

Signal Crayfish (*Pacifastacus leniusculus*)

Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, February 2011

Revised, June 2015



Photo: National Park Service

1 Native Range, and Status in the United States

Native Range

From GISD (2005):

“Endemic to western North America between the Pacific Ocean and the Rocky Mountains. Occurs from British Columbia in the north, central California in the south, and Utah in the east.”

Status in the United States

From Schuster et al. (2010):

“California - Introduced, Idaho, Nevada - Introduced, Oregon, Utah - Introduced, Washington”

Means of Introductions in the United States

From Fofonoff et al. (2003):

“*Pacifastacus leniusculus* was introduced to various California watersheds, possibly as early as 1898, in San Francisco. An official transplant was made in 1912 to hatcheries in Santa Cruz

County, and in later years, they were introduced to the Sacramento-San Joaquin watershed. They were present in the Delta by 1959, and are now abundant (Riegel 1959). Other California locations include the Monterey Bay watershed, and upper reaches of the Sacramento watershed in the Sierras (USGS Nonindigenous Aquatic Species Program 2010). Two records near the coast were from the Carmel River and the Little Sur Rivers, south of Monterey Bay, two and one miles from the ocean, respectively (Riegel 1959).”

“In 2002, one specimen was caught in the Buskin River on Kodiak Island, Alaska (USGS Nonindigenous Aquatic Species Program 2011). This could have been a bait release.”

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2015):

“Kingdom Animalia
Subkingdom Bilateria
Infrakingdom Protostomia
Superphylum Ecdysozoa
Phylum Arthropoda
Subphylum Crustacea
Class Malacostraca
Subclass Eumalacostraca
Superorder Eucarida
Order Decapoda
Suborder Pleocyemata
Infraorder Astacidea
Superfamily Astacoidea
Family Astacidae
Genus *Pacifastacus*
Subgenus *Pacifastacus* (*Pacifastacus*)
Species *Pacifastacus leniusculus* (Dana, 1852)”

“Direct Children:

Subspecies *Pacifastacus leniusculus klamathensis* (Stimpson, 1857)
Subspecies *Pacifastacus leniusculus leniusculus* (Dana, 1852)
Subspecies *Pacifastacus leniusculus trowbridgii* (Stimpson, 1857)”

“Taxonomic Status: valid”

Size, Weight, and Age Range

From GISD (2005):

“Males are up to 16cm in length from tip of rostrum to end of telson, females up to 12cm; much larger individuals have been recorded, i.e. 95mm carapace length. The weight is typically 60 and 110g at 50 and 70mm carapace length.”

“Size at maturity is usually 6-9cm TL at an age of 2-3 years, although maturity can occur as early as 1 year.”

Environment

From GISD (2005):

“*Pacifastacus leniusculus* occupies a wide range of habitats from small streams to large rivers (e.g. Columbia River) and natural lakes, including sub-alpine lakes, such as Lakes Tahoe and Donner (Lowery & Holdich, 1988; Lewis, 2002). However, it also grows well in culture ponds. It is tolerant of brackish water and high temperatures. It does not occur in waters with a pH lower than 6.0.”

Climate/Range

From Fofonoff et al. (2003):

“Broad Temperature Range: Cold temperate-Warm temperate”

“Broad Salinity Range: Nontidal Limnetic-Polyhaline”

Distribution Outside the United States

Native

From Schuster et al. (2010):

“Canada (British Columbia)”

Introduced

From Schuster et al. (2010):

“Austria; Belgium; Cyprus; Denmark; Finland; France; Germany; Greece; Italy; Japan; Latvia; Lithuania; Luxembourg; Netherlands; Poland; Portugal; Russian Federation; Spain; Sweden; Switzerland; United Kingdom (Great Britain)”

Means of Introduction Outside the United States

From Holdich et al. (2009):

“Three of the North American NICS [(non-indigenous crayfish species)] have been introduced into Europe to supplement crayfish stocks, as many populations of ICS [(indigenous crayfish species)] have been devastated by crayfish plague since the mid-19th century, and for aquaculture, i.e. ... *Pacifastacus leniusculus* (Dana) to Sweden in 1959 (Abrahamsson, 1973)”

Short description

From Fofonoff et al. (2003):

“Male crayfish of the genus *Pacifastacus* (Signal Crayfish) lack hooks on the ischia (3rd segment) of the walking legs, while females lack the annulus ventralis (seminal receptacle), which in cambarid crayfish, is located between the 4th and 5th pairs of walking legs (Hobbs 1991). The margin of the rostrum in *P. leniusculus* is smooth. ... The overall color of the animal is dark brown, but a turquoise and white patch at the base of the claw is distinctive (Riegel 1959; Taugbøl and Johnsen 2006).”

Biology

From GISD (2005):

“Nutrition

As an opportunistic polytrophic feeder, *P. leniusculus* will eat anything that is available, including other crayfish. The diet was found to shift from aquatic insects in juveniles, to more plant material in adults in some American populations (Lewis, 2002). However, Guan & Wiles (1997) found that cannibalism increased with size and that more animal than plant material was consumed by adults in a British river.”

“Reproduction

The breeding cycle is typical of a cool temperate zone species, although *P. leniusculus* grows faster and reaches a greater size than its counterparts. ... Mating and egg laying occurs during October in the vast majority of populations. Egg incubation time ranges from 166 to 280 days. In natural populations hatching occurs from late March to the end of July depending on latitude and temperature. Egg numbers usually range from 200 to 400, although some individuals of 66mm CL have been reported as having over 500 eggs. Based on the use of the lipofuscin technique it has been estimated that some individuals can live 16 years, and other estimates state that it may be as long as 20 years. Some individuals may grow to a large size, i.e. 95mm CL, but this may not represent a great age, but that of a fast-growing newly introduced population that encounters little competition. Estimates of survivorship to age 2 vary from 10-52%, being dependent on both abiotic and biotic factors. Competition and cannibalism can greatly affect survival in dense populations. Stebbing et al. (2003) demonstrated for the first time the presence of a sex pheromone, released during the breeding season by mature females, that stimulates courtship and mating behaviour in male *P. leniusculus*.”

“Lifecycle stages

Pacifastacus leniusculus has a typical life cycle of a member of the crayfish family Astacidae, and which is therefore very similar to that of indigenous European crayfish. The eggs hatch into miniature crayfish that stay with the mother for three stages, the third stage gradually becoming more and more independent of the mother. Juveniles undergo as many as 11 moults during their first year, but by age 3 this is reduced to two moults per year, and by age 4 onwards to one moult per year (Lewis, 2002).”

Human uses

From GISD (2005):

“Commercially harvested in the western USA, mainly in Washington and Oregon States, although a larger harvest is obtained from the introduced population in the Sacramento River (Lewis, 2002). It was originally hoped that stocking *P. leniusculus* into European waters would revive catches of crayfish to their pre-plague levels, particularly in Sweden and Finland (Skurdal et al. 1999), this has not proved to be the case. In Sweden the catch in 1996 was 265 tonnes (compared to 52 for *A. astacus*) and that cultured amounted to 42 tonnes (compared to 12 for *A. astacus*). The catch of *P. leniusculus* in Finland in 2001 was 22 tonnes (compared to 57.5 for *A. astacus*). However, the Finnish catch of *P. leniusculus* is increasing and is estimated to double every 1-2 years. In 2004 it exceeded 50% of the catch (Erkamo et al. 2004). *P. leniusculus* fetches approximately half the price as *A. astacus* in Finland and Sweden. The introduced species has done better in southern Sweden than in the north and in Finland, and this may be a consequence of the cool climatic conditions in the latter two regions (Henttonen & Huner, 1999). In Europe as a whole in 1994 a total of 355 tonnes of *P. leniusculus* originated from capture fisheries and 51 tonnes from culture. This represents only 9% of European capture fisheries and 32.5% of culture fisheries (Ackefors, 1998, 1999).”

Diseases

From Holdich et al. (2009):

“Crayfish plague, caused by the fungus-like organism *Aphanomyces astaci* Schikora, is listed in the top 100 of the “World’s Worst” invaders by the International Union for Conservation of Nature (IUCN) (Lowe et al., 2000). ... Unestam and Weiss (1970) isolated *A. astaci* from *P. leniusculus* from the Sacramento River and Lake Tahoe in western North America thus proving that the pathogen originated from North America. ... Unestam (1969) found that North American crayfish species are highly resistant to infection by *A. astaci*, suggesting that they are largely immune to its effects and live in a balanced host-parasite relationship with the parasite probably as a result of coevolution. ... However, Cerenius and Söderhäll (1992) found that the presence of the pathogen in *P. leniusculus* means that its immune system is constantly alerted and the animal is under permanent stress. If it then becomes additionally stressed by other parasites or environmental conditions it can die rapidly from crayfish plague. This can cause high mortalities in both aquaculture and the wild, and may explain some of the mortalities in *P. leniusculus* populations in Sweden (Edsman, 2009, pers. comm.) and Finland (Pursiainen, 2009, pers. comm.), as well in other North American NICS elsewhere. Cerenius and Söderhäll (1992) stress that the absence of melanised patches in *P. leniusculus* is not an indication that it is free from crayfish plague.”

From Jiravanichpaisal et al. (2001):

“The signal freshwater crayfish *Pacifastacus leniusculus* was found to be susceptible to infection with white spot syndrome virus (WSSV).”

Crayfish plague and white spot disease are OIE-reportable diseases.

Threat to humans

None reported.

3 Impacts of Introductions

From GISD (2005):

“*P. leniusculus* displays opportunistic polytrophic feeding habits, although more animal than plant material may be consumed if available. It can have a considerable impact on populations of macro-invertebrates, benthic fish, and aquatic plants (Guan & Wiles 1997; Nyström 1999; Lewis 2002), it also has been used to clear weed from ponds on fish farms. Griffiths et al. (2004) found that the presence of *P. leniusculus* significantly reduced the number of Atlantic salmon using shelters in artificial test arenas. Sooty crayfish (see *Pacifastacus nigrescens* in IUCN Red List of Threatened Species), a native to the western US, has become extinct partly due to interspecific competition with *P. leniusculus*, which was introduced into its range. *P. leniusculus* has also been implicated in causing a reduction in the range of the already narrowly endemic shasta crayfish (see *Pacifastacus fortis* in IUCN Red List of Threatened Species) in the western America (Taylor 2002).”

“*P. leniusculus* was introduced into Japan from Portland, Oregon five times during 1926 to 1930, where it has reduced the range of the indigenous *Cambaroides japonicus* on the island of Hokkaido (Hiruta 1996; Kawai & Hiruta 1999). It has also been found in some lakes on Honshu (Hiruta, S. 2005). In Europe, it has extirpated populations of the indigenous crayfish species, particularly the white-clawed crayfish (see *Austropotamobius pallipes* in IUCN Red List of Threatened Species in England (Holdich 1999; Hiley 2003). However, in Finland it coexisted with the noble crayfish, (see *Astacus astacus* in IUCN Red List of Threatened Species), in a lake for 30 years, before reproductive interference led to the demise of the latter species (Westman et al. 2002). Its main impact has been as a vector of the crayfish plague fungus, *Aphanomyces astaci*, which has caused large-scale mortalities amongst indigenous European crayfish populations, particularly in England (Alderman 1996). The disease has recently been confirmed in *P. leniusculus* from western Hungary, which could have serious implications for indigenous crayfish in the Danube catchment (Kiszely 2004).”

“Their burrows can reach high densities, i.e.14 m⁻¹, and they can have a serious impact on bank morphology, causing them to collapse. It was considered to be a non-burrowing species, but in Europe in constructs burrows under rocks or in river and lake banks (Guan, 1994; Sibley, 2000).”

From Griffiths et al. (2004):

“The proportion of Atlantic salmon sheltering was significantly lower in the presence than in the absence of signal crayfish when the interspecific treatment (Atlantic salmon plus signal crayfish) effected a doubling in density compared to the intraspecific treatment (Atlantic salmon alone). The proportion of signal crayfish sheltering was independent of the presence of Atlantic salmon. When total density was constant, the proportion of Atlantic salmon sheltering was significantly higher in intraspecific (52.8%) than interspecific trials (27.3%). Atlantic salmon out of shelter during the day in winter are believed to be very vulnerable to predators and the capacity for fish

to share shelters with one another is known to be very low. Therefore, competition from crayfish for winter shelters may lead to detrimental effects on Atlantic salmon populations.”

From Light (2005):

“Signal crayfish (*Pacifastacus leniusculus*) in Sagehen Creek were associated with reduced growth rates and gut fullness of Paiute sculpin (*Cottus beldingi*) in earlier experiments. This paper assesses potential behavioral mechanisms of competition between the two species. I conducted experiments to determine crayfish effects on sculpin behavior and habitat use in a stream observation facility at the Sagehen Research Station, California, USA. Sculpin reduced their use of refuges and pools, shifted into higher-velocity microhabitats, and spent more time fleeing in the presence of crayfish. Crayfish used refuges, pools, and low-velocity habitats more than sculpin in either treatment. Both species were notably nocturnal, with most activity at dusk and night observations, although crayfish were more strongly so than sculpin. Detailed field surveys of lower Sagehen Creek found that potential refuges (unembedded rocks) were closely associated with total crayfish and sculpin numbers, suggesting that cover is at least sometimes limiting under natural conditions. By displacing sculpin from refuges and pools and increasing their activity rate, crayfish may increase the likelihood of predation on sculpin. Behavioral shifts in sculpin appear to be at least partly responsible for the reduced growth rates of sculpin in the presence of crayfish.”

From Moorhouse et al. (2014):

“Crayfish were intensively trapped and removed from two tributaries of the River Thames to test the hypothesis that lowering signal crayfish densities would result in increases in macroinvertebrate numbers and taxon richness. We removed 6181 crayfish over four sessions, resulting in crayfish densities that decreased toward the center of the removal sections. Conversely in control sections (where crayfish were trapped and returned), crayfish density increased toward the center of the section. Macroinvertebrate numbers and taxon richness were inversely correlated with crayfish densities. Multivariate analysis of the abundance of each taxon yielded similar results and indicated that crayfish removals had positive impacts on macroinvertebrate numbers and taxon richness but did not alter the composition of the wider macroinvertebrate community.”

4 Global Distribution



Figure 1. Global distribution of *P. leniusculus*. Map from GBIF (2015).

5 Distribution within the United States



Figure 2. Native (green) and introduced (red) ranges of *P. leniusculus* in the continental U.S. Map from Fofonoff et al. (2003).

6 Climate Matching

Summary of Climate Matching Analysis

The climate match (Sanders et al. 2014; 16 climate variables; Euclidean Distance) was high throughout the West. Medium to high matches were found in the Mid-Atlantic states and parts of the Southeast, New England, and the Midwest, including the Great Lakes region. Climate match

was low in the south and central US. Climate 6 match indicated that the US has a high climate match. The range for a high climate match is 0.103 and greater; climate match of *P. leniusculus* is 0.381.

Crayfishes have been observed to establish populations in climates different from that found within their native range (M. Hoff, U.S. Fish and Wildlife Service, personal communication). The climate match shown here may be an underestimate of climate suitability for the establishment of *P. leniusculus*.

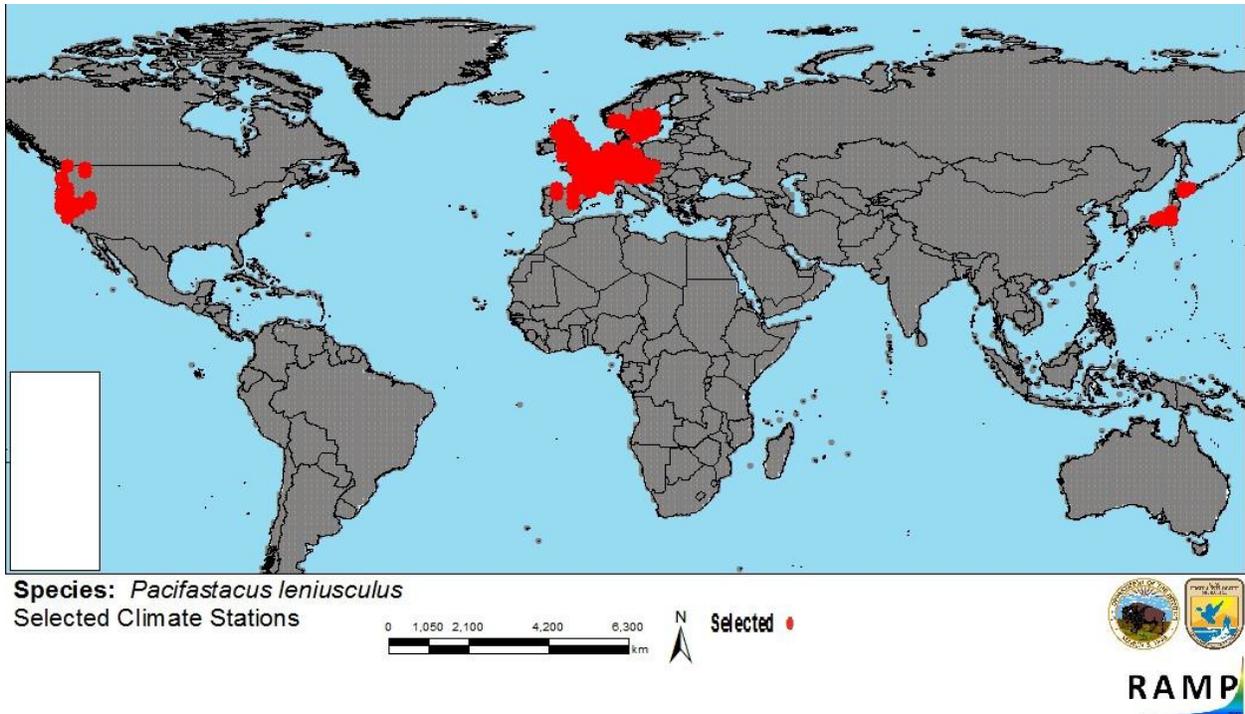


Figure 3. RAMP (Sanders et al. 2014) source map showing weather stations selected as source locations (red) and non-source locations (gray) for *P. leniusculus* climate matching. Source locations from Kawai et al. (2004), GISD (2005), GBIF (2015), and USGS (2015).

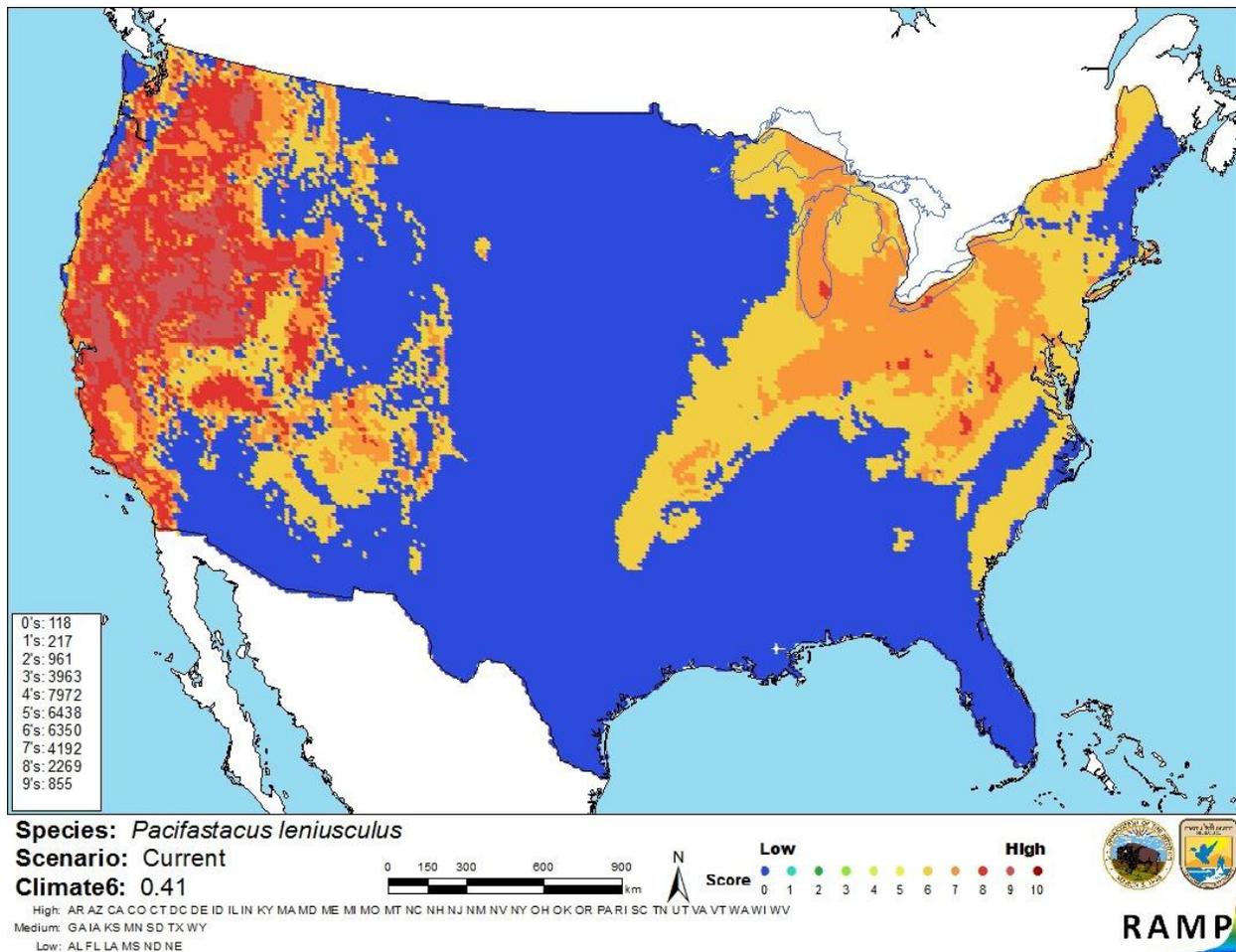


Figure 4. Map of RAMP (Sanders et al. 2014) climate matches for *P. leniusculus* in the continental United States based on source locations reported by Kawai et al. (2004), GISD (2005), GBIF (2015), and USGS (2015). 0= Lowest match, 10=Highest match.

7 Certainty of Assessment

Information on the biology, distribution, and impacts of *P. leniusculus* is readily available. Negative impacts from introductions of this species are adequately documented in the scientific literature. No further information is needed to evaluate the negative impacts the species is having where introduced. Certainty of this assessment is high.

8 Risk Assessment

Summary of Risk to the Continental United States

Native to the Pacific Northwest, *P. leniusculus* has established itself in new areas of the US, Europe, and Japan. Its invasion has led to the decline of native crayfish species, both through competition and as a vector of crayfish plague. This crayfish also alters native habitats, reduces abundances of macroinvertebrates and macrophytes, and influences the behavior of native fish. High climate matches in a good portion of the US increase the risk. Overall risk for this species is high.

Assessment Elements

- History of Invasiveness: High**
- Climate Match: High**
- Certainty of Assessment: High**
- Overall Risk Assessment Category: High**

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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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numbers and taxon richness of macroinvertebrate species. *Ecology and Evolution* 4(4):494-504.

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