker et al. 2018). *Cherax robustus* occurs in some of these wetlands, with other *Cherax* species generally further inland, where the soil has a higher clay content (e.g. soils of metamorphic origin; CSIRO Ecosystem Sciences 2011) (K. Aland pers. comm. 2020). Most suitable *C. robustus* habitat on the Sunshine Coast is in this thin strip of wallum wetland that runs north-south, paralleling the coast. This same area has seen a boom in residential development in recent decades. An impact of this is possible changes in plant nutrient availability, resulting in observable changes to some areas of heathland, causing them to become weed and grass dominated (Fig. 5) (K. Aland pers. comm. 2020). These wallum swamps are also dependent on fire. Without appropriate fire management, wallum heath transition to communities dominated by paperbark and other trees and shrubs, as has been also observed on K'gari (Stewart et al. 2020). These factors potentially impact habitat availability and quality for *C. robustus*. Another related threat to the habitat of the species is the invasion of exotic plants from neighbouring garden areas. For example, the banks of Sunshine Creek at the

northern end of the Sunshine Coast are heavily infested with Singapore daisy (*Sphagneticola trilobata*) (J. Short pers. comm. 2020).

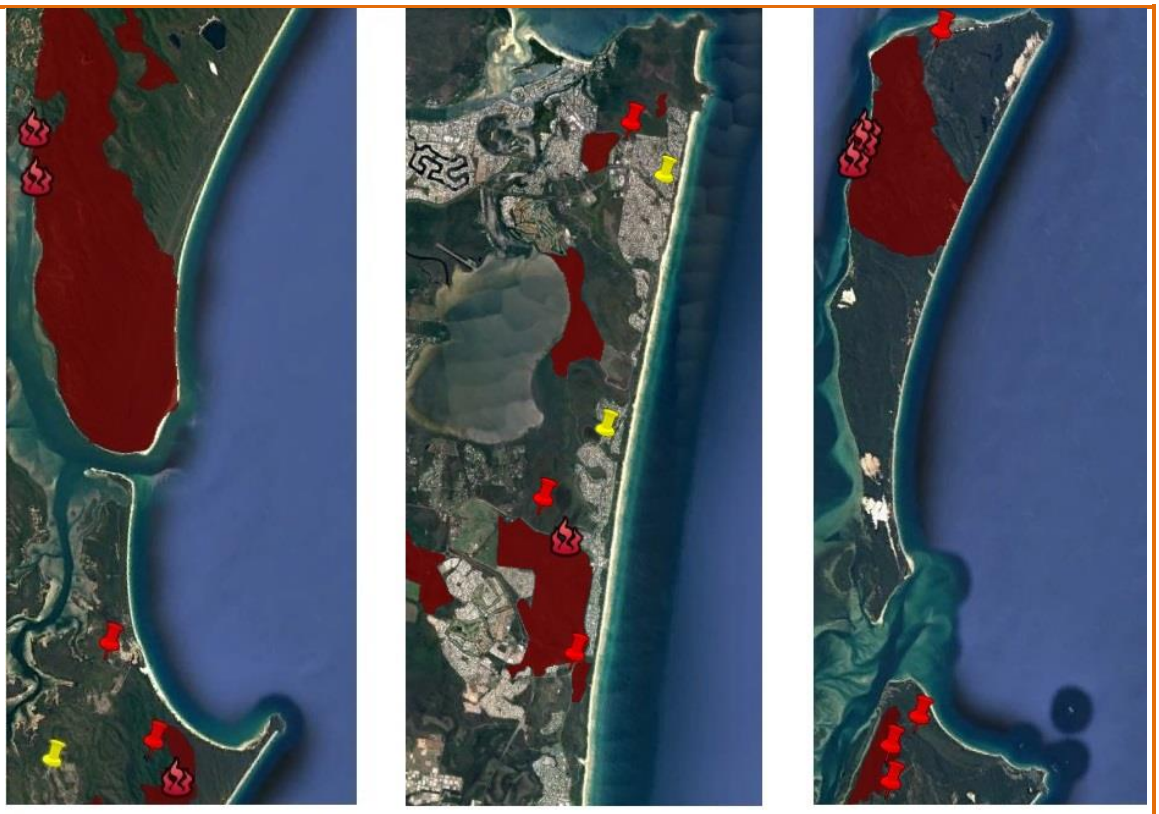
Fig. 5: *Cherax robustus* habitat on the Sunshine Coast (2017, Google Earth). Inset shows typical spread of grass and weeds (vivid green) into wetland fringes that abut housing developments. Green circles = *C. robustus* sites. N.B. the southernmost site burned in the 2019 bushfires.

Cherax robustus is found in a number of different Queensland Regional Ecosystems (REs) on the Sunshine Coast (Queensland Herbarium 2019), with 12.2.12 (closed heath on seasonally waterlogged sand plains) being the most common. However, this species is also found at a small number of sites in quite varied REs on the Sunshine Coast, including 12.2.5, 12.2.15,12.3.2, 12.3.4, 12.3.5, 12.5.3, and 12.5.9. While five of these eight REs are classed as "least concern" more generally under the *Vegetation Management Act 1999*, all eight have issues of particular concern on the Sunshine Coast.

Sunshine Coast REs hosting *C. robustus* (information from Queensland Herbarium 2019):

- 12.2.5 (*Corymbia intermedia* +/- *Lophostemon confertus* +/- *Banksia* spp. +/- *Callitris columellaris* open forest on beach ridges usually in southern half of bioregion): "vulnerable south of Noosa due to weed invasion, recreational use and threat of over-frequent fire"
- 12.2.12 (Closed heath on seasonally waterlogged sand plains): "Subject to high rate of clearing for urbanisation south of Noosa; the RE is considered to be endangered in this area"
- 12.2.15 (*Gahnia sieberiana*, *Empodisma minus*, *Gleichenia* spp. closed sedgeland in coastal swamps): "This ecosystem has been subject to disturbance and extensively in filled or modified by urban development in the south of bioregion and the RE is considered to be endangered in this area"
- 12.3.2 (*Eucalyptus grandis* tall open forest on alluvial plains): "Habitat fragmented by land uses such as horticulture and rural residential. Much of this RE is prone to infestation by weeds, especially *Lantana camara*"
- 12.3.4 (*Melaleuca quinquenervia*, *Eucalyptus robusta* woodland on coastal alluvium): "Extensively cleared for pine plantation"
- 12.3.5 (*Melaleuca quinquenervia* open forest on coastal alluvium): "Extensively cleared for sugar cane and urban development in south of bioregion. Subject to weed invasion, especially groundsel *Baccharis halimifolia*. Data on clearing rate between 1995 and 1997 indicate that the RE continues to experience an annual loss in excess of 1% of

	current extent per year. Generally a palustrine wetland although also some areas have been converted to lacustrine water bodies associated with the construction of bunding and levees" • 12.5.3 (*Eucalyptus racemosa* subsp. *racemosa* woodland on remnant Tertiary surfaces): "Extensively cleared for exotic pine plantation, horticulture and urban development" • 12.5.9 (Sedgeland to heathland in low lying areas on complex of remnant Tertiary surface and Tertiary sedimentary rocks): "Habitat is being cleared or impacted by rural residential development in some areas" At least four *Cherax robustus* sites at the Sunshine Coast are in REs classed as non-remnant vegetation (Queensland Herbarium 2019). Thus, while *C. robustus* is largely restricted to native undisturbed areas, there is some evidence that it can persist, at least for a while, in some less than ideal situations, such as adjacent to housing estates (as in Fig. 5). The species has also been located in some Sunshine Coast sites previously cleared for cane farming and cattle grazing, that have since regenerated (T. Howell pers. comm. 2020). *Cherax robustus* has also been found in some of the exotic pine forests on the mainland (R. McCormack pers. comm. 2020; A. Bentley pers. comm. 2020) and Bribie Island, where small groundwater or spring-fed creeks still host some remnant habitat (P. Negus pers. comm. 2020). Level of current impact = moderate/high (location dependent).
Hydrological modification	The residential development that has taken place in recent decades on the Sunshine Coast on the thin strip of wallum wetland habitat has had the effect of covering the western slope of the coastal dunes with hard surfaces, potentially impacting the hydrology of the wallum wetlands by discharge of storm water into the margins of the wetlands, which can raise the pH of the water. It also potentially contributes to pollution and nutrient plumes in the wetlands (K. Aland pers. comm. 2020). Level of current impact = moderate/high (location dependent).
Drought	Severe drought is a potential driver of habitat and population loss for *C. robustus*, even within protected areas, as it can lower local, shallow water tables in all locations, on which this species relies. The most severe rainfall deficit on record for parts of Southeast Queensland, including for example North Stradbroke Island, occurred throughout 2019 to early 2020. Many wetlands and, perhaps importantly for *C. robustus*, the wetland peat sediment, dried for prolonged periods (Queensland Government unpublished data; J. Marshall pers. comm. 2020). It is unclear how such habitat drying has impacted *C. robustus* populations, but anecdotally, many dead *C. robustus* were observed on the dry sediment surface of Fern Gully and Welsby Lagoons on North Stradbroke Island (J. Marshall pers. comm. 2020). Many wallum wetlands that support *C. robustus* populations are connected to groundwater, which buffers them from the immediate impacts of periods with little rainfall. However, extended drought conditions can lower groundwater levels and result in the drying of wetlands. North Stradbroke Island experienced an ongoing rainfall deficit (i.e. less than long-term mean rainfall) from 2016-2019. Close association with a perched groundwater system, and sporadic rainfall, maintained surface water in the wetland throughout most of this period, but the extended drought period resulted in complete loss of surface water on occasion. During such times, dead *C. robustus* were observed on the dry wetland bed. The frequency and severity of droughts are expected to increase under climate change in wallum regions, increasing the frequency and duration of wetland drying, and posing a threat to the persistence of *C. robustus* populations. Level of current impact = moderate.
Bushfire	Very intense and broad-scale fire activity (2019 – 2020) took place in many parts of Queensland, burning about 6,617,430 ha (3.8% of the State) (Threatened Species Operations 2020), which was followed in 2020 by a major fire on K'gari. These fires were associated with a severe drought, which would have already depleted much surface water prior to the fires. In particular, dried-out peat from wallum wetlands becomes highly flammable (ANU 2009). These bushfires occurred throughout the Southeast Queensland region across all areas home to *C. robustus*. Of 64 identified *C. robustus* sites, 13% of them are within the fire zone (8 sites at K'gari, Cooloola, Sunshine Coast, Bribie Island, Moreton Island) and 22% are less than 2 km from the fire front (14 sites at K'gari, Cooloola, Sunshine Coast, Bribie Island, Moreton Island, North Stradbroke Island) (Fig. 6). There is currently limited on-the-ground confirmation of the impacts on these particular sites or this species, however the fire damage was reasonably severe in the wetlands of Moreton Island that are home to *C. robustus* (T. Christensen pers. comm. 2020).



A) Fraser Is. & Cooloola (Great Sandy NP) B) Sunshine Coast (Mainland) C) Moreton & North Stradbroke islands

Fig. 6: *Cherax robustus* distribution records for parts of its range (not to same scale) overlaid with extent of bushfires (in red) between August & December 2019 (Queensland Government 2020b). Flames = *C. robustus* sites within fire zone, red pins = sites <2 km from fire, yellow pins = >2 km from fire. Displayed in Google Earth Pro (version 7.3.2.5776).

It is not clear what the direct impact of fire on crayfish populations may be, however another crayfish (Ellen Clark's Crayfish; *Euastacus clarkae*) suffered a mass kill directly after a fire (McCormack 2015). Similarly, *Cherax destructor* (freshwater yabby) abundances declined after fire events, perhaps due to associated lessening of habitat quality (Johnston et al. 2014). Indirect impacts of fire are potentially long-lasting and include serious habitat degradation and/or destruction. For example, peat swamps and fens often change permanently after a serious fire (Threatened Species Operations 2020). There are also ensuing water quality issues that highly impact freshwater species (Bryant et al. 2012). Sediment and ash run-off from fires can degrade water quality, such as low dissolved oxygen (Silva et al. 2020), and can lead to a change in the pH of the water, which could seriously impact *C. robustus* (Brooks 1987). Level of current impact = moderate/high (location dependent).

Feral pigs	Feral pigs appear to be more of a problem in some of the more pristine island national parks than elsewhere. Smaller parks nearer to human populations on the Sunshine Coast, such as Noosa and Mooloola River national parks, do not report feral pigs as a major problem (QPWS 1999a,b; QDNPSR 2015; J. Plant pers. comm. 2020; A. Jensen pers. comm. 2020). However, the K'gari and Cooloola sections of the Great Sandy National Park report feral pigs negatively impacting threatened fauna (EPA 2005). On Bribie Island, feral pigs have been damaging freshwater areas (QDNPRSR 2013). There has been a long-standing problem on Moreton Island, where feral pigs are considered one of the major threats to native animal communities (QPWS 2007), however there is a major pig control strategy there (T. Christensen pers. comm. 2020). There are few to no feral pigs on North Stradbroke Island (K. Crouch pers. comm. 2020; WildNet [QDES 2020]). Level of current impact = low (location dependent).
Unauthorised collecting	Australian crayfish are for sale in Australia and overseas (legally and illegally, including online), although it is not known if *C. robustus* are among these (none were found offered for sale on the internet on 16 April, 2020). A legal trade in *C. robustus* is planned to start soon, based on breeding stock (J. Coe pers. comm. 2020), which could either lessen the potential impacts of collecting (as the crayfish will be available for purchase) or increase the impacts (if these crayfish are now seen to have a monetary value). It is unclear how prevalent the issue of unauthorised collecting could be within national parks, but at least one case of illegal collecting of crayfish was detected on Moreton Island (T. Christensen pers. comm. 2020), and there has

	been freshwater fish poaching in the Great Sandy National Park (L. Behrendorff pers. comm. 2020). Level of current impact = unknown/low.
Future threats – actual	**Impact of threat**
Habitat loss due to development	The urban, suburban, and peri-urban development of the Sunshine Coast is likely to continue, with a projected 71% increase in the human population of the Sunshine Coast over the next 25 years (2016 to 2041), which is almost 3% per year (Queensland Treasury 2018). There is an argument that because the habitat of *C. robustus* is naturally fragmented, human-induced fragmentation might not pose such a problem. However, these areas of *C. robustus* habitat are not large, and they are shrinking due to development and climate change. Furthermore, they are fragile and are experiencing the negative effects of development. Level of future impact = high (location dependent).
Hydrological modification	Hydrological modification will continue hand in hand with development on the Sunshine Coast (see 'Habitat loss due to development' above). Level of future impact = high (location dependent).
Drought	The frequency and intensity of drought is likely to increase (see 'Climate change' below), which will have the effect of lowering local water tables that maintains the wetlands and lakes where *C. robustus* lives (ANU 2009). Changing rainfall and water temperatures can also affect the water's pH levels (ANU 2009; Shuker 2016), to which *C. robustus* is particularly sensitive (Brooks 1987). Level of future impact = high.
Bushfire	The widespread nature of the 2019-2020 bushfires has led to an inevitable discussion of the role of future climate change in increased fire risk (see Climate change below). Climate projections for Southeast Queensland indicate the likelihood of harsher fire conditions, meaning that fires like those of 2019-2020 may not be unusual events in the near future (ANU 2009; DEHP 2016). The fires of the future are likely to be even more intense and come with a greater frequency. A drier climate will make the fens habitat favoured by *C. robustus* more likely to burn (ANU 2009), potentially destroying them. The entire distribution of *C. robustus* is in an area of proven fire risk. Level of future impact = high.
Climate change	Climate change works in concert with, and is an intensifier of, many of the previously mentioned threats (e.g. human impacts, droughts, bushfires). Similarly, more extreme weather events, such as cyclones and floods, can also severely impact freshwater crayfish. *Cherax destructor* had large declines in abundance in all habitats after floods in Victoria (Johnston et al. 2014), and mass mortality has been recorded in *E. valentulus* in southern Queensland after a flash flood (Furse et al. 2012). The various manifestations of climate change are a real threat to freshwater crayfish, which are very sensitive to changes in temperature and water availability, tend to be highly specialised, and often have limited distributions (Hossain et al. 2018). Climate modelling for the Southeast region of Queensland predicts significant, rapid future changes to climate (DEHP 2016). This includes higher temperatures, reduced rainfall, increasing drought, more extreme weather events, and harsher fire weather (ANU 2009). Level of future impact = high.
Feral pigs	Feral pigs will continue to provide a threat to *C. robustus*, both to individuals and to their general habitat quality. Feral pigs may be moving from the south of Cooloola into the Noosa area (EPA 2005). Level of future impact = low (location dependent).
Future threats – potential	**Impact of threat**
Crayfish plague	*Aphanomyces astaci* (crayfish plague) is a highly contagious fungal disease that is uniformly fatal (100% mortality) to susceptible species (e.g., Panteleit et al. 2017), and it is considered one of the world's worst invasive species (Lowe et al. 2000). Crayfish plague is not currently known in Australia, but is documented as fatal to Australian freshwater crayfish (Unestam 1975), and it poses an extremely high risk to native freshwater crayfish species (DAWE 2019). Illegally imported specimens of the North American crayfish species known to carry the disease have been seized in multiple Australian states (Department of Primary Industries & Regional Development 2021; Business Queensland 2021), but not known to be infected. A single, illegally-imported crayfish infected with crayfish plague has the capacity to devastate the entire Australian crayfish fauna. Increasing illegal wildlife/aquarium trade appreciably increases the risk and probability of the disease's introduction to Australia. Level of future impact = unknown.

*CONSERVATION ADVICE: THREAT ABATEMENT AND RECOVERY ACTIONS

Give an overview of recovery and threat abatement/mitigation actions that are underway, have been formally proposed or that you would like to recommend. Address all threats listed or state threats that lack conservation advice.

Current threats	**Abatement or recovery action underway**
Bushfire	Each national park has its own specific fire management strategy, which aims to protect life, property and the conservation values of the park (EPA 2005). This hazard reduction is achieved in various ways, including creating fire breaks, conducting fuel reduction burns, monitoring fuel build-up, and mosaic burning for proper functioning of many native ecosystems in conservation zones (T. Christensen pers. comm. 2020). Controlled burns are often “cool” burns, done when there is sufficient moisture in the vegetation (J. Plant pers. comm. 2020), which means the sedges are singed but not fully burned or destroyed.
Feral pigs	Feral pig control programs exist in many national parks. There is an ongoing feral pig control program on Bribie Island that involves baiting (B. McLarty pers. comm. 2020, QDNPRSR 2013). In the Great Sandy National Park, monitoring is via observation and trail cameras since numbers are too low for formal trapping processes (L. Behrendorff pers. comm. 2020). On Moreton Island, the objective is complete eradication, with a comprehensive feral pig program involving trapping, shooting, poisoning, monitoring and recording. A total of 336 pigs have been eliminated since the middle of 2012 (499 since 2000) (T. Christensen pers. comm. 2020; QPWS 2007).
	Abatement or recovery action proposed
Unauthorised collecting	Regular checks should be made of the internet to see if *C. robustus* are offered for sale illegally, and if so, the relevant parties prosecuted for illegal collecting. Anyone found collecting illegally should also be prosecuted. Further, information on correct hygiene protocols should be made available to those collecting legally to avoid introducing pathogens (for example: www.aabio.com.au/new/wp-content/uploads/2012/02/Hygiene-Protocol-2010.pdf). The Queensland Government is working on protocols (J. Furse pers. comm. 2020).
Future threats – actual	**Abatement or recovery action underway**
	Abatement or recovery action proposed
Habitat loss due to development, Hydrological modification	Research should focus on ways to reduce the impacts of development on wallum habitat, including the hydrology. The distribution of *C. robustus* is poorly understood, especially on the mainland, and so a coordinated project to document its precise contemporary distribution will go a long way to aid any future species management and risk analyses. Understanding the distributions of the Queensland *Cherax* species should be a very high research priority (J. Furse pers. comm. 2020). Research should also focus on resilience of the species to invasive species and encroachment of urbanisation (Coughran & Furse 2012).
Drought	Groundwater levels and water quality should be measured in wallum wetlands to monitor the potential health of the wetland communities.
Bushfire	The entire distribution of *C. robustus* falls within the Coastal Wallum/Heath Area of the Southern Queensland Post-fire Response Project Areas (Threatened Species Operations 2020). *Cherax robustus* is sympatric with many of the priority species from this project (four acid wallum frogs, two freshwater fishes), and would benefit from many of the same remedial actions proposed for those species in this area. These include getting a full picture of the extent and severity of the fire, and its effects on the populations of the target species in particular and habitat in general (including water quality) (Threatened Species Operations 2020). Detailed population surveys should be undertaken, and pest management efforts increased. The recovery of the target species and overall environment should be monitored for both direct and indirect effects of fire (habitat degradation, water quality issues, associated increased predation pressure) to determine how well they can recover after bushfires in the future.
Climate change	Detailed monitoring of the health of both *C. robustus* populations (numbers, distribution, population dynamics, etc.) and its habitat (vegetation, water availability, water quality parameters, groundwater interactions) should be undertaken to see if they are being adversely affected by the various factors associated with climate change.
Future threats – potential	**Abatement or recovery action underway**

	Abatement or recovery action proposed

IMPACT OF TRANSFERRING A THREATENED SPECIES TO NEAR THREATENED OR LEAST CONCERN

Omit this section and proceed to 'Listing class/category' if the nomination does not involve transferring a species from a threatened class to Least Concern or Near Threatened.

If the threatened species (Extinct, Extinct in the Wild, Critically Endangered, Endangered or Vulnerable) were moved to Least Concern or Near Threatened, what would be the impact if conservation actions for the species were reduced or ceased? Would the species decline at such a rate that it would be eligible for listing under a threatened class again in the foreseeable future? Provide evidence, expert advice and appropriate references to support your response.

Conservation action	Impact on the species if abatement/recovery action is reduced or ceases

Listing class/category

CURRENT LISTING CLASS/CATEGORY

[Please mark the boxes that apply by double clicking them with your mouse.]

In what class is the species currently listed under the **NC Act**?

☐Extinct	☐Extinct in the Wild	☐Critically Endangered	☐Endangered
☐Vulnerable	☐Near Threatened	☐Least Concern	☒Not listed

In what category is the species currently listed under the **EPBC Act**?

☐Extinct	☐Extinct in the Wild	☐Critically Endangered	☐Endangered
☐Vulnerable	☐Conservation Dependent		☒Not listed

NOMINATED LISTING CLASS

To what class under the **NC Act** is the species being nominated?

☐Extinct	☐Extinct in the Wild	☐Critically Endangered	☐Endangered
☒Vulnerable	☐Near Threatened	☐Least Concern	☐Not listed

Nominating a species to transfer to another class

REASON FOR A NOMINATION TO TRANSFER TO ANOTHER CLASS

What is the reason for the nomination?

☐Genuine change of status	☒New knowledge	☐Mistake	☐Other
Taxonomic change - ☐'split'	☐newly described	☐'lumped'	☐no longer valid

INITIAL LISTING

Describe the reasons for the species' initial listing under the NC Act and/or the EPBC Act and, if available, the criteria under which it was formerly considered eligible.

Click or tap here to enter text.

CHANGES IN SITUATION LEADING TO THE NOMINATION TO TRANSFER TO ANOTHER CLASS

Please complete (a), (b) OR (c) as appropriate to the nomination.

(a) Critically Endangered, Endangered, Vulnerable or Near Threatened

Describe the change in circumstances that make the species eligible for listing in a class other than Extinct and Extinct in the Wild.

Cherax robustus is being nominated as Vulnerable because of its restricted distribution in wallum habitat in eight locations. These locations are all threatened by habitat loss, changed hydrological conditions or reduction of habitat quality, all of which will be exacerbated by continued climate change. The mainland locations in particular are also threatened by habitat loss and degradation in the face of rapid urban and peri-urban development.

(b) Extinct in the Wild

A native species is eligible to be included in the Extinct in the Wild class if: (a) thorough searches have been conducted for the species; and (b) the species has not been seen in the wild over a period appropriate for its life cycle or form. The species may still survive in cultivation, captivity or as a naturalised population (or populations) well outside the historic range.

Describe how circumstances have changed that now make the species eligible for listing as Extinct in the Wild. Provide details of the last valid record or observation of the species in the wild.

Click or tap here to enter text.

(c) Extinct

A native species is eligible to be included in the Extinct class if there is no reasonable doubt that the last member of the species has died. A taxon is presumed Extinct when exhaustive surveys in the known and/or expected habitat, at appropriate times (diurnal, seasonal, annual), throughout its historic range have failed to record an individual.

Describe how circumstances have changed that now make the species eligible for listing as Extinct. Provide details of the last valid record or observation for the species in the wild and captivity.

Click or tap here to enter text.

Eligibility against the criteria

Standard of scientific evidence and adequacy of survey

For this assessment is it considered that the survey of the species has been adequate and there is sufficient scientific evidence to support the listing outcome.

CRITERION A

Population size reduction (reduction in total numbers) measured over the longer of 10 years or 3 generations based on any of A1 to A4

	Critically Endangered (CR)	Endangered (EN)	Vulnerable (VU)	Near Threatened (NT)
A1	**≥ 90%**	**≥ 70%**	**≥ 50%**	**≥ 20%**
A2, A3, A4	**≥ 80%**	**≥ 50%**	**≥ 30%**	**≥ 20%**

A1 Population reduction observed, estimated, inferred or suspected in the past and the causes of the reduction are clearly reversible AND understood AND ceased.

A2 Population reduction observed, estimated, inferred or suspected in the past where the causes of the reduction may not have ceased OR may not be understood OR may not be reversible.

A3 Population reduction, projected or suspected to be met in the future (up to a maximum of 100 years) [*(a) cannot be used for A3*]

A4 An observed, estimated, inferred, projected or suspected population reduction where the time period must include both the past and the future (up to a max. of 100 years in future), and where the causes of reduction may not have ceased OR may not be understood OR may not be reversible.

based on any of (a) to (e)

(a) direct observation [*except A3*]

(b) an index of abundance appropriate to the taxon

(c) a decline in area of occupancy, extent of occurrence and/or quality of habitat

(d) actual or potential levels of exploitation

(e) the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites

Please identify whether the species meets A1, A2, A3 or A4. Include an explanation, supported by data and information, on how the species meets the criterion (A1 – A4). If available include information on:

- whether the population trend is increasing, decreasing or static
- estimated generation length and method used to estimate the generation length

You must provide a response. If there is no evidence to demonstrate a population size reduction, this must be stated.

Insufficient data to determine eligibility.

Available population data are insufficient to assess under Criterion A, as little is known about the population size of *Cherax robustus* through time. Criterion A4 may apply here, but adequate population data are not available to assess this. It is very likely that mainland populations have been reduced dramatically, in particular those outside reserves on the Sunshine Coast, but this is just anecdotal. It is likely that the population size will decline due to habitat loss in the face of the expansion and development of the area for human populations. Within the national parks, there will also be likely population reduction due to more intense bushfires and droughts in the future.

CRITERION B:

Geographic distribution is precarious for either extent of occurrence AND/OR area of occupancy				
	Critically Endangered (CR)	**Endangered (EN)**	**Vulnerable (VU)**	**Near Threatened (NT)**
B1. Extent of occurrence (EOO)	**< 100 km²**	**< 5,000 km²**	**< 20,000 km²**	**< 40,000 km²**
B2. Area of occupancy (AOO)	**< 10 km²**	**< 500 km²**	**< 2,000 km²**	**< 4,000 km²**
AND at least 2 of the following 3 conditions for CR, EN or VU:				AND (b) for NT
(a) Severely fragmented OR Number of locations	**= 1**	**≤ 5**	**≤ 10**	**Not applicable**
(b) Continuing decline observed, estimated, inferred or projected in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals				**≥ 10% within the longer of 10 years or 3 generations**
(c) Extreme fluctuations in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) number of locations or subpopulations; (iv) number of mature individuals				**Not applicable**

Please refer to the 'Guidelines for Using the IUCN Red List Categories and Criteria' for assistance with interpreting the criterion particularly in relation to calculating 'extent of occurrence', 'area of occupancy' and understanding of the definition and use of 'severely fragmented', 'locations', 'continuing decline' and 'extreme fluctuations'.

Please identify whether the species meets B1 or B2. Except for Near Threatened species, include an explanation, supported by data and information, on how the species meets at least 2 of (a), (b) or (c). For Near Threatened species, include an explanation, supported by data and information, on how the species meets (b).

Please note that locations must be defined by a threat. A location is a geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals of the species present.

If available, include information on:

- Whether there are smaller populations of the species within the total population and, if so, the degree of geographic separation between the smaller populations within the total population
- Any biological, geographic, human induced or other barriers enforcing separation

You must provide a response. If there is no evidence to demonstrate that the geographic distribution is precarious for either extent of occurrence AND/OR area of occupancy, this must be stated.

Cherax robustus meets the thresholds for listing as **Vulnerable (VU)** under criteria **B1ab(iii)** and **B2ab(iii)** based on size of EOO and AOO, number of locations, and threats of habitat loss/degradation and hydrological changes caused by development and various impacts of climate change.

1) B1: EOO of 7701 km^2. Much of the calculated EOO area for *C. robustus* includes the sea, urban areas, forests, and other highly unsuitable environments for this species.

2) B2: AOO of 212 km^2. As *C. robustus* is largely restricted to the patchy and relatively rare wallum areas, and within that to the margins of freshwater areas, the actual area of habitation will be much smaller.

a: Known from eight locations largely within the wallum habitat of Southeast Queensland. They are considered to be different locations due their shared threat types and levels, as well as their discrete geographic nature and shared land management regimes.

The locations are;

1. K'gari
2. Cooloola (mainland section of Great Sandy National Park)
3. Tin Can Bay (mainland)
4. Northern Sunshine Coast (mainland)

5. Southern Sunshine Coast (mainland)
6. Bribie Island
7. Moreton Island
8. North Stradbroke Island.

b(iii): Projected decline in area, extent and/or quality of habitat due to drought and bushfires (all locations) and development (mainland, Bribie Island). This decline has and will result from a number of different threatening processes, often working in combination. Drought and bushfire are threats to all locations across the species' distribution (Queensland Government 2020b; Threatened Species Operations 2020), with both becoming more intense with continued climate change. In mainland locations (especially the Sunshine Coast) and Bribie Island, there is the added threat of direct habitat loss from development which is continuing apace. Accompanying the development is a concomitant change to the hydrological regime (including contaminant runoff), which will continue to degrade habitat.

CRITERION C

Small population size and decline					
		Critically Endangered (CR)	**Endangered (EN)**	**Vulnerable (VU)**	**Near Threatened (NT)**
Estimated number of mature individuals		**< 250**	**< 2,500**	**< 10,000**	**< 20,000**
AND either (C1) or (C2) is true					AND (C1) is true
C1 An observed, estimated or projected continuing decline of at least (up to a max. of 100 years in the future		**25% in 3 years or 1 generation (whichever is longer)**	**20% in 5 years or 2 generations (whichever is longer)**	**10% in 10 years or 3 generations (whichever is longer)**	**10% in 10 years or 3 generations (whichever is longer)**
C2 An observed, estimated, projected or inferred continuing decline AND its geographic distribution is precarious for its survival based on at least 1 of (a) or (b):					
(a)	(i) Number of mature individuals in each subpopulation	**≤ 50**	**≤ 250**	**≤ 1,000**	**Not applicable**
	OR				
	(ii) % of mature individuals in one subpopulation =	**90 – 100%**	**95 – 100%**	**100%**	**Not applicable**
(b) Extreme fluctuations in the number of mature individuals		**Applicable**	**Applicable**	**Applicable**	**Not applicable**

Please identify the estimated total number of mature individuals and either an answer to C1 or C2. Include an explanation, supported by data and information, on how the species meets the criteria. Note: If the estimated total number of mature individuals is unknown but presumed to be likely to be >10 000, you are not required to provide evidence in support of C1 or C2, just state that the number is likely to be >10 000.

You must provide a response. If there is no evidence to demonstrate small population size and decline this must be stated.

There are **insufficient data** to assess *Cherax robustus* against the thresholds for listing under criterion C as there is little information available to determine a robust estimate of the number of mature individuals.

CRITERION D:

Very small population				
	Critically Endangered (CR)	**Endangered (EN)**	**Vulnerable (VU)**	**Near Threatened (NT)**
D1. Number of mature individuals	**< 50**	**< 250**	**D1. < 1,000**	**D1. < 3,000**
OR				
D2. [Only applies to the VU and NT categories] Restricted area of occupancy or number of locations with a plausible future threat that could drive the taxon to CR or EX in a very short time.	**Not applicable**	**Not applicable**	**D2. Typically: AOO < 20 km² or number of locations ≤ 5**	**D2. Typically: AOO < 40 km² or number of locations ≤ 10**

Please identify the estimated total number of mature individuals and evidence of how the figure was derived.

For Criterion D2, please provide information on the species' area of occupancy, number of locations and plausible threats.

You must provide a response. If there is no evidence to demonstrate eligibility, this must be stated.

Cherax robustus is **not eligible** for listing under criterion D.

CRITERION E:

Quantitative Analysis				
	Critically Endangered (CR)	**Endangered (EN)**	**Vulnerable (VU)**	**Near Threatened (NT)**
Indicating the probability of extinction in the wild to be:	**≥ 50% in 10 years or 3 generations, whichever is longer (100 years max.)**	**≥ 20% in 20 years or 5 generations, whichever is longer (100 years max.)**	**≥ 10% within 100 years**	**≥ 5% within 100 years**

Please identify the probability of extinction and evidence of how the analysis was undertaken.

You must provide a response. If there has been no quantitative analysis undertaken this must be stated.

Cherax robustus is **not eligible** for listing under this criterion because no quantitative analysis of populations is available

SUMMARY OF CRITERIA UNDER WHICH THE SPECIES IS ELIGIBLE FOR LISTING AS: CR, EN, V, NT, EW or EX

Please mark the criteria and sub-criteria that apply.

☐Criterion A	☐A1 (specify at least one of the following) ☐a) ☐b) ☐c) ☐ d) ☐e); **AND/OR** ☐A2 (specify at least one of the following) ☐a) ☐b) ☐c) ☐d) ☐e); **AND/OR** ☐A3 (specify at least one of the following) ☐a) ☐b) ☐c) ☐d) ☐e); **AND/OR** ☐A4 (specify at least one of the following) ☐a) ☐b) ☐c) ☐d) ☐e)
☒Criterion B **Vulnerable**	☒B1 (specify at least two of the following) ☒a) ☒biii) ☐c); **AND/OR** ☒B2 (specify at least two of the following, other than NT) ☒a) ☒biii) ☐c)
☐Criterion C	☐estimated number of mature individuals **AND** ☐C1 **OR** ☐C2 ☐a (i) **OR** ☐a (ii) **OR** ☐C2 ☐b)
☐Criterion D	☐D1 **OR** ☐ D2
☐Criterion E	

☐EX

☐EW

☐LC Species nominated to change from a higher conservation class to Least Concern.

No above boxes apply.

Other Considerations

*INDIGENOUS CULTURAL SIGNIFICANCE

Is the species known to have cultural significance for Indigenous groups within Australia? If so, to which groups? Provide information on the nature of this significance if publicly available.

This species has no known cultural significance to the Yuggera, Gubbi Gubbi, and Badtjala people.

FURTHER STUDIES

Identify relevant studies or management documentation that might relate to the species (e.g. research projects, national park management plans, recovery plans, conservation plans, threat abatement plans, etc.).

ADDITIONAL COMMENTS/INFORMATION

Please include any additional comments or information on the species such as survey or monitoring information, and maps that would assist with the consideration of the nomination.

Click or tap here to enter text.

IMAGES OF THE SPECIES

Please include or attach images of the species if available, and indicate if you are in a position to authorise their use.

Fig. 7: *Cherax robustus* removed from housing development near Caloundra, Sunshine Coast, 2016 (Photo: Nathan Bignell, Feathertail Photography, used with permission).

Reviewers and references

REVIEWER(S)

Has this nomination been peer-reviewed? Have relevant experts been consulted on this nomination? If so, please include their names, current professional positions and contact details.

This nomination has been peer-reviewed by Dr. John Short and was read and commented on by Dr. James Furse (Griffith University), Robert McCormack (Australian Aquatic Biological), Dr. Andrew Bentley (frc environmental), Leanda Garvie (University of the Sunshine Coast), Dr. Jonathan Marshall, Dr. Alisha Steward, and Peter Negus (Water Planning Ecology, DES).

A large number of people provided information, advice and guidance in the preparation of this nomination. They include: Glynn Aland (Seqwater), Kieran Aland (Queensland Museum), L. Behrendorff (QPWS), A. Bentley (frc environmental), N. Bignell (The Fauna Catcher), S. Bignell (Feathertail Photography), T. Christensen (QPWS), J. Coe (Jardini International), J. Coughran (Sheridan College), K. Crouch (Kayak), P. Davie (Queensland Museum), J. Esdaile (QPWS), J. Furse (Griffith University), L. Garvie (University of the Sunshine Coast), I. Gynther (DES), R. Hobson (QPWS), T. Howell (Freshwater Ecology Consulting), A. Jensen (QPWS), A. Karklis (QPWS), W. Martin (DES), J. Marshall (DES), R. McCormack (Australian Aquatic Biological), B. McLarty (QPWS), E. Meyer, V. Moscato (Native Foresters), P. Negus (DES), J. Plant (QPWS), D. Potter (Queensland Museum), C. Shultz (DES), O. Scully, J. Short (BioAccess Australia), Brendon Yetman (QPWS).

REFERENCE LIST

Please list key references/documentation you have referred to in your nomination.

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Nominator's Details

Note: Your details are subject to the provisions of the *Privacy Act 1988* and will not be divulged to third parties, except for state and territory governments and scientific committees that have agreed to collaborate on national threatened species assessments using a CAM. If there are multiple nominators please include details below for all nominators.

TITLE (e.g. Mr/Mrs/Dr/Professor/etc.)

Dr

FULL NAME

Timothy J. Page

ORGANISATION OR COMPANY NAME (IF APPLICABLE)

Griffith University

CONTACT DETAILS

DECLARATION

I declare that, to the best of my knowledge, the information in this nomination and its attachments is true and correct.

Signed: * *If submitting by email, please attach an electronic signature*	Date: 18/05/2020 (original submission) 21/10/2021 (minor revision)

Lodging your nomination

Completed nominations may be lodged either:
1. by email in Microsoft Word format to: SpeciesTechnical.Committee@des.qld.gov.au
2. by mail to: The Chair
   Species Technical Committee
   Queensland Herbarium
   Mount Coot-tha Rd
   Toowong QLD 4066

*** If submitting by mail, you must include an electronic copy on a memory stick.**

Suggested citation:

Page, T.J. (2021). Nomination to change the conservation class of *Cherax robustus* under the Queensland *Nature Conservation Act 1992* (minor revision of 2020 version). Department of Environment and Science, Brisbane.