

Exotic cyclopoid copepod (*Thermocyclops crassus*) detected in Lake Erie



Connolly, J.K.¹, Watkins, J.M.¹, Warren, G.J.², and Rudstam, L.G.¹

¹Cornell University, Department of Natural Resources, 110 Fernow Hall, Ithaca, NY, 14853, USA

²US Environmental Protection Agency, Great Lakes National Program Office (US EPA GLNPO) 77 W. Jackson Blvd., Chicago, IL 60604



Why Is This Detection Important?

- First detection of a new exotic invertebrate species in the Great Lakes since 2006 (Pothoven et al., 2007).



Thermocyclops crassus (Fischer, 1853)

- Small cyclopoid copepod approximately 0.6-0.9mm in length
- Free Living/Planktonic copepod
- Suggested to be largely herbivorous (Hopp and Maier, 2005)
- Displays preference for mesotrophic to eutrophic environments
- Native range includes most of Europe, as well as parts of Asia, and Africa
- Native range includes temperate and tropical climates
- Few isolated introductions to the western hemisphere have been documented (Reid, 1989)



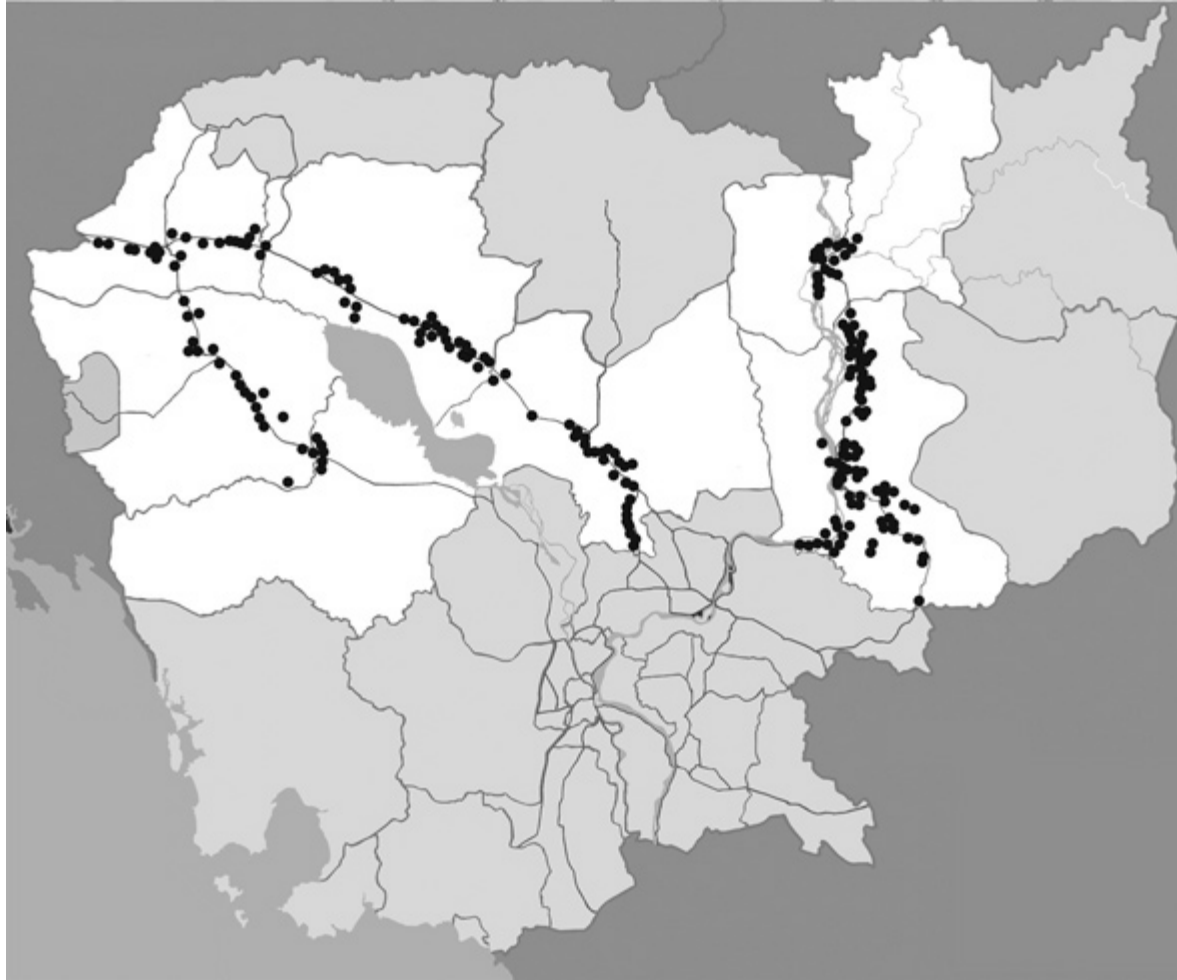
Thermocyclops crassus Native Range



T. crassus native range in Europe (Bledzki and Rybak, 2016).

- *T. crassus* is widespread and common across most of continental Europe.

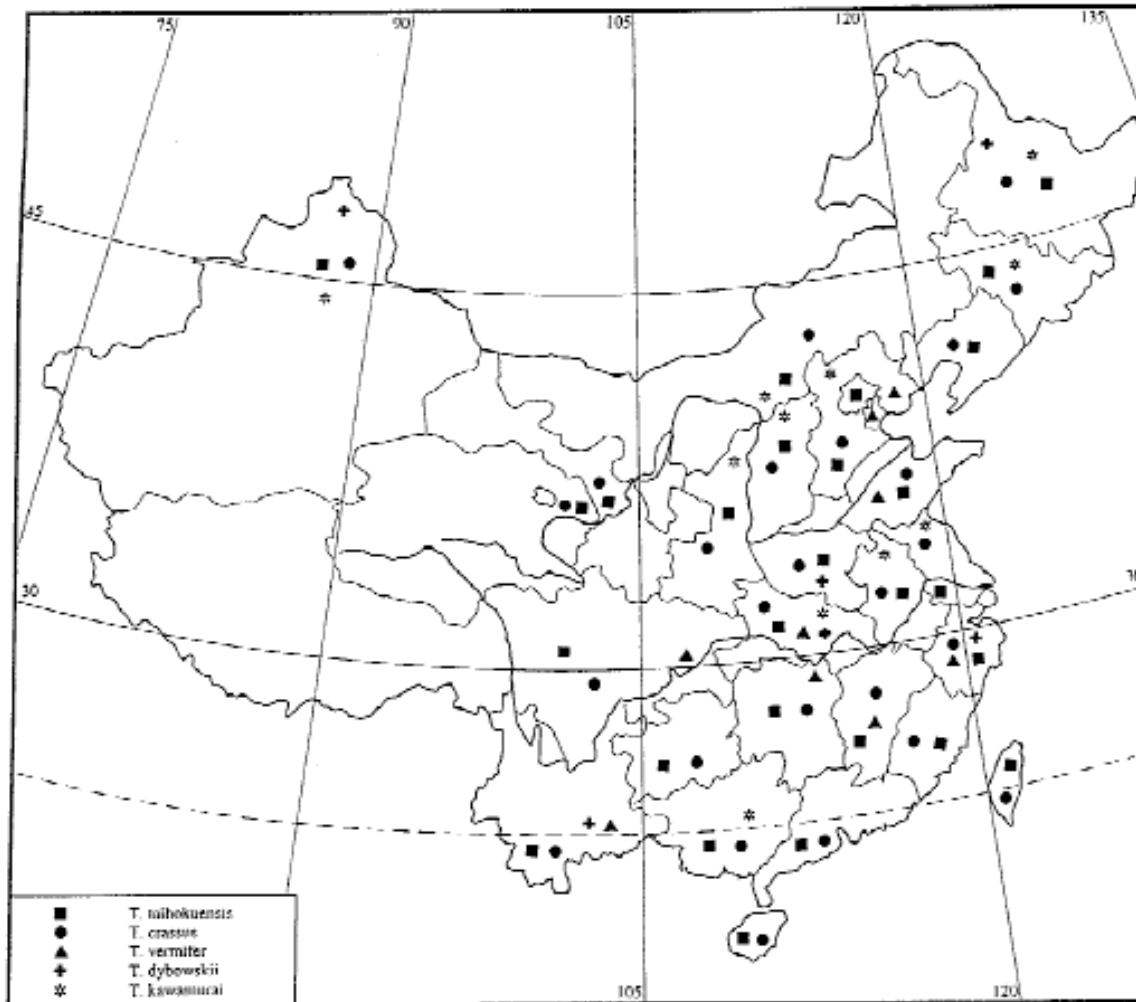
Thermocyclops crassus Native Range



T. crassus range in Cambodia (Chaicharoen et al., 2011).

- During 2011 intensive sampling of Cambodia, *T. crassus* was the most commonly encountered member of the genus.

Thermocyclops crassus Native Range



T. crassus native range in China (Xiaoming, 1999).

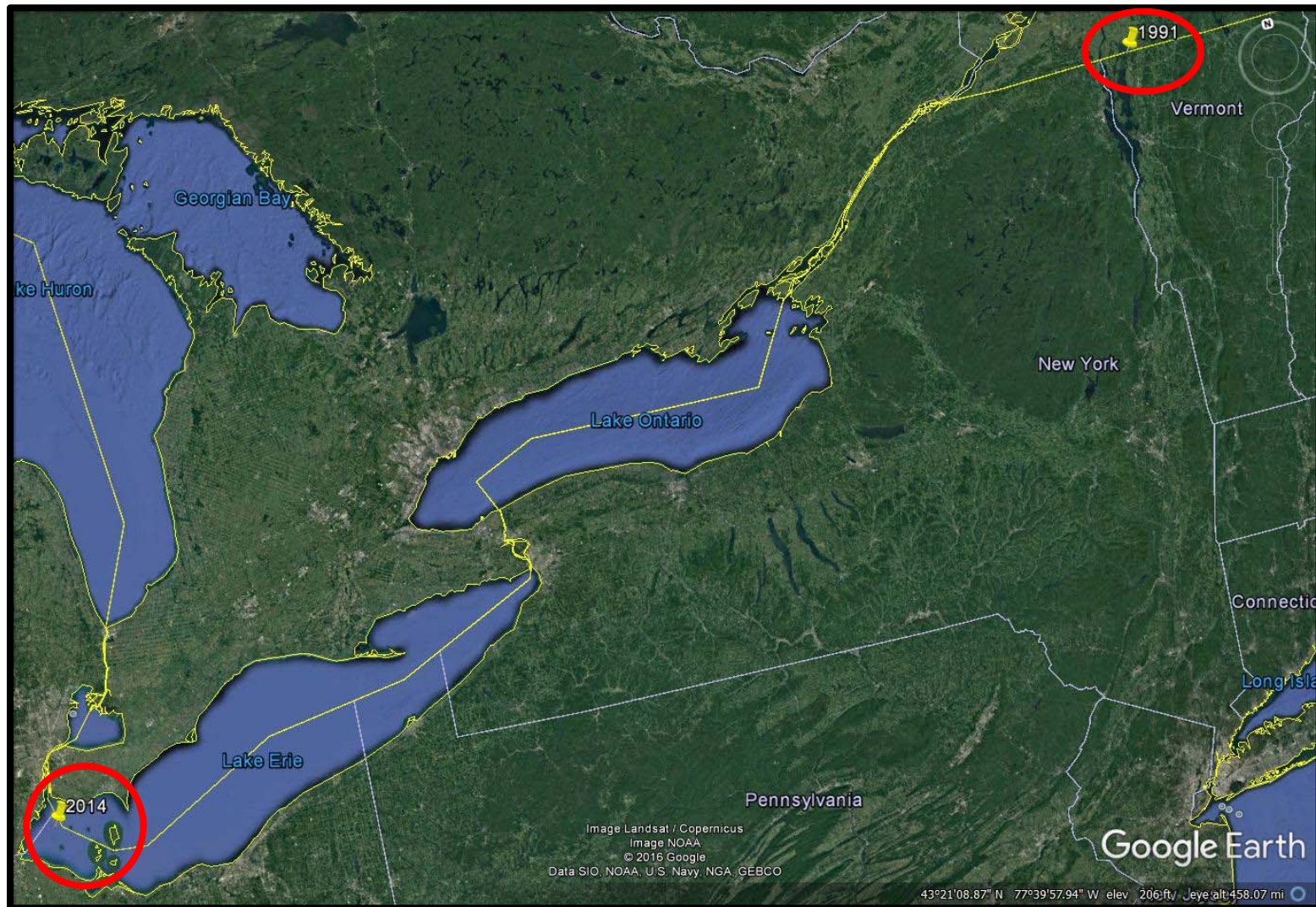
- *T. crassus* is common and widespread throughout much of China with the exception of the Tibetan plateau.

Thermocyclops crassus Western Hemisphere Introductions:



- **1983** small ponds, San José province, Costa Rica (Collado et al., 1984)
- **1998** small ponds and lagoons, Tabasco state, Mexico (Gutiérrez-Aguirre and Suárez-Morales, 2000)

Thermocyclops crassus Western Hemisphere Introductions:



- **1991** Missisquoi Bay, Lake Champlain, USA & Canada (Duchovnay et al., 1992)
- **2014** Western basin, Lake Erie, USA & Canada (Connolly et al., 2017)

Detection of *Thermocyclops crassus* in Lake Erie



- *T. crassus* detections were made as part of a U.S. EPA GLNPO long-term biological monitoring program and underscores the need for regular monitoring efforts.
- Initial detection of *T. crassus* occurred in samples collected August 2014. No detections of *T. crassus* have been reported in the Great Lakes prior to this date.
- Subsequent detections occurred in samples collected August 2015 & August 2016.

Method of *Thermocyclops crassus* Introduction into Lake Erie

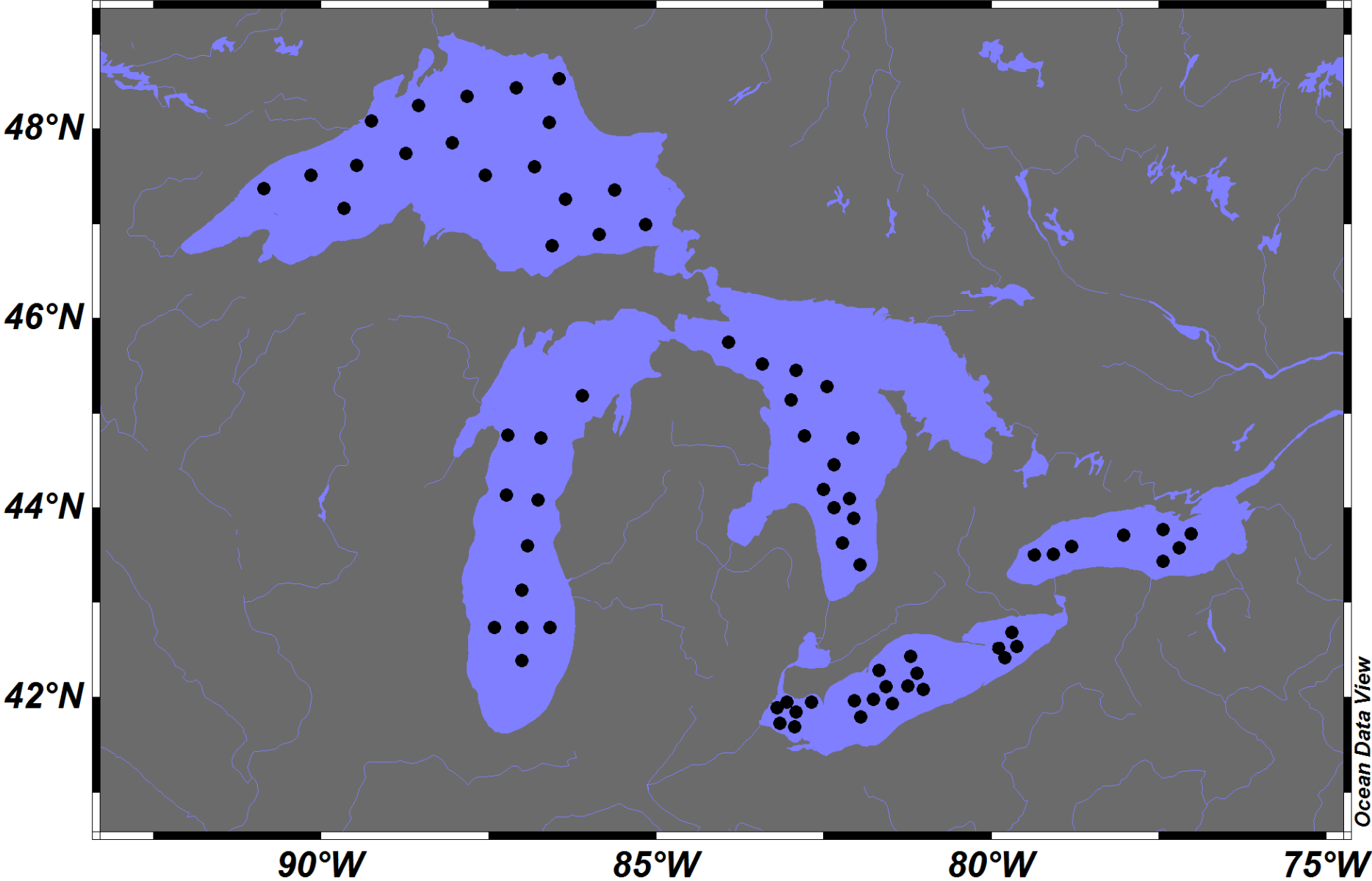
- The specific method of *Thermocyclops crassus* introduction into Lake Erie is currently unknown.



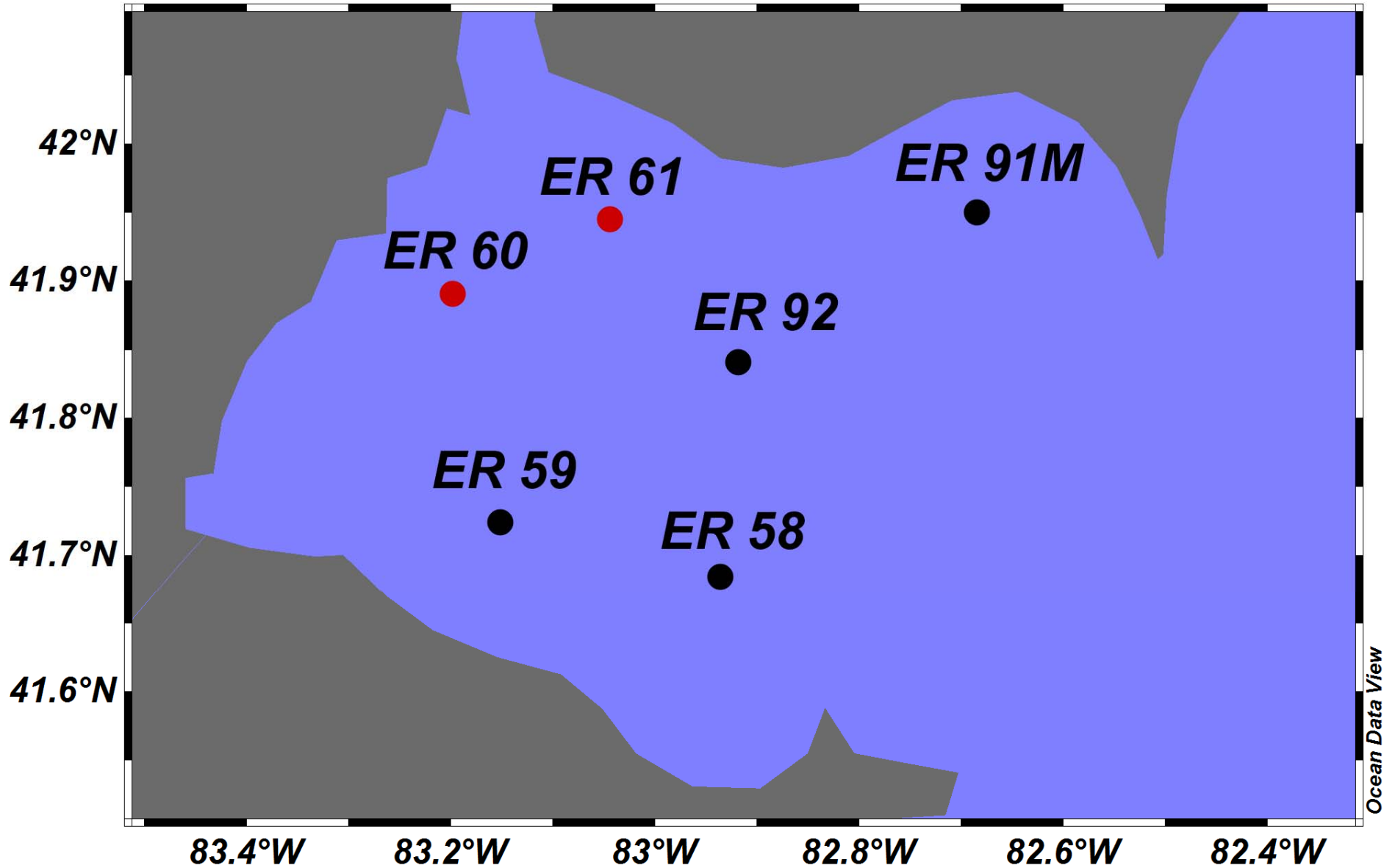
Possible Methods of Introduction:

- Ballast water exchange from Trans-oceanic vessels (Duggan et al., 2005).
- Transport from Lake Champlain via unknown mechanism.
- Introduced prior to 2014 but remained undetected due to sustained extremely low density.

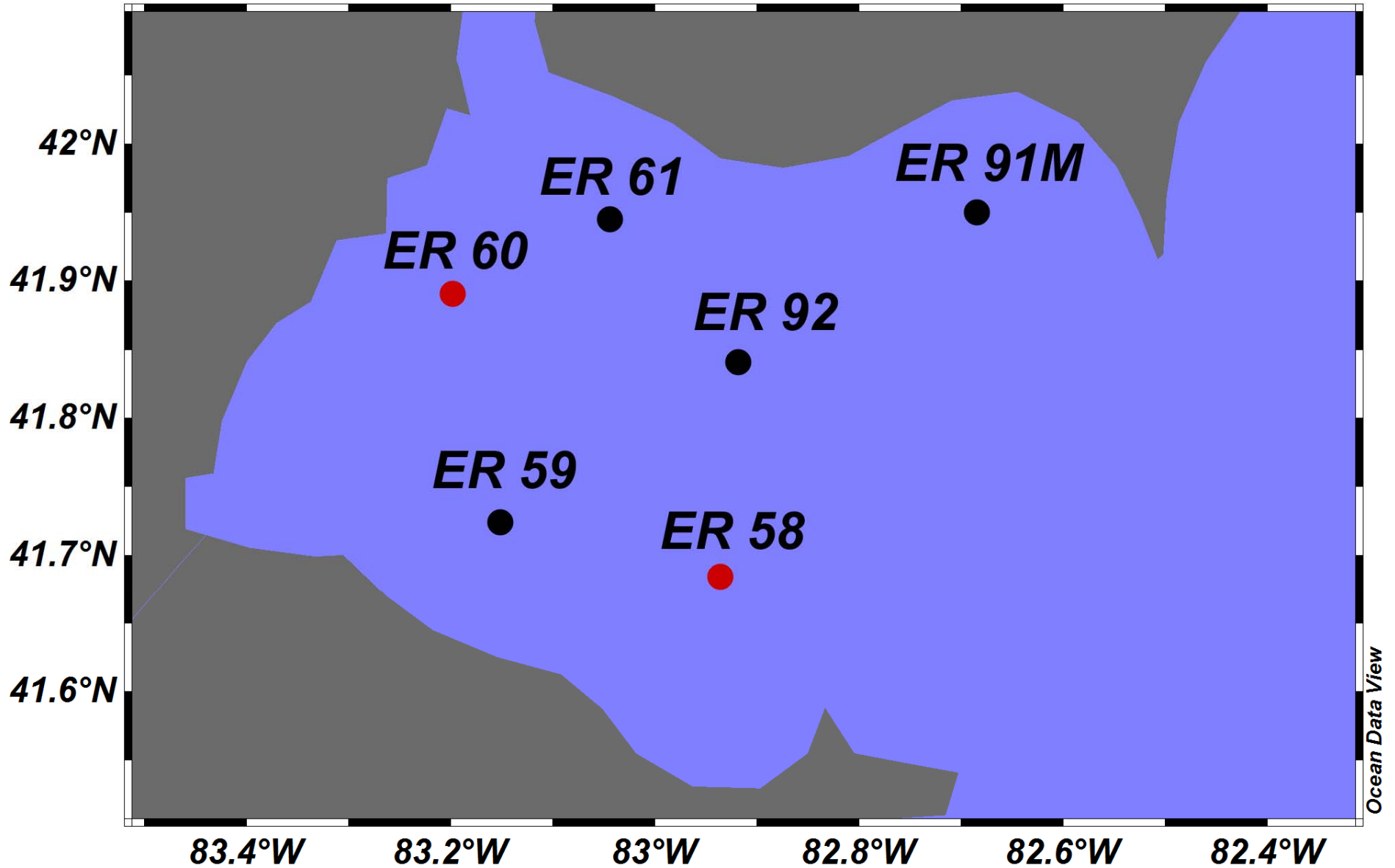
Monitoring *Thermocyclops crassus* Range in Lake Erie



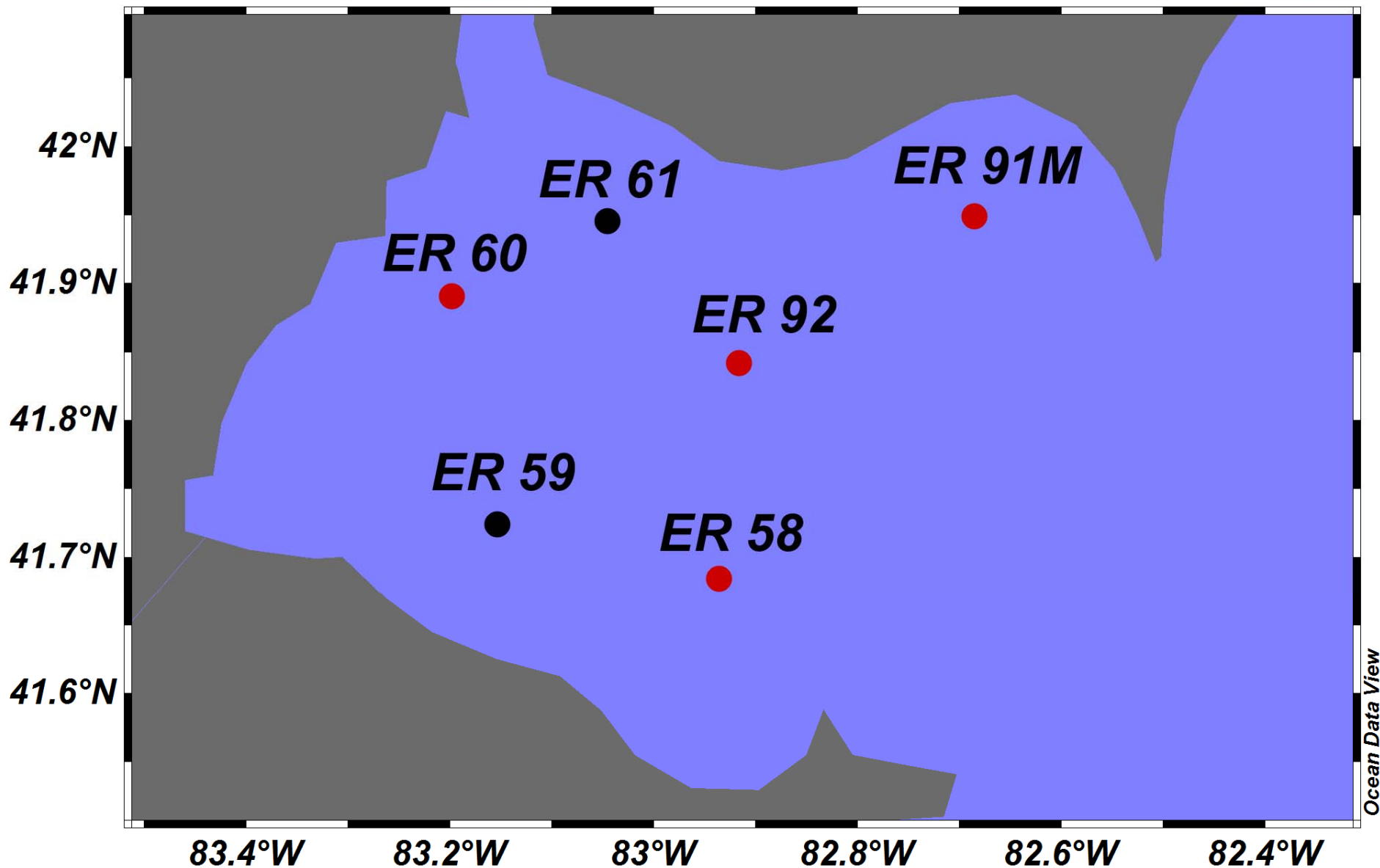
Monitoring *Thermocyclops crassus* Range in Lake Erie: 2014



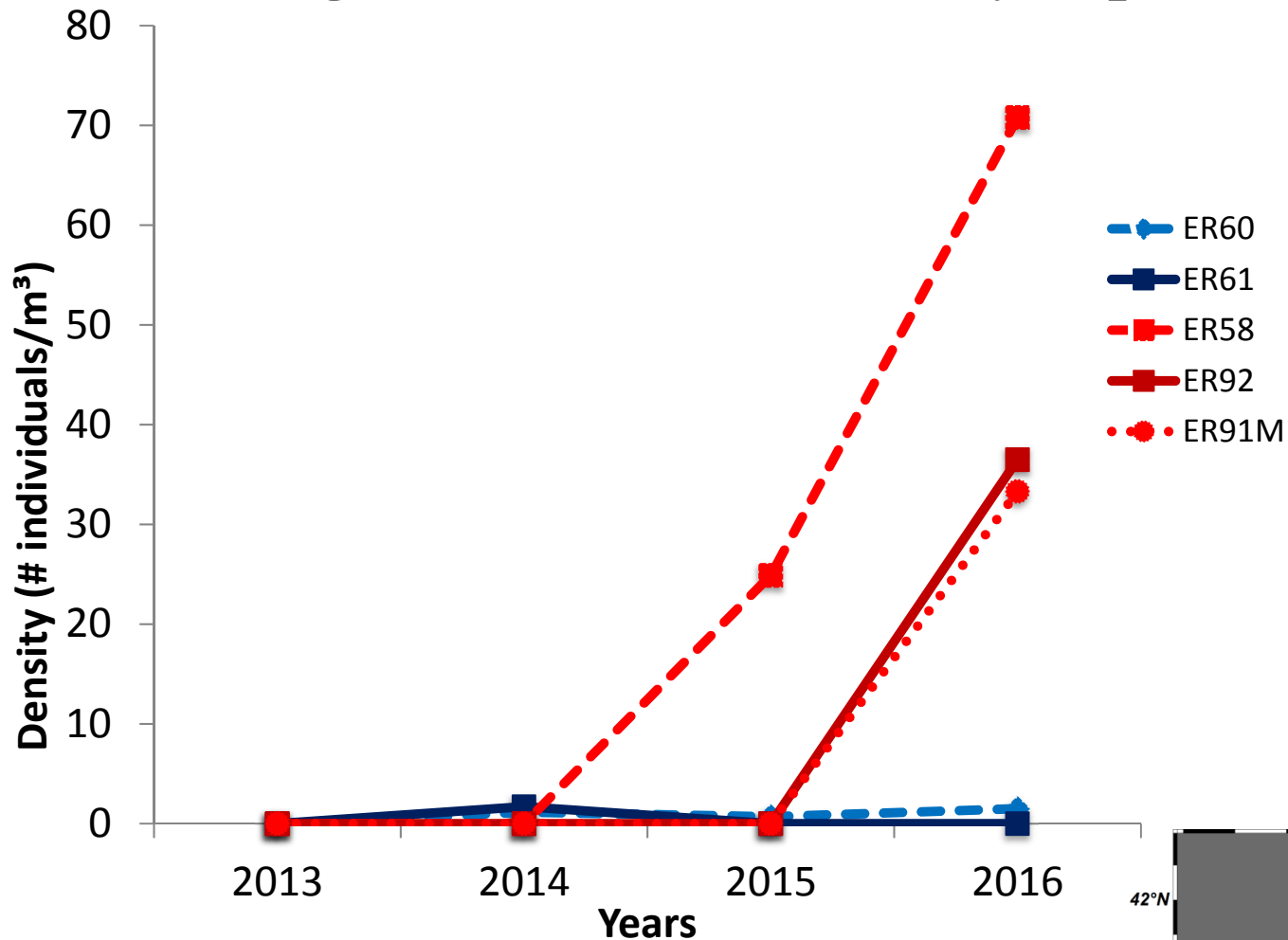
Monitoring *Thermocyclops crassus* Range in Lake Erie: 2015



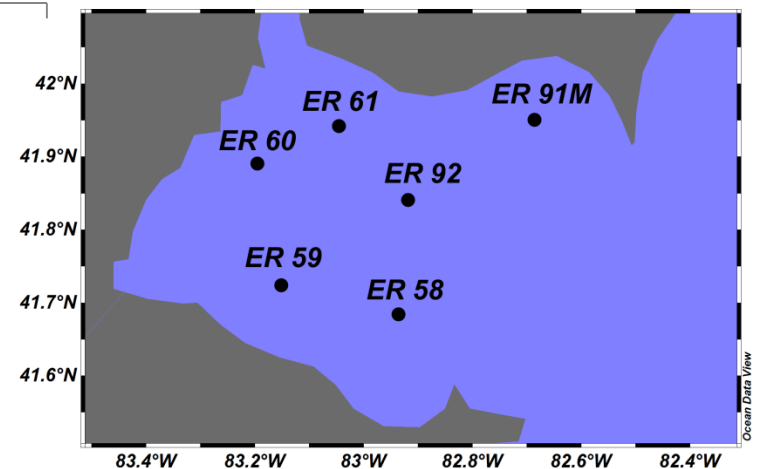
Monitoring *Thermocyclops crassus* Range in Lake Erie: 2016



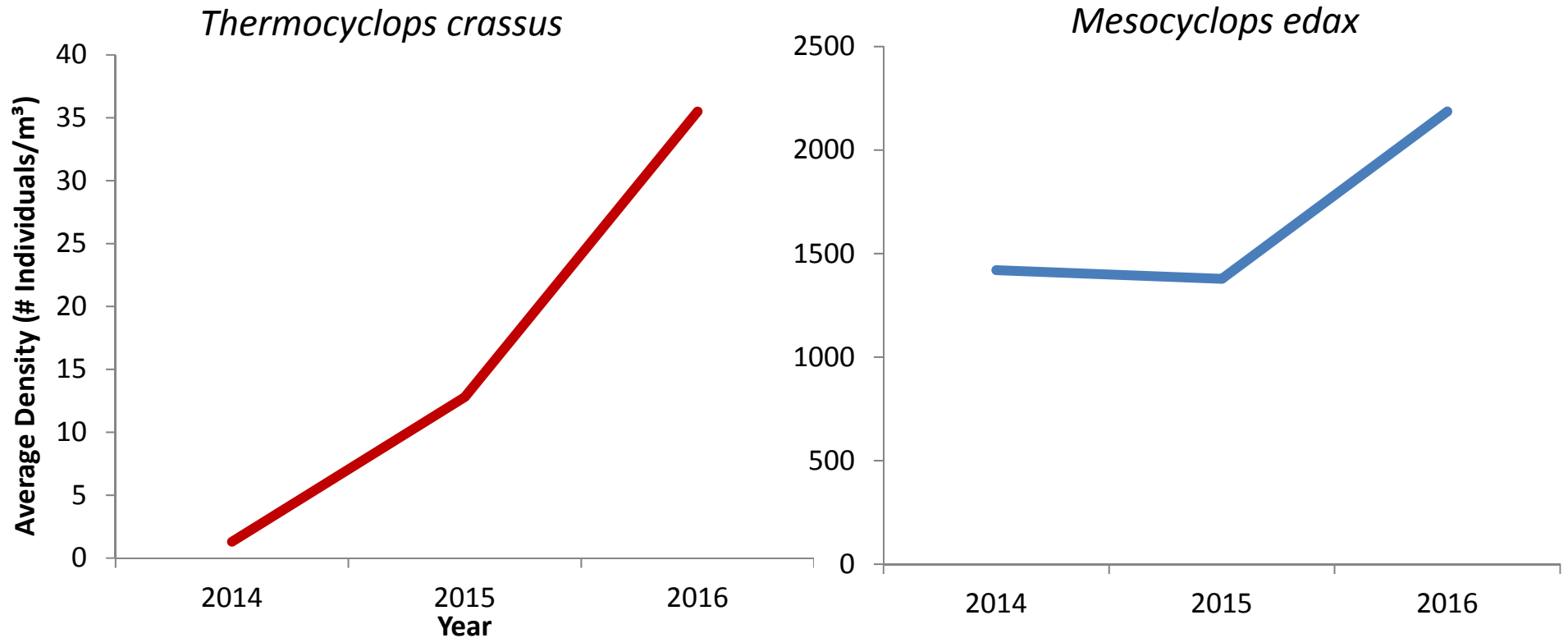
Monitoring Densities of *Thermocyclops crassus* in Lake Erie



Densities of adult *T. crassus* at individual biological monitoring sites in western Lake Erie 2013-2016.



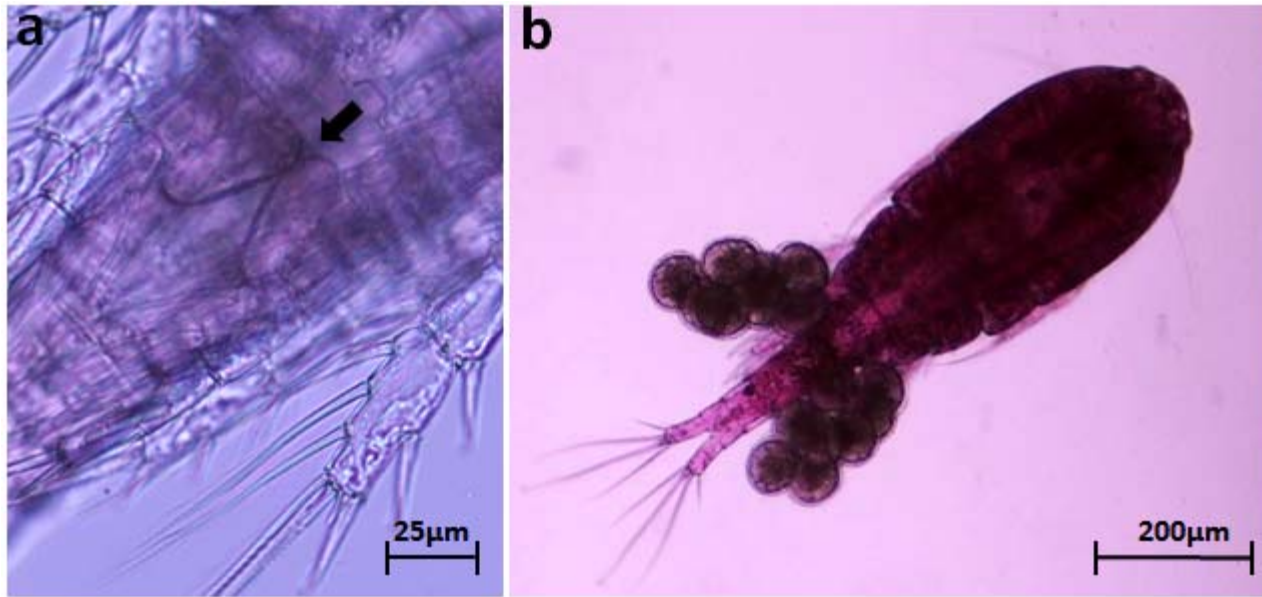
Monitoring Densities of *Thermocyclops crassus* in Lake Erie



(Left) Average densities of adult *T. crassus* in western Lake Erie August 2014-2016. (Right) Average densities of adult *M. edax* in western Lake Erie August 2014-2016.

- *T. crassus* densities increased each year but remained low in comparison to native cyclopoid copepod species.

Evidence of *Thermocyclops crassus* Reproduction in Lake Erie

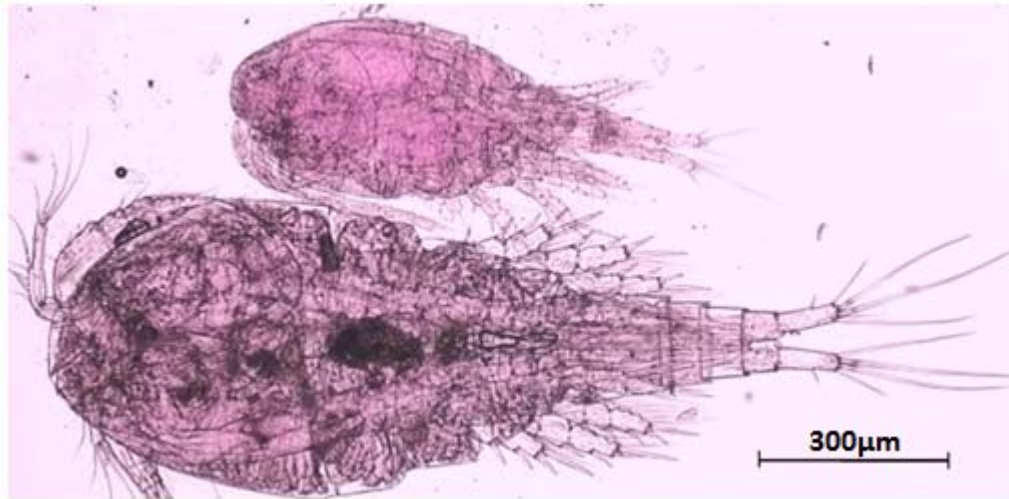


(a) Female *T. crassus* with spermatophores attached to genital segment. (b) Female *T. crassus* carrying egg sacs.

- In 2014 one female *T. crassus* specimen was found with spermatophores attached to the genital aperture.
- In 2016 one female *T. crassus* specimen was found with egg sacs attached to the genital segment.
- We conclude that a breeding population has been established in Lake Erie.

Distinguishing *Thermocyclops crassus* from *Mesocyclops edax*:

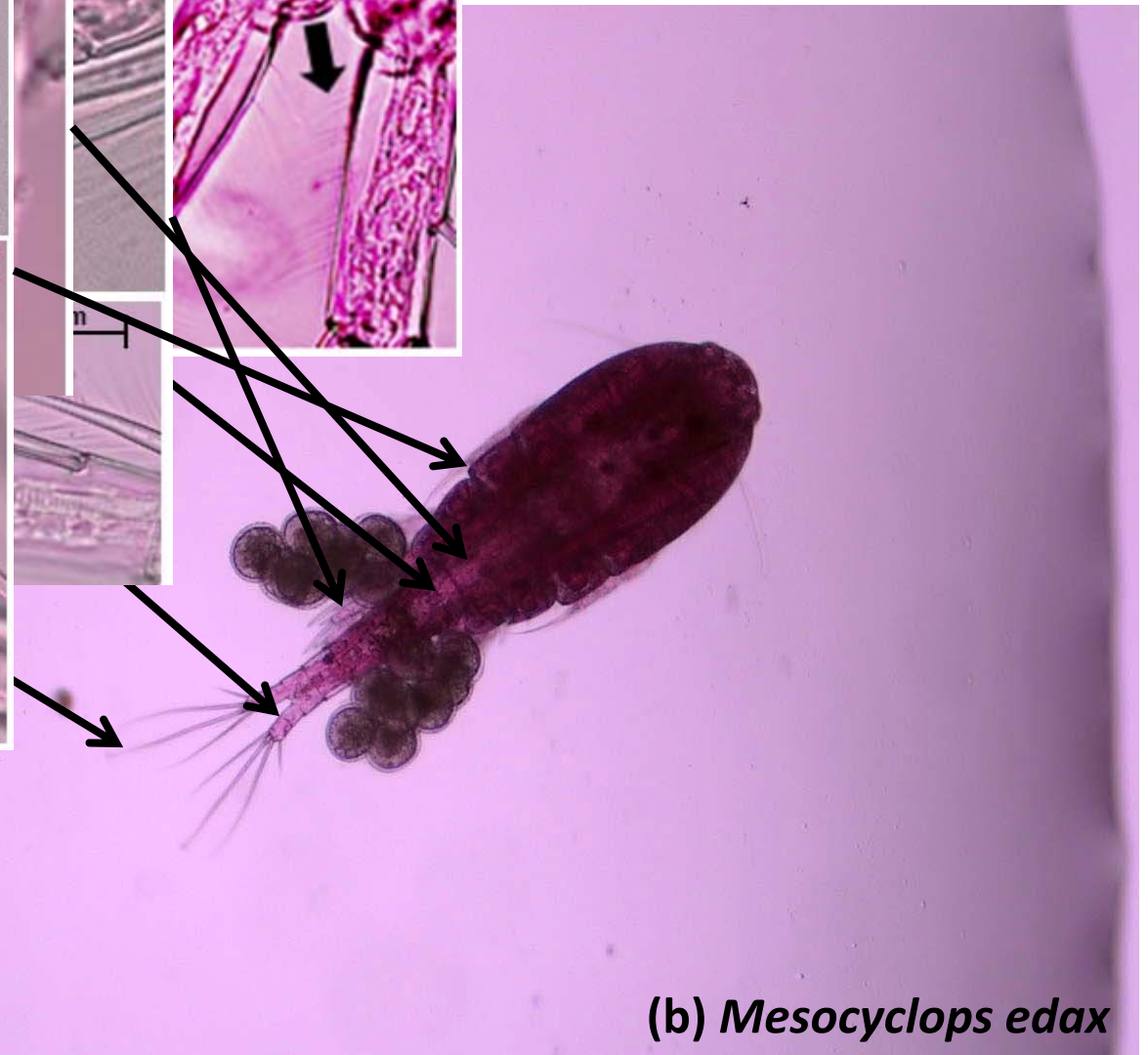
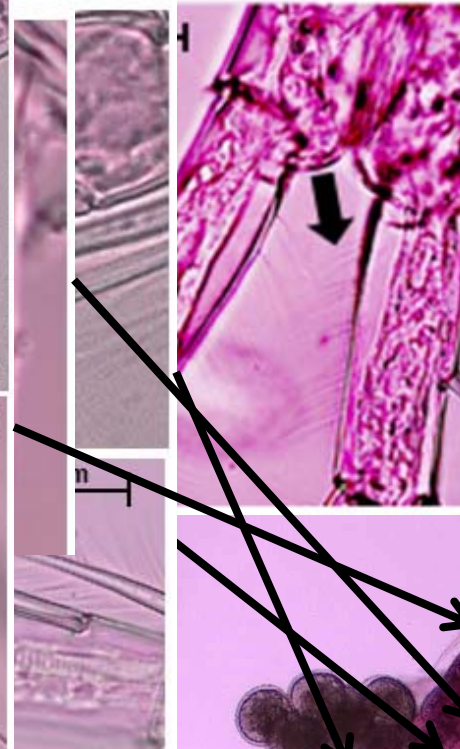
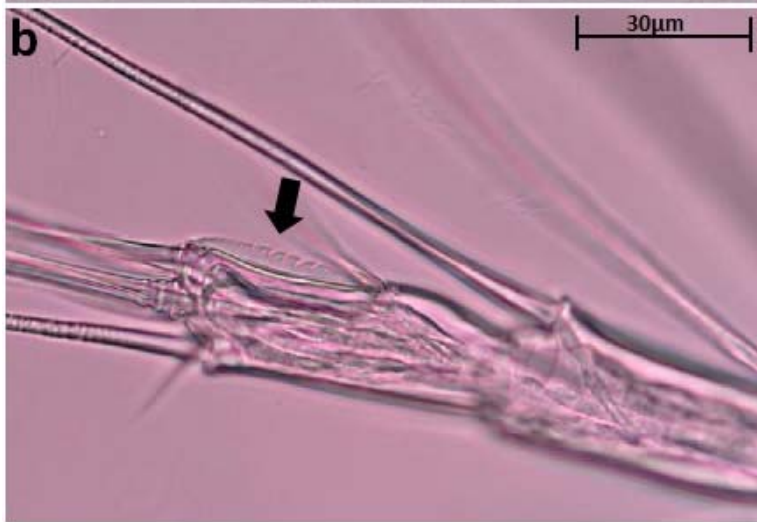
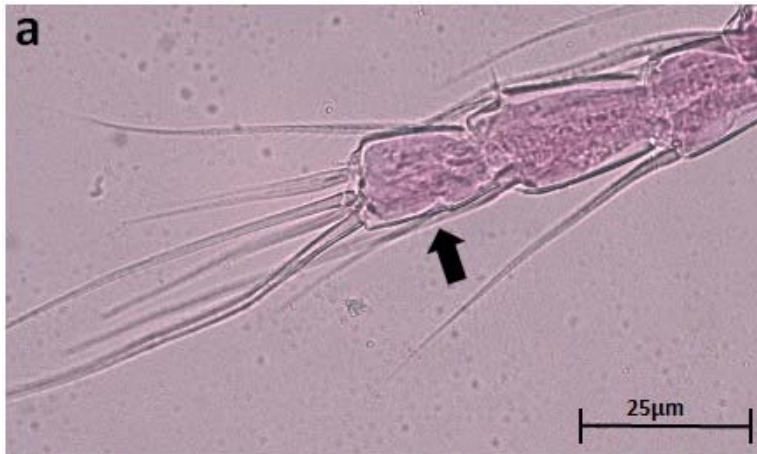
Size:



(above) dorsal view of nonnative *Thermocyclops crassus* female,
(below) dorsal view of native *Mesocyclops edax* female.

- *Mesocyclops edax* is a common North American copepod and the closest relative to *T. crassus* native to the Great Lakes.
- *M. edax* and *T. crassus* bear a resemblance at a gross morphological level and share similar setal arrangements on the caudal ramus.
- Female *T. crassus* are noticeably smaller in length than female *M. edax*.

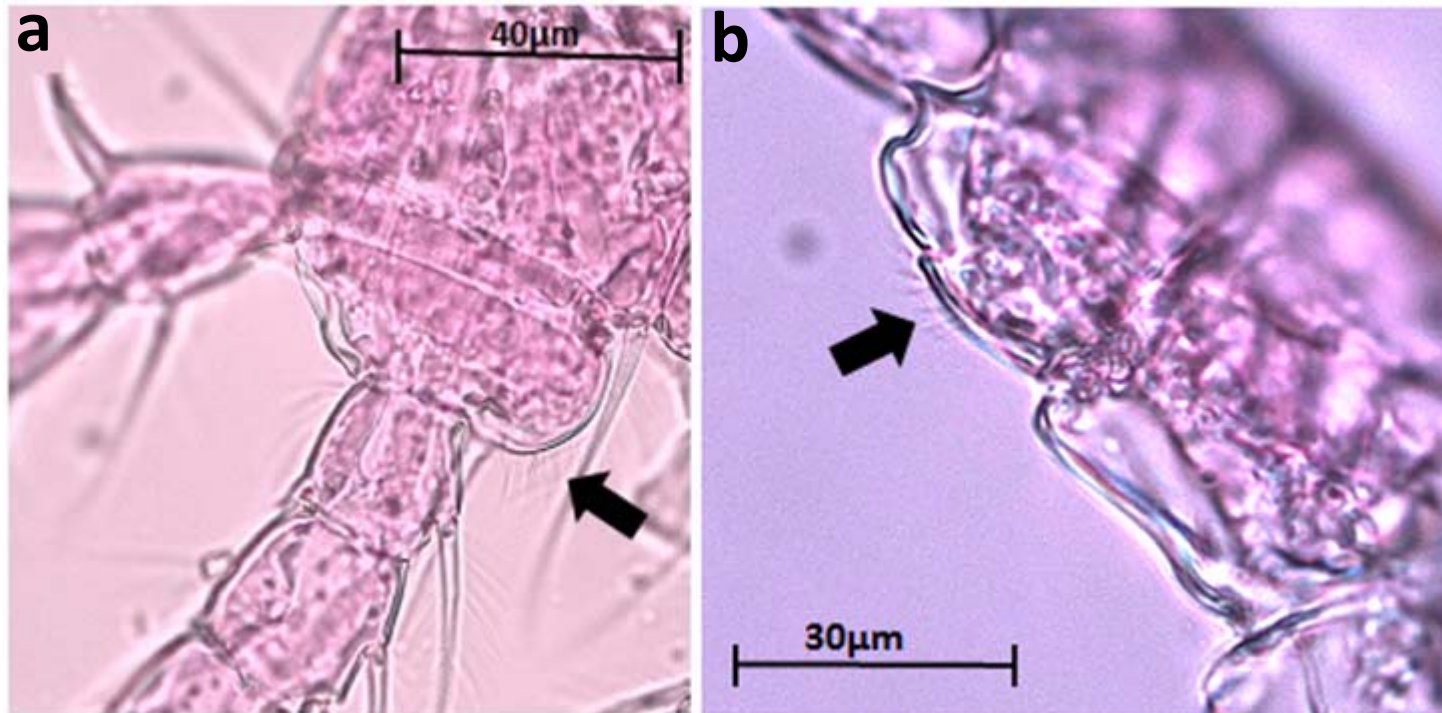
Distinguishing *Thermocyclops crassus* from *Mesocyclops edax*: Morphology:



(a) *Thermocyclops crassus*

(b) *Mesocyclops edax*

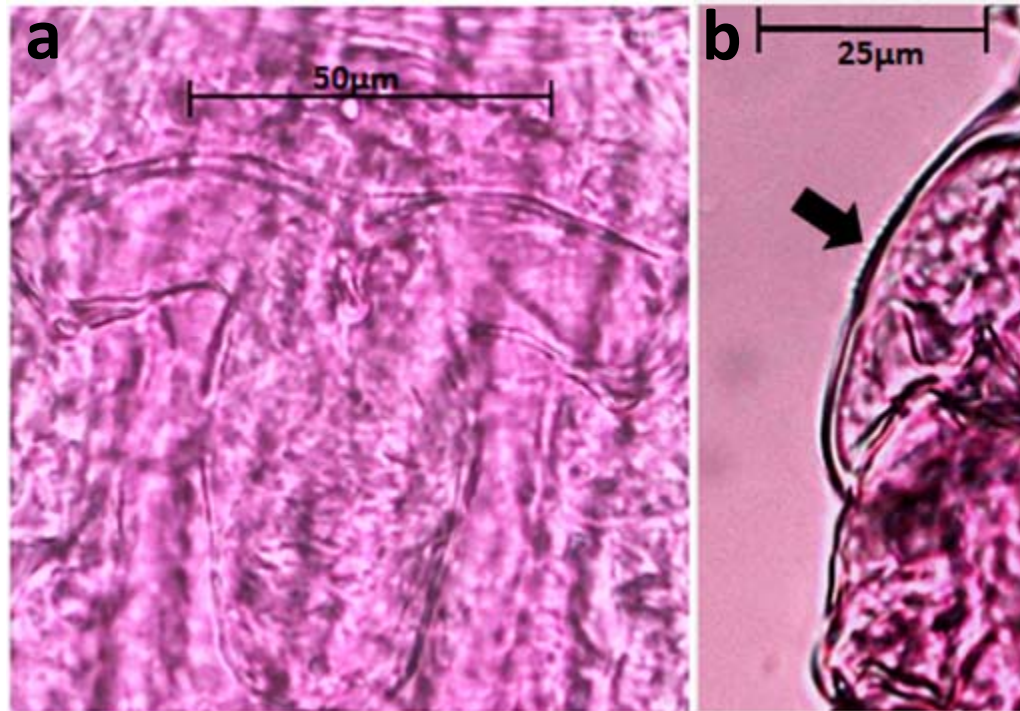
Distinguishing *Thermocyclops crassus* from similar *Thermocyclops* species:



(a) Female *T. crassus* leg one basipodite. (b) Female *T. crassus* leg 4 basipodite.

- Distinguishing *T. crassus* from the closely related European species *T. oithonoides*, and morphologically similar pantropical species *T. decipiens*.

Distinguishing *Thermocyclops crassus* from similar *Thermocyclops* species:

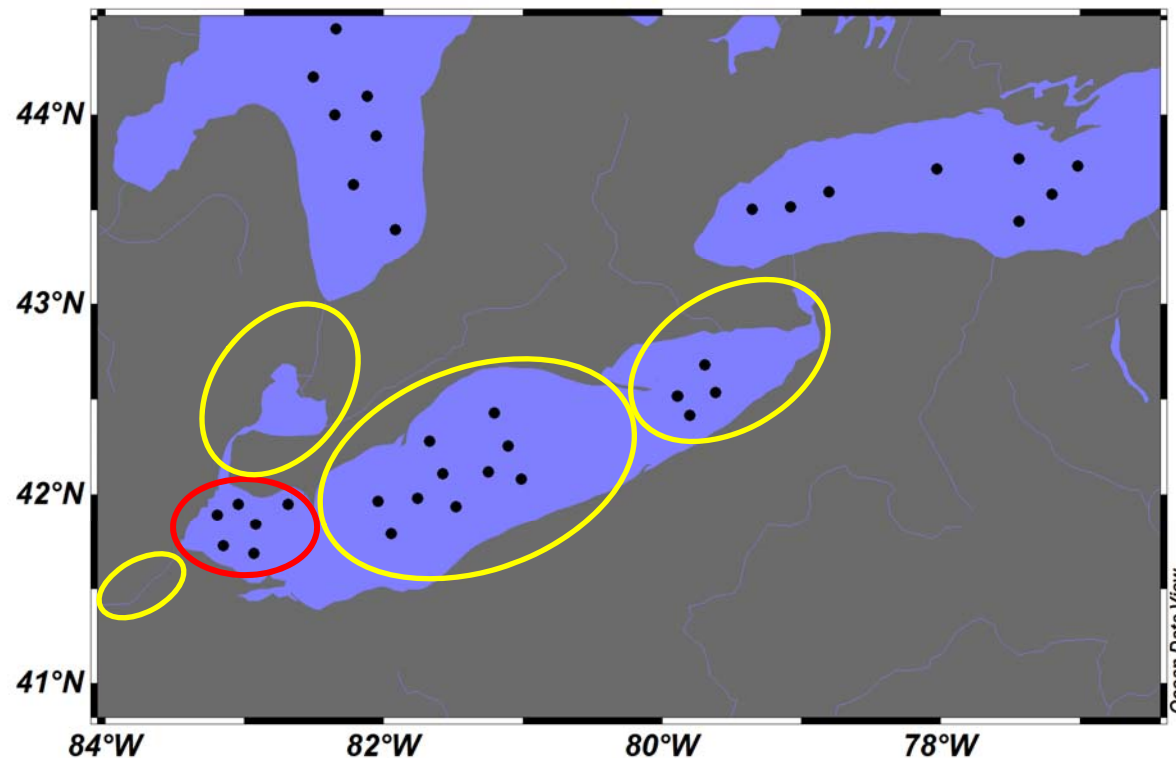


(a) Female *T. crassus* seminal receptacle. (b) Female *T. crassus* pediger 5 lateral margin.

- Distinguishing *T. crassus* from the closely related European species *T. oithonoides*, and morphologically similar pantropical species *T. decipiens*.

Improving Detection of *Thermocyclops crassus*

- When initial detection of *T. crassus* occurred in Lake Erie in 2014 densities were extremely low, about 1 individual/m³.
- Early detections of *T. crassus* could be improved by employing genetic detection techniques such as DNA meta barcoding where there is a potential risk of *T. crassus* colonization.



Implications of *Thermocyclops crassus* introduction into Lake Erie

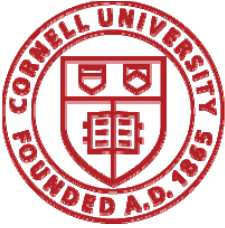
- It's currently unknown if *T. crassus* could become a major component of the zooplankton community in Lake Erie and elsewhere in the Great Lakes.
- Given *T. crassus* spread across Lake Erie's Western Basin over 3 years, it's possible that Lake Erie's Central basin may be colonized next.
- The preference of *T. crassus* for mesotrophic to eutrophic environments may limit its spread to Lake Erie and productive near shore embayments of the Great Lakes.
- *T. crassus* can become abundant in warm climates and may benefit from warmer temperatures associated with climate change.
- *T. crassus* shares its habitat with several previous invertebrate introductions. These include *Daphnia lumholtzi*, *Bythotrephes longimanus*, and *Eurytemora carolleeae*. All of these previously introduced species remain much less abundant in comparison to native planktonic crustaceans in western Lake Erie.

Acknowledgements

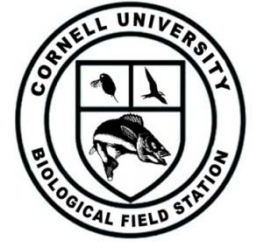


BUFFALO STATE
The State University of New York





Literature Cited:



- Bledzki, L.A., Rybak, J.I., 2016. Freshwater Crustacean Zooplankton of Europe. Springer International Publishing Switzerland.
- Chaicharoen, R., Sanoamuang, L., Holynska, M., 2011. A review of the genus *Thermocyclops* (Crustacean: Copepoda: Cyclopoida) in Cambodia. Zoological Studies 50, 780-803.
- Collado, C., Defaye, D., Dussart, B.H., Fernando, C.H., 1984. The freshwater Copepoda (Crustacea) of Costa Rica with notes on some species. Hydrobiologia 119, 89–99.
- Connolly, J.K., Watkins, J.M., Hinchey, E.K., Rudstam, L.G., Reid, J.W., 2017. New cyclopoid copepod (*Thermocyclops crassus*) reported in the Laurentian Great Lakes. J. Great Lakes Res. 43.
- Duchovnay, A., Reid, J.W., McIntosh, A., 1992. *Thermocyclops crassus* (Crustacea Copepod) present in North America: a new record for Lake Champlain. J. Great Lakes Res. 18, 415–419.
- Duggan, I.C., van Overdijk, C.D.A., Bailey, S.A., Jenkins, P.T., Limén, H., MacIsaac, H.J., 2005. Invertebrates associated with residual ballast water and sediments of cargo-carrying ships entering the Great Lakes. Can. J. Fish. Aquat. Sci. 62, 2463–2474.
- Gutiérrez-Aguirre, M., Suárez-Morales, E., 2000. The Eurasian *Thermocyclops crassus* (Fischer, 1853) (Copepoda, Cyclopoida) found in southeastern Mexico. Crustaceana 73, 705–713.
- Hopp, U., Maier, G., 2005. Implication of the feeding limb morphology for herbivorous feeding in some freshwater cyclopoid copepods. Freshw. Biol. 50, 742–747.
- Pothoven, S.A., Grigorovich, I.A., Fahnenstiel, G.L., Balcer, M.D., 2007. Introduction of the Ponto-Caspian bloody-red mysid *Hemimysis anomala* into the Lake Michigan basin. J. Great Lakes Res. 33, 285–292.
- Reid, J.W., 1989. The distribution of species of the genus *Thermocyclops* (Copepoda, Cyclopoida) in the western hemisphere, with description of *T. parvus*, new species. Hydrobiologia 175, 149–174.
- Xiaoming, G., 1999. The genus *Thermocyclops* Kiefer, 1927 (Copepoda: Cyclopidae) in China. Hydrobiologia 403, 87-95.

Questions?

