U.S. Fish & Wildlife Service

Bosmina coregoni (a water flea, no common name)
Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, March 2023
Revised, April 2023
Web Version, 5/21/2024

Organism Type: Crustacean
Overall Risk Assessment Category: Uncertain

Photo: Dmitry Kulakov. Licensed under CC BY 4.0. Available: https://www.inaturalist.org/photos/53113205 (March 2023).

1 Native Range and Status in the United States

Native Range

From Fofonoff et al. (2018):

"Taxonomic problems make it difficult to define the range and habitat of *B. coregoni*, but studies using genetics and detailed morphological examination indicate that it is native to northern and eastern Europe, from Scandinavia to central Europe and eastern Russia ([De Melo and Hebert 1994a]; Kotov et al. 2009)."

From Beaver et al. (2018):

"*Bosmina (E.) coregoni* is widespread across lakes and reservoirs in Europe and Asia (Lieder 1983). It is likely endemic to the Palearctic region of the globe, as a post-glacial species morph from ancestral Palearctic *B. (E.) longispina* (Faustová et al. 2010, Faustová et al. 2011)."

Status in the United States

According to Kipp et al. (2024; using the synonym *Eubosmina coregoni*), nonindigenous occurrences of *Bosmina coregoni* have been reported in the following U.S. States. Range of years reported, watersheds where reported, and current introduction status (one or more watersheds) are included in parentheses.

- Illinois (1966; Lake Michigan; established)
- New York (1967–2006; Lake Champlain, Lake Erie, Lake Ontario, Middle Hudson, Mohawk, Saranac River, Schoharie, Seneca, Upper Susquehanna; established)
- Massachusetts (1885; Cape Cod; unknown)
- Michigan (1967–2006; Lake Huron, Lake Michigan; established)
- Minnesota (2001; Lake Superior; established)
- Missouri (1994–1995; Lake of the Ozarks, Pomme De Terre, Sac; established)
- Ohio (1998–2004; Lake Erie; established)
- Oregon (2008–2011; Lower Columbia; unknown)
- Pennsylvania (1967–2002; Lake Erie, Shenango; established)
- Vermont (Richelieu River; unknown)
- Washington (2006–2013; Lake Washington [unknown status], Lower Columbia-Clatskanie; established)
- Wisconsin (1999–2001; Lake Michigan, Lake Superior; established)

From Kipp et al. (2023):

"First known occurrence in the US was in 1966 from Lake Michigan; by the 1970s–1980s it was considered to have spread to all the Great Lakes and by the 1990s it was present in many inland lakes within 100 km of the Great Lakes (Mills et al. 1993; [De Melo and Hebert 1994a])."

"Established throughout all the Great Lakes drainages; however, status in Lake Superior is uncertain."

"One of the dominant zooplankton species in the Great Lakes; average numbers from a 1970 sample of Otsego Lake showed densities of 30,000 organisms per m^3."

From Beaver et al. (2018):

"*Bosmina (Eubosmina) coregoni* Baird was found in 39 lakes [in the United States] (5% of all lakes in which Bosminidae were present), and was primarily concentrated around the Great Lakes region (Ohio, Michigan, Indiana, Illinois, Pennsylvania and New York) […]
Bosmina (E.) coregoni was found in 13 of 47 states including Colorado, Illinois, Indiana,

Kansas, Michigan, Minnesota, New York, Ohio, Oregon, Pennsylvania, South Dakota, Vermont and Washington. *Bosmina (E.) coregoni* was present in all nine ecoregions of the continental U.S., with highest mean biomass in the Coastal Plains […], Upper Midwest […] and Western Xeric […] regions."

From Smits et al. (2013):

"Until now [2008-2012] this species has not been reported on the Pacific coast of North America, but has been detected as far west as […] Missouri (Suchy et al. 2010; Mabee 1998)."

"Here we report the presence of *B. coregoni* in three geographically distinct freshwater locations on the west coast: the Lower Columbia River Estuary (LCRE), Lake Washington in western Washington state, and the Columbia River Basin in south-eastern Washington state. *Bosmina coregoni* was detected on multiple sampling dates in Lake Washington and the LCRE between 2008 and 2012."

"While we documented the presence of *B. coregoni* only in three freshwater locations along the west coast of North America, this species' prolific invasion history in the Great Lakes region suggests its current range may extend far beyond our sampling area."

From Fofonoff et al. (2018):

"In long-term sampling (2005-2013) from a pier in Vancouver, Washington, on the tidal Columbia river, it [*B. coregoni*] comprised 0.5 % of zooplankton individuals and reached a peak abundance of 846 m-3, but declined to low levels (7 m-3) by 2013 (Dexter et al. 2015)."

"It is reported on several species lists for freshwater tributaries of Chesapeake Bay (Brownlee and Jacobs 1987; Steinberg and Condon 2009), but these records may have resulted from use of a European zooplankton key (George Mateja 1998, personal communication). We have no reliable records from East Coast tidal waters."

No records of *Bosmina coregoni* in trade in the United States were found.

Regulations
No species-specific regulations on possession or trade were found for *Bosmina coregoni* in the United States.

Means of Introductions within the United States
From Kipp et al. (2024):

"*Eubosmina coregoni* was very likely introduced via ballast water to the Great Lakes and transferred within the network of ports by further ballast water movement and exchange. It probably expanded into inland lakes via long-distance dispersal and migration (Mills et al. 1993; [De Melo and Hebert 1994a])."

"Suchy and Hann (2007) suggested that the transfer of *E. coregoni* in the digestive tract of rainbow smelt (*Osmerus mordax*) may be responsible for introducing the species to water bodies west of the Laurentian Great Lakes, demonstrating how waterflea resting eggs may transform biological predation from a form of control to a vector for transport."

From Smits et al. (2013):

"An exact invasion mechanism for this species in our study area [west coast of North America] may never be established, since cladocerans and their resting eggs can be transported in a variety of ways, including migratory birds, recreational boats, and direct hydrological connections (Figuerola and Green 2002; Havel and Medley 2006). The presence of this species in non-coastal eastern Washington suggests between-lake dispersal mechanisms such as recreational boating or migrating waterfowl, and suggests the possibility that *B. coregoni*'s range has expanded across the continent in this fashion."

From Fofonoff et al. (2018):

"Ballast water is an unlikely vector to the Columbia estuary, since this species is not known to occur in eastern Asia (Kotov et al. 2009). Other possible vectors are those that have been suggested for interior lakes, including: stocked fishes, fishing gear, boats, aquatic plants, and natural dispersal by waterfowl (Smits et al. 2013)."

Remarks

From Fofonoff et al. (2018):

"As a result of the difficulty and confusion in the systematics and identification of *Bosmina* spp., it is probably frequently overlooked and sometimes erroneously reported (De Melo and Hebert 1994b)."

Eubosmina coregoni is a commonly used synonym of *Bosmina coregoni*. More recently, *Eubosmina* has been considered a subgenus, so the species is also referred to as *Bosmina* (*Eubosmina*) *coregoni*. Both the scientific names *Bosmina coregoni* and *Eubosmina coregoni* were used as search terms to find information for this report.

From Kotov et al. (2009):

"Earlier authors (Deevey & Deevey 1971; Taylor et al. 2002) regarded *Eubosmina* Seligo, 1900 as a separate genus. Indeed, two well-defined clades exist within the genus, and the designation of genera is arbitrary. But, morphological differences between *Bosmina* and '*Eubosmina*' are extremely small when compared with the differences between the genera of other anomopods."

"We have used the weak morphological differentiation to justify the single-genus approach in our taxonomy."

From Haney et al. (2013):

"*Eubosmina* as a genus is being eliminated from the literature in favor of *Bosmina*."

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From WoRMS (2023):

Biota > Animalia (Kingdom) > Arthropoda (Phylum) > Crustacea (Subphylum) > Allotriocarida (Superclass) > Branchiopoda (Class) > Phyllopoda (Subclass) > Diplostraca (Superorder) > Anomopoda (Order) > Bosminidae (Family) > *Bosmina* (Genus) > *Bosmina* (*Eubosmina*) (Subgenus) > *Bosmina* (*Eubosmina*) *coregoni* (Species)

According to WoRMS (2023), *Bosmina coregoni* is the current valid name for this species.

The following synonyms of *Bosmina coregoni* from Kipp et al. (2023, 2024) and WoRMS (2023) were used to search for information for this report: *Eubosmina coregoni* and *Bosmina longispina*.

Size, Weight, and Age Range

From Kipp et al. (2024):

"**Size:** from 0.2 to 0.8 mm in length (Pennak 1989; Barbiero and Tuchman 2004)"

Environment

From Kipp et al. (2024):

"The distribution of *E. coregoni* varies seasonally in the Great Lakes. In Lake Michigan, it occurs in the nearshore region at 5–10 m from the surface in fall and winter, but more frequently at 20–30 m depth in the height of the summer. In the same lake, it is relatively uniformly distributed horizontally in fall and winter, but in summer it occurs significantly more frequently in water 0–18 km from shore than in open water."

"This is a freshwater species. It can experience mortality at salinities of 3‰ (Nauwerck 1991)."

Climate

According to Fofonoff et al. (2018), *Bosmina coregoni* has a broad temperature range of cold temperate-warm temperate.

Distribution Outside the United States

Native

From Fofonoff et al. (2018):

"Taxonomic problems make it difficult to define the range and habitat of *B. coregoni*, but studies using genetics and detailed morphological examination indicate that it is native to northern and eastern Europe, from Scandinavia to central Europe and eastern Russia ([De Melo and Hebert 1994a]; Kotov et al. 2009)."

From Beaver et al. (2018):

"*Bosmina (E.) coregoni* is widespread across lakes and reservoirs in Europe and Asia (Lieder 1983). It is likely endemic to the Palearctic region of the globe, as a post-glacial species morph from ancestral Palearctic *B. (E.) longispina* (Faustová et al. 2010, Faustová et al. 2011)."

Introduced

From Fofonoff et al. (2018):

"It has spread to smaller lakes in the Great Lakes drainage [including in Canada]; and to Lake Winnipeg, Manitoba; […] (Mabee 1998; [De Melo and Hebert 1994a]; USGS Nonindigenous Aquatic Species Program 2013)."

From Suchy et al. (2010):

"*Eubosmina coregoni* Baird 1857 is the first known nonindigenous zooplankter to invade Lake Winnipeg. […] this species was detected in sediments dated to the early 1990s from Lake of the Woods, Ontario (Suchy and Hann, 2007). Salki (1996) found low numbers of *E. coregoni* (as *E. longispina*) in the 1994 zooplankton community of Lake Winnipeg at two of 30 sampling sites: the Traverse Bay region (Winnipeg River inflow) in the South Basin and at the Nelson River outflow in the North Basin. Previous comprehensive zooplankton sampling throughout Lake Winnipeg in 1929 (Bajkov, 1934) and 1969 (Patalas and Salki, 1992) failed to uncover *E. coregoni*. From 1969 to 1994, zooplankton sampling was not undertaken on Lake Winnipeg, and it is conceivable that *E. coregoni* may have invaded the lake during this surveillance gap."

Means of Introduction Outside the United States

From Suchy et al. (2010):

"Over the last century, water bodies such as the Laurentian Great Lakes have received increasing numbers of NIS [nonindigenous species] due to the discharge of ballast water (Mills et al., 1993; Ricciardi and MacIsaac, 2000). In contrast, lakes in Central Canada are more likely to receive NIS as a result of dispersal over land and via interconnecting river systems."

Short Description

From Kipp et al. (2023):

“Females of this water flea exhibit larger and more variable traits with respect to the carapace and antennules than do males. The females’ large antennules are located anteriorly and ventrally. The females’ postabdominal claw is emarginate near the tip and has proximal pecten only, with 3–5 short spines. That of the male becomes very narrow distally. The anterior sensory bristle of this species is near the end of the rostrum and close to the attachment of the antennules. There is no mucro or the mucro is extremely small. The lateral headpore is close to the attachment of the mandibles but relatively far from the headshield (Deevey and Deevey 1971; Pennak 1989; Dodson and Frey 1991; Lord et al. 2006).”

Biology

From Kipp et al. (2024):

“Found in freshwater ponds and lakes. Algae-eating cladoceran; in less populated, homeostatic waters, *E. coregoni* infrequently reproduces sexually and instead maintains populations by parthenogenic females; maximum populations are found in late June in the US.”

“In eutrophic lakes in Europe, *E. coregoni* is often dominant in spring and fall. However, in the Great Lakes it is almost completely absent in spring and is more abundant in summer, potentially reaching densities of around 69,000 per m^2 in western Lake Erie and around 44,500 per m^2 in Lake Ontario. It has also been recorded at high densities in the fall in Lake Ontario and Lake Michigan (Roth and Stewart 1973; Geller and Müller 1981; Johansson and O’Gorman 1991; Barbiero et al. 2001).”

“*Eubosmina coregoni* filter feeds and feeds raptorially, selecting specific phytoplankton in the water column. It specifically selects particles of 0.5–5 µm in size and thus is much more tolerant of eutrophic conditions and the presence of cyanobacteria such as *Cylindrospermopsis raciborskii* than many larger *Daphnia spp*. Larger cladocerans experience difficulty feeding in the presence of cyanobacteria because they do not feed selectively and longer algae filaments clog their filtering apparatuses (Henning et al. 1991; Mayer et al. 1997; Cyr 1998; Donabaum et al. 1999).”

“Reproduction in *E. coregoni* can occur either between sexual females and males, or parthenogenetically in asexual females. The mean number of eggs found per individual from 1981–1986 in Lake Ontario ranged from around 0.4–1.2. *E. coregoni* can produce resting eggs that can stay dormant in the sediments for long periods of time. These eggs will hatch under the influence of specific environmental conditions. For example, *E. coregoni* was once recorded to emerge from resting eggs after a drought and the re-acidification of a lake in Sudbury, Canada (Johansson and O’Gorman 1991; Arnott and Yan 2002; Lord et al. 2006).”

Human Uses

No information was found on human uses of *Bosmina coregoni*.

Diseases

No information was found associating *Bosmina coregoni* with any diseases listed by the World Organisation of Animal Health (2023).

From Green (1974):

"*Jahnel's bacterium*
This rod form was described from *Daphnia longispina* in the Lunzersee, Austria. […] Infection always proved fatal to specimens brought into the laboratory. The same, or a similar bacterium was found in *Bosmina coregoni* var *longispina* from the same lake. […] Known only from the original locality in Austria."

"*Pythium daphnidarum* Petersen […]
Infection of the host takes place through the cuticle. Infections are most frequently found in the field in mid-summer, but may develop in laboratory populations at any time of year. […] The original description was based on infections found in the Danish lakes, Fure Sø, Esrom Sø and Hald Sø. The hosts were *Daphnia cucullata*, *D. hyalina* and *Bosmina coregoni*."

"*Colacium vesiculosum* Ehrenberg […]
There are numerous records of this species in the literature, mainly from Europe and North America but also from Australia (Playfair, 1921). [Distribution records include] Esthwaite [England], on *Ceriodaphnia megalops*, *Alonopsis elongata* and *Bosmina coregoni* (Jul. 1953)."

Threat to Humans

No information was found on threats to humans from *Bosmina coregoni*.

3 Impacts of Introductions

No information regarding documented impacts of introductions of *Bosmina coregoni* was found. The following quotations concern possible impacts.

From Smits et al. (2013):

"No studies from the Great Lakes region have directly addressed the ecological impacts of *B. coregoni* introduction to new aquatic habitats. In sporadically monitored lakes, realization of its presence can trail initial invasion by decades (Suchy and Hann 2007). Lake Washington's zooplankton community, monitored continuously since 1960 (Edmondson et al. 2003; Hampton and Schindler 2006), has undergone substantial shifts in species composition and abundance, often in clear response to changing environmental factors (Edmondson and Litt 1982). The addition of *B. coregoni* may shift population dynamics within the zooplankton community, since *B. coregoni* is larger than co-occurring bosminids *B. liederi* and *B. longispina* but likely too small to fall prey to juvenile sockeye salmon or other planktivorous fish (Scheuerell et al. 2005)."

From Fofonoff et al. (2018):

"The freshwater cladoceran *Bosmina coregoni* has become one of the dominant zooplankters of the Great Lakes, particularly in Lake Erie but was reduced to low levels of abundance after the invasion of the predatory cladoceran *Bythotrephes longimanus* (Mills et al. 1993; Barbiero [and Tuchman] 2004). The extent to which *B. coregoni* has affected native zooplankton composition or food webs is unclear. The very low abundances of this cladoceran in the Columbia River estuary (Smits et al. [2013]) indicate that detectable impacts are unlikely, at this time."

From Kipp et al. (2023):

"It is possible that the presence of *E. coregoni* and that of zebra mussel veligers (*Dreissena polymorpha*) in the zooplankton in Lake Ontario could have aided the establishment of the exotic blueback herring (*Alosa aestivalis*). *E. coregoni* also serves as a food item to introduced alewife (*A. pseudoharengus*) and the introduced spiny waterflea (*Bythotrephes longimanus*) in the Great Lakes (Mills et al. 1995; Molloy et al. 1997; Grigorovich et al. 1998)."

No species-specific regulations on possession or trade were found for *Bosmina coregoni* in the United States.

4 History of Invasiveness

The history of invasiveness for *Bosmina coregoni* is Data Deficient. There are records of established populations introduced beyond this species' native range across North America. Multiple authors have speculated on the potential impacts of *B. coregoni* where it has been introduced, but realized impacts of these introductions are unknown.

5 Global Distribution

Figure 1. Reported global distribution of *Bosmina coregoni*. Map from GBIF Secretariat (2022). Map created in Rstudio (2022) by utilizing data from GBIF Secretariat (2022) and using the tidyverse, leaflet, and rgbif packages (Wickham et al. 2019; Cheng et al. 2022; Chamberlain et al. 2023). Observations are reported from North America, Iceland, Brazil, Falkland Islands, Europe, and western Russia. Points in the Arctic Ocean; Nunavut and British Columbia, Canada; Iceland; Brazil; and the Falkland Islands were excluded from climate matching because they could not be verified as established populations.

6 Distribution Within the United States

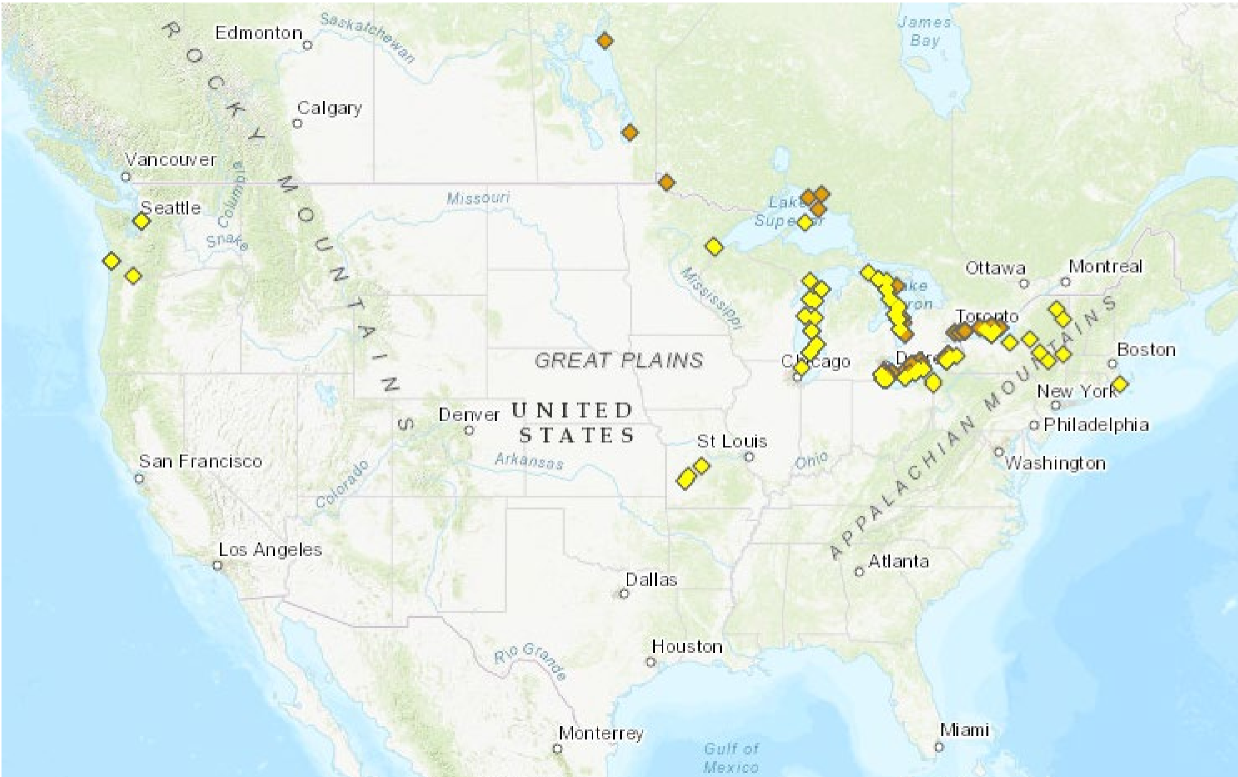

Figure 2. Reported distribution of *Bosmina coregoni* in the United States. Map from Kipp et al. (2024). U.S. observations are shown in yellow and are located in the Great Lakes, Missouri, and the Pacific Northwest. Observations from Canada are shown in orange. The reported occurrence from Cape Cod, Massachusetts, was not used to select source points for the climate matching analysis because of uncertainty about the status of that reported introduction.

7 Climate Matching

Summary of Climate Matching Analysis

The highest climate matches for *Bosmina coregoni* in the contiguous United States were found in the coastal Pacific Northwest, Great Lakes, and Midwest regions. High matches were also found in the Northeast and Mid-Atlantic regions, scattered through the Rocky Mountains, and along the Sierra Nevada. Low matches were found in the Sonoran and Mojave Desert regions of the Southwest, the Central Valley of California, the Olympic Peninsula of Washington, peninsular Florida, and along the Gulf Coast from Florida to Louisiana. Medium matches covered the interior Southeast, the western Great Plains, coastal California, and much of the interior West. The overall Climate 6 score (Sanders et al. 2023; 16 climate variables; Euclidean distance) for the contiguous United States was 0.701, indicating that Yes, there is establishment concern for this species. The Climate 6 score is calculated as: (count of target points with scores ≥ 6)/(count of all target points). Establishment concern is warranted for Climate 6 scores greater than or equal to 0.002 based on an analysis of the establishment success of 356 nonnative aquatic species introduced to the United States (USFWS 2024).

Projected climate matches in the contiguous United States under future climate scenarios are available for *Bosmina coregoni* (see Appendix). These projected climate matches are provided as additional context for the reader; future climate scenarios are not factored into the Overall Risk Assessment Category.

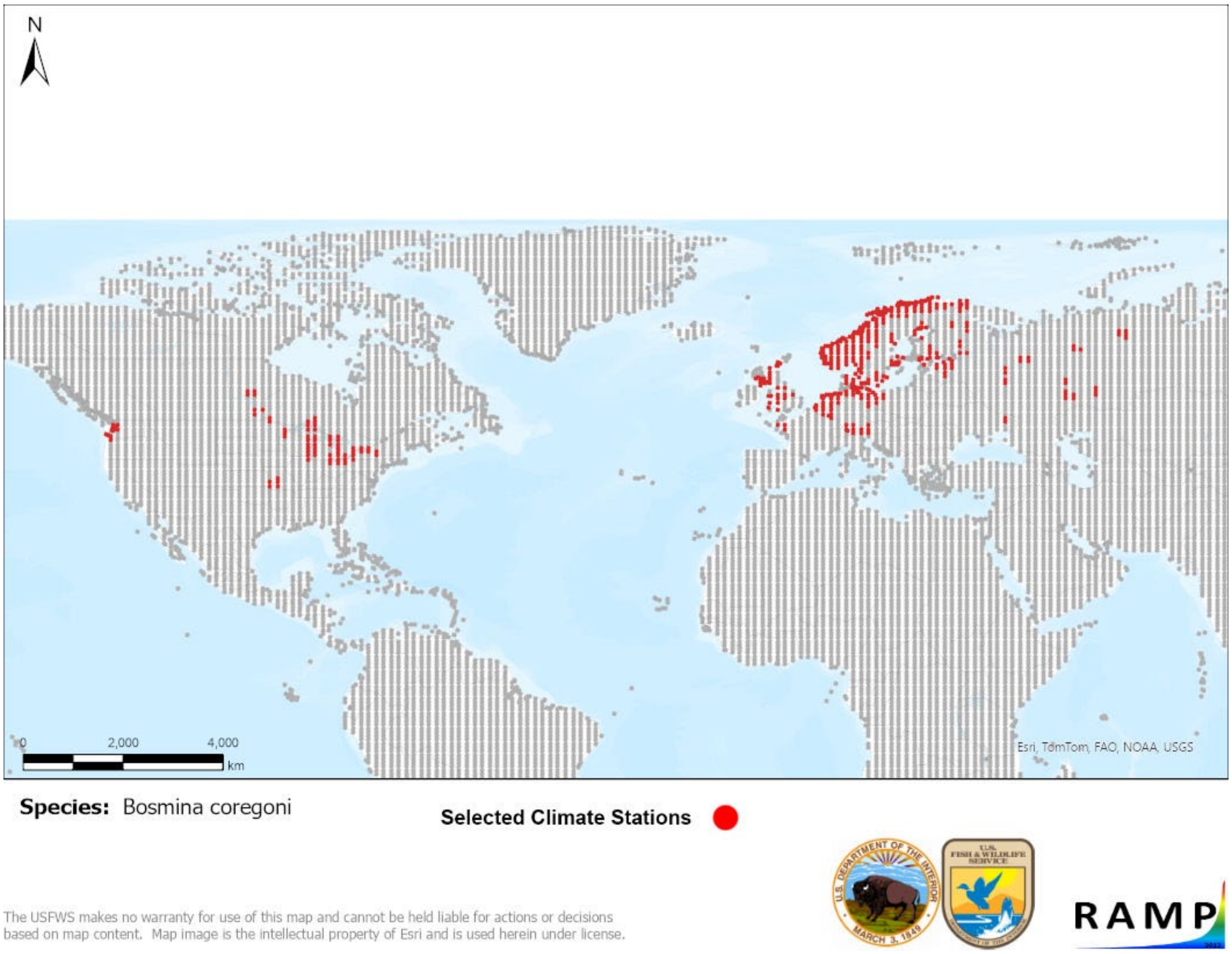

Figure 3. RAMP (Sanders et al. 2023) source map showing weather stations in North America, Europe, and western Russia selected as source locations (red; United States, Canada, United Kingdom, Norway, Sweden, Finland, Russia, Denmark, Belgium, The Netherlands, Germany, Switzerland, Italy, Austria, Poland, and Russia) and non-source locations (gray) for *Bosmina coregoni* climate matching. Source locations from GBIF Secretariat (2022). Selected source locations are within 100 km of one or more species occurrences, and do not necessarily represent the locations of occurrences themselves.

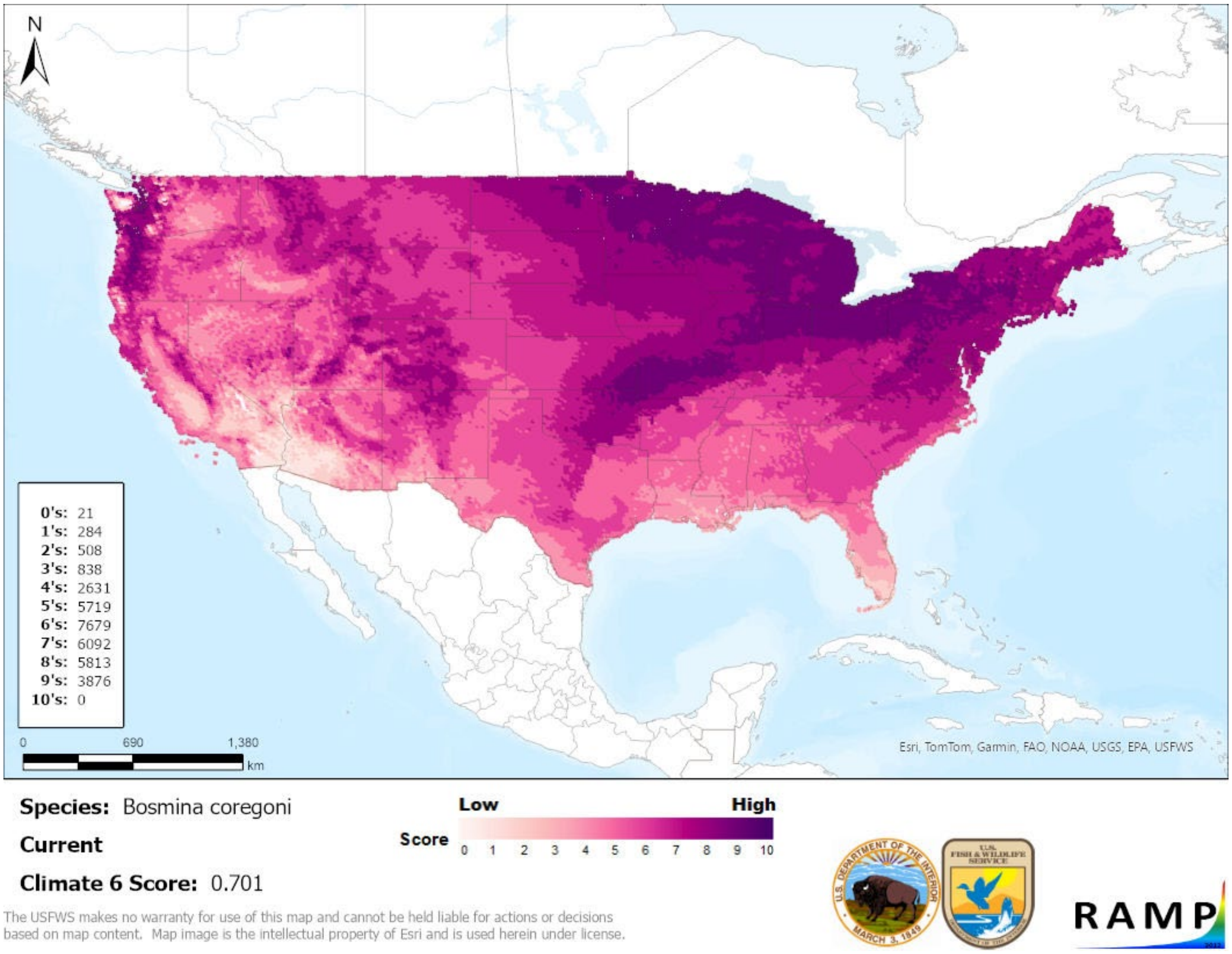

Figure 4. Map of RAMP (Sanders et al. 2023) climate matches for *Bosmina coregoni* in the contiguous United States based on source locations reported by GBIF Secretariat (2022). Counts of climate match scores are tabulated on the left. 0/Pale Pink = Lowest match, 10/Dark Purple = Highest match.

8 Certainty of Assessment

The certainty of assessment for *Bosmina coregoni* is Low. Taxonomic problems have made it difficult to differentiate the range of *B. coregoni* from those of other bosminids. Information on this species' biology and pathway of introduction into the United States is available. It has been hypothesized to have a role in shifting species composition and abundance of the zooplankton and fish communities in some locations where introduced. However, there is currently a lack of documentation of such proposed impacts.

9 Risk Assessment

Summary of Risk to the Contiguous United States

Bosmina coregoni is a species of water flea native to freshwaters of Europe and Asia. In the 1960s, it was introduced to the Great Lakes basin, probably through ballast water exchange. It has expanded its U.S. range to the Northeast, the Pacific Northwest, and Missouri. There are currently no regulations regarding this species within the United States. *B. coregoni* is a dominant constituent of the zooplankton community in some lakes in the contiguous United States, but specific ecological impacts of its abundance are not clear. Therefore, the History of Invasiveness is classified as Data Deficient. The climate matching analysis for *B. coregoni* in the contiguous United States indicates establishment concern for this species. High climate match was particularly widespread in the midwestern and northeastern United States. Certainty of this assessment is low due to a lack of evidence regarding the suggested negative impacts of this species' introduction. The Overall Risk Assessment Category for *Bosmina coregoni* in the contiguous United States is Uncertain.

Assessment Elements

- **History of Invasiveness (see section 4): Data Deficient**
- **Establishment Concern (see section 7): Yes**
- **Certainty of Assessment (see section 8): Low**
- **Remarks, Important additional information: *Eubosmina coregoni* is a commonly used synonym of *Bosmina coregoni*.**
- **Overall Risk Assessment Category: Uncertain**

10 Literature Cited

Note: The following references were accessed for this ERSS. References cited within quoted text but not accessed are included below in section 11.

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11 Literature Cited in Quoted Material

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.

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Appendix

Summary of Future Climate Matching Analysis

Future climate projections represent two Shared Socioeconomic Pathways (SSP) developed by the Intergovernmental Panel on Climate Change (IPCC 2021): SSP5, in which emissions triple by the end of the century; and SSP3, in which emissions double by the end of the century. Future climate matches were based on source locations reported by GBIF Secretariat (2022).

Under the future climate scenarios (figure A1), on average, high climate match for *Bosmina coregoni* was projected to occur primarily in the Great Lakes, Midwest, and Northeast regions of the contiguous United States. Smaller areas of high match appeared in the Rocky Mountains and along the Northern Pacific Coast under multiple scenarios. Most areas of high match were more restricted under SSP5 than under SSP3, and in 2085 relative to 2055. Areas of low climate match were projected to occur in southern Florida, along the Gulf Coast, and in the Southwest region. The Climate 6 scores for the individual future scenario models (figure A2) ranged from a low of 0.209 (model: UKESM1-0-LL, SSP5, 2085) to a high of 0.564 (model: MPI-ESM1-2-HR, SSP5, 2055). All future scenario Climate 6 scores were above the Establishment Concern threshold, indicating that Yes, there is establishment concern for this species under future scenarios. The Climate 6 score for the current climate match (0.701, figure 4) falls above the range of scores for future projections. The time step and climate scenario with the most change relative to current conditions was SSP5, 2085, the most extreme climate change scenario. Under multiple time step and climate scenarios, the northern Northeast saw a moderate increase in the climate match relative to current conditions. No large increases were observed regardless of time step and climate scenarios. Under one or more time step and climate scenarios, other areas within the Northeast, as well as within the Appalachian Range, Great Lakes, Mid-Atlantic, Northern Plains, and Southeast saw a large decrease in the climate match relative to current conditions. Additionally, areas within California, the Colorado Plateau, Great Basin, Northern Pacific Coast, Southern Atlantic Coast, Southern Plains, Southwest, and Western Mountains saw a moderate decrease in the climate match relative to current conditions. Additional, very small areas of large or moderate change may be visible on the maps (figure A3). At the 2055 time step, the changes were smaller in magnitude than at the 2085 time step. Under SSP5 in 2085, all regions of the contiguous United States had areas for which moderate to large changes in climate match were predicted.

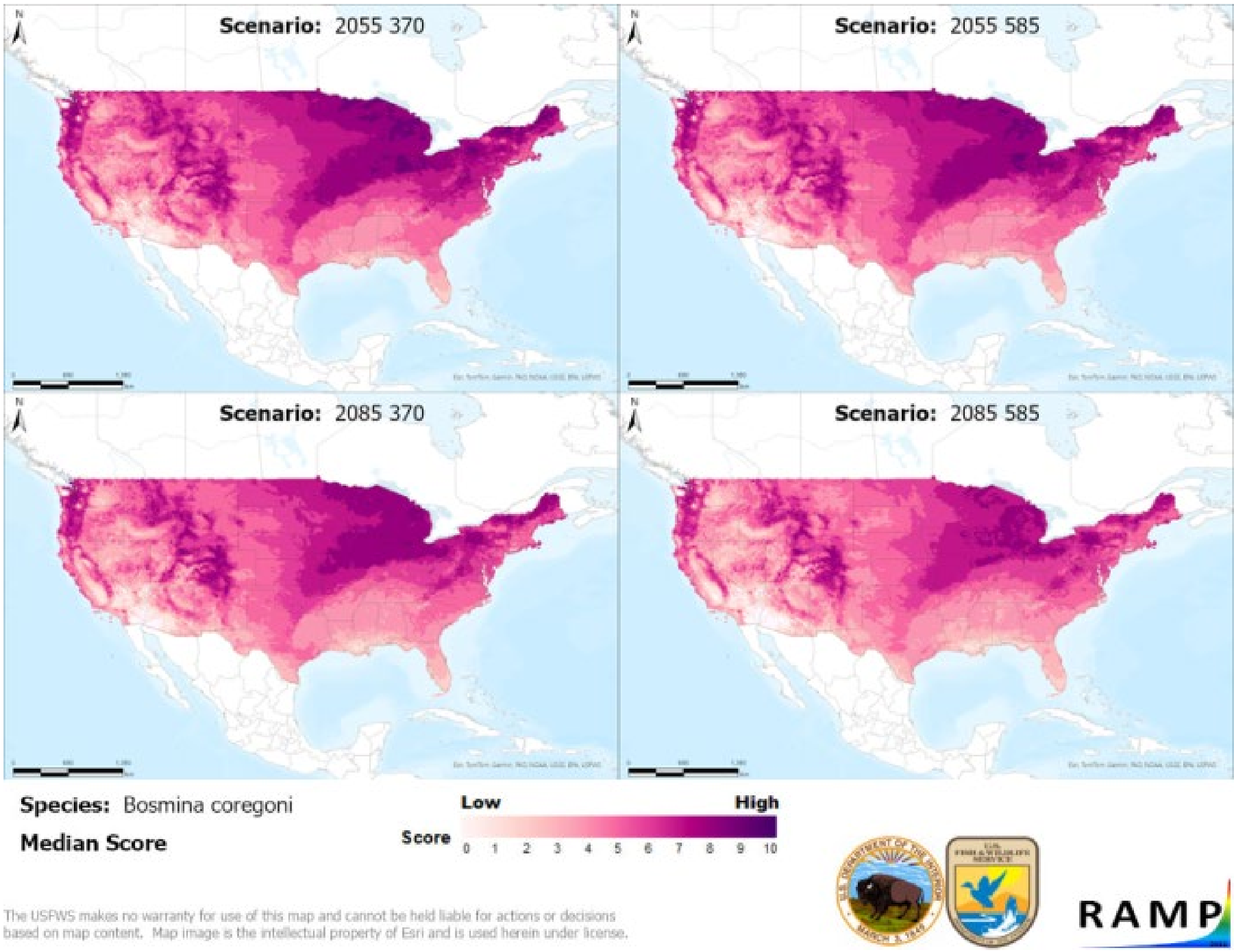

Figure A1. Maps of median RAMP (Sanders et al. 2023) climate matches projected under potential future climate conditions using five global climate models for *Bosmina coregoni* in the contiguous United States. Climate matching is based on source locations reported by GBIF Secretariat (2022). Shared Socioeconomic Pathways (SSPs) used (from left to right): SSP3, SSP5 (IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global climate models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0. 0/Pale Pink = Lowest match, 10/Dark Purple = Highest match.

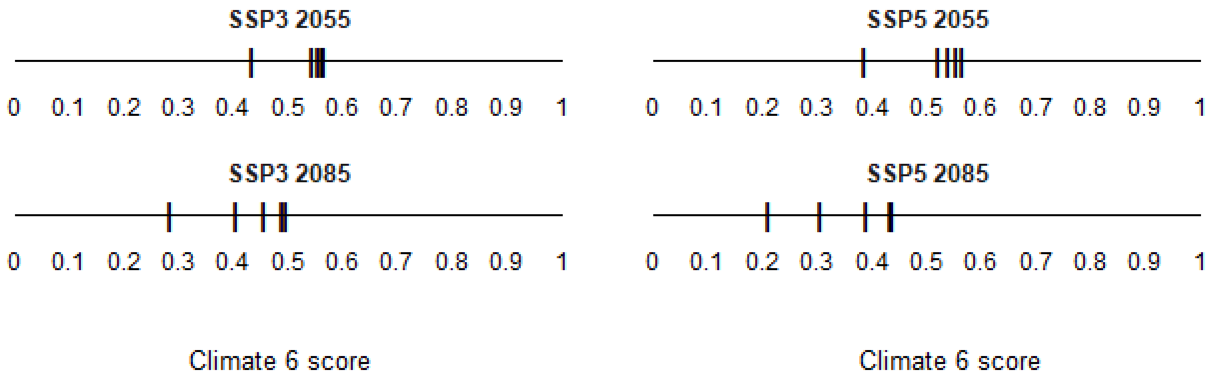

Figure A2. Comparison of projected future Climate 6 scores for *Bosmina coregoni* in the contiguous United States for each of five global climate models under four combinations of Shared Socioeconomic Pathway (SSP) and time step. SSPs used (from left to right): SSP3, SSP5 (Karger et al. 2017, 2018; IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global climate models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0.

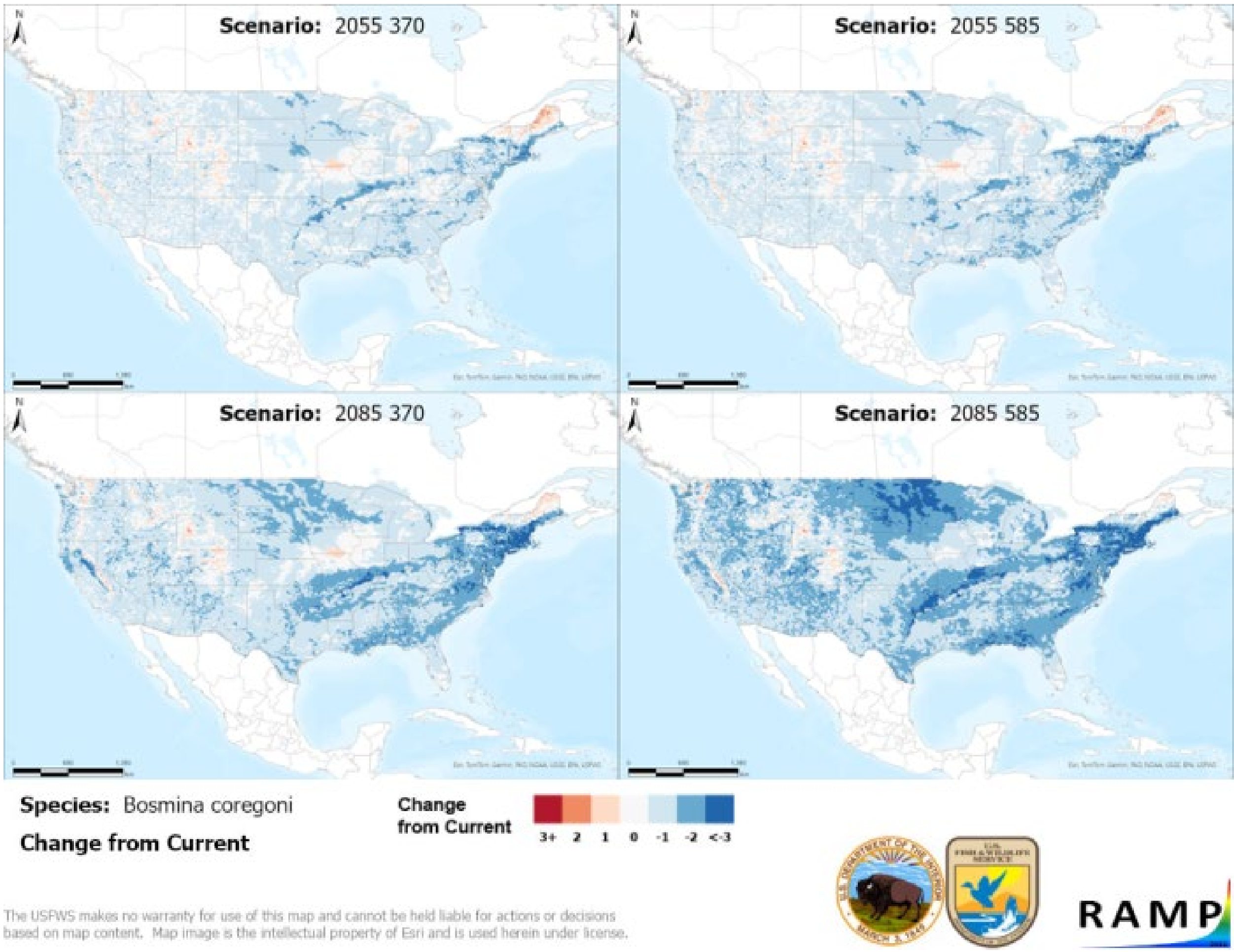

Figure A3. RAMP (Sanders et al. 2023) maps of the contiguous United States showing the difference between the current climate match target point score (figure 4) and the median target point score for future climate scenarios (figure A1) for *Bosmina coregoni* based on source locations reported by GBIF Secretariat (2022). Shared Socioeconomic Pathways (SSPs) used (from left to right): SSP3, SSP5 (IPCC 2021). Time steps: 2055 (top row) and 2085 (bottom row). Climate source data from CHELSA (Karger et al. 2017, 2018); global models used: GFDL-ESM4, UKESM1-0-LL, MPI-ESM1-2-HR, IPSL-CM6A-LR, and MRI-ESM2-0. Shades of blue indicate a lower target point score under future scenarios than under current conditions. Shades of red indicate a higher target point score under future scenarios than under current conditions. Darker shades indicate greater change.

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