

Danube crayfish (*Pontastacus leptodactylus*)

Ecological Risk Screening Summary

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1 Native Range and Status in the United States

Native Range

From Gherardi and Souty-Grosset (2010):

“Austria; Azerbaijan; Belarus; Bosnia and Herzegovina; Bulgaria; Croatia; Georgia; Greece; Hungary; Iran, Islamic Republic of; Israel; Kazakhstan; Kyrgyzstan; Moldova; Romania; Russian Federation; Serbia (Serbia); Slovakia; Turkey (Turkey-in-Asia, Turkey-in-Europe); Turkmenistan; Ukraine”

“This is a widespread species and can be found throughout Europe, eastern Russia, and the middle east [sic]. However it is absent from some of the northern European countries such as Norway and Sweden, and the southern European countries Spain and Portugal (Souty-Grosset et al. 2006). It is considered indigenous in the eastern part of its range, but has been introduced into many of the western European countries (Machino and Holdich 2006, Souty-Grosset et al. 2006).”

From Stucki and Romer (2001):

“This crayfish species, originally from Eastern Europe, Asia Minor and waters around the Caspian Sea, [...]”

Status in the United States

No records of *Pontastacus leptodactylus* in the United States were found.

Means of Introductions in the United States

No records of *Pontastacus leptodactylus* in the United States were found.

Remarks

There was no general consensus on the scientific name of this species. This screening uses the most recent taxonomic revision as the accepted name: *Pontastacus leptodactylus*. However, in the interest of gathering as complete information as possible, searches were also conducted using the synonym *Astacus leptodactylus*. This species is also sometimes referred to as the Turkish crayfish.

Text descriptions of the distribution indicate that *Pontastacus leptodactylus* has a range, both introduced and native, extending from Western Europe into Russia and the Middle East. The locations available for use in the climate match were much more limited; the results of the climate match could change if a more complete distribution was available to use as source locations.

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

Crandall (2016) lists *Astacus leptodactylus* with a status of unaccepted and that the accepted name is *Pontastacus leptodactylus*.

From Crandall (2017):

“Classification: Biota > Animalia (Kingdom) > Arthropoda (Phylum) > Crustacea (Subphylum) > Multicrustacea (Superclass) > Malacostraca (Class) > Eumalacostraca (Subclass) > Eucarida (Superorder) > Decapoda (Order) > Pleocyemata (Suborder) > Astacidea (Infraorder) > Astacoidea (Superfamily) > Astacidae (Family) > *Pontastacus* (Genus) > *Pontastacus leptodactylus* (Species)”

“Status accepted”

“Synonymised names *Astacus angulosus* Rathke, 1837

Astacus leptodactylus Eschscholtz, 1823

Astacus leptodactylus boreoorientalis Birstein & Vinogradov, 1934”

From Gherardi and Souty-Grosset (2010):

“*Astacus leptodactylus* is referred to as a species complex. In the 1950s this species was believed to belong to the subgenus *Astacus* (*Pontastacus*) along with *A. (P.) pachypus*, *A. (P.) pylzowi* and *A. (P.) kessleri*. The following four subspecies were attributed to *A. (P.) leptodactylus*: *eichwaldi*, *cubanicus*, *salinus*, and *leptodactylus*. Karaman (1962, 1963) however does not acknowledge *A. (P.) cubanicus* as a subspecies. In the 1970s, *Pontastacus* was raised to generic level. In the 1980s, Brodskij made a number of revisions within *Pontastacus* but the number of taxa varied within papers. In the mid 1990s Starobogatov (1995) split *Pontastacus* into two genera: *Pontastacus* - *P. angulosus* (Rathke, 1837); *P. cubanicus* (Birstein & Winogradov, 1934); *P. danubialis* (Brodskij, 1967); *P. eichwaldi* (Bott, 1950); *P. intermedius* (Bott, 1950); *P. kessleri* (Schimkewitsch, 1886); *P. pylzowi* (Skorikov, 1911); *P. salinus* (Nordmann, 1942), and *Caspiastacus* with two species. However, there is great deal of criticism over the recent revision in taxonomy made by Ukrainian and Russian taxonomists as it appears to be based on little evidence.”

Size, Weight, and Age Range

From NatureSpot (2015):

“Turkish Crayfish are also known as Turkish Narrow-clawed Crayfish and are usually about 15 cm long but can be up to 30 cm.”

Environment

From Gherardi and Souty-Grosset (2010):

“This species is found in both fresh and brackish waters, e.g. lagoons, estuaries, as well as running freshwater rivers in the Ponto-Caspian Basin. Across Europe it is found in lakes, canals and rivers. It is tolerant to changes in temperature, low oxygen content, and low water transparency, and is known to occur in saline conditions such as estuaries. Tolerance experiments indicated that O+ juveniles and adults are well adapted for surviving salinities of at least 21ppt in the long term, and will tolerate being transferred directly back into freshwater. However, their ability to colonize the estuarine environment may be restricted to areas of low salinity (i.e. 7ppt) due to the adverse effects of seawater on egg development and hatching (Holdich, Harlioğlu and Firkins 1997).”

Climate/Range

No specific records on climate/range were found for *Pontastacus leptodactylus*.

Distribution Outside the United States

DAISIE (2017) lists the populations in Croatia and France as cryptogenic. It was listed as both introduced (Gherardi and Souty-Grosset 2010) and native (Aghababyan et al. 2015) to Armenia.

Native

From Gherardi and Souty-Grosset (2010):

“Austria; Azerbaijan; Belarus; Bosnia and Herzegovina; Bulgaria; Croatia; Georgia; Greece; Hungary; Iran, Islamic Republic of; Israel; Kazakhstan; Kyrgyzstan; Moldova; Romania; Russian Federation; Serbia (Serbia); Slovakia; Turkey (Turkey-in-Asia, Turkey-in-Europe); Turkmenistan; Ukraine”

“This is a widespread species and can be found throughout Europe, eastern Russia, and the middle east [sic]. However it is absent from some of the northern European countries such as Norway and Sweden, and the southern European countries Spain and Portugal (Souty-Grosset et al. 2006). It is considered indigenous in the eastern part of its range, but has been introduced into many of the western European countries (Machino and Holdich 2006, Souty-Grosset et al. 2006).”

From Stucki and Romer (2001):

“This crayfish species, originally from Eastern Europe, Asia Minor and waters around the Caspian Sea, [...]”

Introduced

FAO (2017) lists *Pontastacus leptodactylus* for Austria, Belgium, France, Germany, Italy, Spain, Switzerland, Established populations are listed for Austria, Belgium, France, Germany, Italy, the Netherlands, and the United Kingdom, and probably established populations are listed for Spain, and Switzerland.

DAISIE (2017) lists *Pontastacus leptodactylus* as alien in the European part of Russia.

From Gherardi and Souty-Grosset (2010):

“Armenia (Armenia); Belgium; Czech Republic; Denmark; Finland; France; Germany; Italy; Latvia; Lithuania; Luxembourg; Netherlands; Poland; Switzerland; United Kingdom (Great Britain); Uzbekistan”

From Soes and Koese (2010):

“[...] there have been several introductions of the Eastern European narrow-clawed crayfish (*Astacus leptodactylus*) within the Netherlands. This species has only established a few local populations (Adema 1982, Timmermans et al. 2003).”

From Gherardi et al. (2010):

“In the UK, *A. astacus*, *Astacus leptodactylus*, and *P. leniusculus* have been designated as pests under the Wildlife and Countryside Act; much of Britain has been declared a no-go area for the keeping of *P. leniusculus* and the whole of Britain for the keeping of all other NICS (except the tropical *Cherax quadricarinatus*). Similarly, in Japan all species of *Astacus* and *Cherax*, *O. rusticus*, and *P. leniusculus* have been deemed as Invasive Alien Species under the Invasive Alien Species Act; their import and keeping alive are banned except for scientific purposes.”

Means of Introduction Outside the United States

Pontastacus leptodactylus was introduced to Austria and the UK for use in aquaculture (FAO 2017).

From NatureSpot (2015):

“Turkish Crayfish [*Astacus leptodactylus*] have been imported into Britain for the restaurant trade since the 1970s. However, some crayfish have escaped or been deliberately introduced into the wild [...].”

From Petrusek et al. (2006):

“The narrow-clawed crayfish, *Astacus leptodactylus*, was introduced to Czechia at the end of the 19th century in order to replenish the reduced native populations of the noble crayfish.”

From Soes and Koese (2010):

“The species is almost certainly introduced by the consumption trade, although the first specimens observed in the Netherland might have entered the country indirectly from Germany. [...] A record of the narrow-clawed crayfish in the Brinckborsthaven in Voorburg (province Zuid Holland) in 1989 might originate from a sample that was released by an inhabitant of a houseboat shortly before the specimen was caught at the same location (Anonymus 1989). Van Laar (1984) observed two specimens in a school aquarium in the city of Amerfoort (province of Utrecht) in 1983. The specimens turned out to be leftovers from a restaurant near Haarzuilens (province of Utrecht).”

“Due to the small but ongoing trade in living specimens of the narrow-clawed crayfish, we expect that the species will continue to show up regularly at unpredictable sites. Some of the introductions might result in local populations but, taking the last thirty years as a precedent, we don't expect large population expansions.”

Short Description

From NatureSpot (2015):

“Pale yellow to pale green in colour [sic]. Sides of carapace very rough. Two pairs of ridges behind the eye sockets. Rostrum well developed with parallel sides and long apex. Claws: Long and narrow, upper surface rough, underside same colour [sic] as body.”

Biology

From Gherardi and Souty-Grosset (2010):

“In addition, this species is active during the day and during winter. [...] Furthermore, it is an omnivorous species, but demonstrates a preference for zoobenthos, which makes up to 97.2% of the weight of its food in the first year of life in the Caspian Sea.”

Human Uses

From Gherardi and Souty-Grosset (2010):

“This species is commercially harvested for food. It is harvested both from the wild, and from aquaculture operations.”

“There have been fluctuations in the harvest of this species over the years, though is [sic] said to have shown an increasing trend since 1995. However, since 2005 there has been a decline in the catch from 2,317 tonnes in 2004, to 809 tonnes in 2005, to 797 tonnes in 2006, and to 750-760 in 2007.”

From Soes and Koese (2010):

“The narrow-clawed crayfish has been of high commercial value for the catering industry, especially in Eastern Europe, Turkey and Iran, although Turkish stocks severely suffered from crayfish plague and overfishing (Skurdal & Taugbøl 2002).”

“Wholesaler Jan van As (Amsterdam) sells ‘a few hundred kilo’s a year’ of the specimen. The animals are obtained from France, but are cultivated in Turkey. The species is also cultured for fishponds (koidream.nl, Veenendaal).”

Diseases

Crayfish plague (*Aphanomyces astaci*) is on the 2017 list of OIE reportable diseases.

Poelen et al. (2014) list *Pontastacus leptodactylus* as a host of *Saprolegnia parasitica*.

From Gherardi and Souty-Grosset (2010):

“Two of the greatest threats to this species are [...] and crayfish plague (*Aphanomyces astaci*) (Lózan 2000).”

Threat to Humans

No records of possible threats to humans were found.

3 Impacts of Introductions

The following detail actual impacts from introduced populations of *Pontastacus leptodactylus*.

From Chucholl (2016):

“Noble crayfish [*Astacus astacus*] and narrow-clawed crayfish [*Pontastacus leptodactylus*], by contrast, compete for the same lentic habitats, as evidenced by several lakes in the study area in which the former native species was displaced by narrow-clawed crayfish over the course of several years (Sauter and Chucholl, unpubl. data).”

From Harlioğlu (1996):

“The results presented here show that both juvenile *P. leniusculus* and *A. leptodactylus* can have a dramatic impact on plant and macroinvertebrate communities over a long time period (Experiments 1 and 2) as well as over a short time period (Experiments 3,4 and 5). For example, 12 or 13 mm (CL) juveniles of the two species had a detrimental impact on *Cladophora* and *Asellus*, and even *Planorbis* contortus number. However, the impact of the 12 or 13 mm (CL) juveniles on the number of *P. contortus* was not as fast as was observed on *Cladophora* and *Asellus*. In comparison to the impact of 12 or 13 mm (CL) juveniles on the snail species, the impact of 25 or 27 mm (CL) juveniles of the two species was more significant.”

“It can be concluded from this study that even low densities of juvenile *P. leniusculus* and *A. leptodactylus* can have an adverse effect on plant and macroinvertebrate communities (Experiments 1 and 2).”

“The results show that both juvenile and adult *P. leniusculus* and *A. leptodactylus*, and adult *A. pallipes* consumed fish eggs at a high rate. Although there was no significant difference between adults of *P. leniusculus* and *A. leptodactylus*, the consumption rate of carp eggs and brown trout eggs by juvenile *A. leptodactylus* was significantly higher than that of juvenile *P. leniusculus* in some cases.”

The following detail potential impacts from introduced populations of *Pontastacus leptodactylus*.

From NatureSpot (2015):

“More aggressive and faster breeding than our [United Kingdom’s] native White-clawed crayfish.”

From Stucki and Romer (2001):

“Since *A. leptodactylus* is known to be a good colonizer and a strong competitor of other crayfish species (Cukerzis, 1968, 1973, 1988; Köksal, 1988; Holdich, 1999), we suppose that *A. leptodactylus* displaced the formerly present native species *A. astacus* and *A. torrentium* from numerous lakes and ponds.”

From Gherardi (2007):

“As a consequence, because of their large numbers, coupled with their wide trophic plasticity, NICS exert a greater direct (through consumption) or indirect (through competition) effect on the other biota, particularly on crayfish species, benthic fish, mollusks, and macrophytes (Nyström et al. 1996). This is also true for those species that apparently have not caused much environmental degradation, such as *A. leptodactylus* in England whose high numbers are producing considerable problems for anglers (Holdich 1999b).”

From Gherardi and Souty-Grosset (2010):

“These features and the high fecundity and fast growth suggest that it can outcompete *Astacus astacus*.”

From Soes and Koese (2010):

“Impact

Not recorded. Large quantities of the narrow-clawed crayfish were observed in a reservoir (Craneweyer, now primary [sic] used for recreation and fishing) near Kerkrade in Limburg, 2009, which raised some concern among local fisherman.”

From Harlioğlu (1996):

“However, the study also showed that the adult of *P. leniusculus* and *A. leptodactylus* would have a dramatic impact on the juveniles of *A. pallipes* if they had been introduced in a native crayfish population where the juveniles of the native crayfish had released from their mother.”

4 Global Distribution

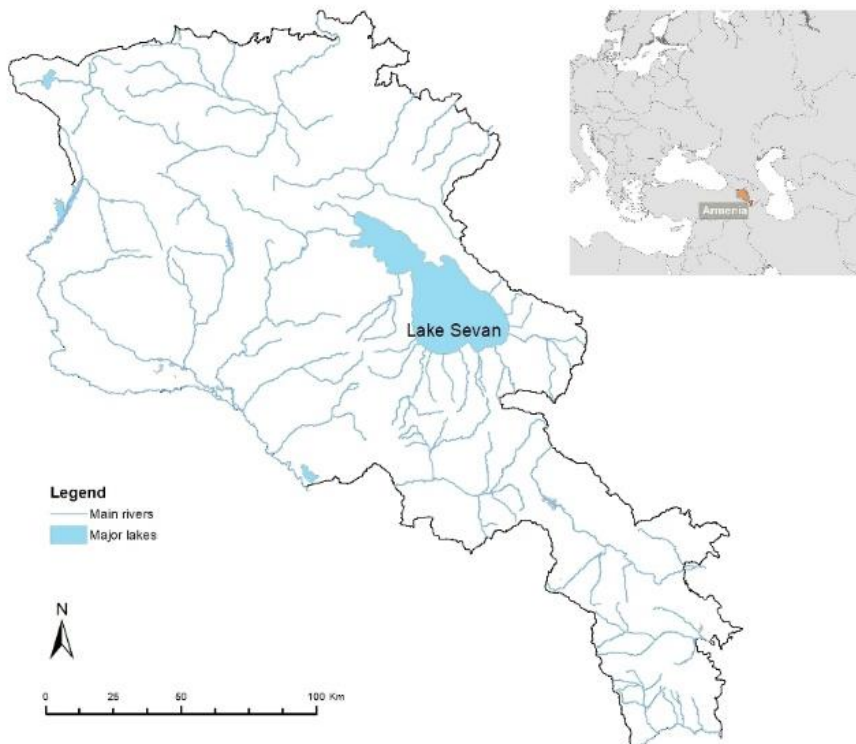


Figure 1. Location of Lake Sevan in Armenia, which contains a population of *Pontastacus leptodactylus*. Map from Aghabayan et al. (2015: Figure 1).

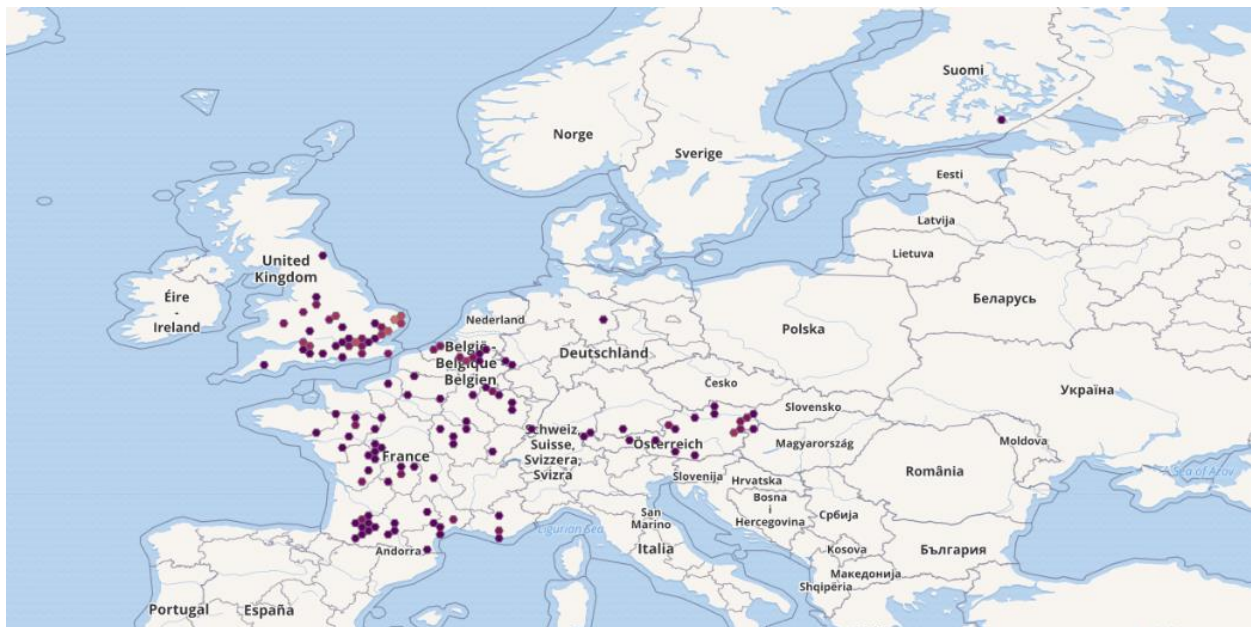


Figure 2. Known global distribution of *Astacus leptodactylus* in Europe. Map from GBIF Secretariat (2017a).



Figure 3. Known global distribution of *Pontastacus leptodactylus* in Europe. Map from GBIF Secretariat (2017b).

Additional known locations of *Pontastacus leptodactylus* in the Netherlands are given in Soes and Koese (2010).

5 Distribution Within the United States

No records of *Astacus leptodactylus* in the United States were found.

6 Climate Matching

Summary of Climate Matching Analysis

The climate match for *Pontastacus leptodactylus* was high in the Great Lakes, areas of the Great Plains and Midwest, along the Appalachian Mountains and coastal areas of Massachusetts and Long Island. There were areas of low climate match along the Pacific Coast, in the Southwest, and the Gulf Coast from Southern Texas to Florida. The match was medium everywhere else. The Climate 6 score (Sanders et al. 2014; 16 climate variables; Euclidean distance) for the contiguous U.S. was 0.366, high, and individually high in Arizona, Arkansas, Colorado, Connecticut, Delaware, Illinois, Indiana, Iowa, Kansas, Kentucky, Maryland, Massachusetts, Michigan, Missouri, Montana, Nebraska, New Jersey, New Mexico, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Dakota, Tennessee, Texas, Utah, Vermont, Virginia, West Virginia, Wisconsin, and Wyoming.

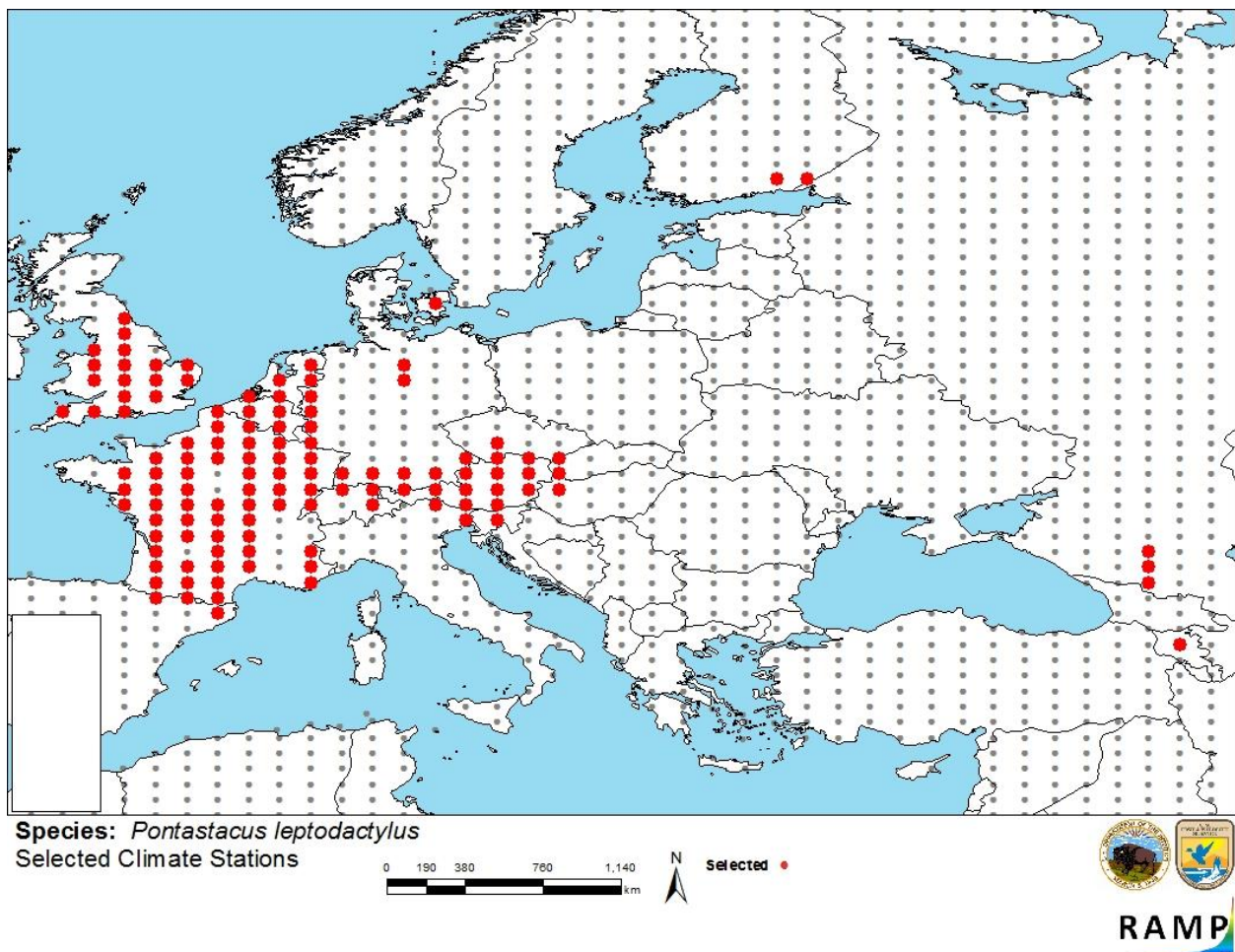


Figure 4. RAMP (Sanders et al. 2014) source map showing weather stations selected as source locations (red) and non-source locations (gray) for *Pontastacus leptodactylus* climate matching. Source locations from Soes and Koese (2010), Aghabayan et al. (2015), and GBIF Secretariat (2017a,b).

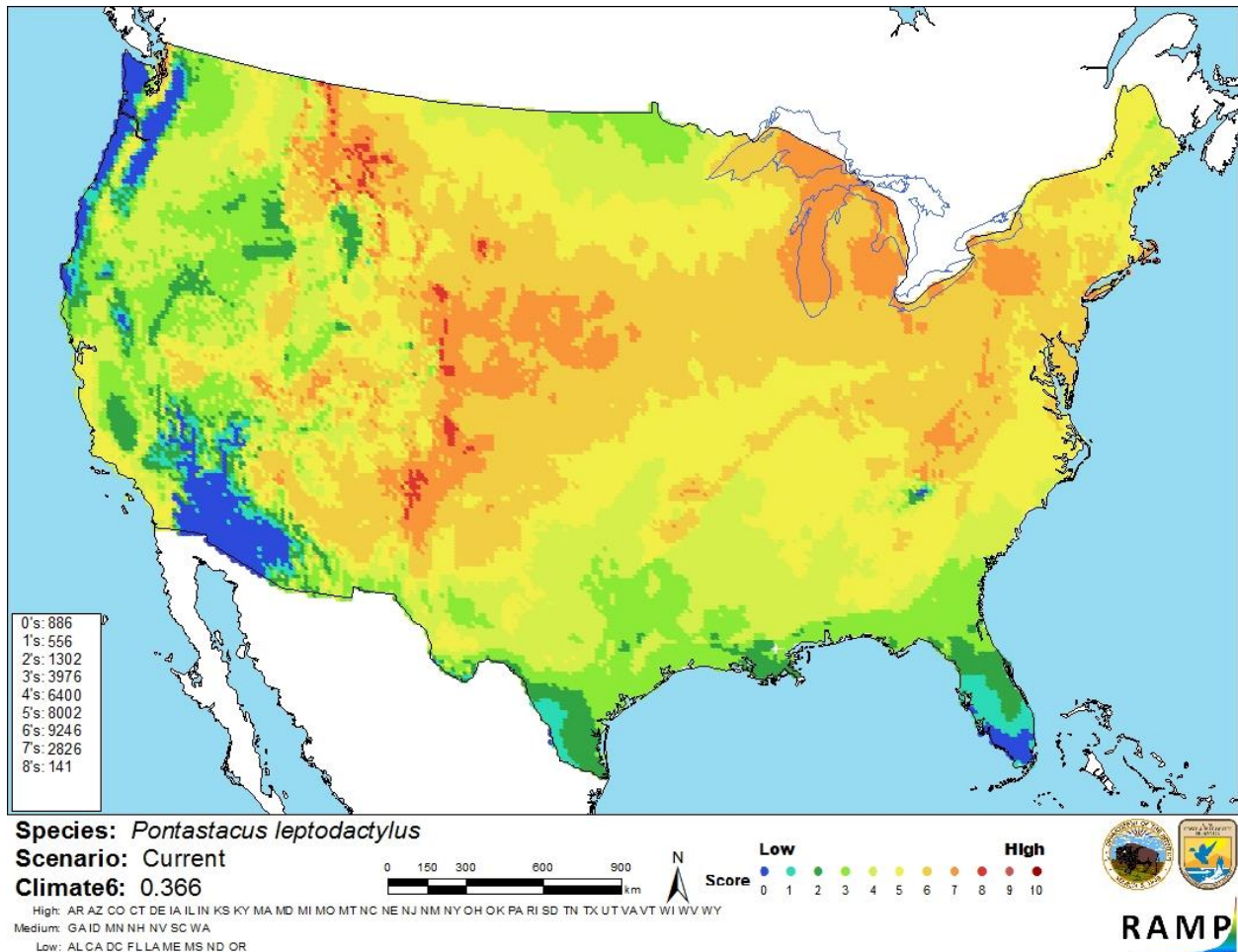


Figure 5. Map of RAMP (Sanders et al. 2014) climate matches for *Pontastacus leptodactylus* in the contiguous United States based on source locations reported by Soes and Koese (2010), Aghabayan et al. (2015), and GBIF Secretariat (2017a,b). 0 = Lowest match, 10 = Highest match.

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
$0.000 \leq X < 0.005$	Low
$0.005 < X < 0.103$	Medium
≥ 0.103	High

7 Certainty of Assessment

The certainty of this assessment is medium. There was adequate, quality biological and ecological information available for *Pontastacus leptodactylus*. *P. leptodactylus* has a history of introductions with recorded impacts. The distribution used for the climate match was not complete based on text descriptions of the range but no further detailed maps were available.

8 Risk Assessment

Summary of Risk to the Contiguous United States

Pontastacus leptodactylus is a freshwater crayfish native to Europe. The history of invasiveness is high. There are many instances of introduction and establishment for *P. leptodactylus*. Records of impacts were found, including the displacement of a native crayfish species. The climate match is high. The climate 6 score was 0.366, high. The certainty of assessment is medium. The overall risk assessment category is high.

Assessment Elements

- **History of Invasiveness (Sec. 3): High**
- **Climate Match (Sec. 6): High**
- **Certainty of Assessment (Sec. 7): Medium**
- **Remarks/Important additional information** There are disagreements on the correct taxonomy of this species. A more detailed distribution would provide a more correct climate match, however the author's scientific opinion is that the climate match category would remain high. **This species can carry and transmit crayfish plague, an OIE reportable disease.**
- **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.

- Aghababyan, K., G. Khanamirian, E. Ghukasyan, and N. Badalyan. 2015. Abundance of narrow-clawed crayfishes (*Astacus leptodactylus* Eschscholtz, 1823) and its trends in Lake Sevan, Armenia. *Journal of Aquaculture Engineering and Fisheries Research* 1(3):116–124.
- Chucholl, C. 2016. The bad and the super-bad: prioritising the threat of six invasive alien to three imperiled native crayfishes. *Biological Invasions* 18:1967–1988.
- Crandall, K. A. 2016. *Astacus leptodactylus* Eschscholtz, 1823. In *World Register of Marine Species*. Available: <http://www.marinespecies.org/aphia.php?p=taxdetails&id=885871>. (September 2017).
- Crandall, K. A. 2017. *Pontastacus leptodactylus* (Eschscholtz, 1823). In *World Register of Marine Species*. Available: <http://www.marinespecies.org/aphia.php?p=taxdetails&id=885112>. (September 2017).
- DAISIE European Invasive Alien Species Gateway. 2017. *Astacus leptodactylus*. Available: <http://www.europe-aliens.org/speciesFactsheet.do?speciesId=53225>. (September 2017).

- FAO (Fisheries and Agriculture Organization of the United Nations). 2017. Database on introductions of aquatic species. FAO, Rome. Available: <http://www.fao.org/fishery/introsp/search/en>. (September 2017).
- GBIF Secretariat. 2017a. GBIF backbone taxonomy: *Astacus leptodactylus* Eschscholtz, 1823. Global Biodiversity Information Facility, Copenhagen. Available: <https://www.gbif.org/species/4417551>. (September 2017).
- GBIF Secretariat. 2017b. GBIF backbone taxonomy: *Pontastacus leptodactylus* (Eschscholtz, 1823). Global Biodiversity Information Facility, Copenhagen. Available: <https://www.gbif.org/species/8946295>. (September 2017).
- Gherardi, F. 2007. Understanding the impact of invasive crayfish. Pages 507–542 in F. Gherardi, editor. Biological invaders in inland waters: profiles, distribution, and threats. Invading nature, Springer series in invasion ecology, volume 2. Springer, Netherlands.
- Gherardi, F., L. Aquiloni, J. Diéguez-Urbeondo, and E. Tricarico. 2010. Managing invasive crayfish: is there a hope? *Aquatic Sciences* 73:185–200.
- Gherardi, F., and C. Souty-Grosset. 2010. *Astacus leptodactylus*. The IUCN red list of threatened species. Version 2014.3. Available: <http://www.iucnredlist.org/details/full/153745/0>. (March 2015).
- Harlioglu, M. M. 1996. Comparative biology of the signal crayfish, *Pacifastacus leniusculus* (Dana), and the narrow-clawed crayfish, *Astacus leptodactylus* eschscholtz. Doctoral dissertation. University of Nottingham, UK.
- NatureSpot. 2015. Turkish crayfish – *Astacus leptodactylus*. Available: <http://www.naturespot.org.uk/species/turkish-crayfish>. (March 2015).
- Petrusek, A., L. Filipová, Z. Ďuriš, I. Horká, P. Kozák, T. Polícar, M. Štambergová, and Z. Kučera. 2006. Distribution of the invasive spiny-cheek crayfish (*Orconectes limosus*) in the Czech Republic. Past and present. *Bulletin Français de la Pêche et de la Pisciculture* 380-381:903–918.
- Poelen, J. H., J. D. Simons, and C. J. Mungall. 2014. Global Biotic Interactions: an open infrastructure to share and analyze species-interaction datasets. *Ecological Informatics* 24:148–159.
- Sanders, S., C. Castiglione, and M. Hoff. 2014. Risk assessment mapping program: RAMP. U.S. Fish and Wildlife Service.
- Soes, M., and B. Koese. 2010. Invasive freshwater crayfish in the Netherlands: a preliminary risk analysis. Ministry of Agriculture, Nature and Food Quality, Bureau Waardenburg, interim report EIS2010-01, Wageningen, Netherlands.

Stucki, T. P., and J. Romer. 2001. Will *Astacus leptodactylus* displace *Astacus astacus* and *Austropotamobius torrentium* in Lake Ägeri, Switzerland? *Aquatic Sciences* 63:477–489

10 References Quoted But Not Accessed

Note: The following references are cited within quoted text within this ERSS, but were not accessed for its preparation. They are included here to provide the reader with more information.

Adema, J. P. H. M. 1982. *Astacus leptodactylus* - Eschscholz introduced in the Netherlands. *Bijdragen tot de Faunistiek van Nederland. Zoologische Bijdragen* 28:5–8.

Anonymous. 1989. Rivierkreeftje. *Haagse Courant*.

Cukerzis, J. 1968. Interspecific relations between *Astacus astacus* L. and *Astacus leptodactylus* Esch. *Ekologia Polska* A:629–636.

Cukerzis, J. 1973. Biologische Grundlagen der Methode der künstlichen Aufzucht der Brut des *Astacus astacus* L. *Freshwater Crayfish* 1:187–201.

Cukerzis, J. M. 1988. *Astacus astacus* in Europe. Pages 309–340 in D. M. Holdich, and R. S. Lovery, editors. *Freshwater crayfish – Biology, management and exploitation*. Timber Press, Portland, Oregon.

Holdich, D. M. 1999. The negative effects of established crayfish introductions. *Crustacean Issues* 11:31–47.

Holdich, D. M. 1999b. The introduction of alien crayfish species into Britain for commercial exploitation – an own goal? Pages 85–97 in J. C. Von Vaupel Klein, and F. R. Schram, editors. *The biodiversity crisis and Crustacea*. A. A. Balkema, Rotterdam, Netherlands.

Holdich, D. M., M. M. Harlioğlu, and I. Firkins. 1997. Salinity adaptations of crayfish in British waters with particular reference to *Austropotamobius pallipes*, *Astacus leptodactylus* and *Pacifastacus leniusculus*. *Estuarine, Coastal and Shelf Science* 44:147–154.

Karaman. 1962. [Source material did not give full citation for this reference].

Karaman. 1963. [Source material did not give full citation for this reference].

koidream.nl. [Source material did not give full citation for this reference].

Köksal, G. 1988. *Astacus leptodactylus* in Europe. Pages 365–397 in D. M. Holdich, and R. S. Lovery, editors. *Freshwater crayfish – biology, management and exploitation*. Timber Press, Portland, Oregon.

- Lozán, J. L. 2000. On the threat to the European crayfish: a contribution with the study of the activity behaviour of four crayfish species (Decapoda: Astacidae). *Limnology* 30:156–161.
- Machino, Y., Holdich, D.M. 2006. Distribution of crayfish in Europe and adjacent countries: updates and comments. *Freshwater Crayfish* 15:292–323.
- Nyström, P., C. Brönmark, and W. Granéli. 1996. Patterns in benthic food webs: a role for omnivorous crayfish? *Freshwater Biology* 36:631–646.
- Skurdal, J., and T. Taugbøl. 2002. *Astacus*. In D. Holdich. *Biology of freshwater crayfish*. Blackwell Science, Oxford, UK.
- Souty-Grosset, C., D. M. Holdich, P. Y. Noël, J. D. Reynolds, and P. Haffner. 2006. *Atlas of crayfish in Europe*. Muséum national d’Histoire naturelle, Paris.
- Starobogatov. 1995. [Source material did not give full citation for this reference].
- Timmermans, G., R. Lipmann, M. Melchers, and H. Holsteijn. 2003. De zoetwaterkreeften van Nederland. *Natura* 112-121.
- Van Laar, V. 1984. Waarnemingen van de Galische rivierkreeft en wolhandkrab in 1982. *Te Velde* 27:6–8.