Yabby (*Cherax destructor*)
Ecological Risk Screening Summary

U.S. Fish & Wildlife Service, September 2012
Revised, September 2014, February 2019
Web Version, 7/12/2019

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1 Native Range and Status in the United States

Native Range

From CABI (2019):

"*C. destructor* ranges over 2 million km^2 in its native range from South Australia and the southern parts of the Northern Territory in the west, to the Great Dividing Range in the east (Riek, 1967; Sokol, 1988)."

"It appears that yabbies were largely restricted to lower altitude habitats in inland areas of southeastern Australia including the Murray-Darling Basin before European settlement, with the *Euastacus* spp. found in higher altitude habitats and the coastal river systems."

Status in the United States

No records of *Cherax destructor* in the wild in the United States were found.

From CABI (2019):

"[…] the specimens [*Cherax destructor*] came from a crayfish farm in California (USA) […]"

From USFWS (2016a):

"The yabby was officially listed as an injurious wildlife species by the U.S. Fish and Wildlife Service in 2016 under the Lacey Act (18.U.S.C.42). Importation and shipping between the continental United States and the District of Columbia, the Commonwealth of Puerto Rico, or any territory or possession of the United States is prohibited."

From USFWS (2016b):

"Of the 11 species, four species (crucian carp, Nile perch, wels catfish, and yabby) have been imported in only small numbers since 2011 […]"

The Florida Fish and Wildlife Conservation Commission has listed the crayfish, *Cherax destructor* as a prohibited species. Prohibited nonnative species (FFWCC 2019), "are considered to be dangerous to the ecology and/or the health and welfare of the people of Florida. These species are not allowed to be personally possessed or used for commercial activities."

From Fusaro et al. (2019):

"Pennsylvania prohibits people from transporting, introducing or importing any fish, bait fish or fish bait including crayfish (PA State Laws, Title 30). It is unlawful to possess, import or sell *C. destructor* in Ohio (OAC Chapter 1501:31-19). It is illegal to possess, import, sell, or offer to sell *C. destructor* in Michigan (NREPA Part 413). Illinois lists *C. destructor* as an injurious species as defined by 50 CFR 16.11-15. Therefore *C. destructor* cannot be "possessed, propagated, bought, sold, bartered or offered to be bought, sold, bartered, transported, traded, transferred or loaned to any other person or institution unless a permit is first obtained from the Department of Natural Resources (17 ILL. ADM. CODE, Chapter 1, Sec. 805)." This law also states that any interstate transporter is prohibited from transferring "any injurious species from one container to another; nor can they exchange or discharge from a container containing injurious species without first obtaining written permission from the Department (17 ILL. ADM. CODE, Chapter 1, Sec. 805)." The law also prohibits the release of any injurious species, including *C. destructor*. Wisconsin prohibits the transportation, possession, transfer of, or introduction of all nonnative crayfish (Wisconsin Chapter NR 40). Minnesota lists *C. destructor* as prohibited meaning that a person may not possess, import, purchase, sell, propagate, transport, or introduce *C. destructor* (Minnesota Rule 6216.0250)."

Means of Introductions in the United States

No records of *Cherax destructor* in the wild in the United States were found.

Remarks

A previous version of this ERSS was originally published in 2012 and revised in September 2014.

From CABI (2019):

"Notwithstanding its wide distribution and its invasive potential, *C. destructor* is still classified by IUCN (2010) as Vulnerable. The main threats to this species are degradation of native vegetation and water pollution as a result of fertilizer and insecticide run-off from agricultural farms, as well as increased predation and competition from introduced alien species. The Australian Fisheries Management Act of 1994 designated the yabbies' ecosystem as an Endangered Ecological Community, requiring vegetation management, run-off control and extensive surveying; without continued conservation efforts this ecosystem is under threat of irreversible degradation."

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From Crandall (2016):

"Animalia (Kingdom) > Arthropoda (Phylum) > Crustacea (Subphylum) > Multicrustacea (Superclass) > Malacostraca (Class) > Eumalacostraca (Subclass) > Eucarida (Superorder) > Decapoda (Order) > Pleocyemata (Suborder) > Astacidea (Infraorder) > Parastacoidea (Superfamily) > Parastacidae (Family) > *Cherax* (Genus) > *Cherax destructor* (Species)"

"Status accepted"

Size, Weight, and Age Range

From McCormack (2014):

"*Cherax destructor* can obtain a large size of 81 mm OCL [occipital carapace length] and weight 350 grams (McCormack 2008)."

From CABI (2019):

"The species was demonstrated to mature at the end of its first year of life, […] and attain a similar size to the smooth marron *C. cainii* in its first year of life (29 mm OCL [occipital carapace length], […]), […]. The life span is at least 3 years and possibly up to 6 years (Souty-Grosset et al., 2006). […] Individual growth is highly variable, and the maximum size of around

220 g for adult yabbies is reached within 2 to 3 years (Withnall, 2000). The larger yabbies are males. The chelipeds grow faster than the rest of the body, reaching the weight of 100 g in large males (Lawrence and Jones, 2002)."

Environment

From CABI (2019):

"*C. destructor* is found in a wide variety of habitats, such as desert mound springs, alpine streams, subtropical creeks, rivers, billabongs, ephemeral lakes, swamps, farm dams, and irrigation channels (Sokol, 1988; Horwitz and Knott, 1995; Austin et al., 2003; Souty-Grosset et al., 2006). The majority of the range of *C. destructor* is characterized by high summer temperatures and low annual rainfall producing an environment conducive to frequent stagnation and desiccation."

"Environmental Requirements

C. destructor is adapted to a wide range of water temperatures, between 1°C and 35°C. It does not grow at water temperatures below 15°C and falls into a state of partial hibernation (i.e. metabolism and feeding cease) when water temperature drops below 16°C (Withnall, 2000). Growth ceases at 34°C and mortalities start to occur at 36°C (Mills, 1983; Morrissy et al., 1990; Merrick and Lambert, 1991; Morrissy and Cassells, 1992). The ideal temperature range for optimum growth is 20-25°C (Withnall, 2000).

It tolerates high salinities, with growth ceasing at 8 ppt (approximately equal to 25% seawater) and mortalities starting to occur at 16 ppt (Mills and Geddes, 1980). It tolerates oxygen concentration <1 mg L-1, being able to survive for a short time at 0 mg L-1 oxygen (Mills, 1983; Morrissy and Cassells, 1992).

Waters with a pH between 7.5 and 8.5 are preferred; however, yabbies can tolerate a pH of 7.0 and 9.0; a pH of below 7.0 increases the toxicity of dissolved metals within the water column and makes the exoskeleton softer, and a pH of above 9.0 greatly increases the toxicity of ammonia (PIRSA, 2011).

Alkalinity and hardness levels of 50-300 mg-1 provide a good buffering effect to pH swings associated with the respiration of aquatic flora and fauna; a lack of calcium in the water results in soft-shelled yabbies (PIRSA, 2011).

[…] they seem to prefer water with moderate levels of turbidity. […] Secchi depths of 20-60 cm are recommended for the optimal management of farm ponds (PIRSA, 2011).

Khan and Nugegoda (2007) showed that *C. destructor* 4-week old juveniles were less sensitive to trace metals than most other tested aquatic organism, showing 96-h LC50 values of 379 µg L-1 for cadmium, 494 µg/L-1 for copper, 50 mg L-1 for iron and 327 mg L-1 for nickel."

Climate/Range

From USFWS (2016a):

"The common yabby inhabits temperate and tropical climates."

Distribution Outside the United States

Native

From CABI (2019):

"*C. destructor* ranges over 2 million km^2 in its native range from South Australia and the southern parts of the Northern Territory in the west, to the Great Dividing Range in the east (Riek, 1967; Sokol, 1988)."

"It appears that yabbies were largely restricted to lower altitude habitats in inland areas of southeastern Australia including the Murray-Darling Basin before European settlement, with the *Euastacus* spp. found in higher altitude habitats and the coastal river systems."

Introduced

From Vedia and Miranda (2013):

"The first introduction of *C. destructor* into Spain and Europe took place in Girona (Catalonia) in 1983, involving specimens from California (Souty-Grosset et al., 2006). Subsequently (1984-1985), another introduction was conducted in the province of Zaragoza, where a population was eventually stabilised in Gordués, near Sos del Rey Católico (Holdich et al., 2009). Because *C. destructor* is sensitive to aphanomycosis, some of its populations have been eradicated using the crayfish plague pathogen. However, some populations persist to the present day (Holdich et al., 2009). It is believed that there are at least four stable populations in Spain: one in Aragon and three in Navarra (Souty-Grosset et al., 2006) […]. Moreover, this species has been detected in other European countries in recent years. For example, a population was detected in Italy in 2008, and one individual was reported in Lake Geneva, Switzerland (Scalici et al., 2009)."

From CABI (2019):

"The species was introduced to Western Australia from western Victoria in 1932 (Victorian Aquaculture Council, 1999; Western Australia Fisheries, 1999; Austin, 1985; Morrissy and Cassells, 1992). […]. In 1982, *C. destructor* was for the first time collected from a wild aquatic system in sympatry with a native crayfish species (*Cherax quinquecarinatus*) in Western Australia (Austin, 1985; Lynas et al., 2004). By 1985, most known yabby sites were still east of the Albany Highway. They have since then shown a continuing strong spread. Currently, *C. destructor* occurs from Hutt River in the north to Esperance in the southeast (Morrissy and Cassells, 1992; Horwitz and Knott, 1995; Beatty et al., 2005a). The species has also colonized cave streams via temporary, short streams on the coastal sand-plain. Isolated populations occur in coastal plain rivers to the west of the Darling Scarp and in the arid northern Goldfields Region near Leonora. […] The species is also present in Tasmania (Lynas et al., 2007), after illegal introductions since the 1960s (Elvey et al., 1997). It was first recorded in Glen Morriston

Rivulet, a small permanent stream, near Ross in the centre of the island, which is also inhabited by a Tasmanian endemic crayfish, *Astacopsis franklinii*. It is known from six other areas in Tasmania (from north to south: Devonport, Birralee, Launceston, Golden Valley, Cressy/Longford, Sandford; Elvey et al., 1997).

Outside Australia, *C. destructor* is known from Spain and Italy in Europe, from the People's Republic of China in Asia, and from South Africa and Zambia in Africa. […] In Italy, an established and highly dense (0.28 females m-2 and 0.24 males m-2) population of *C. destructor* was found in September 2008 (Scalici et al., 2009). This population was found in five abandoned cultivation ponds (40 x 9 x 6 m, depth about 0.6 m, with muddy bottom covered by submerged macrophytes) in the Natural Preserve of ''Laghi di Ninfa'' (Province of Latina, central Italy). The subsequent genetic characterization confirmed that the population belongs to *C. destructor*. No within-population variation emerged (Scalici et al., 2009). […]

It is expected that *C. destructor* will extend its distribution range as an effect of global warming. The use of consensus techniques to generate a quantitative description of the environmental conditions favouring the establishment of four problematic invasive decapods in the Iberian Peninsula, including *C. destructor*, showed that this species, along with *Procambarus clarkii*, has reduced suitability in colder areas, whereas the suitability for *P. leniusculus* is greatly reduced in warmer areas (Capinha and Anastácio, 2011). *Cherax destructor* presents a small invasive range in the upper Ebro basin in the Iberian Peninsula. This region is dominated by moderate suitability values, which might help explain its reduced colonization rate in the Iberian Peninsula compared with the other two crayfish species. However, areas that offer high environmental suitability for *C. destructor* in the Iberian Peninsula, and that are highly susceptible to its invasion, are located downstream of its current invasive range in the Ebro basin (Capinha and Anastácio, 2011)."

Means of Introduction Outside the United States

From CABI (2019):

"*C. destructor* has also been translocated (for aquaculture and the aquarium trade, possibly also by recreational fishers) to drainages in New South Wales east of the Great Dividing Range, […]. This wide range in distribution is probably partly due to translocation by aboriginal Australians (Horwitz and Knott, 1995), as the species is used as a subsistence food for some tribes (Horwitz and Knott, 1995)."

"The first site of introduction was a farm dam at Narembeen, 280 km east of Perth (Lynas et al., 2007; Austin, 1985; Morrissy and Cassells, 1992). In an attempt to prevent the spread of the species into wild aquatic systems of the naturally forested, higher rainfall region of the Southwest Coast Drainage Division that is home to all 11 endemic freshwater crayfish species of this state (Austin and Knott, 1996; Horwitz and Adams, 2000), the Department of Fisheries in Western Australia allows the culture of *C. destructor* (still referred to as *C. albidus* by that Department) only east of Albany Highway between Perth and Albany. The site of introduction was thought to be characterized by a landscape that would not have facilitated the natural spread of the crayfish. On the contrary, the elevated interest in crayfish for commercial reasons, together with the hardiness of the species and its ability to grow even in stagnant farm dams, have led it to spread widely (Austin, 1985; Morrissy and Cassells, 1992; Horwitz and Knott, 1995; Beatty et al., 2005a."

"The first introduction to Spain occurred in 1983: the specimens came from a crayfish farm in California (USA) and were released into a pond in Girona, Catalonia (Souty-Grosset et al., 2006)."

"Yabbies are commonly used as bait by recreational fishers (Nguyen, 2005), e.g. for redfin perch and trout fishing in the large irrigation dams to the south of Perth, Western Australia, with unused live bait often being discarded directly into the water (Morrissy and Cassells, 1992). The species is known as a culinary delicacy also in Europe and farmed in some countries, e.g. Italy. It is an aquarium species that is easy to maintain, and can be purchased through e-commerce (e.g. eBay) [no evidence of availability in the United States was found]. The species is increasingly used in research. As a result of all these uses by humans, the potential for specimens to be released and become established is extremely high, especially in temperate and warmer climates.

Human activity has also aided the spread of the species through misguided information and recreational carelessness. For example, in Western Australia many farmers think that they are culturing the indigenous koonac, *Cherax preissii* (Lynas et al., 2007), and the ability of *C. destructor* to walk out of unsecured dams into adjacent waterways is undoubtedly a major route of introduction from aquaculture facilities."

"*C. destructor* has been introduced intentionally into Western Australia, Tasmania and Europe for aquaculture purposes (Horwitz, 1990). Natural dispersal may occur within the same basin but nothing is known about its migration ability. Anecdotal reports suggest that *C. destructor* emerges from hypoxic water to breathe air and migrates between waterbodies (Morris and Callaghan, 1998)."

Short Description

From CABI (2019):

"An accurate description of *C. destructor* is provided by Souty-Grosset et al. (2006), as follows:

Body: carapace smooth, single pair of post-orbital ridges forming a pair of long keels on the anterior carapace; no spines on shoulders behind cervical groove. Dorsal surface of telson without spines, membranous over posterior half.

Rostrum: short, broad based, triangular; borders tapering to an indistinct acumen; no spines present along borders, borders not raised; indistinct median carina.

Appendages: chelae smooth, elongated and large; inner margin of chelae propodus longer than dactylus; mat of setae along ventral surface of carpus and merus. Short spur on inferior margin of cheliped coxa."

"Colour: green-beige to almost black, blue-grey being common in individuals kept in captivity. Chelae dorsally showing the same colour as body, underside dirty-white or grey coloured.

Colour shows a wide variability depending on the location, season and water conditions and may vary from individual to individual in a single location (Withnall, 2000)."

Biology

From CABI (2019):

"Yabbies dig burrows which can be 0.5-2 m deep; burrows are connected by access shafts to the water, which makes crayfish able to survive over summer in the burrows (Withnall, 2000). Their burrowing behaviour is a cause for concern for farmers and can make the banks of the invaded waterbodies unstable and susceptible to collapse."

"The sex of yabbies can be determined externally: females have gonopores located at the base of the third pairs of pereopods, while male genital papillae are at the base of the fifth pair of pereopods, nearest the abdomen.

Females become sexually mature at a small size and early age, i.e. at 20 g and prior to 1 year old (Lawrence et al., 1998; Beatty et al., 2005a). Sexual maturity is reached when the yabby is approximately 6-10 cm in total length (Withnall, 2000). According to Beatty et al. (2005a), the orbital carapace length (measured from the base of the orbital region to the posterior margin of the branchiostegite) at which 50% of crayfish reached sexual maturity was 21.6 mm for females and 26.5 mm for males."

"Egg development is initiated by longer day lengths, while spawning starts with higher water temperatures. When water temperature is above 15°C, *C. destructor* spawns from early spring to mid summer. However, when water temperature remains between 18°C and 20°C with a long artificial daylength of 14 hours, yabbies are able to spawn repeatedly up to five times a year (Mills, 1983). In Hutt River (Southwest Coast Drainage Division of Western Australia), spawning occurs between July and January (Beatty et al., 2005a), similarly to what was recorded in farm dams in southwestern Western Australia, where newly released juveniles were found between October and February (Morrissy and Cassells, 1992).

The male deposits a spermatophore between the female's fourth and fifth pairs of pereopods after which the female extrudes her eggs, mixes them with sperm and incubates them by attaching eggs to the pleopods under her abdomen in the so-called "brood chamber". The average clutch size is 350 eggs, with females producing from 30 to 450 eggs per brood (Merrick and Lambert, 1991). Clutch size increases with female size, reaching up to more than 1000 for a large female (Withnall, 2000). Approximately 2 mm in length and oval in shape, the fertilized eggs are usually olive green in colour (Withnall, 2000).

Berried females show a form of parental care, keeping eggs cleaned and well oxygenated and removing any mortalities or foreign particles with their fifth pereopods (Withnall, 2000). Incubation takes between 19 and 40 days depending upon temperature (Morrissy et al., 1990). In water temperatures of 20°C, the eggs hatch within 40 days. As temperature increases, the length of time taken to hatch decreases until water temperatures reach 30°C; temperatures above 30°C adversely affect hatching (Withnall, 2000). After hatching, females carry the young and release them when they are stage 3 juveniles. In newly hatched yabbies, moulting may take place every couple of days. Juvenile crayfish weigh approximately 0.02 g upon hatching. Under favourable conditions, a juvenile yabby will grow rapidly, gaining around 0.5 to 1.0 g in the first 60 days. Young are released in early and late summer (Beatty et al., 2005a).

After the young leave the mother, the female can spawn again if environmental conditions are favourable (Morrissy et al., 1990; Beatty et al., 2005a) […]. Based on observations on specimens of *C. albidus* (*C.* [*destructor sensu*] Austin et al., 2003) held in aquaria, McRae and Mitchell (1995) suggested that, following spawning, ovaries are held in a constant state of readiness, with oocytes present at the end of primary vitellogenesis able to undergo secondary vitellogenesis (increase in mean size from 400 to 2000 μm); similar findings were made in a Western Australian population (Beatty et al., 2005a). McRae and Mitchell (1997) noted that, provided the female *C. destructor* was not ovigerous and had sufficient nutritional reserves, the presence of males was a cue that induces new maturation of oocytes. The reproductive potential of this species is thus very large and increases its potential for invasiveness (Beatty et al., 2005a)."

"Moulting frequency decreases as yabbies get older until they only moult once or twice a year (Withnall, 2000)."

"Little is known about the natural diet of *C. destructor,* except that it is an opportunistic and omnivorous feeder, immature forms being more so. Plant material and detritus often dominate the gut contents, with arthropods making up only a small fraction of the total (Souty-Grosset et al., 2006). However, a stable isotope study of the assimilated diet of a translocated wild population of *C. destructor* demonstrated that the species occupied a primarily predatory trophic position in summer (consuming introduced *Gambusia holbrooki*) before shifting to a primarily herbivorous role in winter (Beatty, 2006). This highlighted an opportunistic diet that maximised consumption of high-protein food items when available.

C. destructor is also cannibalistic, particularly in overcrowded situations or if there is insufficient natural food available. Animals that have recently moulted are more susceptible to being cannibalized (Souty-Grosset et al., 2006).

A study on the ability of differently sized *C. destructor* to prey on zooplankton was conducted by Meakin et al. (2008). In yabbies lighter than 15 g, the feeding mode on *Daphnia* sp. involved rapid searching and probing with the first two pairs of walking legs. Once a prey item was located, the chelae on the end of these walking legs would grasp the zooplankton and then rapidly move it towards the mouthparts. Yabbies heavier than 25 g tended to use their walking legs to push the *Daphnia* sp. nearer to their third maxillipeds which would then force or scoop the zooplankton towards the mouthparts. A short-term feeding trial showed that there was no significant difference between size classes in regards to zooplankton consumption except that yabbies lighter than 15 g consumed over 5% of their body weight whereas yabbies at weight classes of 15–24.9, 25–34.9 and 35–45 g consumed only 1.08, 0.8 and 0.6% of their body weight, respectively. In the presence of both live zooplankton and a pellet diet, yabbies spent significantly more time feeding on zooplankton (85%) than on inert pellets (15%).

Linton et al. (2009) analyzed food utilization and digestive ability in *C. destructor* in comparison to *Engaeus sericatus*. The faeces consisted of mainly plant material with minor amounts of arthropods, algae and fungi. The morphology of the gastric mill of *C. destructor* suggests that it is mainly involved in crushing food material, being seemingly relatively efficient in grinding soft materials such as animal protein and algae. High amounts of lipids are accumulated in the midgut glands (about 60% of the dry mass), mostly composed of triacylglycerols (81-82% of total lipids). The dominating fatty acids were 16:0, 16:1(n-7), 18:1(n-9), 18:2(n-6), and 18:3(n-3). The two latter fatty acids can only be synthesized by plants and are thus indicative of the consumption of terrestrial plants by crayfish. The complement of digestive enzymes, such as proteinases, cellulase, β-glucosidase, laminarinase and xylanase within the midgut gland suggests that *C. destructor* is capable of hydrolyzing a variety of substrates associated with an omnivorous diet. High total protease and N-acetyl-β-D-glucosaminidase activity in the midgut gland of *C. destructor* suggests that this species is able to digest animal materials in the form of arthropods.

C. destructor is a nocturnal species. Feeding behaviour is mostly controlled by the amount of light filtering through the water and it is often found that the greatest periods of activity occur shortly before dawn and just after dusk (Withnall, 2000). Water temperature also plays an important role in the level of activity. At the temperature extremes, feeding rate decreases along with metabolic rate, which will result in reduced growth (Withnall, 2000)."

Human Uses

From McCormack (2014):

"*Cherax destructor* is currently commercially grown by 72 licenced commercial farmers in NSW [New South Wales, Australia] (NSW DPI 2012a). The cultured yabbies are sold alive for a range of purposes including: food for human consumption; food for native animals (e.g. in zoos, reptile parks); feeder yabbies for aquarium species; pets for aquariums; research stock of schools and Universities; bait for recreational fishermen and dam stock to seed farm dams as a home grown food source (McCormack 2005)."

From Vedia and Miranda (2013):

"The Yabbie is commercially produced in some regions of Australia (New South Wales, Victoria and South Australia), and it is considered a delicacy and sold live in North America [not known to be currently sold in the United States], Switzerland, Germany and England (Souty-Grosset et al., 2006)."

From CABI (2019):

"*C. destructor* has also been translocated (for aquaculture and the aquarium trade, possibly also by recreational fishers) […]. This wide range in distribution is probably partly due to translocation by aboriginal Australians (Horwitz and Knott, 1995), as the species is used as a subsistence food for some tribes (Horwitz and Knott, 1995)."

"*C. destructor* has a relatively high commercial value. In its native central-eastern Australia, it represents about 90% of crayfish production. Yabbies are commonly used as bait by recreational fishers (Nguyen, 2005), e.g. for redfin perch and trout fishing in the large irrigation dams to the south of Perth, Western Australia, with unused live bait often being discarded directly into the water (Morrissy and Cassells, 1992). The species is known as a culinary delicacy also in Europe and farmed in some countries, e.g. Italy. It is an aquarium species that is easy to maintain, and can be purchased through e-commerce (e.g. eBay). The species is increasingly used in research."

"*C. destructor* is the main fished and cultivated species of freshwater crayfish in Australia, with a total production of 67 tons in 2009 vs. a maximum of 336 tons reached in 1994 (FAO fishery statistics; http://www.fao.org/fishery/en). Farming of this species commenced in the early 1980s in South Australia and then spread from South Australia to Western Australia, Victoria and New South Wales (Lawrence and Jones, 2002). […] Extensive pond or dam production has reported yields of 400-690 kg ha-1 yr-1 (Lawrence and Jones, 2002). The adoption of intensive farming was expected to increase yield up to 1500-2000 kg ha-1 yr-1 (Lawrence and Jones, 2002).

[…] Live yabbies are supplied within Australia to top restaurants and retail fish shops (Western Australia Fisheries, 1999).

Approximately 70% of the yabbies produced in Western Australia are exported to Asia and Europe (Lawrence et al., 1998). In Europe, *C. destructor* specimens can be found for sale (live) at restaurants in Lausanne near Lake Geneva. Some 10-15 tons of live *C. destructor* are imported annually into Germany from Australia (Souty-Grosset et al., 2006) and in the 1990s the species was known in fish markets in England (Souty-Grosset et al., 2006). In 1997, 3.7 tons were cultivated in Italy (although this figure may have included some *C. quadricarinatus*) (Souty-Grosset et al., 2006)."

"Olszewski (1980), Sokol (1988), and Horwitz and Knott (1995) report that yabbies are a subsistence food for some Aboriginal tribes in Australia. There is a positive impact due to the recreational value of "yabbying" (i.e. catching yabbies). In Australian rivers and farm dams, this is a popular summertime activity, particularly with children."

Diseases

OIE lists *Aphanomyces astaci* (crayfish plague) as an OIE-reportable disease (OIE 2019). *Cherax destructor* is susceptible to the crayfish plague.

Poelen et al. 2014 lists *Pyxicola jacobi, Pyxicola bicalceata, Lagenophrys darwini, Vorticella jaerae, Vorticella flexuosa, Vorticella convallaria, Vorticella calciformis, Vairimorpha cheracis, Vaginicola ampulla, Tokophrya cyclopum, Thelohania parastaci, Thelohania montirivulorum, Setonophrys seticola, Setonophyrs lingulata, Setonophrys communis, Pyxicola pusilla, Pyxicola carteri, Lagenophrys willisi, Setonophrys spinosa, Lagenophrys occulosa, Acineta fluviatilis, Acineta tuberosa, Austramphilina elongata,* and *Epistylis* as parasites of *Cherax destructor.*

From Mrugala et al. (2016):

"The potential interactions of *Cherax destructor* with three *Aphanomyces astaci* genotype groups occurring in Central European freshwaters were assessed for the first time. As suggested by Unestam (1975), we confirmed an elevated resistance of *C. destructor* to the crayfish plague pathogen in comparison to European *Astacus astacus*. Depending on the pathogen virulence, this may lead to chronic infections or delayed mortalities in *C. destructor* populations. Therefore, it seems possible that under certain conditions this Australian crayfish species may contribute to *A. astaci* spread in Central Europe."

From CABI (2019):

"*C. destructor* is susceptible to the crayfish plague caused by the oomycete *Aphanomyces astaci*. However, testing for crayfish plague since 1989 has shown that this disease is not present in Australia (Jones and Lawrence, 2001). Other diseases and pathogens reported for this species are: burn spot disease, *Psorospermium* sp., and thelohaniasis (Jones and Lawrence, 2001; Moodie et al., 2003; Souty-Grosset et al., 2006).

Specifically, the microsporidian *Thelohania parastaci* is known to be carried by the yabby (Horwitz, 1990; Moodie et al., 2003). *Thelohania* was found in Western Australia farm dam populations of yabbies in the 1990s (Jones and Lawrence, 2001), and has since been reported in yabby populations in the Hutt River (Beatty, 2005). It is also known as "chalky tail" due to the *Thelohania* organism causing the tail muscle to become white and chalky in appearance.

Ectocommensal protozoans, temnocephalid flatworms and *Epistylis* sp. can infect *C. destructor*. The platyhelminth *Temnocephala* is an ectocommensal that resides on the exoskeleton of yabbies. It is often associated with low salinity and nutrient-rich waters. Eggs of temnocephalids are laid on the underside of the abdomen of yabbies and sometimes in their gill cavity. Temnocephalids are rarely harmful unless they are present in extremely high densities. Presence of adult temnocephalids or their eggs within the gill chamber of yabbies may cause respiratory problems. Their appearance may also reduce the market value. Adult temnocephalids can easily be removed by washing the yabbies in a salt bath for a couple of minutes. However the eggs of temnocephalids are extremely adherent and remain even after steaming and boiling (PIRSA, 2011).

Nematodes, such as *Gammarinema* sp., have been found in the gill chamber and cestodes in the muscle tissue (Jones and Lawrence, 2001; Souty-Grosset et al., 2006)."

Threat to Humans

From CABI (2019):

"No social negative impact is known. The possibility exists that this species might be a vector of parasites and diseases that might affect humans."

No further information on the possibility of zoonosis from *Cherax destructor* was found.

3 Impacts of Introductions

From Coughran and Daly (2012):

"Because of their superior biological attributes, translocated *C. destructor* have the potential to rapidly out–compete endemic crayfish species (Coughran et al., 2009). The population [of *Cherax destructor*] at Fitzroy Falls [New South Wales, Australia], for example, appears to be rapidly displacing an endemic crayfish, *Euastacus dharawalus*, which is now considered Critically Endangered (IUCN, 2011, Coughran and Furse, 2010; Furse & Coughran, 2011a, b, c). […]. The situation at Fitzroy Falls has the potential to cause the extinction of the iconic native crayfish that is only known from that site, and similar situations could be occurring elsewhere in coastal NSW."

"There are several coastal species of frog at potential risk from predation by *C. destructor*. The TSC [Threatened Species Conservation] Act 1995 (New South Wales Government, 2012) lists 29 frog species that are either critically endangered (5 spp.), endangered (12 spp) or vulnerable (12 spp.) to extinction (as at 8th July 2011) of these species, two critically endangered, four endangered and five threatened species are considered at risk from impacts of *C. destructor* […]. Four of these are considered at high risk of being impacted by *C. destructor*, as they breed in creeks (lotic) and lay their eggs in a single or several masses, hence making them more susceptible to being eaten than species that lay their eggs as dispersed, single units."

From McCormack (2014):

"*Cherax destructor* was first documented in Calverts Creek (Tributary Mooney Mooney Creek – […]) at Mt White in 2008 as part of the ACP [Australia Crayfish Project] general surveys. At that time a 50 m section of the main creek was surveyed, both *Euastacus australasiensis* and *C. destructor* were in good numbers and captured together. Surprisingly, a follow up survey of the same 50 m section of creek in February 2012 failed to find any crayfish at all, where once they were both plentiful. This was so unusual that we repeated the survey in March 2012 but again we only found macro invertebrates at the survey site. Further surveys of the surrounding area investigated five feeder streams into Calverts creek; one site produced no crayfish and the other 4 streams contained only *C. destructor* in residence (McCormack 2012a). Qualitative evidence would suggest that it has displaced the native *Euastacus australasiensis*.

Since that time *C. destructor* have spread throughout the Mooney Mooney Creek catchment and continue to spread rapidly (McCormack 2012a)."

"Little Mooney Mooney Creek […] was originally surveyed on the 1st December 2010. The creek was surveyed at the road bridge both upstream and downstream, and at that time the main creek contained *Euastacus spinifer* with *Euastacus australasiensis* found within adjacent, smaller, tributaries. The same site was surveyed again in February 2012. At this time, the main creek still contained relatively good numbers of *E. spinifer* upstream but *E. spinifer* was absent downstream with only *C. destructor* present in large numbers. *Euastacus spinifer* has seemingly been replaced by *C. destructor* downstream of a road crossing."

"In April 2011 both *Euastacus hirsutus* and *C. destructor* were captured together in Barrengarry

Creek […]. A total of nine *E. hirsutus* and six *C. destructor* were captured. One of the *Euastacus* crayfish was infected with thelohania.

In November 2011 a survey of Dharawal Creek found both endemic *E. hirsutus* and *C. destructor* together in the creek […]. A total of 30 crayfish were captured in our survey, 11 *E. hirsutus* and 19 *C. destructor*. Of the 30 crayfish only one, *E. hirsutus* displayed signs of thelohania infection. These are the only ACP records of thelohania in *Euastacus* crayfish (in thousands of ACP records), we speculate that the invasive *C. destructor* may be responsible for the pathogen transmission to *E. hirsutus*."

"The aggressive interactions between [*Euastacus*] *dharawalus* and *C. destructor* in Wides Meadow Creek was first recorded by Coughran et al. (2009).

[…] Our surveys in the creek below the reservoir using standard recreational fishing methods over a one hour duration captured over 5 kgs of crayfish. Only three *E. dharawalus* for a total weight of 143 grams were captured. At the same time, at the same site, 73 *C. destructor* were captured for a total weight of 5 kg. The native endemic crayfish *E. dharawalus* was outnumbered 24:1 by *C. destructor*. Both species are probably competing for the same resources, Coughran et al. (2009) first suggested that translocated *Cherax* species may easily out compete and rapidly displace this endemic *Euastacus* crayfish.

Euastacus dharawalus (Morgan 1997) was listed in November 2011 as a "Critically Endangered Species" by the NSW Fisheries Scientific Committee, making it the first *Euastacus* species in Australia to be listed as Critically Endangered under any State or Federal Government conservation legislation."

From Gherardi (2010):

"Once introduced for aquaculture and kept in outdoor ponds, crayfish almost inevitably escape and easily establish self-sustaining populations in the colonised habitats. *Cherax destructor*, for instance, after its first introduction into Western Australian farm dams for aquaculture in 1932, rapidly spread, and it now threatens the 11 endemic crayfish species of this state."

From Gherardi (2007):

"Burrowing by several NICS (e.g. *P. clarkii*, *P. leniusculus*, and *C. destructor*) can be a problem in areas other than agricultural, e.g. lawns, golf courses, levees, dams, dykes, and in rivers and lakes (e.g. Anastacio and Marques 1997). A few authors have lamented the damage caused by *C. destructor* burrowing to dam walls and irrigation canals (de Moor 2002)."

From CABI (2019):

"Yabbies dig burrows which can be 0.5-2 m deep; burrows are connected by access shafts to the water, which makes crayfish able to survive over summer in the burrows (Withnall, 2000). Their burrowing behaviour is a cause for concern for farmers and can make the banks of the invaded waterbodies unstable and susceptible to collapse."

"Given the extent of *C. destructor*'s range expansion and its capacity to colonize a wide diversity of waterbodies, it is expected that it will continue to progress into larger river systems throughout south-western Australia, as has occurred with a number of invasive fishes (Morgan et al., 2004; Beatty et al., 2005a)."

"*C. destructor* has also been translocated (for aquaculture and the aquarium trade, possibly also by recreational fishers) to drainages in New South Wales east of the Great Dividing Range, where it has become invasive and in some cases has the potential to displace other crayfish, such as *Euastacus* spp. (S Ahyong, Australian Museum, personal communication, 2011)."

"Despite its range expansion and suitability as colonizers, little research has been undertaken to ascertain the possible ecological impacts of the invasive *C. destructor*. We may infer that environmental impacts should be high both when it is the only crayfish species in the ecosystem of introduction and when other crayfish species are present (see Gherardi (2007) for a general discussion on the impacts of alien crayfish). These effects are due to the high fecundity, quick growth rate, high population densities, competitive ability, and feeding habits of the species (Beatty et al., 2005a; Beatty, 2006). Biodiversity may decrease due to the potential of *C. destructor* to hybridize with congeneric species (to be proven), to compete for food or space (e.g. with indigenous crayfish species), to prey on macroinvertebrates including snails (Beatty, 2006), as well as on fishes (Beatty, 2006) and amphibians (to be proven), to consume macrophytes (to be proven), and to be a vector of parasites.

The spread of yabbies into natural habitats has generated potential for interactions with indigenous fauna (Beatty et al., 2005a). For example, the spread of yabbies into the Swan-Avon catchment in Western Australia has led to their possible interaction with the critically endangered western swamp tortoise, *Pseudemydura umbrina*, near the Ellen Brook Nature Reserve proclaimed for preservation of the tortoise (Bradsell et al., 2002). Yabbies showed strongly aggressive and predatory behaviour towards tortoise hatchlings in a laboratory study using hatchlings of a non-endangered species of tortoise (Bradsell et al., 2002).

Body size and chelae size are major factors determining the outcome of competitive interactions between individual crayfish (Gherardi et al., 1999). *C. destructor* possesses chelae of considerable size (Austin and Knott, 1996). Furthermore, its growth rate in the first year of life in a wild translocated population was demonstrated to be similar to that of the large smooth marron *C. cainii* (Beatty et al., 2005a), and therefore it would be capable of competing with that species and outcompeting the relatively small gilgie *C. quinquecarinatus* for access to resources (Beatty et al., 2005b; Beatty, 2006). The potential impact of the yabby on the koonac, *C. preissii*, is currently unknown, but juvenile koonacs are likely to be outcompeted by larger yabbies when they emerge from burrows (Lynas et al., 2007).

Potential impacts on *Engaewa* spp. are likely due to changes to the induced habitat alteration, changes to food web dynamics, and the introduction of diseases. *C. destructor* may be also a threat to the hairy marron, *C. tenuimanus*, and its fishery, as it breeds faster and may carry diseases (Souty-Grosset et al., 2006). Although the Tasmanian *Astacopsis franklinii* is competitively superior to *C. destructor*, at least in the laboratory setting, direct predation on juveniles, quick population growth, ability to resist desiccation by burrowing, the introduction of alien parasites and diseases are all means that might allow the replacement of *A. franklinii* by *C. destructor* (Elvey et al., 1997)."

"Behavioural studies proved the ability of *C. destructor* to outcompete the smooth marron *C. cainii* and the gilgie *C. quinquecarinatus* (Lynas et al., 2007). Results from both aggressive behaviour and sediment competition trials indicate that, in habitats of co-occurrence where there is substantial overlap in resource use, the potential for exclusion of smooth marron and/or gilgies by the invasive yabby is high (Lynas, 2002; Lynas et al., 2007). In the laboratory, yabbies were found to be capable of evicting both smooth marron and gilgies from suitable substrates, thereby indicating the exclusion of these species from the use of a limiting resource at least under laboratory situations (Lynas et al., 2007). In natural environments, the smooth marron is likely to be at a disadvantage."

"Furthermore, *C. destructor* has the potential to compete with *C. cainii* for food resources, as investigated by Beatty (2006) using multiple stable isotope analyses. In summer, the two species occupy similar predatory trophic positions: their assimilated diet consisted of a large proportion of *Gambusia holbrooki*. In winter, although *C. cainii* continued to assimilate animal matter, *C. destructor* appeared to shift towards a more herbivorous/detrital diet. Such ability to switch trophic positions, when an otherwise abundant, high protein food sources (i.e. fish) becomes limited (as was the case in winter in the Hutt River), allows it to coexist with *C. cainii* and possibly to outcompete it."

"Indigenous crayfish are at risk from infection from the microsporidian *Thelohania parastaci* carried by the yabby. Western Australian crayfish species had not been exposed previously to the disease and therefore are likely to be susceptible. This microsporidian could be transmitted to indigenous species by yabbies. Infection of crayfish by this parasite leads to the destruction of striated and cardiac muscle tissue, resulting in reduced locomotor activity (Cossins and Bowler, 1974; Quilter, 1976). Survival time of infected individuals has been reported to range from a few months (in the New Zealand *Paranephrops zealandicus*) to two years (in the European *Austropotamobius pallipes*), although whether death is always inevitable for infected individuals has yet to be ascertained (Moodie et al., 2003). *Thelohania*, therefore, may increase the risk of predation of infected crayfish and reduces their ability to compete with healthy individuals."

"Due to its high reproductive potential, burrowing behaviour, and wide tolerance to environmental conditions, *C. destructor* has the potential to become a major threat to the indigenous crayfish species in Europe, if it becomes more widely established."

Cherax destructor was officially listed as an injurious wildlife species by the U.S. Fish and Wildlife Service in 2016 under the Lacey Act (18.U.S.C.42) (USFWS 2016a). The Florida Fish and Wildlife Conservation Commission has listed it as a prohibited species.

From Fusaro et al. (2019):

"Pennsylvania prohibits people from transporting, introducing or importing any fish, bait fish or fish bait including crayfish (PA State Laws, Title 30). It is unlawful to possess, import or sell

C. destructor in Ohio (OAC Chapter 1501:31-19). It is illegal to possess, import, sell, or offer to sell *C. destructor* in Michigan (NREPA Part 413). Illinois lists *C. destructor* as an injurious species as defined by 50 CFR 16.11-15. Therefore *C. destructor* cannot be "possessed, propagated, bought, sold, bartered or offered to be bought, sold, bartered, transported, traded, transferred or loaned to any other person or institution unless a permit is first obtained from the Department of Natural Resources (17 ILL. ADM. CODE, Chapter 1, Sec. 805)." This law also states that any interstate transporter is prohibited from transferring "any injurious species from one container to another; nor can they exchange or discharge from a container containing injurious species without first obtaining written permission from the Department (17 ILL. ADM. CODE, Chapter 1, Sec. 805)." The law also prohibits the release of any injurious species, including *C. destructor*. Wisconsin prohibits the transportation, possession, transfer of, or introduction of all nonnative crayfish (Wisconsin Chapter NR 40). Minnesota lists *C. destructor* as prohibited meaning that a person may not possess, import, purchase, sell, propagate, transport, or introduce *C. destructor* (Minnesota Rule 6216.0250)."

4 Global Distribution

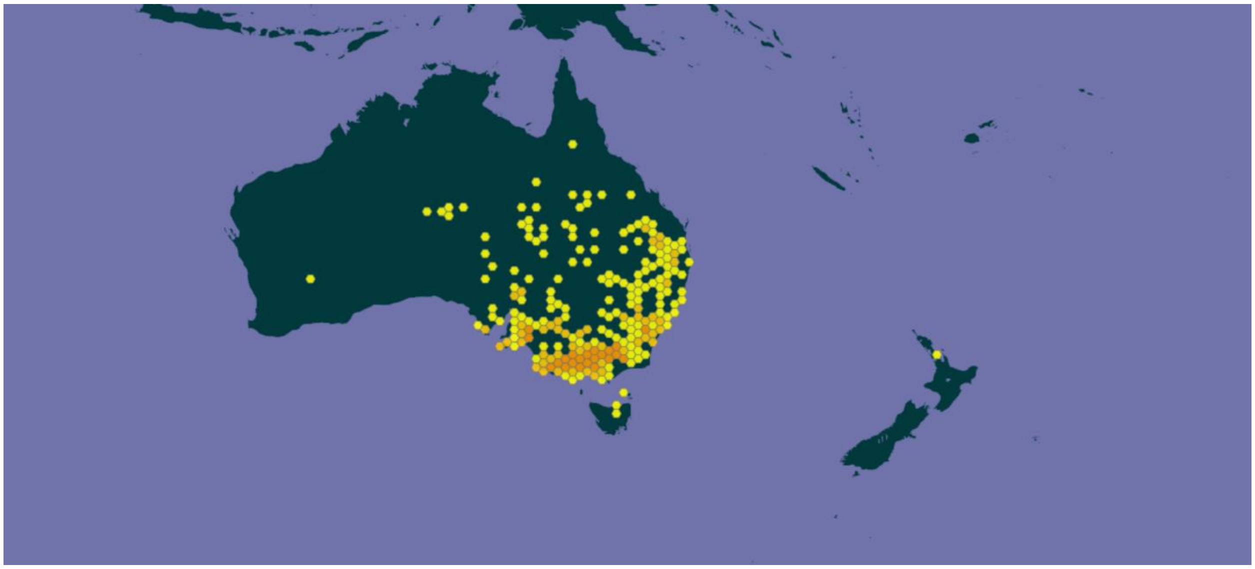

Figure 1. Map of Australia and New Zealand showing locations where *Cherax destructor* has been reported. Map from GBIF Secretariat (2019).

Specific locations of established populations of *Cherax destructor* in northeastern Spain and central Italy are given in Vedia and Miranda (2013).

5 Distribution Within the United States

No records of *Cherax destructor* in the wild in the United States were found.

6 Climate Matching

Summary of Climate Matching Analysis

The climate match for *Cherax destructor* was medium to high for the majority of the contiguous United States. The western Puget Sound area of Washington, and southern Texas, Arizona and New Mexico, and parts of Florida had a very high climate match. The Rocky Mountain and northern Plains and Midwest states had a low climate match. The Climate 6 score (Sanders et al. 2018; 16 climate variables; Euclidean distance) for the contiguous United States was 0.158, which indicates a high overall climate match (scores 0.103 and greater are considered high). Arizona, California, Florida, Georgia, Massachusetts, New Mexico, Nevada, Oklahoma, Texas, Virginia, Washington, and West Virginia had high individual Climate 6 scores. The following states had medium individual Climate 6 scores: Arkansas, Idaho, Indiana, Maryland, Missouri, North Carolina, New Jersey, New York, Oregon, Rhode Island, South Carolina, Tennessee, and Utah. All remaining States had low individual Climate 6 scores.

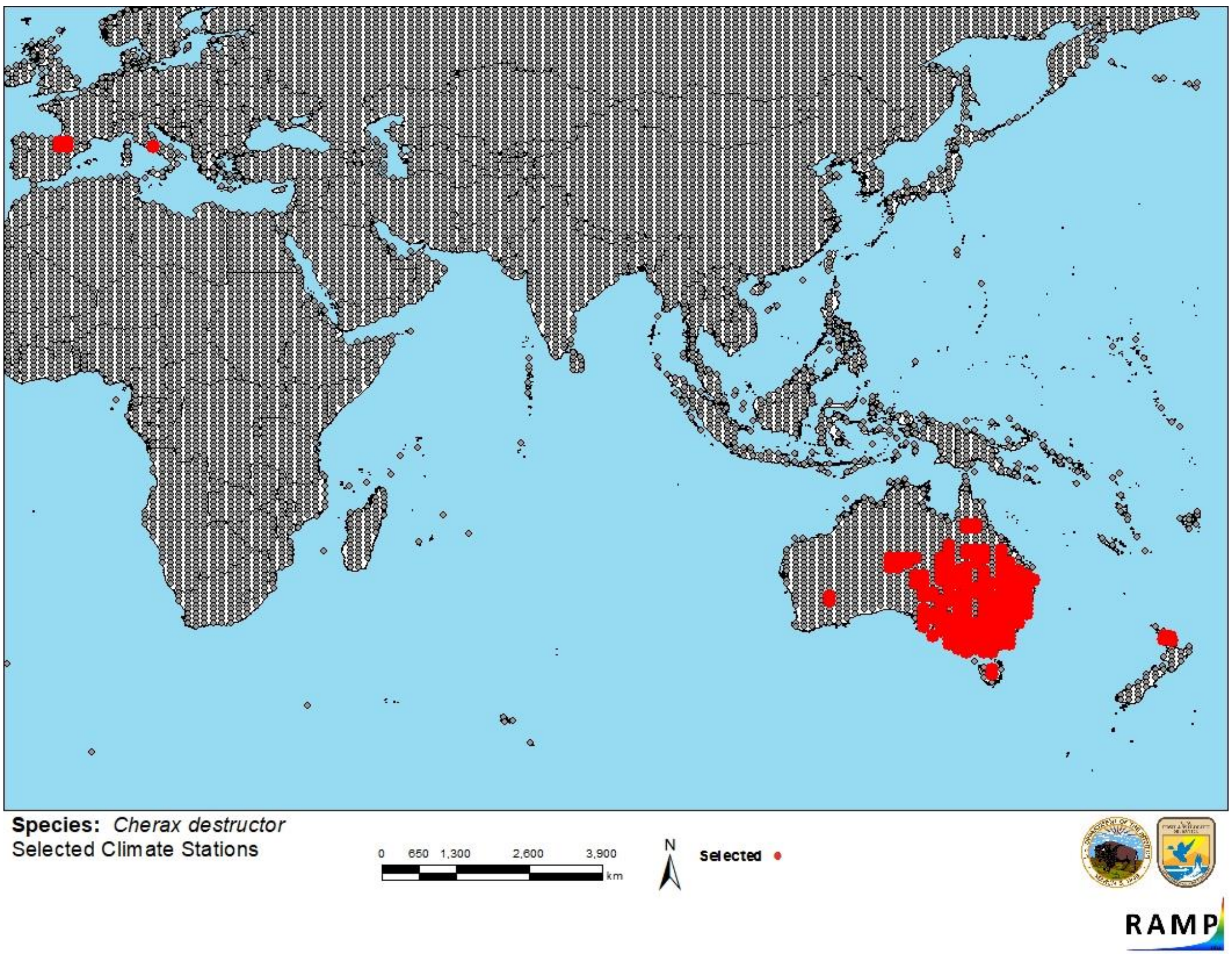

Figure 2. RAMP (Sanders et al. 2018) source map showing weather stations selected as source locations (red; Australia, New Zealand, Spain, Italy) and non-source locations (gray) for *Cherax destructor* climate matching. Source locations from Vedia and Miranda (2013) and GBIF Secretariat (2019).

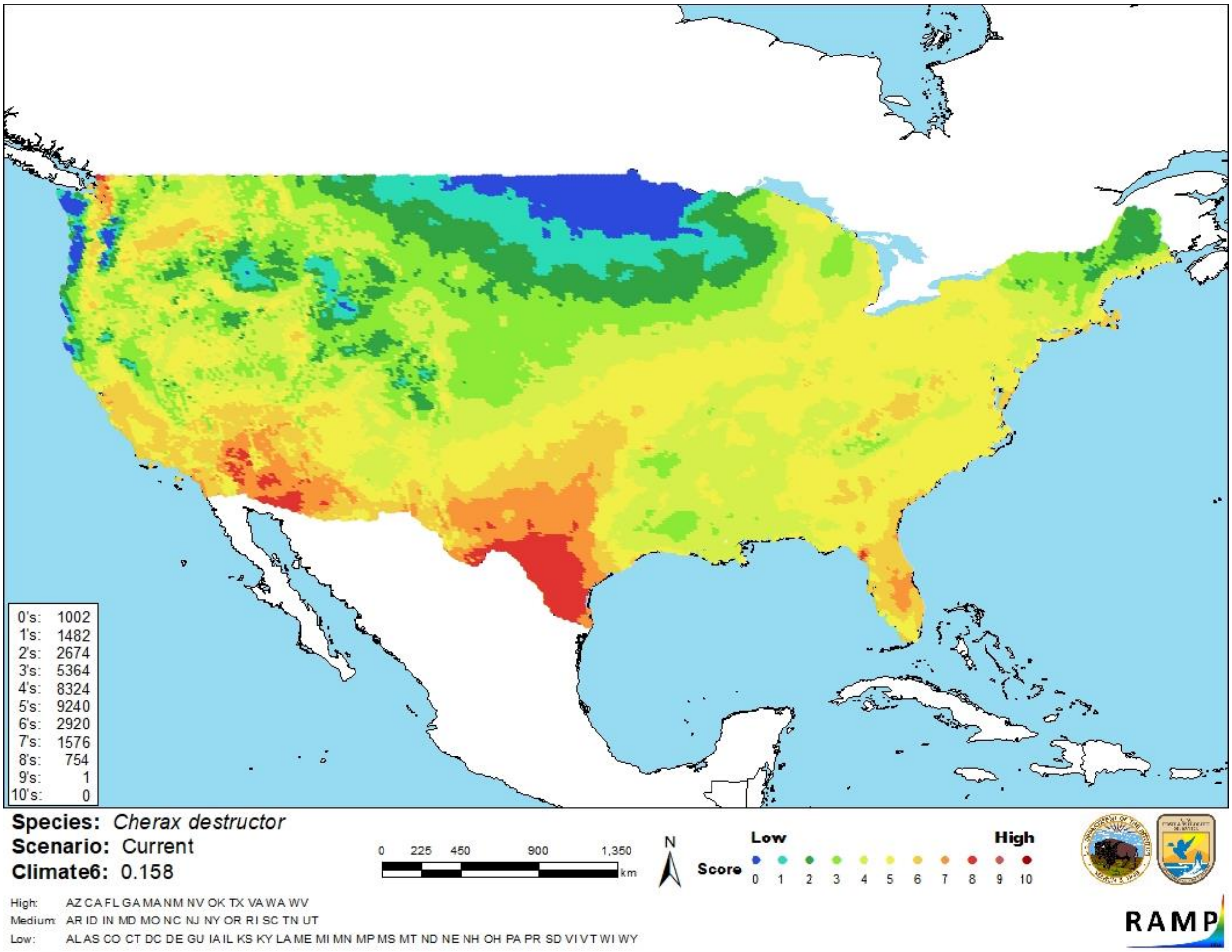

Figure 3. Map of RAMP (Sanders et al. 2018) climate matches for *Cherax destructor* in the contiguous United States based on source locations reported from Vedia and Miranda (2013) and GBIF Secretariat (2019). 0 = Lowest match, 10 = Highest match.

The High, Medium, and Low Climate match Categories are based on the following table:

Climate 6: Proportion of (Sum of Climate Scores 6-10) / (Sum of total Climate Scores)	Climate Match Category
0.000≤X≤0.005	Low
0.005<X<0.103	Medium
≥0.103	High

7 Certainty of Assessment

The certainty of assessment for *Cherax destructor* is high. There was a wealth of information on distribution, introductions, and biology of *Cherax destructor.* Actual impacts of introduction are documented in peer-reviewed sources.

8 Risk Assessment

Summary of Risk to the Contiguous United States

Cherax destructor is a freshwater crayfish native to Southeastern Australia. *C. destructor* is an opportunistic feeder that can be found in a wide range of habitats and water conditions. This species is common in aquaculture and is gaining popularity as an aquarium species and in research. *C. destructor* is used as bait by recreational anglers and is sold live as a delicacy for restaurants in Australia and Europe. The history of invasiveness is high. *C. destructor* has been introduced for aquaculture and possibly as discarded bait from recreational fishermen. It has been reported as introduced and established in Western Australia, Tasmania, Italy and Spain. There are currently no reported introductions of this species in the United States. *C. destructor* is listed as federally injurious by USFWS and prohibited from importation; it is also a prohibited species in multiple States. It has been reported as a possible vector for crayfish plague and *Thelohania parastaci*. There is evidence from Australia that introduction of *C. destructor* has resulted in thelohania infection in the native, endemic crayfish. In addition, it rapidly expands its range after introduction and has been shown to compete with native crayfish species resulting in species displacement and it contributed to the listing of a native species as endangered. *C. destructor* can damage property, mainly farm irrigation channels with its burrowing behavior; burrows in the banks collapse when water levels drop, destabilizing the bank. The overall climate match for the contiguous United States was high. Most of the contiguous United States had medium to high climate matches; low matches were found in northern New England, Midwest, Plains, and areas of the Pacific Northwest. The certainty of assessment is high due to abundant and high quality information. The overall risk assessment category for *Cherax destructor* is high.

Assessment Elements

- **History of Invasiveness (Sec. 3): High**
- **Climate Match (Sec. 6): High**
- **Certainty of Assessment (Sec. 7): High**
- **Remarks/Important additional information:** Listed as injurious wildlife by USFWS. *Cherax destructor* is susceptible to the crayfish plague.
- **Overall Risk Assessment Category: High**

9 References

Note: The following references were accessed for this ERSS. References cited within quoted text but not accessed are included below in Section 10.

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