# Fishhook Waterflea (*Cercopagis pengoi)*
## Ecological Risk Screening Summary

**U.S. Fish & Wildlife Service, February 2011**
**Revised, September 2017**
**Web Version, 11/30/2017**


Photo: J. Liebig, NOAA GLERL.

# 1 Native Range and Nonindigenous Occurrences

## Native Range

From Benson et al. (2017):

"Black, Caspian, Azov, and Aral seas of Europe and Asia (Makarewicz et al. 2001)"

## Status in the United States

From Benson et al. (2017):

"Great Lakes Region
Lake Ontario in 1998, Lake Erie in 2002 (Presque Isle), Lake Huron in 2002 (USEPA 2008), Lake Michigan in 1999 (Charlebois 2001), Finger Lakes et al. (Canandaiga, Cayuga, Keuka, Cross, Otisco, Owasco, and Seneca lakes) of New York. In the summer of 2001, *C. pengoi* was found in Muskegon Lake east of Lake Michigan (Therriault et al. 2002). A single specimen was collected from Lake Superior in 2003, but the species is not believed to be established there."

"Considered established in Lake Ontario, establishing itself quickly (similar to the invasion patterns in Europe) in the other Great Lakes (except L. Huron and Superior) and other inland lakes due to recreational boat traffic and other human activities (USEPA 2008)."

## Means of Introduction into the United States

From Benson et al. (2017):

"Ballast water, boating"

From Birnbaum (2011):

"The colonization of North America by *Cercopagis pengoi* appears to be a secondary introduction from the Baltic Sea via ballast water (Cristescu et al. 2001)."

## Remarks

From Benson et al. (2017):

"According to the EPA's GARP model, *C. pengoi*, a free-swimming macroinvertebrate, would likely find suitable habitat throughout the Great Lakes region, except for the deeper waters of Lake Superior. However, population densities of the fishhook water flea increase with distance from shore (IUCN 2010), suggesting that this species may be able to occupy the entire region, including the deeper waters of Lake Superior, given sufficient time (USEPA 2008)."

# 2 Biology and Ecology

## Taxonomic Hierarchy and Taxonomic Standing

From ITIS (2017):

"Kingdom Animalia
 Subkingdom Bilateria
  Infrakingdom Protostomia
   Superphylum Ecdysozoa
    Phylum Arthropoda
     Subphylum Crustacea
      Class Branchiopoda
       Subclass Phyllopoda
        Order Diplostraca
         Suborder Cladocera
          Infraorder Onychopoda
           Family Cercopagididae
            Genus *Cercopagis*
             Species *Cercopagis pengoi* (Ostroumov, 1891)"

"Current Standing: valid"

## Size, Weight, and Age Range

From Birnbaum (2011):

"Body length of females varies from 1.2 to 2.0 mm and that of males from 1.1-1.4 mm. The caudal process exceeds the main body 5-7 times by length (Mordukhai - Boltovskoi and Rivier 1987); however there is a high degree of regional variability in morphology (Grigorovich et al. 2000)."

## Environment

From CABI (2017):

"*C. pengoi* has a wide tolerance to salinity (from freshwater to 17 practical salinity units (psu)) […] (Gorokhova et al., 2000). The highest population densities are usually found at temperatures of 16-26ºC and at salinities of up to 10 ‰ (Mordukhai-Boltovskoi and Rivier, 1987; Rivier, 1998). Both in the Caspian Sea (Rivier, 1998) and Lake Ontario (Ojaveer et al. 2001) the abundance of *C. pengoi* increases with distance from shore suggesting that this is a typical pelagic species. In the Caspian Sea, *C. pengoi* performs diurnal vertical migrations. During the daytime they sink down to 50-60 m and at night they move up to the surface. Newly-born individuals do not descend deeper than 20-30 m (Mordukhai-Boltovskoi and Rivier, 1987). However, there is no evidence of diurnal migrations of *C. pengoi* in the Baltic Sea (Krylov et al., 1999)."

"*C. pengoi* is capable of hyperosmotic regulation, and its hemolymph is hyperosmotic to surrounding water (from freshwater up to 5-8 psu). The species is osmoconformer in the very short range from 5-8 up to 17 psu. From the point of view of osmotic regulation *C. pengoi* resembles freshwater organisms and clearly distinguished from marine and Caspian Podonidae."

## Climate/Range

From Birnbaum (2011):

"*Cercopagis pengoi* is a euryhaline and eurythermic species, occurring in […] waters with highly variable temperatures (3 – 38 ºC; cf. Gorokhova et al. 2000)."

From Panov (2006):

"They are eurythermic, they first appear in the summer plankton at water temperatures between 15 and 17°C and during autumn they appear in the zooplankton at relatively low temperatures of 8°C."

From CABI (2017):

"The highest population densities are usually found at temperatures of 16-26ºC and at salinities of up to 10 ‰ (Mordukhai-Boltovskoi and Rivier, 1987; Rivier, 1998)."

## Distribution Outside the United States

### Native

From Benson et al. (2017):

"Black, Caspian, Azov, and Aral seas of Europe and Asia (Makarewicz et al. 2001)"

### Introduced

From Panov (2006):

"Reservoirs of Don and Dnieper rivers, Baltic Sea, Great Lakes of North America"

From Birnbaum (2011):

"First findings in Estonia were in southern coast of the Gulf of Finland (Muuga Bay) and the northeastern Gulf of Riga (Pärnu Bay), in 1992 (Ojaveer et al. 2000). In difference from the Gulf of Riga where the species continued its presence in 1993-1994, *C. pengoi* was not encountered in zooplankton samples in the Gulf of Finland in these years. Since 1995, the species was continuously reported from several localities in the northern and eastern Gulf of Finland (e.g., Kivi 1995, Avinski 1997, Uitto et al. 1999). At some stations, sampled in September 1995 in the Gulf of Riga, it comprised 25% of the total zooplankton biomass (Ojaveer and Lumberg 1995, Ojaveer et al. 1998). Since then the distribution area of *Cercopagis* has substantially expanded to include:
1) western Baltic and northern Baltic proper (the Gotland basin and Stockholm archipelago, west coast of the Baltic Proper, 1997, Gorokhova et al. 2000)
2) northern Baltic (Gulf of Bothnia, 1999, Andersen and Gorokhova 2004, ICES 2005. )
3) southern Baltic (Gulf of Gdansk, Vistula lagoon, 1999, Pomeranian Bay, 2004, Naumenko and Polunina 2000, Zmudzinski 1999, Bielecka et al. 2000, ICES 2005)."

## Means of Introduction Outside the United States

From Birnbaum (2011):

"Presumably introduced with the ballast water and by attachment to hulls or fishing gears (Leppäkoski and Olenin 2000)."

## Short Description

From CABI (2017):

"*C. pengoi* is greyish white and almost transparent. […] The most pronounced parts of its body are the head, the second pair of antenna (containing two branches), four pairs of thoracic legs (the first leg is 3-4 times longer than other legs), abdomen, caudal process and a brood pouch in females. The head is essentially composed of a large single eye, where the amount of black pigment makes less than one half of the diameter of the eye. […] The long caudal process has a loop-like curvature at the end (Mordukhai-Boltovskoi and Rivier, 1987; Rivier 1998). Parthenogenic females of the first generation of *C. pengoi* that hatch from resting eggs are anatomically distinct from parthenogenic females of following generations. They have a short, straight caudal spine unlike the characteristically looped caudal spine of parthenogenically-produced individuals (Simm and Ojaveer, 1999)."

## Biology

From Indiana Department of Natural Resources (2005):

"The life span of a water flea can be several days up to a week. In the spring, the population emerges from resting eggs that have laid dormant over the winter. During the peak population period from spring through fall, the population is comprised of mostly females. With the absence of males, the females reproduce by a process called parthenogenesis. Parthenogenesis requires no fertilization and the offspring are clones of the mother. When the temperature begins to cool and food is becoming scarce in the fall, both males and females are produced via parthenogenesis. The sex of a spiny water flea is not determined by genetics but by environmental factors. The presence of males allows for sexual reproduction to occur in the fall. The eggs produced by sexual reproduction have a [t]hick coating that allows them to withstand the winter on the lake bottom. These eggs are called resting eggs and can lie dormant for long periods of time. All eggs are carried on the females back in a balloon like pouch. They can have up to a dozen offspring when reproducing by parthonogenesis. Females producing resting eggs have clutches that range from usually one or two. After reproduction is complete, whether it be by parthenogenesis or sexual reproduction, the adult dies."

From Benson et al. (2017):

"*Cercopagis pengoi* lives in brackish and freshwater lakes. It exhibits diurnal vertical migrations in its native range and feeds on other zooplankton."

"Resting eggs are […] resistant to desiccation, freeze-drying and ingestion by predators (such as other fish). They can be easily transported to other drainage basins by various vectors, particularly if they are still in the female's body (the barbed caudal spine allows attachment to ropes, fishing lines, waterfowl feathers, aquatic gear, vegetation and mud). Resting eggs can hatch regardless of whether the carrier female is alive or dead."

From GISD (2015):

"Female, both parthenogenic and gametogenic, and male *Cercopagis pengoi* possess 3 life-history stages or instars, which differ by number of spines, or barbs, on the caudal process. At each molt, the animal sheds its exoskeleton to the base of the caudal process. A new pair of proximal barbs and the growth of an intercalary segment are inserted between the existing tail spine and the body. The newborn parthenogenic females (instar I) have one pair of barbs on the caudal process, compact oval embryos in the brood pouch without a pointed apex. The second stage (instar II) has two pairs of barbs and the mature stage (instar III) of the parthenogenic female has a large brood pouch with a pointed apex housing embryos. In males at this stage paired penes behind the last thoracic legs and a toothed hook on the first pair of legs are developed (Mordukhai-Boltovskoi & Rivier, 1987; Rivier 1998). Parthenogenic females of the first generation of *C. pengoi* proceed through 3 moult yielding 4 pairs of proximal barbs on the caudal process unlike the females of following generations that undergo 2 molts to reach adulthood (Simm & Ojaveer 1999)."

"*Cercopagis pengoi* is a generalist feeder which preys on various species of cladocerans, copepods, rotifers, i.e., both micro- and mesozooplankton (Mordukhai-Boltovskoi 1968; Laxson et al. 2003; Gorokhova et al. 2005; Lehtiniemi and Linden 2006; Pichlova-Ptacnikova and Vanderploeg 2009). It is able to capture and handle prey about its own body size to those seventeen times smaller."

## Human Uses

From GISD (2015):

"In the Baltic and in the Great Lakes, zooplanktivorous fish and mysids are reported to prey on *C. pengoi*, implying that it has become a new food source. Its importance increases in larger fish (Antsulevich and Välipakka 2000; Gorokhova et al. 2004; Ojaveer et al. 2004; Bushnoe et al. 2003) and in actively migrating mysids (Gorokhova and Lehtiniemi 2007)."

## Diseases

No information available.

## Threat to Humans

From CABI (2017):

"*C. pengoi* interferes with fisheries by clogging nets and fishing gears. Presence of the species results in economic losses at fish farms (intense clogging of nets)."

"Fishermen have complained of allergic reactions after removing *C. pengoi* from their nets."

# 3 Impacts of Introductions

From Benson et al. (2017):

"*Cercopagis pengoi* is a consumer of other zooplankton. As such it competes with other planktivores of the Great Lakes, including the alewife (*Alosa pseudoharengus*) and rainbow smelt (*Osmerus mordax*) (Bushnoe et al. 2003). Its long spine makes it less palatable to planktivorous fish. For these reasons *C. pengoi* could have a serious effect on the food supply of planktivores. For example, yearling alewife compete directly with *C. pengoi* because they are planktivorous, and cannot consume *C. pengoi* due to the caudal appendage. Once alewife reach their first year they are large enough to handle the caudal appendage (Bushnoe et al. 2003). *C. pengoi*'s establishment in Lake Ontario in 1998 corresponded with the lowest alewife populations in twenty years (Makarewicz et al. 2001)."

"A 2002 study of the food web impacts of *C. pengoi* showed that the depth at which *C. pengoi* exists is depleted of small organisms (<0.15 mg) (Benoit et al. 2002). It is unclear as to whether this is due to predator evasion or *C. pengoi* consumption, but in either case the smaller organisms are forced into deeper, cooler strata, causing growth rate changes (Benoit et al. 2002). The full impact of *C. pengoi* on the food web has not yet been extensively studied."

From Birnbaum (2011):

"Due to the massive spread of *Cercopagis* in, e.g. Pärnu Bay (Gulf of Riga), the population abundance of the small-sized cladoceran *Bosmina coregoni maritima* has drastically decreased, probably due to direct predation (Ojaveer et al. 2004). In the spring and summer seasons, when the number of *Bosmina* in the water is too low, *Cercopagis* competes with larval and young fish for food. However, *Cercopagis* is itself a very important food for small herring, stickleback, smelt and bleak (due to its numbers) (Ojaveer et al. 2004)."

"Presently, the *Cercopagis* invasion has additionally resulted in elevating relative importance of warm-water planktonic invertebrates in the energy flow to cold-water bentho-pelagic fish (through direct predation). In some sheltered coastal shallow areas characterised by high *Cercopagis* but low predator abundance in the warm season, part of the *Cercopagis* production may die and sink to the bottom, and undergo there heterotrophic decomposition processes. This obviously complicates energy transfer to higher trophic levels in these areas. However, studies to date have shown that sinking of dead animals to bottom is probably not intense in deeper areas (Estonian Marine Institute [unknown date])."

"*C. pengoi* is a potential competitor with young stages of planktivorous fish for herbivorous zooplankton (Vanderploeg et al. 2002). Several lines of evidence indicate that *C. pengoi* may affect resident zooplankton communities by selective predation: Lake Ontario (Benoit et al. 2002); Gulf of Riga (Ojaveer et al. 199[8], 2004); Gulf of Finland (Uitto et al. 1999). Such changes may result in decreased grazing pressure on phytoplankton and enhanced algal blooms. On the other hand, zooplanktivorous fish both in the Baltic (Antsulevich and Välipakka 2000, Gorokhova et al. 2004, Ojaveer et al. 2004) and in the Great Lakes (Bushnoe et al. 2003) have been reported to prey on *C. pengoi* implying that it has become a new food source, particularly for larger fish. It is, however, difficult to study food competition between small fish and *C. pengoi* because of the lack of feeding studies on the latter."

"*C. pengoi* tends to attach to fishing gears, clog nets and trawls, causing problems and substantial economic losses for fishermen (Leppäkoski and Olenin 2000). In the Baltic Sea, the mass development of *Cercopagis* was accompanied by the formation of a "paste" fouling fishing nets and trawls […] (Kivi 1995, Ojaveer and Lumberg 1995). Little is known about the biofouling ability of *C. pengoi* in its native area. However, one may suppose that "the fishing net's plague" "when suddenly all the fishing nets at a vast distance dye during one day being ill by a net's illness, a special algae" could be attributed to *C. pengoi* (Khlebnikov 1990). Biofouling of fishing equipment by *Cercopagis* in the eastern Gulf of Finland is already a serious problem, resulting in substantial economic losses. Economic losses at a fish farm, located at the northern shore of the lower Neva Estuary (Primorsk), in 1996-1998 were at least $50 000. These losses were the result of a drastic decline in the fish catches in the Primorsk (Koivisto) area and cost of unsuccessful fishing efforts in areas with abundant *Cercopagis* due to biofouling of fishing equipment (Panov et al. 1999). The same problem was found at whitefish fisheries in the eastern Gulf of Finland (GAAS 2000), inner parts of the Archipelago Sea (K. Häkkilä, pers. comm.), northern Bothnian Sea (K.-E. Storberg, pers. comm.) and in Lithuania (I. Olenina, pers. comm.). Since 1999, the occurrence of *Cercopagis* within north-eastern range of the Lithuanian coastal zone has had severe impacts on commercial fishery by clogging gill-nets and thus drastically reducing commercial catches."

From Laxson et al. (2003):

"Between 1999 and 2001, a decrease in the abundance of dominant members of the Lake Ontario zooplankton community (*Daphnia retrocurva*, *Bosmina longirostris* and *Diacyclops thomasi*) coincided with an increase in the abundance of *Cercopagis* [*pengoi*]. *Daphnia retrocurva* populations declined despite high fecundity in all 3 years, indicating that food limitation was not responsible. […] Consumption demand of mid-summer populations of *Cercopagis*, estimated from a bioenergetic model of the confamilial *Bythotrephes*, was sufficient to reduce crustacean abundance, although the degree of expected suppression varied seasonally and interannually."

From Golubkov and Litvinchuk (2015):

"The appearance of *Cercopagis* [*pengoi*] in the zooplankton of the Gulf of Finland considerably changed the configuration of the food chain of the ecosystem of the bulk of water in the gulf. As shown earlier, this species effectively eats and suppresses the population of *E*[*urytemora*] *affinis* [Lehtiniemi and Gorokhova 2008], which is an important fish food object. Consequently, a new trophic level, namely predatory invertebrates, has appeared at which, as at every trophic level of consumers, occurs the loss of energy transferred through the trophic chain to further trophic levels, in the given case, to fish. Thus, although *Cercopagis* itself can be consumed by plankton-eating fishes [Antsulevich and Välipakka 2000], the efficiency of energy transfer from phytoplankton to fish has considerably decreased [Golubkov et al. 2010]."

# 4 Global Distribution

**Figure 1.** Known global distribution of *C. pengoi*. Map from GBIF Secretariat (2016). Location in Lake Superior, North America was not included in the climate matching analysis because the species is not known to be established in Lake Superior.

# 5 Distribution Within the United States

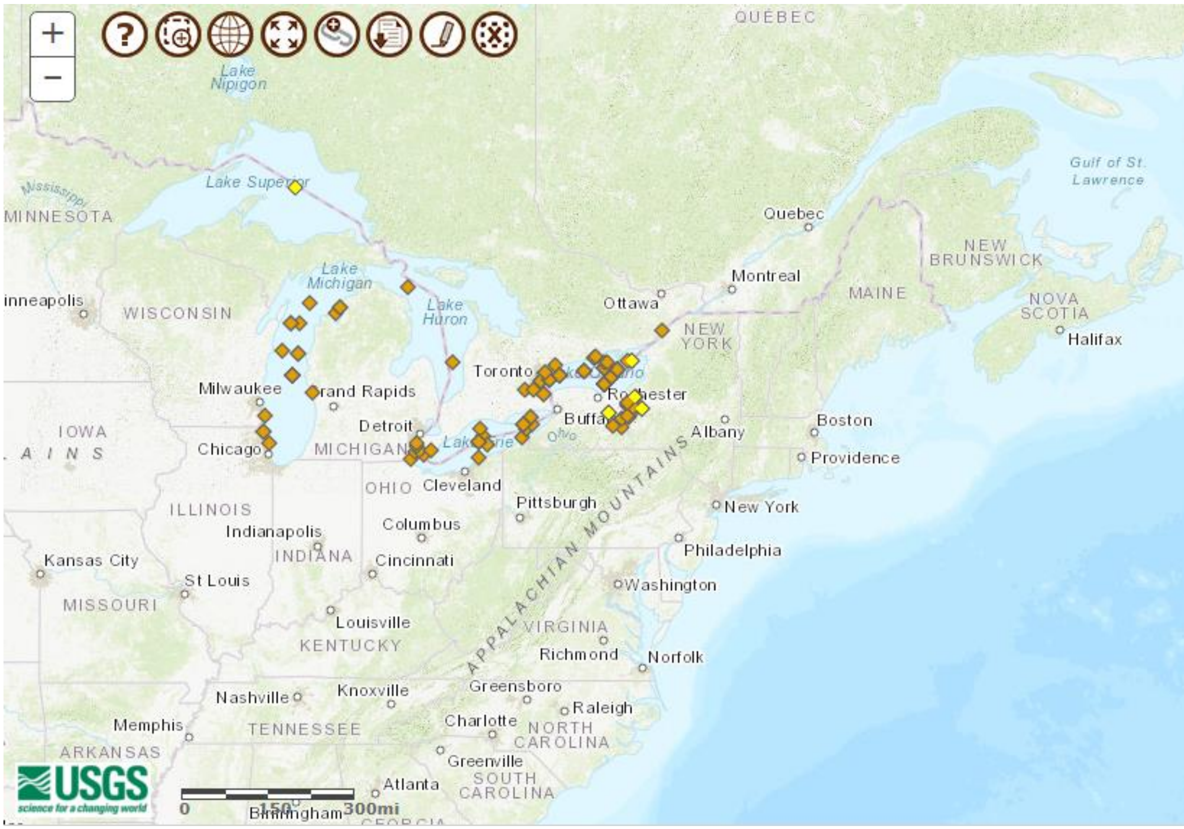

**Figure 2.** Known distribution of *C. pengoi* in the United States. Brown diamonds represent established locations, yellow diamonds represent collections. Only established locations were used in the climate matching analysis. Map from Benson et al. (2017).

# 6 Climate Matching

## Summary of Climate Matching Analysis

The climate match (Sanders et al. 2014; 16 climate variables; Euclidean Distance) was high throughout the Great Lakes, New England, the Central Plains and parts of the Rocky Mountain States. Low matches occurred in the Southeast, parts of the Southwest, and the coastal Pacific Northwest. Elsewhere, the climate match was medium. Climate 6 score indicated that the contiguous U.S. has a high climate match overall; Climate 6 score for *C. pengoi* was 0.379.

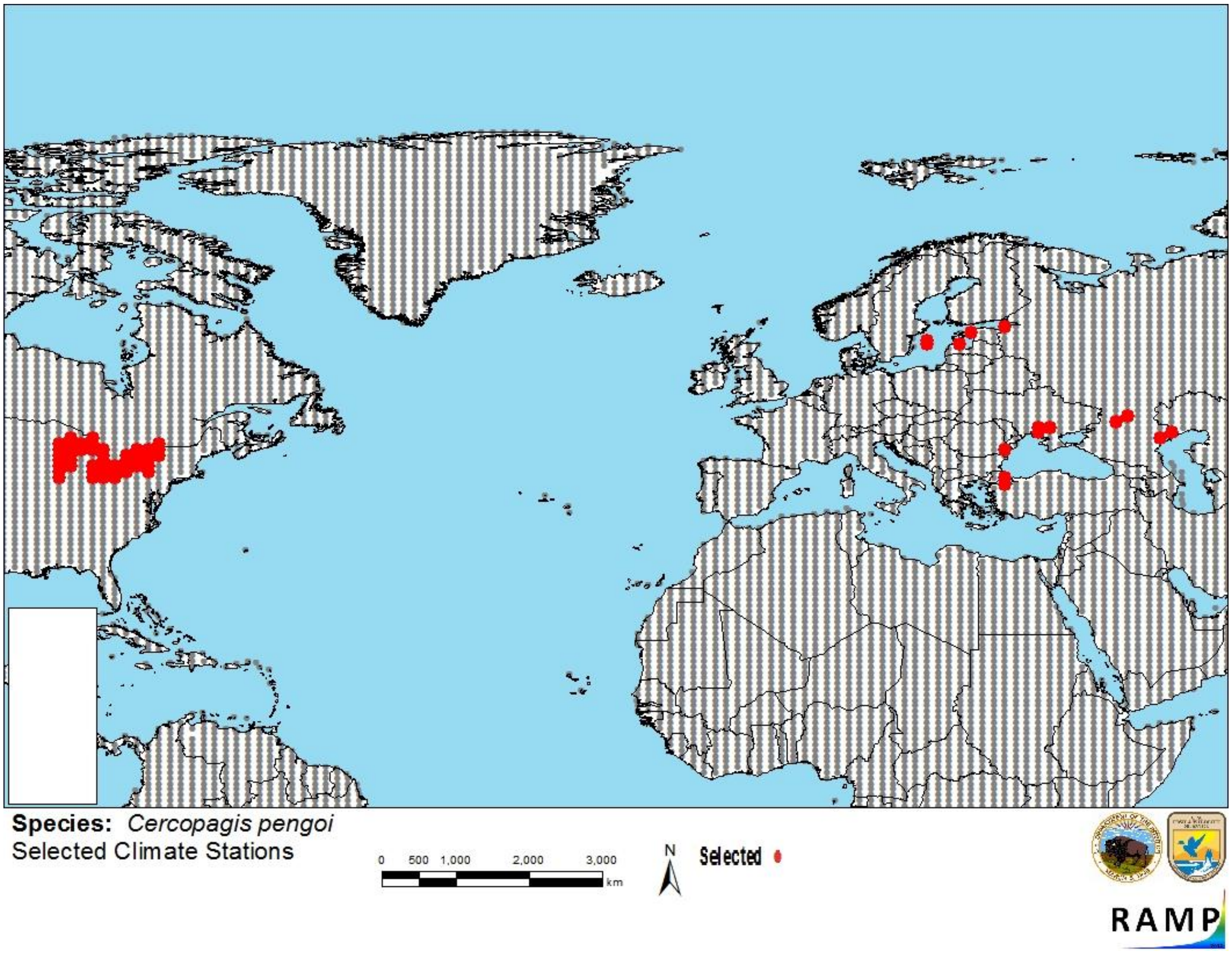


**Figure 3.** RAMP (Sanders et al. 2014) source map showing weather stations selected as source locations (red) and non-source locations (gray) for *C. pengoi* climate matching. Source locations from GBIF Secretariat (2016) and Benson et al. (2017), supplemented by locations from Cristescu et al. (2001; Romania, Russia, and Ukraine) and Güher (2004; Russia and Turkey). Only established locations were used.

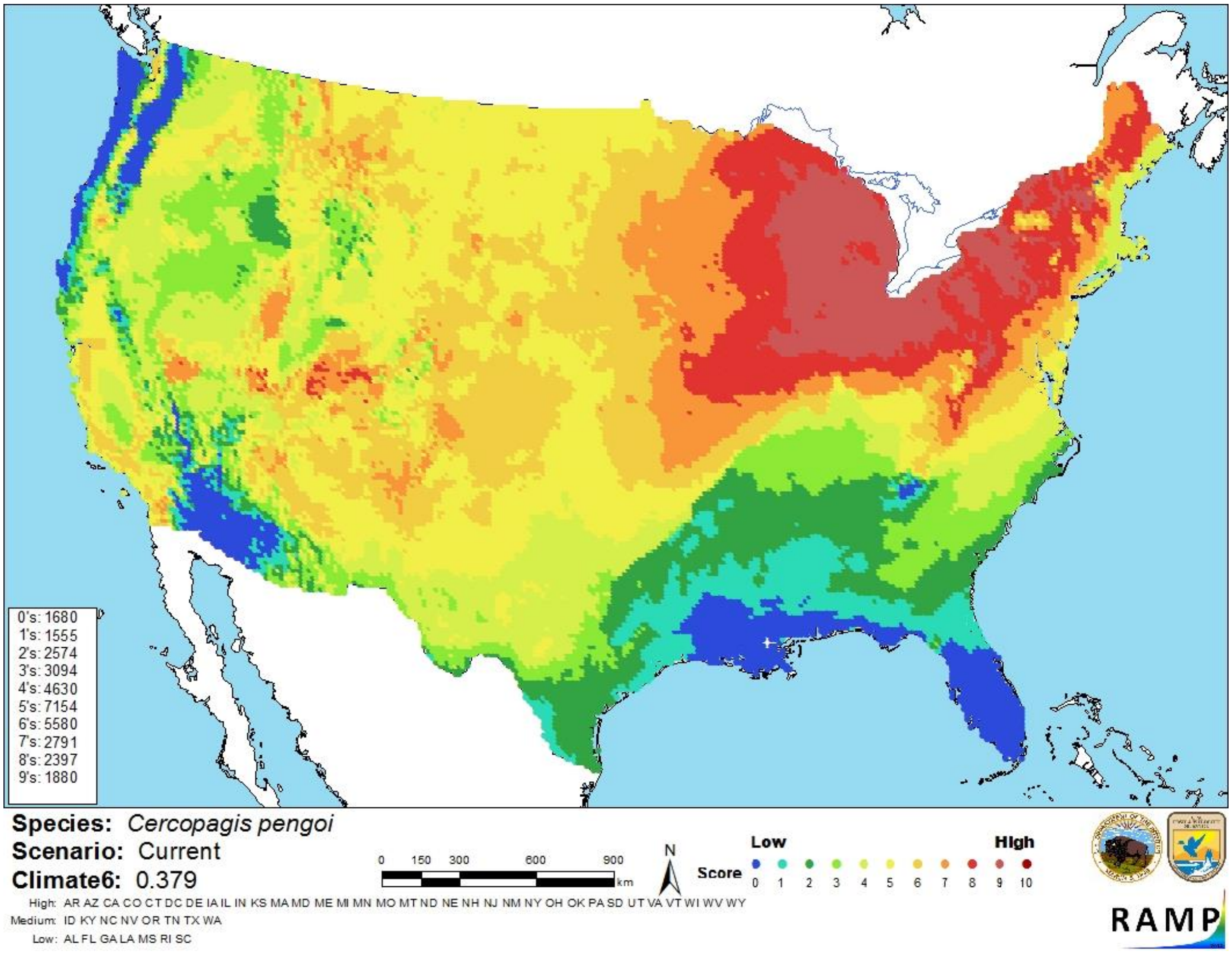


**Figure 4.** Map of RAMP (Sanders et al. 2014) climate matches for *C. pengoi* in the contiguous United States based on source locations reported by GBIF Secretariat (2016) and Benson et al. (2017), supplemented by locations from Cristescu et al. (2001) and Güher (2004). 0=Lowest match, 10=Highest match.

The “High”, “Medium”, and “Low” climate match categories are based on the following table:

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

# 7 Certainty of Assessment

Information is readily available on the biology, ecology, and distribution of *C. pengoi*. Clear, convincing, and scientifically credible information is available from multiple sources on the impacts of *C. pengoi* introduction. Certainty of this assessment is high.

# 8 Risk Assessment

## Summary of Risk to the Contiguous United States

*Cercopagis pengoi* is a cladoceran native to the Black, Caspian, Azov, and Aral Seas. Beginning in the 1990s, *C. pengoi* was introduced and spread in the Baltic Sea and then in the Great Lakes of North America. At present, *C. pengoi* has established populations in all of the Great Lakes except Lake Superior, as well as New York's Finger Lakes. Ballast water and fouled fishing gear are the predominant vectors for *C. pengoi* introduction and spread. Introduced populations of *C. pengoi* have been repeatedly associated with declines in native zooplankton and planktivorous fish, sometimes changing community trophic structure, although zooplanktivorous fish may be able to exploit *C. pengoi* as a food resource. Additionally, biofouling of fishing gear by *C. pengoi* can result in considerable economic costs. The climate matching analysis showed medium to high matches across much of the contiguous U.S. Overall risk posed by *C. pengoi* is high.

## Assessment Elements

- **History of Invasiveness: High**
- **Climate Match: High**
- **Certainty of Assessment: High**
- **Important Additional Information: Parthenogenic**
- **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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