Cyclops abyssorum divergens (a copepod, no common name)

Ecological Risk Screening Summary

U.S. Fish and Wildlife Service, January 2022
Revised, March 2022
Web Version, 4/21/2022

Organism Type: Crustacean
Overall Risk Assessment Category: Uncertain

Photo: J. Connolly. Used with permission.

1 Native Range and Status in the United States

Native Range

From Hołyńska (2008):

"The geographic distribution […] of *C. a. divergens*, as we now understand this taxon, extends at least from the southern part of the UK and Poland in the north to South Iran in the south, and from Portugal in the west to Uzbekistan in the east."

From Hołyńska and Wyngaard (2019):

"*Cyclops [abyssorum] divergens* has a wide Turano-European distribution (occurrence data are missing from Ukraine, Russia and Kazakhstan)."

Status in the United States

According to Connolly et al. (2022), *C. a. divergens* (as *C. divergens*; see Remarks) was first collected from the western basin of Lake Erie in 2013. It was detected again in 2014 and 2019, suggesting that a population is established.

C. a. divergens has not been reported from other locations in the United States. *C. a. divergens* is not in trade in the United States.

From Hawaii Department of Agriculture (2019):

"RESTRICTED ANIMAL LIST (Part B) […] ORDER Cyclopoida FAMILY Cyclopidae *Cyclops* (all species in genus)."

Means of Introductions in the United States

According to Connolly et al. (2022), the mechanism of *C. a. divergens* introduction to Lake Erie is unknown, although a ship ballast-related pathway is hypothesized.

Remarks

The taxonomic authorities used in this ERSS are defined in the SOP for the ERSS process and can be found online (https://www.fws.gov/fisheries/ANS/species_erss.html). The ERSS follows the chosen taxonomic authority for copepods and other crustaceans (World Register of Marine Species; Walter and Boxshall 2021) in treating *Cyclops abyssorum divergens* as the valid scientific name for the subject taxon. However, there is substantial uncertainty surrounding the taxonomy of *Cyclops* species and several recent publications recognize *C. divergens* as the valid scientific name. Information for this assessment was searched for using the valid name according to Walter and Boxshall (2021), *Cyclops abyssorum divergens*, and the following synonyms: *C. divergens*, *C. abyssorum vranae*, *C. bohater ponorensis*, *C. singularis*, *C. strenuus divergens*, and *C. strenuus vranae* (Walter and Boxshall 2021).

From Hołyńska and Wyngaard (2019):

"*Cyclops* has a long history in copepod systematic studies. While it is relatively easy to distinguish this group from other cyclopid genera, delineation of the species and the evolutionary lineages within the genus have always posed serious problems. Their conservative gross morphology, local varieties and different ecophenotypes observed in species with fragmented ranges (e.g., in *C. abyssorum* and *C. scutifer* G.O. Sars, 1863) have resulted in a "fluid taxonomy," in which the taxonomic position of many forms and the number of putative species have changed substantially among different authors [e.g., 45 (sub)species by Lindberg, 1957, vs. 23 species by Einsle, 1996[b]]."

From Hołyńska (2008):

"The morphology of a large majority of the taxa [in the genus *Cyclops*] so far described [60 (sub)species – Lindberg 1957; Dussart and Defaye 2006] is poorly known and their taxonomic positions remain obscure. The evolutionary history of this predominantly Palearctic group seems

to be strongly influenced by pleistocene and post-pleistocene climatic and hydrological changes, and the extent of morphological divergence between *Cyclops* lineages, in comparison to those in more widely distributed cyclopid genera, is often very low. The systematics of the group was further complicated by an erroneous typological species concept (for critique of the typological approach see Nilssen 1979) which, neglecting the morphological and ecological plasticity of species, has resulted in a jungle of names (in Central and Southern Europe alone 20 subspecies, ecotypes and local forms of *Cyclops abyssorum* have already been described) and rendered understanding the biology of the group very difficult."

Additional information for *Cyclops abyssorum divergens* and its synonyms was found during this assessment in languages other than English. This information is not included in the ERSS.

2 Biology and Ecology

Taxonomic Hierarchy and Taxonomic Standing

From Walter and Boxshall (2021):

"Animalia (Kingdom) > Arthropoda (Phylum) > Crustacea (Subphylum) > Multicrustacea (Superclass) > Hexanauplia (Class) > Copepoda (Subclass) > Neocopepoda (Infraclass) > Podoplea (Superorder) > Cyclopoida (Order) > Cyclopida (Suborder) > Cyclopidae (Family) > *Cyclops* (Genus) > *Cyclops abyssorum* (Species) > *Cyclops abyssorum divergens* (Subspecies)"

"Status accepted"

Size, Weight, and Age Range

From Hołyńska (2008):

"Male. Body length 1240–1650 µm. Cephalothorax length/width: 1.1–1.3."

According to Hołyńska (2008), the body length of female *C. a. divergens* syntypes ranged from 1800–1810 µm.

Environment

From Hołyńska (2008):

"Lindberg (1936) described *C. strenuus divergens* from cisterns and wells in the Zagros Mountains at 1600–1700m [...]"

"In a later publication, Lindberg (1942) added several new Iranian records from the Caspian Sea region to the Persian Gulf, from localities near sea level to sites at almost 1700m a.s.l. [above sea level], both fresh and saline habitats, predominantly small and/or ephemeral waterbodies (cistern, water basin, well, puddle, marsh, ricefield)."

"Naidenow and Pandurski (1992) described *C. bohater ponorensis* from subterranean habitats, small ponds and pools near the entrance of a cave at 1300m a.s.l. [above sea level] in the Western Balkans Mountains (Bulgaria)."

From Krajíček et al. (2015):

"*Cyclops divergens* inhabits small astatic puddles, riverine pools and small ponds, but also lives in the plankton of lakes and reservoirs."

Climate

From Hołyńska (2008):

"In a paper on the geographic distribution of cladoceran diversity, Korovchinsky (2006) demonstrated that water fleas have the greatest species richness in the warm temperate subtropical zone (25°–50°), which is also suggested to be the region where primitive taxa are concentrated. In the genus *Cyclops*, which is commonly considered as a cold-adapted group, about half of the (sub)species, including both taxa redescribed here [*C. abyssorum divergens* and *C. ankyrae*], also spread through the above mentioned zone (Lindberg 1957; Dussart and Defaye 2006)."

Distribution Outside the United States

Native

From Hołyńska (2008):

"The geographic distribution […] of *C. a. divergens*, as we now understand this taxon, extends at least from the southern part of the UK and Poland in the north to South Iran in the south, and from Portugal in the west to Uzbekistan in the east."

From Hołyńska and Wyngaard (2019):

"*Cyclops [abyssorum] divergens* has a wide Turano-European distribution (occurrence data are missing from Ukraine, Russia and Kazakhstan)."

Introduced

No nonnative introductions of *C. a. divergens* have been reported outside the United States.

Means of Introduction Outside the United States

No nonnative introductions of *C. a. divergens* have been reported outside the United States.

Short Description

From Hołyńska (2008):

"*Cyclops abyssorum divergens* can be distinguished from congeners by combinations of characters: lack of posterior wings on pediger 4 […]; presence of lateroventral lobes on pediger 5

[…]; inner median caudal seta short, usually 0.5–0.7 times as long as urosome; 17-segmented antennule; transverse row of large spinules on the maxillular palp […], and presence of long setules on the proximal half of the proximalmost seta of the palp […]; the ornamentation of the frontal surface of the maxilliped syncoxopodite (small or medium-sized spinules between median and distalmost setae, tiny more proximally and sometimes near the distal margin) […]; lack of hairs or spinules on the lateral margin of P4 coxopodite […]; couplers caudally bare on P1–P3, and pilose on P4; absence of spinules at the insertion of lateral setae of P5 […]; spine formula 3433 on P1–P4 exopodites; presence of large spinules on the frontal surface of P1 basipodite […]; and long stiff setules on the proximal half of P1 medial spine […]."

Biology

From Einsle (1996a):

"Ecology: In 1994, in the 'Litzelsee' [pond in southern Germany] this species [*Cyclops abyssorum divergens* as *C. singularis*] appeared later than either *C. furcifer* or *C. heberti*. In the samples available it was normally found in early April. The details of diapause behavior are not yet clear. The generation in April consists of the large females with a body size of 2300 to 2400 µm, but following cohorts are smaller, with the summer generation in 1982 averaging 1700 µm in length. The number of eggs per eggsac varied from a high of 80 to 120 in April 1994 to only 20 eggs per eggsac in May 1994 or July 1982. The most striking peculiarity of this species, its extremely high swimming speed, was mentioned above. This too may be seen as species character of remarkable importance."

Human Uses

From El-khodary et al. (2020):

"The copepods value in aquaculture has long been characterized, particularly in the larval rearing of many marine organisms (Lee et al., 2006)."

"*Cyclops* spp. is among the most common zooplankton in fish larval rearing tanks of the Marine Hatchery of the National Institute of Oceanography and Fisheries, Alexandria, Egypt. This study aims to investigate the molecular analysis of this species and to evaluate the effect of a feeding diet composed of soybean, yeast, and microalgae (*Tetraselmis chuii*) on their population density and nutritional value. Phylogenetic identification of this species was conducted using (12S) rRNA molecular marker technique. The analysis showed that the investigated sample could be identified as *Cyclops abyssorum divergens*."

Diseases

No records of OIE-reportable diseases (OIE 2022) were found for *Cyclops abyssorum divergens.*

No information on diseases associated with *Cyclops abyssorum divergens* was found.

Threat to Humans

No information on threats to humans for *Cyclops abyssorum divergens* was found.

3 Impacts of Introductions

Although there is a recent record of introduction for *Cyclops abyssorum divergens* outside of its native range, there is no information available on potential or observed impacts of introduction.

From J. Connolly (Cornell University, personal communication, 2022):

"It's difficult to say if (or to what extent) these newly detected species [*C. a. divergens* and *C. strenuus sibiricus*] might compete with native cyclopoids. In the case of *C.* [*a.*] *divergens* the abundance of the species is very low (almost undetectable) in Lake Erie so at this point I wouldn't think its presence would have a negative impact on native taxa."

Private and commercial use of *C. a. divergens* is restricted in Hawaii, along with other species and subspecies in the genus *Cyclops*.

4 History of Invasiveness

The history of invasiveness for *Cyclops abyssorum divergens* is Data Deficient. Even though there is a record of introduction that has led to establishment in the western basin of Lake Erie in North America, the impacts of this introduction are unknown. No trade history associated with *C. a. divergens* was found.

5 Global Distribution

Figure 1. Known distribution of *Cyclops abyssorum divergens*. Observations are reported from Europe. Map from GBIF Secretariat (2022).

Figure 2. Additional known distribution of *Cyclops abyssorum divergens*. Observations are reported from Lake Erie in North America, Europe, and western Asia. Map from Esri (2022) based on locations described by Hołyńska (2008) and Connolly et al. (2022).

6 Distribution Within the United States

Figure 3. Known distribution of *Cyclops abyssorum divergens* in Lake Erie, United States. Map from Esri (2022) based on locations decribed by Connolly et al. (2022).

7 Climate Matching

Summary of Climate Matching Analysis

The climate match for *Cyclops abyssorum divergens* in the contiguous United States was generally medium to high. High matches were found in western States, the Midwest, Great Lakes

basin, and portions of the Mid-Atlantic and Northeast. Isolated low matches were found in the Pacific Northwest and extreme peninsular Florida. The overall Climate 6 score (Sanders et al. 2021; 16 climate variables; Euclidean distance) for the contiguous United States was 0.855, high (scores greater than or equal to 0.103, are classified as high). All States had high individual Climate 6 scores, except for Florida which had a medium individual Climate 6 score.

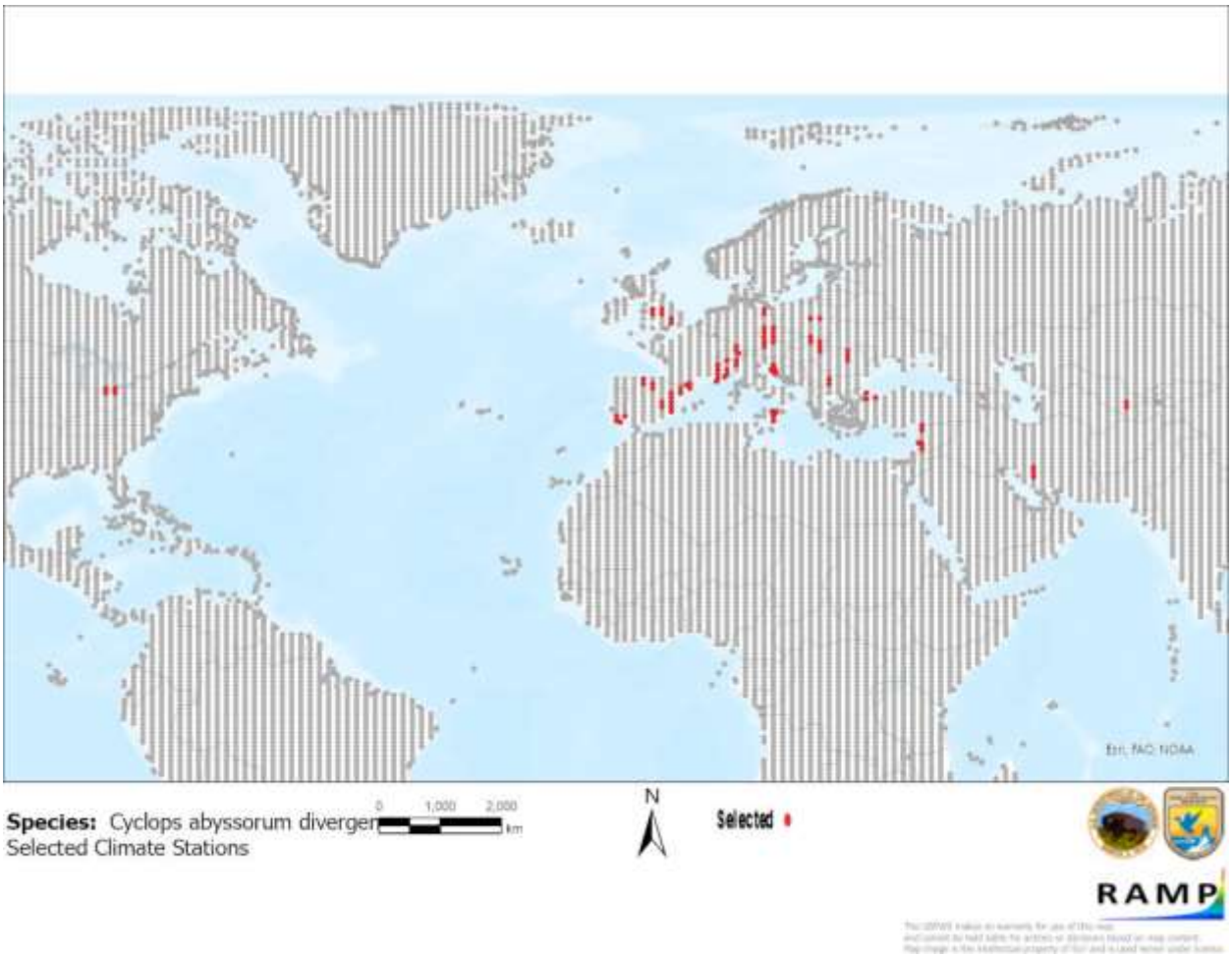

Figure 4. RAMP (Sanders et al. 2021) source map showing weather stations in the northern hemisphere selected as source locations (red; United States, Canada, Portugal, Spain, France, United Kingdom, Switzerland, Italy, Germany, Austria, Poland, Czechia, Croatia, Slovakia, Hungary, Bulgaria, Romania, Turkey, Lebanon, Syria, Iran, and Uzbekistan) and non-source locations (gray) for *Cyclops abyssorum divergens* climate matching. Source locations from GBIF Secretariat (2022), Hołyńska (2008), and Connolly et al. (2022). Selected source locations are within 100 km of one or more species occurrences, and do not necessarily represent the locations of occurrences themselves.

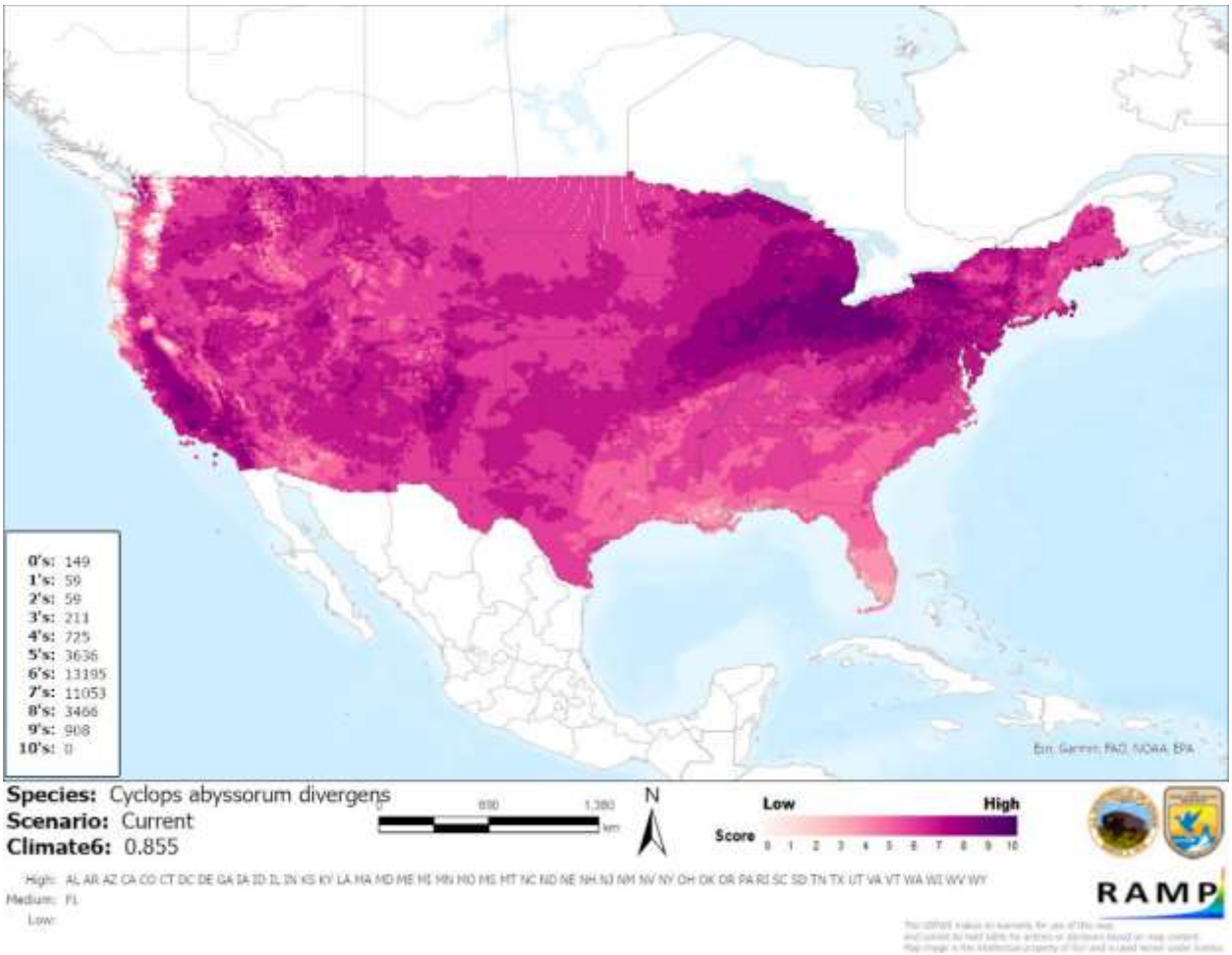

Figure 5. Map of RAMP (Sanders et al. 2021) climate matches for *Cyclops abyssorum divergens* in the contiguous United States based on source locations reported by GBIF Secretariat (2022), Hołyńska (2008), and Connolly et al. (2022). Counts of climate match scores are tabulated on the left. 0/Pale Pink = Lowest match, 10/Dark Purple = Highest match.

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

Climate 6: (Count of target points with climate scores 6-10)/ (Count of all target points)	Overall Climate Match Category
0.000≤X≤0.005	Low
0.005<X<0.103	Medium
≥0.103	High

8 Certainty of Assessment

The certainty of this assessment is low. Biological information for *Cyclops abyssorum divergens* was limited and georeferenced occurrences were not available throughout its range. Additionally, substantial taxonomic uncertainty exists for species and subspecies in the genus *Cyclops*.

C. abyssorum divergens has become established outside its native range, but the impacts of its introduction remain unknown.

9 Risk Assessment

Summary of Risk to the Contiguous United States

Cyclops abyssorum divergens is a cyclopoid copepod with a native range that extends across southern and central Europe to southwest Asia. It has been introduced and become established outside of its native range in western Lake Erie in North America; impacts associated with this introduction are unknown. No trade history was found, and the State of Hawaii restricts private and commercial use of all species in the genus *Cyclops*. The history of invasiveness is Data Deficient. Substantial taxonomic uncertainty was identified during this assessment, with many sources identifying this species as *C. divergens* or other synonyms. The climate match for the contiguous United States was categorically high with the highest matches occurring in western States, the Midwest, Great Lakes basin, and portions of the Mid-Atlantic and Northeast. The certainty of this assessment is low due to a lack of biological information, taxonomic uncertainty, and unknown impacts of introduction. The overall risk assessment category for *C. divergens* is Uncertain.

Assessment Elements

- **History of Invasiveness (Sec. 4): Data Deficient**
- **Overall Climate Match Category (Sec. 7): High**
- **Certainty of Assessment (Sec. 8): Low**
- **Remarks, Important additional information: Some information for this ERSS was derived from sources treating this organism as *C. divergens* or other recognized synonyms of *C. abyssorum divergens*.**
- **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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Walter TC, Boxshall G. 2021. *Cyclops abyssorum divergens* (Lindberg, 1936). World Register of Marine Species. Available: https://www.marinespecies.org/aphia.php?p=taxdetails&id=363055 (January 2022).

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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Einsle UK. 1996b. Copepoda: Cyclopoida: genera Cyclops, Megacyclops, Acanthocyclops. Pages 1–82 in Dumont HJF, editor. Guides to the identification of the microinvertebrates of the continental waters of the world. Volume 14. Leiden, The Netherlands: Backhuys.

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Lee KW, Park HG, Lee SM, Kang HK. 2006. Effects of diets on the growth of the brackish water cyclopoid copepod *Paracyclopina nana* Smirnov. Aquaculture 256:346–353.

Lindberg K. 1936. Notes sur des Cyclopides (Crustacés copépodes) de l'Iran. Bulletin du Musée royal d'histoire naturelle de Belgique 12(17):1–26.

Lindberg K. 1942. Cyclopides (Crustacés copépodes) de l'Inde, XIV–XVIII. Records of the Indian Museum 44:139–190.

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