NOAA Technical Memorandum GLERL-169b
https://doi.org/10.25923/ev88-7488

2018 UPDATE TO "A RISK ASSESSMENT OF POTENTIAL GREAT LAKES AQUATIC INVADERS"

El Lower[1], Nicholas Boucher[2], Peter Alsip[2], Alisha Davidson[3], Rochelle Sturtevant[1]

[1] Michigan Sea Grant
[2] Cooperative Institute for Great Lake Lakes Research, University of Michigan
[3] Wayne State University

NOAA Great Lakes Environmental Research Laboratory
4840 S. State Road, Ann Arbor, Michigan

Tuesday, September 10, 2019

UNITED STATES
DEPARTMENT OF COMMERCE

Wilbur L. Ross, Jr.
Secretary

NATIONAL OCEANIC AND
ATMOSPHERIC ADMINISTRATION

Dr. Neil Jacobs, Acting
Administrator

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El Lower, Nick Boucher, Peter Alsip, Kylan Hopper, Alisha Davidson, and Rochelle Sturtevant

1.0 SUMMARY

This report includes all major changes to Risk Assessments conducted by the GLANSIS project between July 2014 and December 2018. All new assessments were conducted following the same methods outlined in the original Tech Memo (TM-169). All re-assessments are based on new literature surveys using the original as a baseline and conducted using the same methods. All assessments were reviewed by all members of the GLANSIS team and by select external reviewers. Results of each risk assessment are incorporated into the species profiles on the main GLANSIS site (www.glerl.noaa.gov/glansis) as well as incorporated into the new GLANSIS Risk Explorer. The websites are updated more frequently and should be considered the most recent information.

Out of 67 species documented in the original 2014 TM-169 risk assessment, 25 assessments were updated in this publication, and four new species were added. GLANSIS is constantly being updated with new and relevant literature to resolve unknown variables and adjust risk scores accordingly, changes largely reflect advances in the state of knowledge–new publications since 2014–rather than information missed in the original assessment or changes in interpretation of the available data.

Four new species were added to the watchlist, including *Arundo donax, Paraleptasticus wilsonii, Procambarus fallax f. virginalis*, and *Sparganium erectum*. Scores were adjusted for several other species as new information was collected on their biology and behavior in the last several years and published in recent literature. A number of the "unknowns" in the previous version of this document were adjusted to reflect the addition of new information used to calculate their risk score. Twelve "unknown" values were changed to known values in this assessment, reflecting the growth in scientific knowledge and larger body of published literature available since the first edition of this document was published, as well as the importance of this project's regular update cycle.

The 71 watchlist species are included in the table below, with asterisks indicating those that were updated or newly added.

Table 1. Summary of overall risk for each species (asterisks indicate changed or added assessments).

Species	Introduction	Establishment	Environmental Impact	Socioeconomic Impact	Benefits
*Apocorophium lacustre**	High	High	Moderate	Low	Low
Alburnus alburnus	Moderate	High	High	Low	High
Ctenopharyngodon idella	High	Moderate	High	Low	High
Dikerogammarus villosus	Moderate	High	High	Low	Low
Egeria densa	High	Moderate	High	High	Moderate

*Eichhornia crassipes**	High	Moderate	High	High	Moderate
Federicella sultana	High	Moderate	High	High	Low
Hydrilla verticillata	High	Moderate	High	High	High
Myriophyllum aquaticum	High	Moderate	High	Moderate	Moderate
Obesogammarus crassus	Moderate	High	High	Low	Low
Percottus glenii	Moderate	High	High	Low	Moderate
Pistia stratiotes	High	Moderate	High	High	Moderate
*Procambarus fallax f. virginalis**	High	Moderate	High	Moderate	High
Rutilus rutilus	High	Moderate	High	Moderate	Moderate
*Babka gymnotrachelus**	Moderate	High	Moderate	Low	Unknown
Ictalurus furcatus	High	Moderate	Moderate	Low	High
*Lepomis auratus**	High	Moderate	Moderate	Low	Moderate
Limnomysis benedeni	Moderate	High	Moderate	Low	Moderate
Neogobius fluviatilis	Moderate	High	Moderate	Low	Moderate
Pontogammarus robustoides	Moderate	High	Moderate	Low	Moderate
Stratiotes aloides	High	Moderate	Moderate	Moderate	Low
*Calanipeda aquaedulis**	Moderate	Moderate	High	Low	Low
*Channa argus**	Moderate	Moderate	High	Moderate	Moderate
Hygrophila polysperma	Moderate	Moderate	Moderate	High	Moderate
*Hypophthalmichthys molitrix**	Moderate	Moderate	High	High	High
*Hypophthalmichthys nobilis**	Moderate	Moderate	High	High	High
Leuciscus leuciscus	Moderate	Moderate	High	High	Moderate
Osmerus eperlanus	Moderate	Moderate	High	Unknown	Moderate
Perca fluviatilis	Moderate	Moderate	High	Moderate	High
*Sparganium erectum**	Moderate	Moderate	High	Moderate	Moderate
Atherina boyeri	Moderate	Moderate	Moderate	Low	High
*Chelicorophium curvispinum**	Moderate	Moderate	Moderate	Low	Moderate
*Cyclops kolensis**	Moderate	Moderate	Moderate	Low	Low
Echinogammarus warpachowskyi	Moderate	Moderate	Moderate	Low	Moderate
Paramysis (Serrapalpisis) lacustris	Moderate	Moderate	Moderate	Low	Low
Phoxinus phoxinus	Moderate	Moderate	Moderate	Low	Low
*Arundo donax**	Low	Moderate	High	Moderate	Moderate
*Carassius carassius**	Low	High	High	Low	Moderate
*Crassula helmsii**	Low	Moderate	High	Moderate	Low
Limnoperna fortunei	Low	High	High	High	High

Obesogammarus obesus	Low	High	High	Low	Low
*Pseudrasbora parva**	Low	Moderate	High	High	Low
Sander lucioperca	Low	High	High	Unknown	High
*Silurus glanis**	Low	Moderate	High	Low	High
*Cherax destructor**	Low	Moderate	Moderate	Low	Moderate
Oncorhynchus keta	Low	Moderate	Moderate	Low	High
Podonevadne trigona Ovum	Low	Moderate	Moderate	Low	Low
Brachionus leydigii	High	Moderate	Low	Low	Low
*Clupeonella cultriventris**	Low	Moderate	Low	Low	Low
*Cornigerius maeoticus**	Moderate	Moderate	Low	Low	Low
*Cottus gobio**	Moderate	Moderate	Low	Low	Low
*Daphnia cristata**	High	Moderate	Low	Low	Moderate
*Ectinosoma abrau**	Low	Moderate	Low	Low	Low
Filinia cornuta	High	Moderate	Low	Low	Low
Filinia passa	High	Moderate	Low	Low	Low
*Hypania invalida**	Moderate	Moderate	Low	Low	Low
Benthophilus stellatus	Low	Moderate	Unknown	Low	Low
Cyprinella whipplei	Moderate	Moderate	Unknown	Low	Low
Dikerogammarus haemobaphes	Moderate	High	Unknown	Low	Low
Heterocope appendiculata	Moderate	Moderate	Unknown	Low	Low
Heterocope caspia	Moderate	Moderate	Unknown	Low	Low
*Knipowitschia caucasica**	Low	Moderate	Unknown	Low	Low
Leuciscus idus	High	Moderate	Unknown	Low	High
Leyogonimus polyoon	Moderate	Moderate	Unknown	Unknown	Low
Monodacna colorata	Moderate	Moderate	Unknown	Low	Low
*Paraleptastacus spinicaudus triseta**	Moderate	Low	Unknown	Low	Low
*Paraleptastacus wilsonii**	High	Moderate	Unknown	Low	Low
Paramysis (Mesomysis) Intermedia	Moderate	Moderate	Unknown	Low	Low
*Paramysis (Metamysis) ullskyi)**	Moderate	Moderate	Unknown	Low	Low
Rhithropanopeus harrisii	Moderate	High	Unknown	Low	Low
*Sinelobus stanfordi**	Moderate	Low	Unknown	Low	Low

Of the species that were re-assessed for this updated document, *Apocorophium lacustre* retains the distinction of being the only species assessed to score high for both introduction and establishment. Its environmental impact was previously scored as unknown, which we highlighted as a critical gap in scientific knowledge. Assessment of its impact risk has changed from unknown to a moderate risk of environmental impact with low probability of socioeconomic impacts or benefits. This species is now scored with the highest likelihood of becoming invasive.

Eighteen species are now scored as highly likely to be introduced and moderately likely to become established, while 10 species are scored as moderately likely to be introduced and highly likely to be established if introduced for an overall moderate likelihood of introduction and subsequent establishment for these 28 species. Of these, 13 are likely to have high environmental or socioeconomic impacts and 7 are likely to have moderate impacts for an overall potential 20 species moderately likely to become invasive. *Procambarus fallax f. virginalis, Ictalurus furcatus, Lepomis auritus, Stratiotes aloides, Limnomysis benedeni, Neogobius fluviatilis, Pontogammarus robustoides* and *Babka gymnotrachelus* join this list of previously identified species (*Eichhornia crassipes, Pistia stratiotes, Hydrilla verticillata, Egeria densa, Myriophyllum aquaticum, Rutilus rutilus, Ctenopharyngodon idella, Alburnus alburnus, Percottus glenni, Fredericella sultana, Dikerogammarus villosus*, and *Obesogammarus crassus*) that pose the greatest risk to the Great Lakes. Bighead and silver carp (*Hypophthalmichthys* spp.) previously included in this set have been reassessed at slightly lower risk (below). More research is needed to determine the potential impact of *Leuciscus idus, Paraleptastacus wilsonii, Dikerogammarus haemobaphes*, and *Rhithropanopaeus harrisii,* which also have high-moderate probability of introduction and establishment.

Species assessed as moderately likely to to be introduced and moderately likely to become established with high potential for environmental or socioeconomic impacts should be considered as having only slightly lower threat of becoming invasive than the previously mentioned groups. This group now includes *Hypophthalmichthys molitrix, Hypophthalmichthys nobilis, Channa argus, Perca fluviatils, Osmerus eperlanus, Leuciscus leuciscus, Hydrophila polysperma, Sparganium erectum*, and *Calanipeda aquaedulcis*.

Six additional potentially invasive species fall just below these in the risk assessment, scoring with moderate probability for introduction, establishment and environmental or socioeconomic impact. These include *Atherina boyeri, Cyclops kolensis, Paramysis lacustris, Phoxinus phoxinus, Chelicorophium curvispinum,* and *Echinogammarus warpachowskyi.*

More research is still needed to determine the potential impacts of *Cyprinella whipplei, Heterocope appendiculata, Heterocope caspia, Monodacna colorata, Paramysis intermedia, Syngnathus abaster, Paramysis ullskyi* and *Leyogonimus polyoon*, which have moderate probability of introduction and establishment.

We also would like to call attention to a group of eight species that are currently assessed as having a low probability of introduction, but which have a moderate to high probability of establishment and subsequent high impact in the event that they should become introduced. Additional monitoring for these species in the known potential pathways is warranted given the high potential impact. These eight include *Limnoperna fortunei, Obesogammarus obesus, Carassius carassius, Sander lucioperca, Pseudorasbora parva, Siluris glanis, Crassula helmsii* and *Arundo donax*. Despite the overall shipping bias, species with a high potential for introduction—including those of a particular taxonomic group (e.g., fishes, plants)—were fairly evenly distributed among vectors. All assessed taxonomic groups had members with high-moderate potential for introduction. This suggests that managers need to go beyond single vector- or taxon-based assessments when developing their prevention and monitoring strategies.

2.0 ADDENDA

Table 2. New species and major changes to the assessments, etc. originally published in TM-169.

Species	Addenda	Author, date added
Apocorophium lacustre	Potential environmental impact changed from unknown to moderate.	Davidson, 7/11/16
Arundo donax	New risk assessment.	Hopper, 8/14/2018
Babka gymnotrachelus	Inadvertently printed as *Babko gymnotrachelus* in the main text of the original Tech Memo. Potential environmental impact changed from unknown to moderate.	Davidson, 7/8/16
Calanipeda aquaedulcis	Potential environmental impact changed from unknown to high.	Davidson, 7/11/16
Carassius carassius	Moderate probability of establishment changed to high. Potential environmental impact changed from unknown to high.	Alsip, 8/4/2018
Channa argus	Potential environmental impact changed from unknown to high.	Davidson, 7/8/16
Chelicorophium curvispinum	Probability of establishment changed from high to moderate.	Dettloff & Li, 2015
Cherax destructor	Probability of introduction changed from moderate to low.	
Clupeonella cultriventris	Potential environmental impact changed from unknown to low	Davidson, 7/8/16
Cornigerius maeoticus maeoticus	Potential environmental impact changed from unknown to low	Davidson, 7/11/16
Cottus gobio	Potential environmental impact changed from unknown to low	Davidson, 4/11/17
Crassula helmsii	Probability of introduction changed from unknown to low	Fusaro, 6/30/2015
Cyclops kolensis	Probability of environmental impact changed from high to moderate	Davidson, 7/11/16
Daphnia cristata	Probability of environmental impact changed from unknown to low.	Davidson, 7/11/16
Ectinosoma abrau	Potential environmental impact changed from unknown to low.	Davidson, 7/11/16
Eichhornia crassipes	Revision of quantitative scores for introduction potential and establishment potential. Qualitative score does not	Alsip and Lower 11/2/2018

	change. Possible status (to established) change being externally reviewed.	
Hypania invalida	Probability of establishment changed from high to moderate.	Fusaro 2015
Hypophthalmichthys molitrix	Probability of introduction changed from high to moderate. Potential benefits changed from moderate to high.	Alsip 2018
Hypophthalmichthys nobilis	Probability of introduction changed from high to moderate. Potential benefits changed from moderate to high.	Alsip 2018
Knipowitschia caucasica	Probability of introduction changed from moderate to low.	Sturtevant 2015
Lepomis auritus	New risk assessment.	Alsip, 8/10/17
Paraleptastacus spinicaudus triseta	Probability of establishment changed from low to moderate.	Sturtevant 2015
Paraleptastacus wilsonii	New risk assessment.	Boucher, 8/14/2018
Paramysis ullskyi	Probability of environmental impact changed from high to unknown	Sturtevant 2015
Procambarus fallax f. virginalis	New risk assessment.	Lower, 10/12/2018
Pseudorasbora parva	Typographic error in Table 10 of the original Tech Memo in which the species name was given as *Pseudasbora parva.* Potential socio-economic impact changed from unknown to high.	Alsip, 4/3/17
Silurus glanis	Typographic error in Table 10 of the original Tech Memo in which the species name was given as *Siluris glanis*. No changes to risk assessment.	Sturtevant, 2018
Sinelobus standfordi	Errata (inconsistent between table and appendix in original) - environmental impact of this species is unknown.	Sturtevant, 2018
Sparganium erectum	New risk assessment.	Boucher, 12/19/2018

3.0 RISK ASSESSMENTS

Scientific Name: *Apocorophium lacustre*

(Vanhoffen, 1911)
Common Name: Scud

Section C: Potential for Impact

IMPACT POTENTIAL RESULTS

Environmental: Moderate
Socio-Economic: Low
Beneficial: NA
Comments:

POTENTIAL ENVIRONMENTAL IMPACT

NOTE: In this section, a "Not significantly" response should be selected if the species has been studied but there have been no reports of a particular impact. An "Unknown" response is appropriate if the species is poorly studied.

Does the species pose some hazard or threat to the health of native species (e.g., it magnifies toxin levels; is poisonous; is a pathogen, parasite, or a vector of either)? √

Yes, and it has impacted threatened/endangered species, resulted in the reduction or extinction of one or more native populations, affects multiple species, or is a reportable disease	6
Yes, but negative consequences have been small (e.g., limited number of infected individuals, limited pathogen transmissibility, mild effects on populations and ecosystems)	1
Not significantly	0 √
Unknown	U

- *Not significantly.*

Does it out-compete native species for available resources (e.g., habitat, food, nutrients, light)?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species or caused critical reduction, extinction, behavioral changes including modified spawning behavior) on one or more native populations	6
Yes, and it has caused some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population	1 √
Not significantly	0
Unknown	U

- *May have contributed to a decline in the native Gammarus pseudolimnaeus; though likely, it is uncertain (Grigorovich et al. 2008).*
- *A. lacustre is ecologically very similar to C. curvispinum and apparently does not do well in competition; it disappeared from several previously-inhabited sites following invasion by C. curvispinum (Noordhuis et al. 2009).*

- *Abundant in survey of South Atlantic Bight (Jacksonville, Savannah, Charleston and Wilmington) (Power et al. 2006).*
- *A. lacustre will compete with native mussels for food and habitat space and have been known to overwhelm populations (US Army Corps of Engineers, 2013).*

Does it alter predator-prey relationships?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species, caused significant reduction or extinction of one or more native populations, creation of a dead end or any other significant alteration in the food web)	6
Yes, and it has resulted in some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population AND/OR Yes, and it has resulted in some alteration of the food web structure or processes, the effects of which have not been widespread or severe	1 √
Not significantly	0
Unknown	U

- *A. lacustre has been found to alter food webs and decrease faunal diversity in areas of non-native establishment (US Army Corps of Engineers, 2013).*

Has it affected any native populations genetically (e.g., through hybridization, selective pressure, introgression)?

Yes, and it has caused a loss or alteration of genes that may be irreversible or has led to the decline of one or more native species (or added pressure to threatened/endangered species)	6
Yes, some genetic effects have been observed, but consequences have been limited to the individual level	1
Not significantly	0 √
Unknown	U

- *Not significantly.*

Does it negatively affect water quality (e.g., increased turbidity or clarity, altered nutrient, oxygen, or other chemical levels/cycles)?

Yes, and it has had a widespread, long-term, or severe negative effect on water quality AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected water quality to some extent, but the alterations and resulting adverse effects have been limited or inconsistent (as compared with above statement)	1
Not significantly	0 √
Unknown	U

- *Not significantly.*

Does it alter physical components of the ecosystem in some way (e.g., facilitated erosion/siltation, altered hydrology, altered macrophyte/phytoplankton communities, physical or chemical changes to substrate)?

Yes, and it has had a widespread, long term, or severe negative effect on the physical ecosystem AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected the physical ecosystem to some extent, but the alterations and resulting adverse effects have been mild	1
Not significantly	0 √
Unknown	U

- *Not significantly.*

Environmental Impact Total	**2**
Total Unknowns (U)	**0**

Scientific Name: *Arundo donax*

Common Name: Giant reed

Section A: Potential for Introduction

INTRODUCTION POTENTIAL RESULTS

Dispersal: Low
Hitchhiking/Fouling: Unlikely
Unauthorized intentional release: Low
Stocking/Planting/Escape from recreational culture: Unknown
Escape from commercial culture: Unlikely
Shipping: Unlikely

POTENTIAL INTRODUCTION VIA DISPERSAL

Does this species occur near waters (natural or artificial) connected to the Great Lakes basin* (e.g., streams, ponds, canals, or wetlands)?

(*Great Lakes basin = below the ordinary high water mark, including connecting channels, wetlands, and waters ordinarily attached to the Lakes)

Yes, this species occurs near waters connected to the Great Lakes basin and is mobile or able to be transported by wind or water.	100√
No, this species does not occur near waters connected to the Great Lakes basin and/or is not mobile or able to be transported by wind or water.	0
Unknown	U

- *According to USDA plants database* Arundo donax *is found in Harrison county West Virginia and at the southern end of Illinois in counties Alexander, Pope, and Pulaski (USDA 2017)*
- *The primary mode of reproduction for* Arundo donax *is vegetative propagation.* Arundo donax *has rapid clonal rapid spread attributed to its rhizome extension and flood dispersal of rhizome and culm fragments (Mariani et al. 2010).*

What is the proximity of this species to the Great Lakes basin?

This species occurs in waters within 20 kilometers of the Great Lakes basin, and no barrier (e.g., electric barrier, dam) to dispersal is present.	Score x 1
This species occurs in waters within 20 kilometers of the Great Lakes basin, but dispersal to the basin is blocked; or, this species occurs in waters within 100 kilometers of the Great Lakes basin, and no barrier to dispersal is present.	Score x 0.75
This species occurs in waters within 100 kilometers of the Great Lakes basin, but dispersal to the basin is blocked.	Score x 0.5
This species occurs in waters >100 kilometers from the Great Lakes basin.	Score x 0.25√
Unknown	U

- *Harrison County West Virginia and Pope, Alexander, and Pulaski Counties are >100 km from the Great Lakes Basin. The Monongahela River which runs through Harrison County does not have a direct connection to the Great Lakes. Pope, Alexander and Pulaski Counties are found along the Ohio River, which is connected to the Great Lakes Basin via the Erie and Miami canal.*

POTENTIAL INTRODUCTION VIA HITCHHIKING/FOULING

Is this species likely to attach to or be otherwise transported by, or along with, recreational gear, boats, trailers, fauna (e.g., waterfowl, fish, insects), flora (e.g., aquatic plants), or other objects (e.g., packing materials), including as parasites or pathogens, entering the Great Lakes basin?

Yes, this species is known to be able to adhere to certain surfaces or to be transported by other organisms entering the Great Lakes basin.	100
No, this species is not known to be able to adhere to certain surfaces or to be transported by other organisms entering the Great Lakes basin.	0 √
Unknown	U

- Arundo donax *is not known to be transported hitchhiking or fouling despite being well-researched as an invasive in California*

What is the proximity of this species to the Great Lakes basin?

This species occurs in waters within 20 km of the Great Lakes basin.	Score x 1
This species occurs in waters within 100 km of the Great Lakes basin.	Score x 0.5
This species occurs in waters >100 km from the Great Lakes basin.	Score x 0.1
Unknown	U

POTENTIAL INTRODUCTION VIA UNAUTHORIZED INTENTIONAL RELEASE

Is this species sold at aquarium/pet/garden stores ("brick & mortar" or online), catalogs, biological supply companies, or live markets (e.g., purchased for human consumption, bait, ornamental, ethical, educational, or cultural reasons) and as a result may be released into the Great Lakes basin?

Yes, this species is available for purchase.	100√
No, this species this species is rarely/never sold.	0
Unknown	U

- *This species can be found for sale on popular online retailers Ebay and Amazon in addition to gardening supply websites.*
- *Mohlenbrock (2001) states that all Arundo donax in Illinois appear to have escaped from nearby farmhouses*
- *In a document released from MSU Dr. Art Cameron (2010)* Arundo donax *is listed as an ornamental grass suitable for Michigan gardens. Historically Arundo donax was also listed for ornamental use by the Michigan State Pomological Society (1883).*

How easily is this species obtained within the Great Lakes region (states/provinces)?

This species is widely popular, frequently sold, and/or easily obtained within the Great Lakes region.	Score x 1
This species is widely popular, and although trade, sale, and/or possession of this species is prohibited, it is frequently sold on the black market within the Great Lakes region.	Score x 0.5
This species is not very popular or is not easily obtained within the Great Lakes region.	Score x 0.1√
Unknown	U

- *Wisconsin state law prevents sale, purchase, and possession of* Arundo donax *(Wisconsin Chapter NR 40), also prohibited by Illinois whitelist approach to law.*

- Arundo donax *is found in the Great Lakes Region and has been reported in southern tip of Illinois where it is restricted by law (Mohlenbrock 2001).*

POTENTIAL INTRODUCTION VIA STOCKING/PLANTING OR ESCAPE FROM RECREATIONAL CULTURE

Is this species being stocked/planted to natural waters or outdoor water gardens around the Great Lakes region?

Yes, this species is being stocked/planted and/or has ornamental, cultural, medicinal, environmental (e.g., biocontrol, erosion control), scientific, or recreational value in the Great Lakes region.	100√
No, this species cannot be stocked/planted or there is not enough interest to do so in the Great Lakes region.	0
Unknown	U

- Arundo donax *is of important cultural significance through its influence on music dating back 5000 years. The basis for the origin of the most primitive pipe organ, the pan pipe, was made from* Arundo donax. *Reeds for woodwind musical instruments are still made from culms and satisfactory replacements have not been found (Perdue 1958).*
- Arundo donax *has been used for erosion control in the southwest United States (Perdue 1958)*
- *Planted for ornamental purposes (Perdue 1958)*

What is the nature and proximity of this activity to the Great Lakes basin?

This activity is authorized and/or is occurring directly in the Great Lakes.	Score x 1
This activity is occurring in Great Lakes tributaries or connecting waters, or within 20 km of the Great Lakes basin.	Score x 0.75
This activity is <u>likely</u> to occur within 20 km of the Great Lakes basin because of its popularity/value and there are no widespread regulations against stocking/planting.	Score x 0.5
This activity is occurring in waters >20 km from the Great Lakes basin, or despite federal or state regulations in more than half the basin (> 5 states/provinces), this activity <u>may</u> occur within 20 km of the basin because of the species' popularity/value.	Score x 0.25
Unknown	U√

- *No records of* Arundo donax *in Great Lakes Basin*

POTENTIAL INTRODUCTION VIA ESCAPE FROM COMMERCIAL CULTURE

Is this species known to be commercially cultured in or transported through the Great Lakes region?

Yes, this species is being commercially cultured in or transported through the Great Lakes region.	100
No, this species is not commercially cultured in or transported through the Great Lakes region.	0 √
Unknown	U

- *Mohlenbrock (2001) states that all* Arundo donax *in Illinois appear to have escaped from nearby farmhouses.*
- *Use of Arundo donax as fodder for livestock has seen use as fodder for livestock in North America (Tracy and DeLoach 1998). A lack of literature citing* Arundo donax *as a source of fodder in the Great Lakes Region indicates that it is not used for fodder in the region.*

What is the nature and proximity of this activity to the Great Lakes basin?

This activity is unregulated or minimally regulated and is occurring directly in the Great Lakes.	Score x 1
This activity is unregulated or minimally regulated and is occurring in Great Lakes tributaries or connecting waters, or within 20 km of the Great Lakes basin.	Score x 0.75
This activity is strictly regulated but occurs directly in the Great Lakes, and/or this activity involves transport of live organisms on/across the Great Lakes.	Score x 0.5
This activity is strictly regulated but occurs in Great Lakes tributaries, connecting waters, or within 20 km of the Great Lakes basin, and/or this activity involves transport of live organisms within 20 km of the Great Lakes basin.	Score x 0.25
This activity occurs >20 km from the Great Lakes basin and typically does not involve transport of live organisms closer to the basin.	Score x 0.1
Unknown	U

- *Illinois regulates aquatic plants that are not explicitly approved. Therefore,* Arundo donax *is restricted in Illinois.*
- *Occurrences in Illinois are in Pope, Alexander, and Pulaski Counties which are >100km from the Great Lakes Basin (USDA 2017).*

POTENTIAL INTRODUCTION VIA SHIPPING

Is this species capable of surviving adverse environments (i.e. extreme temperatures, absence of light, low oxygen levels) and partial-to-complete ballast water exchange/BWE (e.g., is euryhaline, buries in sediment, produces resistant resting stages, has other attributes or behaviors facilitating survival under these conditions)?

Yes, this species is able to survive in ballast tank environments for weeks at a time and may be suspended in ballast water.	100
Yes, this species is able to survive in ballast tank environments for weeks at a time and is able to survive BWE by burial in ballast sediment.	80
Yes, this species is able to survive in ballast tank environments for weeks at a time and may be suspended in ballast water, but this species is not able to survive BWE.	60
No, but this species is capable of fouling transoceanic ship structures (e.g., hull, chains, chain locker) while in its active or resting stage.	40
No, this species is not able to survive adverse environments, does not foul transoceanic ship structures, or is unlikely to be taken up with ballast.	0√
Unknown	U

- Arundo donax *is dispersed via water, however it has not been known to be dispersed by ballast water. Some traits of* Arundo donax *seem to suggest long term viability of vegetative reproduction propagules. Sprouts rise from disturbed stems or rhizomes even if buried 3 to 10 feet deep (USDA 2014). Stems and rhizomes remain viable for at least one month upon separation from parent plant (Wijte et al. 2005).*
- *Found in estuarine environments such as San Francisco Bay Estuary. Highest salinity treatments (38–42 dS m^{-1}) showed a >80% reduction of growth with zero mortality, indicating the ability to tolerate high levels of salt (Nackley and Kim 2014)*
- Arundo donax *can survive -13.88°C minimum (USDA 2017)*

Does this species occur in waters from which shipping traffic to the Great Lakes originates?

Yes, and this species has been observed in ballast of or fouling ships entering the Great Lakes.	Score x 1

Yes, and this species has been observed in ports that have direct trade connections with the Great Lakes (e.g., Baltic Sea).	Score x 0. 5
Yes, but this species has neither been observed in ballast/fouling ships entering the Great Lakes nor in ports in direct trade with the Great Lakes.	Score x 0.1
No, this species does not occur in waters from which shipping traffic to the Great Lakes originates.	Score x 0
Unknown	U

Potential Vector Scorecard				
Vector	**Raw Points Scored**	**Proximity Multiplier**	**Total Points Scored**	**Probability of Introduction**
Dispersal: Natural dispersal through waterbody connections or wind	**100**	x 0.25	**25**	Low
Hitchhiking/Fouling: Transport via recreational gear, boats, trailers, mobile fauna, stocked/planted organisms, packing materials, host organisms, etc.	**0**	x	**0**	Unlikely
Release: Unauthorized intentional release of organisms in trade (e.g., aquaria, water gardens, live food)	**100**	x 0.1	**10**	Low
Stocking/Planting/Escape from recreational culture: Intentional authorized or unauthorized introduction to natural waters in the Great Lakes OR Accidental introduction to Great Lakes by escape from recreational culture (e.g., water gardens)	**100**	x U	**U**	Unknown
Escape from commercial culture: Accidental introduction to Great Lakes by escape from commercial culture (e.g., aquaculture)	**0**	x U	**0**	Unlikely
Trans-oceanic shipping: Ballast (BOB) or no-ballast-on-board (NOBOB) water exchange/discharge, sediment discharge, hull fouling	**0**	X U	**0**	Unlikely
Total Unknowns (U)	**3**	**Confidence Level**	Low	

Qualitative Statements for GLANSIS Fact Sheet:
Arundo donax has a low probability of introduction to the Great Lakes (Confidence level: low).

Potential pathway(s) of introduction: Unauthorized intentional release, dispersal.

Section B: Potential for Establishment

ESTABLISHMENT POTENTIAL RESULTS

***Arundo donax* has a moderate probability of establishment if introduced to the Great Lakes**

(Confidence level: High)

Comments: *Arundo donax* is a resilient, versatile and fast-growing plant with strong competitive abilities which have led to the plant becoming highly invasive in particular areas of the United States. *Arundo donax* has shown qualities which indicate that it could overwinter however its spread North into colder climates appears to be limited even in its native range. The range of *Arundo donax* potentially could increase with the effects of climate change.

INVASIVE BIOLOGICAL/ECOLOGICAL ATTRIBUTES

How would the physiological tolerance of this species (survival in varying temperature, salinity, oxygen, and nutrient levels) be described?

This species has broad physiological tolerance. It has been reported to survive in wide ranges of temperature (0°C-30°C), salinity (0-16 parts per thousand), oxygen (0-saturated), AND nutrient (oligotrophic-eutrophic) levels.	9
This species has somewhat broad physiological tolerance. It has been reported to survive in a wide range of temperature, salinity, oxygen, OR nutrient levels. Tolerance to other factors is narrower, unknown, or unreported.	6
This species has narrow physiological tolerance. It has been reported to survive in limited ranges of temperature, salinity, oxygen, and nutrient levels.	3
Unknown	U
	8

- Arundo donax *can survive -13.88°C minimum and is found in southern states where temperature frequently exceed 30°C (USDA 2017)*
- *Found in estuarine environments such as San Francisco Bay Estuary. Highest salinity treatment (38–42 dS* m^{-1}*) showed a >80% reduction of growth with zero mortality, indicating the ability to tolerate high levels of salt (Nackley and Kim 2014) Also grows in freshwater riparian habitat (Saltonstall et al. 2010).*
- *Reported by Perdue (1958) that 2 to 3-year-old growth are able to tolerate periods of excessive drought and periods of excessive moisture but quantitative measurements of tolerance were not given. Perdue (1958) also reports water use of 2,000 L/meter per day to sustain growth rate.*
- Arundo donax *is tolerant of soils with low amounts of nitrogen (Perdue 1958).* Arundo donax *showed high and similar biomass at six different nutrient treatments, the lowest of which was 4 mg* L^{-1} *of nitrogen and 0.4 mg* L^{-1} *of phosphorous and the highest treatment contained 16 mg* L^{-1} *of nitrogen and 3.2 mg* L^{-1} *of phosphorous suggesting a wide range of nutrient tolerance (Liao et al. 2017).*
- *Able to grow in heavy clay, loose sand, and gravelly soil (Perdue 1958)*
- Arundo donax *has a low tolerance for calcium carbonate in soil (Perdue 1958)*

How likely is it that any life stage of this species can overwinter in the Great Lakes (survive extremely low levels of oxygen, light, and temperature)?

Likely (This species is able to tolerate temperatures under 5°C and oxygen levels ≤0.5 mg/L)	9
Somewhat likely (This species is able to tolerate some of these conditions OR has adapted behaviorally to avoid them)	6
Somewhat unlikely (This species is able to tolerate conditions close to those specified, but it is not known as an overwintering species)	3
Unlikely	0
Unknown	U

	3

- Arundo donax *can survive -13.88°C minimum temperature (USDA 2017).*
- Arundo donax *is reported to be highly sensitive to frost that occurs after initiation of spring growth (Perdue 1958). However, ecotypes of* Arundo donax longicaulis *are frost tolerant. Antal et al. (2014) noted shoots of two-year-old* Arundo donax *were collected in Hungary in June and October 2013 indicating that these specimens overwintered. It is not known if the longicaulis ecotype exists in the USA*
- Arundo donax *is found in Pope County, Illinois, which experiences frost temperatures of 32-28°F by March 10th or earlier in the spring. In the fall, first freeze occurs at 28°F usually between October 1-10th (Angel 2016). Marion, IL, found in Pope County, receives an average of 14.4 inches of snowfall and 7.4 days of snowfall (Arguez et al.2010). This data suggests some frost and snow tolerance, which suggests the possibility that* Arundo donax *can expand farther north.*
- Arundo donax *was able to tolerate light levels as low as 10% of full sun. Leaf lifespan was longest for those growing under 40% of full sun (Spencer et al. 2005).*
- *At 15°C and 10°C, Wijte et al. (2005) observed that* Arundo donax *exhibited low regeneration and the absence of rooting by stem fragments. They concluded this as the reason that* Arundo donax *has not expanded into cooler regions of America, Europe, and Asia.*
- Arundo donax *cultivation in Germany and Austria has been unstable due to the windy, snowless, and cold winters which have temperatures permanently below 10°C (Antal and Kurucz 2014).*
- *220 frost free days a year are required for growth (USDA 2017)*

If this species is a heterotroph, how would the flexibility of its diet be described?

This species is a dietary generalist with a broad, assorted, AND flexible diet.	9
This species is moderately a dietary generalist with a broad, assorted, OR flexible diet.	6
This species is a dietary specialist with a limited and inflexible diet.	3
This species is an autotroph.	0
Unknown	U
	0

- Arundo donax *is an autotroph.*

How likely is this species to outcompete species in the Great Lakes for available resources?

Likely (This species is known to have superior competitive abilities and has a history of outcompeting other species, AND/OR available literature predicts it might outcompete native species in the Great Lakes)	9
Somewhat likely (This species is known to have superior competitive abilities, but there are few reported cases of this species outcompeting another and no predictions regarding species in the Great Lakes)	6
Somewhat unlikely (This species has average competitive abilities, and there are no reported cases of this species outcompeting another and no predictions regarding species in the Great Lakes)	3
Unlikely (This species is known as a poor competitor that thrives only in environments with low biodiversity, AND/OR available literature predicts it might be outcompeted by a species in the Great Lakes)	0
Unknown	U
	6

- *In California,* Arundo donax *invades riparian habitat easily, especially in disturbed areas. When established, A. donax forms large, continuous, clonal root masses, which can span several acres and often outcompetes native vegetation (Bell 1997).*
- *It has been reported that* Phragmites *have rapidly expanded in wetland systems, often in association with* Arundo donax. *In California the invasion of* Arundo donax *has overshadowed the invasion of* Phragmites. Phragmites *could possibly replace Arundo* donax *in some locations because both grasses occupy a similar ecological niche and* Phragmites *possess a potential advantage in dispersal as they reproduce sexually and clonally (Meyerson et al. 2010).*

How would the fecundity of this species be described relative to other species in the same taxonomic class?

Very high	9
High	6
Moderate	3
Low	0
Unknown	U
	6

- *With favorable conditions growth rate is .3 to .7 m per week over several months and more than 20 tons per hectare of above-ground dry mass can be produced (Perdue 1958).*
- Arundo donax *was ranked first in studies on plant yield in Mediterranean areas producing 36.9 Mg dry matter ha*$^{-1}$ *in a seven-year study (Mariani et al. 2010)*
- *The primary mode of reproduction for* Arundo donax *is vegetative propagation.* Arundo donax *has rapid clonal rapid spread attributed to its rhizome extension and flood dispersal of rhizome and culm fragments (Mariani et al. 2010). Sprouts rise from disturbed stems or rhizomes even if buried 3 to 10 feet deep (USDA 2014). Stems and rhizomes remain viable for at least one month upon separation from parent plant (Wijte et al. 2005).*
- *It is unclear if* Arundo donax *would outcompete* Phragmites, which *have already been established in the Great Lakes region. In the Rio Grande watershed, it has been reported that* Phragmites *have rapidly expanded in wetland systems, often in association with A. donax. In California the invasion of A. donax has overshadowed the invasion of* Phragmites. Phragmites *could possibly replace* Arundo donax *in some locations because both grasses occupy a similar ecological niche and* Phragmites *possess a potential advantage in dispersal as they reproduce sexually and clonally.* Phragmites *posses another competitive advantage in reproduction as their rhizomes are not impacted by the cold while* Arundo donax *rhizomes will be stressed by the winters giving* Phragmites *the advantage in early Spring growth (Meyerson et al. 2010, Wijte et al. 2005).*

How likely are this species' reproductive strategy and habits to aid establishment in new environments, particularly the Great Lakes (e.g., parthenogenesis/self-crossing, self-fertility, vegetative fragmentation)?

Likely (The reproductive strategy or habits of this species are known to aid establishment in new environments, AND available literature predicts establishment in the Great Lakes based on these attributes)	9
Somewhat likely (The reproductive strategy or habits of this species are known to aid establishment in new environments, but there is no literature available regarding establishment in the Great Lakes based on these attributes)	6
Somewhat unlikely (The reproductive strategy or habits of this species could potentially aid establishment in new environments, but there is no literature available regarding establishment in the Great Lakes based on these attributes)	3
Unlikely (The reproductive strategy or habits of this species are not known to aid establishment in new environments)	0

Unknown	U
	6

- *It is well adapted to disturbance because of its ability to reproduce vegetatively.* Arundo donax *fragments spread by drifting downstream where stems and rhizomes will root and establish in new habitats (Bell 1997).*
- Arundo donax *altered fire fuel types and loads in southern California. Riparian ecosystems next to fire-prone shrublands appear to be shifting to an invasive plant-fire regime cycle (Brooks et al. 2004). Evidence suggests that* Arundo donax *is changing riparian ecosystems from flood to fire-defined (Bell 1997). Research by (Coffman et al. 2010) suggests wildfire promotes invasion of riparian ecosystems by* Arundo donax *due to fire-adapted phenology, high growth rate, and growth response to nutrient enrichment.* Arundo donax *were dominant in the first year following wildfire and composed 99% of vegetative cover in study sites.*
- Arundo donax *has become dominant in watersheds in Southern California (Bell 1997)*
- Arundo donax *is tolerant of a wide range of environmental conditions*

ENVIRONMENTAL COMPATIBILITY

How similar are the climatic conditions (e.g., air temperature, precipitation, seasonality) in the native and introduced ranges of this species to those in the Great Lakes region?

Very similar (The climatic conditions are practically identical to those of the Great Lakes region)	9
Similar (Many of the climatic conditions are similar to those of the Great Lakes region)	6
Somewhat similar (Few of the climatic conditions are similar to those of the Great Lakes region)	3
Not similar	0
Unknown	U
	3

- Arundo donax *is native to countries surrounding the Mediterranean Sea and parts of Pacific Basin (Perdue 1958, USDA 2017).* Arundo donax *requires 220 frost free days a year for growth (USDA 2017)*
- Arundo donax *is found in Pope County, Illinois which experiences frost temperatures of 32-28°F March 10th or earlier in the spring. In the fall first freeze occurs at28°F i from October 1-10th (Angel 2016). Marion, IL receives an average of 14.4 inches of snowfall and 7.4 days of snowfall (Arguez et al. 2010).*

How similar are other abiotic factors that are relevant to the establishment success of this species (e.g., pollution, water temperature, salinity, pH, nutrient levels, currents) in the native and introduced ranges to those in the Great Lakes?

Very similar (These factors are practically identical to those of the Great Lakes region)	9
Similar (Many of these factors are similar to those of the Great Lakes region)	6
Somewhat similar (Few of these factors are similar to those of the Great Lakes region)	3
Not similar	0
Unknown	U
	6

- *Found in estuarine environments such as San Francisco Bay Estuary. Highest salinity treatments (EC 40) (38–42 dS m^{-1}) showed a >80% reduction of growth with zero mortality, indicating the ability to tolerate* *high levels of salt (Nackley and Kim 2014). Also grows in freshwater riparian habitat (Saltonstall et al. 2010).*

- *Reported by Perdue (1958) that 2 to 3-year-old growth are able to tolerate periods of excessive drought and periods of excessive moisture but quantitative measurements were not noted. Perdue (1958) also reports water use of 2,000 L/meter per day to sustain growth rate.*
- *Tolerant of soils with low amounts of nitrogen (Perdue 1958). In Liao et al. (2017), A. donax showed high and similar biomass at six different nutrient treatments, the lowest of which was 4 mg L^{-1} of nitrogen and 0.4 mg L^{-1} of phosphorous and the highest treatment contained 16 mg L^{-1} of nitrogen and 3.2 mg L^{-1} of phosphorous suggesting a wide range of nutrient tolerance.*
- *Able to grow in heavy clay, loose sand, and gravelly soil (Perdue 1958)*
- Arundo donax *has a low tolerance for calcium carbonate in soil (Perdue 1958)*
- *pH requirements minimum of 4.8 and maximum of 7.0 (USDA 2017)*

How abundant are habitats suitable for the survival, development, and reproduction of this species in the Great Lakes area (e.g., those with adequate depth, substrate, light, temperature, oxygen)?

Abundant (Suitable habitats can be easily found and readily available)	9
Somewhat abundant (Suitable habitats can be easily found but are in high demand by species already present)	6
Somewhat scarce (Suitable habitats can be found occasionally)	3
Scarce (Suitable habitats are rarely found)	0
Unknown	U
	2

- Arundo donax *cultivation in Germany and Austria has been unstable due to the windy, snowless, and cold winters which have temperatures permanently below 10°C (Antal and Kurucz 2014)*
- *Wijte et al. (2005) found that* Arundo donax *exhibited low regeneration and the absence of rooting by stem fragments at 15°C and 10°C. They concluded this as the reason that* Arundo donax *has not expanded into cooler regions of America, Europe and Asia.*
- *220 frost free days a year are required (USDA 2017)*
- Arundo donax *is highly invasive in California riparian habitat. It is unclear if* Arundo donax *would outcompete* Phragmites *which have already been established in the Great Lakes region. In the Rio Grande watershed it has been reported that* Phragmites *have rapidly expanded in wetland systems, often in association with* Arundo donax. *In California the invasion of* Arundo donax *has overshadowed the invasion of* Phragmites. Phragmites *could possibly replace* Arundo donax *in some locations because both grasses occupy a similar ecological niche and* Phragmites *possess a potential advantage in dispersal as they reproduce sexually and clonally.* Phragmites *posses another competitive advantage in reproduction as their rhizomes are not impacted by the cold while* Arundo donax *rhizomes will be stressed by the winters giving* Phragmites *the advantage in early Spring growth (Meyerson et al. 2010, Wijte et al. 2005).*

How likely is this species to adapt to or to benefit from the predicted effects of climate change on the Great Lakes freshwater ecosystems (e.g., warmer water temperatures, shorter duration of ice cover, altered streamflow patterns, increased salinization)?

Likely (Most of the effects described above make the Great Lakes a better environment for establishment and spread of this species OR this species could easily adapt to these changes due to its wide environmental tolerances)	9
Somewhat likely (Several of the effects described above could make the Great Lakes a better environment for establishment and spread of this species)	6
Somewhat unlikely (Few of the effects described above would make the Great Lakes a better environment for establishment and spread of this species)	3

Unlikely (Most of the effects described above would have no effect on establishment and spread of this species or would make the environment of the Great Lakes unsuitable)	0
Unknown	U
	6

- Arundo donax *can survive -13.88°C minimum and it is found in southern states where temperature frequently exceed 30°C (USDA 2017). Warmer temperatures would likely expand the range to which* Arundo donax *could spread north.*
- *Found in estuarine environments such as San Francisco Bay Estuary. Highest salinity treatments (EC 40) (38–42 dS m^{-1}). This species showed a >80% reduction of growth with zero mortality, indicating the ability to tolerate high levels of salt (Nackley and Kim 2014). In its native range it grows in freshwater (Bell 1997).*
- Arundo donax *is highly sensitive to frost that occurs after initiation of spring growth (Perdue 1958). However, ecotypes of A. donax longicaulis are reportedly have frost tolerant properties. In Antal et al 2014 shoots of two-year-old overwintered* Arundo donax *were collected in Hungary in June and October 2013. Unknown if ecotype exists in USA.* Arundo donax *would likely benefit from shorter duration of ice cover and warmer temperatures from climate change.*
- *It is well adapted to disturbance because of its ability to reproduce vegetatively, which leads to the dispersal of* Arundo donax *fragments downstream where stems and rhizomes will root and establish (Bell 1997). Altered streamflow could benefit the spread of* Arundo donax *via streamflow dispersion to new habitat.*

How likely is this species to find an appropriate food source (prey or vegetation in the case of predators and herbivores, or sufficient light or nutrients in the case of autotrophs)?

Likely (All possible nutritive food items—including species in the Great Lakes that may be considered potential food items—are highly abundant and/or easily found)	9
Somewhat likely (Some nutritive food items—including species in the Great Lakes that may be considered potential food items—are abundant and/or search time is low to moderate)	6
Somewhat unlikely (Few nutritive food items—including species in the Great Lakes that may be considered potential food items—are abundant and/or search time is moderate to high)	3
Unlikely (All possible nutritive food items—including species in the Great Lakes that may be considered potential food items—are relatively scarce and/or search time is high)	0
Unknown	U
	9

- *Tolerant of soils with low amounts of nitrogen (Perdue 1958). In Liao et al. (2017),* Arundo donax *showed high and similar biomass at six different nutrient treatments, the lowest of which was 4 mg L^{-1} of nitrogen and 0.4 mg L^{-1} of phosphorous and the highest treatment contained 16 mg L^{-1} of nitrogen and 3.2 mg L^{-1} of phosphorous suggesting a wide range of nutrient tolerance.*
- Arundo donax *was able to tolerate light levels as low as 10% of full sun. Leaf lifespan was longest for those growing under 40% of full sun (Spencer et al. 2005)*

Does this species require another species for critical stages in its life cycle such as growth (e.g., root symbionts), reproduction (e.g., pollinators, egg incubators), spread (e.g., seed dispersers), or transmission (e.g., vectors)?

Yes, and the critical species (or one that may provide a similar function) is common in the Great Lakes and can be easily found in environments suitable for the species being assessed; OR,	9

No, there is no critical species required by the species being assessed	
Yes, and the critical species (or one that may provide a similar function) is moderately abundant and relatively easily found in particular parts of the Great Lakes	6
Yes, and the critical species (or one that may provide a similar function) is relatively rare in the Great Lakes AND/OR can only be found occasionally in environments suitable for the species being assessed	3
Yes, and the critical species (or one that may provide a similar function) is not present in the Great Lakes but is likely to be introduced	0
Yes, but the critical species (or one that may provide a similar function) is not present in the Great Lakes and is not likely to be introduced	-80% total points (at end)
Unknown	U
	9

- Arundo donax *is not dependent on another species during critical stages of its life cycle. It reproduces asexually (Perdue 1997).*

How likely is the establishment of this species to be aided by the establishment and spread of another species already in the Great Lakes?

Likely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established and spread in the Great Lakes, AND available literature predicts this previous invader might promote the establishment of this species, AND/OR there have been cases reported of this species aiding the establishment of this species in other areas)	9
Somewhat likely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established and spread in the Great Lakes)	6
Somewhat unlikely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established in the Great Lakes BUT it is still confined to a small area of the Lakes and the likelihood of encounter with this species assessed is hard to predict)	3
Unlikely (A non-indigenous species to the Great Lakes that facilitates the development of this species has not been established in the Great Lakes)	0
Unknown	U
	0

- *There are currently no reports that discuss the facilitated spread of* Arundo donax *by any species.* Arundo donax *reproduces vegetatively and spreads by the dispersal of fragments via floods (Bell 1997).*

How likely is establishment of this species to be prevented by the herbivory, predation, or parasitism of a natural enemy this is already present in the Great Lakes and may preferentially target this species?

Likely (The ability of the natural enemy to prevent the establishment of this species in introduced ranges or limiting populations of this species in native ranges is well documented in the literature AND this natural enemy is abundant and widespread in the Great Lakes)	-80% total points (at end)
Somewhat likely (The ability of the natural enemy to prevent the establishment of this species in introduced ranges or limiting populations of this species in native ranges is suggested in the literature OR this natural enemy has limited distribution in the Great Lakes)	-60% total points (at end)

Somewhat unlikely (There are few cases reported of such a natural enemy preventing the establishment of this species in introduced ranges or limiting populations of this species in native ranges OR this natural enemy has low abundance in the Great Lakes)	-10% total points (at end)
Unlikely (Such a natural enemy is particularly rare or is not present in the Great Lakes)	0
Unknown	U
	-10%

- Arundo donax *stems and leaves contain a variety of noxious chemicals, which likely protect it from insects and grazers. Chemicals include silica, triterpines, sterols, cardiac glyscoides, curare-mimicking indoles, hydroxamic acid, and other alkaloids (Bell 1997; Zúńiga et al. 1983). Methods of control in its native range are unclear but corn borers, spider mites, and aphids have been reported to infest the plant (Bell 1997).*
- *While not natural to the region, potential biological controls exist.* Arundo donax *is not palatable, but livestock will graze on young green shoots during the dry season. Angora or Spanish goats can be used to suppress resprouts after other treatments have been completed. Rhizaspidioutus donacis is an insect found in the native range of* Arundo donax *and is expected to become available in the United States for use as a biological control agent. Rhizaspidioutus donacis attacks rhizomes and underground buds. Currently no biological control is approved (USDA Forest Service 2014).*

PROPAGULE PRESSURE

On average, how large and frequent are inoculations (introduction events) from the potential vectors identified in Section A for this species? (What is the total number of individuals introduced?)

Frequent, large inocula	9
Frequent, moderate inocula	6
Frequent, small inocula OR infrequent, large inocula	3
Infrequent, small or moderate inocula	0
Unknown	U
	0

- Arundo donax *sees unlikely, low, and unknown inocula to the Great Lakes*

HISTORY OF INVASION AND SPREAD

How extensively has this species established reproducing populations in areas outside its native range as a direct or indirect result of human activities?

Very extensively (many invasive populations of this species have been reported in areas widely distributed from the native range)	9
Extensively (some invasive populations of this species have been reported in areas widely distributed from the native range)	6
Somewhat extensively (few invasive populations of this species have been reported in areas widely distributed from the native range OR all invasive populations are in close proximity to each other)	3
Not extensively (no invasive populations of this species have been reported)	0
Unknown	U
	9

- Arundo donax *was intentionally introduced to Los Angeles in the 1820's for erosion control and thatching for roofs (Hoshovsky 1987). In North America, it can now be found in AL, AR, AZ, CA, DE, FL, GA, HI, IL, KY, LA, MD, MO, MS, NM, PR, SC, TN, TX, UT, VI, WV (USDA 2017).*
- Arundo donax *has invaded Mediterranean, subtropical and semiarid riparian zones worldwide (Lambert et al. 2010).*

How rapidly has this species spread by natural means or by human activities once introduced to other locations?

Rapidly (This species has a history of rapid spread in introduced ranges)	9
Somewhat rapidly (This species has a history of moderately rapid spread in introduced ranges)	6
Somewhat slowly (This species has a history of moderately slow spread in its introduced ranges)	3
Slowly (This species has a history of slow to no spread in its introduced ranges)	0
Unknown	U
	9

- Arundo donax *has rapid clonal rapid spread attributed to its rhizome extension and flood dispersal of rhizome and culm fragments (Mariani et al. 2010).*
- Arundo donax *thrives in riparian communities with disturbed hydrology from anthropogenic manipulation (Nackkley and Kim 2015).*
- *Fire disturbance also facilitates the spread of* Arundo donax. *Research by Coffman et al. (2010) suggests wildfire promotes invasion of riparian ecosystems by* Arundo donax *due to fire-adapted phenology, high growth rate, and growth response to nutrient enrichment.* Arundo donax *were dominant in the first year following wildfire and composed 99% of vegetative cover in study sites.*

Are there any existing control measures in the Great Lakes set to prevent the establishment and/or spread of this species?

Yes, and they are likely to prevent establishment or spread of the species. (There are no reported cases of this species adapting or avoiding current measures. These measures are highly effective in preventing the establishment and spread of this species)	-90% total points (at end)
Yes, and they are moderately likely to prevent establishment or spread of the species. (There are few reported cases of this species adapting or avoiding current measures used to control its establishment and spread)	-50% total points (at end)
Yes, but they are unlikely to prevent establishment or spread of the species. (There are many reported cases of this species adapting or avoiding current measures used to control its establishment and spread)	-20% total points (at end)
No control methods have been set to prevent the establishment and/or spread of this species	0
Unknown	U
	-20%

- Arundo donax *is identified as an invasive plant species by the Wisconsin DNR: thus transportation, possession, transfer, and introduction are prohibited by law (Wisconsin Chapter NR 40).*
- *Illinois regulates aquatic plants that are not explicitly approved. Therefore,* Arundo donax *is restricted in Illinois.*
- Arundo donax *chemical and physical control methods require application over 3-5 years for complete control of the plant due to its efficient vegetative reproduction (USDA Forest Service 2014).*

<table>
<tr><th colspan="5">Establishment Potential Scorecard</th></tr>
<tr><td>Points</td><td>Probability for Establishment</td><td colspan="2">Total Points (pre-adjustment)</td><td>82</td></tr>
<tr><td rowspan="2">>100</td><td>High</td><td colspan="2">Adjustments</td><td></td></tr>
<tr><td></td><td>Critical species</td><td>A (1- 0%)</td><td>82</td></tr>
<tr><td rowspan="2">51-99</td><td>Moderate</td><td>Natural enemy</td><td>B (1-10%)</td><td>73.8</td></tr>
<tr><td></td><td>Control measures</td><td>C (1-20%)</td><td>59.04</td></tr>
<tr><td>0-50</td><td>Low</td><td colspan="2">Probability for Establishment</td><td>Moderate</td></tr>
<tr><td># of questions answered as “unable to determine”</td><td>Confidence Level</td><td colspan="3"></td></tr>
<tr><td>0-1</td><td>High</td><td colspan="2" rowspan="2">Total # of questions unknown</td><td rowspan="2">0</td></tr>
<tr><td>2-5</td><td>Moderate</td></tr>
<tr><td>6-9</td><td>Low</td><td colspan="2" rowspan="2">Confidence Level</td><td rowspan="2">High</td></tr>
<tr><td>>9</td><td>Very low</td></tr>
</table>

Qualitative Statements for GLANSIS Fact Sheet:
Arundo donax has a moderate probability of establishment if introduced to the Great Lakes (Confidence level: high).

Section C: Potential for Impact

IMPACT POTENTIAL RESULTS

Environmental: High
Socio-Economic: Moderate
Beneficial: Moderate

POTENTIAL ENVIRONMENTAL IMPACT

Does the species pose some hazard or threat to the health of native species (e.g., it magnifies toxin levels; is poisonous; is a pathogen, parasite, or a vector of either)?

Yes, and it has impacted threatened/endangered species, resulted in the reduction or extinction of one or more native populations, affects multiple species, or is a reportable disease	6
Yes, but negative consequences have been small (e.g., limited number of infected individuals, limited pathogen transmissibility, mild effects on populations and ecosystems)	1
Not significantly	0√
Unknown	U

Does it out-compete native species for available resources (e.g., habitat, food, nutrients, light)?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species or caused critical reduction, extinction, behavioral changes including modified spawning behavior) on one or more native populations	6√
Yes, and it has caused some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population	1
Not significantly	0
Unknown	U

- *In Southern California,* Arundo donax *outcompetes native vegetation due to its tall, dense stands that receive more sunlight, soil moisture, and nutrients. Arundo donax has displaced native vegetation including* Salix *spp.,* Baccharis salicfolia*,* Propulus *spp. This plant provides nesting habitat for native birds including the federally endangered* Viero bellii pusillus *and the federally threatened* E. traili *(Oakins 2001).*

Does it alter predator-prey relationships?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species, caused significant reduction or extinction of one or more native populations, creation of a dead end or any other significant alteration in the food web)	6
Yes, and it has resulted in some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population AND/OR Yes, and it has resulted in some alteration of the food web structure or processes, the effects of which have not been widespread or severe	1 √
Not significantly	0

Unknown	U

- Arundo donax *has led to decline in arthropod abundance in Southern California. This implies negative effects to habitat value of birds and wildlife whose diets are mostly composed of insects found in native riparian vegetation (Herrera and Dudley 2003).*

Has it affected any native populations genetically (e.g., through hybridization, selective pressure, introgression)?

Yes, and it has caused a loss or alteration of genes that may be irreversible or has led to the decline of one or more native species (or added pressure to threatened/endangered species)	6
Yes, some genetic effects have been observed, but consequences have been limited to the individual level	1
Not significantly	0
Unknown	U√

- *Evidence shows* Arundo donax *reproduces asexually (Saltonstall et al. 2010)*
- *Ecological effects of* Arundo donax *invasion lacks empirical data (Lambert et al. 2010)*

Does it negatively affect water quality (e.g., increased turbidity or clarity, altered nutrient, oxygen, or other chemical levels/cycles)?

Yes, and it has had a widespread, long-term, or severe negative effect on water quality AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6 √
Yes, it has affected water quality to some extent, but the alterations and resulting adverse effects have been limited or inconsistent (as compared with above statement)	1
Not significantly	0
Unknown	U

- *In the Santa Ana Watershed, research suggests that* Arundo donax *lacks canopy structure to provide significant shading of bank-edge river habitats which results in warmer water.* Arundo donax*-dominated riverine areas have warmer water temperatures that typically result in lower oxygen concentrations and lower diversity of aquatic animals. In the Santa Ana River system this effect appears to be responsible for decline of Arroyo chub (*Gila orcuttii*), Threespine Stickleback (*Gasterosteus aculatus*), Speckled Dace (*Rhinichthys osculus*), and Santa Ana sucker (*Catostomus santaanae*). Other potential effects include increased pH in shallower sections of river because of higher algal photosynthetic activity. The higher pH facilitates conversion of ammonium to ammonia causing further water quality problems (Bell 1997)*
- Arundo donax *has changed timing and quality of organic matter inputs for federally threatened* Oncorhynchus mykiss *and* Oncorhynchus kisutch *and freshwater shrimp (Oakins 2001).*

Does it alter physical components of the ecosystem in some way (e.g., facilitated erosion/siltation, altered hydrology, altered macrophyte/phytoplankton communities, physical or chemical changes to substrate)?

Yes, and it has had a widespread, long term, or severe negative effect on the physical ecosystem AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6 √
Yes, it has affected the physical ecosystem to some extent, but the alterations and resulting adverse effects have been mild	1
Not significantly	0

Unknown	U

- *When established,* Arundo donax *will form large, continuous clonal root masses which can cover several acres. Root masses can become more than a meter thick and stabilize banks and terraces largely altering hydrology (Bell 1997). Root masses are also brittle causing undercutting of the bank, bank slumping and sedimentation of the river or stream (Oakins 2001).*
- *In Southwestern United States,* Arundo donax *uses significantly more water than native vegetation, thus further altering the natural flood regime.* Arundo donax *has been shown to transpire 56,250 acre-feet of water over the course of a year compared to native species which transpired 18,700 acre-feet (USDA 2014).*
- Arundo donax *increases algal activity caused by lower oxygen concentrations (Bell 1997).*

Environmental Impact Total	**19**
Total Unknowns (U)	**1**

POTENTIAL SOCIO-ECONOMIC IMPACT

Does the species pose some hazard or threat to human health (e.g., it magnifies toxin levels, is poisonous, a virus, bacteria, parasite, or a vector of one)?

Yes, significant effects on human health have already been observed	6
Yes, but negative consequences have not been widespread, long lasting, or severe	1 √
Not significantly	0
Unknown	U

- *If* Arundo donax *is left unmanaged it poses a fire hazard, which is a safety hazard for humans (Oakins 2001)*

Does it cause damage to infrastructure (e.g., water intakes, pipes, or any other industrial or recreational infrastructure)?

Yes, it is known to cause significant damage	6
Yes, but the costs have been small and are largely reparable or preventable	1 √
Not significantly	0
Unknown	U

- Arundo donax *alterations to hydrology can force streams in new directions resulting in accelerated erosion of stream banks, which can lead to lost property and expensive property repairs (Oakins 2001)*
- *If* Arundo donax *is left unmanaged it poses a fire hazard for nearby buildings (Oakins 2001)*
- Arundo donax *alterations to hydrology can result in areas being designated as high flood risk which increases in higher insurance costs and reduced property value (CIPC 2011).*

Does it negatively affect water quality (i.e. in terms of being less suitable for human use)?

Yes, it has significantly affected water quality, and is costly or difficult to reverse	6
Yes, but the effects are negligible and/or easily reversed	1
Not significantly	0 √
Unknown	U

- *Lower oxygen concentrations attributed to* Arundo donax *in shallow waters has increased pH levels due to higher algal photosynthetic activity. The higher pH facilitates conversion of ammonium to ammonia causing further water quality problems (Bell 1997)*
- *In the Rio Grande Basin--where water supply is limited— a water conservation plan estimates a $4.38 return for every dollar invested in control of* Arundo donax *(Seawright et al. 2009). However, in the Great Lakes--where water supply is not a concern—the water of consumption of* Arundo donax *does not compete with human consumption significantly.*

Does it negatively affect any markets or economic sectors (e.g., commercial fisheries, aquaculture, agriculture)?

Yes, it has caused significant damage to one or more markets or economic sectors	6
Some damage to markets or sectors has been observed, but negative consequences have been small	1 √
Not significantly	0
Unknown	U

- Arundo donax *alterations to hydrology can result in areas being designated as high flood risk which increases in higher insurance costs and reduced property value (CIPC 2011).*

Does it inhibit recreational activities and/or associated tourism (e.g., through frequent water closures, equipment damage, decline of recreational species)?

Yes, it has caused widespread, frequent, or otherwise expensive inhibition of recreation and tourism	6
Yes, but negative consequences have been small	1
Not significantly	0 √
Unknown	U

- *Faster, narrower stream flow can reduce potential water recreation (Oakins 2001).*

Does it diminish the perceived aesthetic or natural value of the areas it inhabits?

Yes, the species has received significant attention from the media/public, significantly diminished the natural or cultural character of the area, or significantly reduced the area's value for future generations	6
Yes, but negative consequences have been small	1 √
Not significantly	0
Unknown	U

- Arundo donax *outcompetes native vegetation and dominates riparian habitats where it invades.* Arundo donax *were dominant in the first year following wildfire and composed 99% of vegetative cover in study sites (Coffman et al. 2010). These monocultures of* Arundo donax *would outcompete native vegetation and remove the aesthetic value of riparian habitats. However, there is a lack of reports of diminished value to the landscape.*
- Arundo donax *has negatively impacted native populations of arthropods, birds, and fish in Southern California*

Socio-Economic Impact Total	**3**
Total Unknowns (U)	**0**

POTENTIAL BENEFICIAL EFFECT

NOTE: In this section, a "Not significantly" response should be selected if there have been no reports of a particular effect. An "Unknown" response is appropriate if the potential for a particular effect might be inferred but has not been explicitly reported or if there is an unresolved debate about a particular effect.

Does it act as a biological control agent for aquatic weeds or other harmful nonindigenous organisms?

Yes, it has succeeded significantly as a control agent	6

Yes, it has had some success as a control agent, but may be inconsistent or lack a desired level of effectiveness	1
Not significantly	0 √
Unknown	U

- *Not significantly.*

Is it commercially valuable (e.g., for fisheries, aquaculture, agriculture, bait, ornamental trade)?

Yes, it is economically important to at least one of these industries	6
Yes, but its economic contribution is small	1
Not significantly	0 √
Unknown	U

- *Historically, reeds for woodwind musical instruments were made from culms of* Arundo Donax*, in 1958 Perdue stated, "Satisfactory replacements have still not been found." Arundo donax is still valuable for use in woodwind instruments to this day because of its influence on the tone quality and performance of instruments in which it is used. The acoustic properties of* Arundo donax *have remained in study (Obataya 1999).*
- Arundo donax *is of particular interest as an energy crop and was ranked first in studies on plant yield in Mediterranean areas. This plant has a high productivity, a low demand for nutrients, is resistant to stress, and produces low carbon emissions, thus making making it suitable for cultivation as an energy crop (Mariani et al. 2010). The use of* Arundo donax *for water treatment was also noted to be attractive as a potential source of biomass for energy production (Idris et al. 2011).*

Is it recreationally valuable (e.g., for sport or leisurely fishing, as a pet, or for any other personal activity)?

Yes, it is commonly employed recreationally and has some perceived value for local communities and/or tourism	6
It is sometimes employed recreationally, but adds little value to local communities or tourism	1 √
Not significantly	0
Unknown	U

- Arundo donax *is of important cultural significance through its influence on music dating back 5000 years. The basis for the origin of the most primitive pipe organ, the pan pipe, was made from* Arundo donax. *Reeds for woodwind musical instruments are still made from culms and satisfactory replacements have not been found (Perdue 1958).*
- Arundo donax *has been cultivated as an ornamental plant (Perdue 1958)*

Does the species have some medicinal or research value (i.e. outside of research geared towards its control)?

Yes, it has significant medicinal or research value	6
It has some medicinal or research value, but is not of high priority OR It is potentially important to medicine or research and is currently being or scheduled to be studied	1√
Not significantly	0
Unknown	U

- Arundo donax *has "great promise" for development of novel drugs for human diseases. It has shown antibacterial activity against methicillin resistant Staphylococcus aureus. In addition, it has displayed antimicrobial effects against standard bacterial strains with maximum effect on* E. coli *and* Pseudomonas aeruginosa *compared to 14 examined plant species.* Arundo donax *has also shown antifungal activity shown against four basidiomycetes.* Arundo donax *has displayed anthelmintic properties of approximately 55% efficacy against gastrointestinal parasites.* Arundo donax *possesses significant antifeedant activity against boll weevil* Anthonomus grand*. Also among benefits is antiproliferative activity towards cancer cell lines and mitogenic towards human peripheral blood mononuclear cells was purified from the rhizomes. The rhizome contains five tryptamines. Finally, ethanolic extract of rhizomes produced hypotensive and antispasmodic effects against histamine, serotonine and acetlylecholine induced spasms (Al-Snafi 2015).*

Does the species remove toxins or pollutants from the water or otherwise increase water quality?

Yes, it reduces water treatment costs or has a significant positive impact for the health of humans and/or native species	6
Yes, but positive impact for humans or native species is considered negligible	1√
Not significantly	0
Unknown	U

- Arundo donax *can be used for nutrient removal from wastewater. Compared to* C. lacryma-jobi *and* I. wilsonii*,* Arundo donax *was the most efficient at removing nitrogen and phosphorous because of its rapid growth rate. Rhizomes of* Arundo donax *re-sprout quickly after removing top growth through cutting. Harvesting shoots is a good choice for nutrient removal from pollutedwaters (Liao et al. 2017).*
- Arundo donax *was shown also to be effective in treatment of stormwater and wastewater from a dairy processing factory. Arundo donax was effective at removing biochemical oxygen demand, total nitrogen, total phosphorous, and suspended solids. The use of* Arundo donax *for water treatment was also noted to be attractive as a potential source of biomass for energy production (Idris et al. 2011).* Arundo donax*'s ability to remove nutrients from water suggests high potential to reduce anthropogenic eutrophication in Great Lakes Basin reported by Beeton (1963).*
- *Multiple studies have also shown* Arundo donax *to be effective in phytoremediation of heavy metals.* Arundo donax *can accumulate high concentrations of arsenic, cadmium, and nickel without detrimental effect (Mirza et al. 2010; Papazoglou et al. 2004).* Arundo donax *can also survive concentrations of copper, lead, zinc, and mercury and decrease concentrations in the soil. Plants were yellow green in comparison to control and chlorophyll concentration decreased 20-60%, but plant height was not reduced (Han and Hu 2005).*
- *Direct and indirect sewage discharges are large sources of heavy metals in Lake Erie (Nriagu et al. 1979).*

Does the species have a positive ecological impact outside of biological control (e.g., increases the growth or reproduction rates of other species, fills an important gap in the food web, supports the survival of a species that is threatened, endangered species, or commercially valuable)?

Yes, it significantly contributes to the ecosystem in one or more of these ways	6
Yes, it provides some positive contribution to the ecosystem, but is not vital	1
Not significantly	0 √
Unknown	U

Beneficial Effect Total	**3**
Total Unknowns (U)	**0**

Scientific Name: *Babka gymnotrachelus*

Common Name: Racer goby

Section C: Potential for Impact

IMPACT POTENTIAL RESULTS

Environmental: Moderate
Socio-Economic: Low
Beneficial: Unknown

Comments: Ponto-Caspian goby identified as having high probability of invasion if introduced to the Great Lakes (Kolar and Lodge 2002, Stepien and Tumeo 2006, U.S. EPA 2008). Potential pathway of introduction: ballast water.

Though Kolar and Lodge (2002) have predicted based on results of multiple models that racer goby spread will be fast in the Great Lakes, it is typically rare relative to other Ponto-Caspian gobiid species. Jurajda et al. (2005) and Ohayon and Stepien (2007) note a dominance in abundance of round goby and bighead goby over racer goby; as well, Kovac et al. (2009) note a limited density for racer goby relative to that of round goby and of bighead goby. Additionally, round goby has been found to typically have higher distribution and abundance than even bighead goby (Copp et al. 2005, Jurajda et al. 2005, Kovac et al. 2009), and phylogenetically, racer goby is more closely related to bighead goby than it is to the other three Ponto-Caspian gobiids present already in the Great Lakes (Simonovic 1999). Further, Kakereko et al. (2009) found low abundance (2.5%) of racer goby even when round goby and bighead goby weren't present in the invaded Polish Vistula River and Ondrackova et al. (2005, 2012) report that racer goby hadn't become abundant in the upper Danube despite its presence there for nearly a decade. Given the low abundance in invaded habitats and apparent lack of impacts, several potential impacts are noted below but still scored as 'not significant.'

Environmental impact has been changed to "moderate" from "unknown" in this updated document (TM-169b, 2019), with all other impact scores remaining unchanged.

POTENTIAL ENVIRONMENTAL IMPACT

NOTE: In this section, a "Not significantly" response should be selected if the species has been studied but there have been no reports of a particular impact. An "Unknown" response is appropriate if the species is poorly studied.

Does the species pose some hazard or threat to the health of native species (e.g., it magnifies toxin levels; is poisonous; is a pathogen, parasite, or a vector of either)?

Yes, and it has impacted threatened/endangered species, resulted in the reduction or extinction of one or more native populations, affects multiple species, or is a reportable disease	6

Yes, but negative consequences have been small (e.g., limited number of infected individuals, limited pathogen transmissibility, mild effects on populations and ecosystems)	1 √
Not significantly	0
Unknown	U

- *As a benthivore, racer goby ingests sediment, and toxins deposited in sediments are therefore also ingested by these fish; goby consumption of dreissenids has also been suggested to facilitate bioaccumulation of contaminants to upper food web levels (Kornis et al. 2012). The toxins accumulated by the racer and other gobies are transferred up the food chain when they are eaten by larger fish, birds, or water snakes (Corkum et al. 2004, Kornis et al. 2012).*
- *Racer gobies are known hosts for several European parasites including the trematode* Cryptocotyle concavum *and the acanthocephalan* Pseudoechinorhynchus *(Najdenova 1974, Smirnov 1986), the monogenean* Gyrodactylus proterorhini *(Mierzejewska et al. 2011, Mierzejewska et al. 2012), the digenean* Bucephalus polymorphus *(Kvach and Mierzejewska 2011), the ciliate* Trichodina domerguei *(Mierzejewska 2007 as cited in Mierzejewska et al. 2012), and others (Ondrackova et al. 2012).*
- Bucephalus polymorphus *also uses* Dreissena polymorpha *as a host for the early components of its life cycle, and these mussels are the source of its cercariae, which infect the gobies (Kvach and Mierzejewska 2011); gobies eaten by pike or perch carry the parasite to them, its definitive hosts (Kvach et al. 2011). Racer goby presence could facilitate the infection of pike and/or perch in Great Lakes waters.*
- *Invading populations of racer gobies have been documented to have lower parasite species richness than is the case for populations in their native range (Ondrackova et al. 2012); similar findings exist for round gobies (Corkum et al. 2004). Pronin et al. (1997) notes that low parasite loads are also found in Great Lakes populations of* Dreissena polymorpha*, a primary food source for Great Lakes gobies.*
- *The distributions of the previously named parasites, specifically their presences in the Great Lakes, were not uncovered in this literature review. Additionally, Great Lakes native species that can serve as hosts for known parasites of racer goby were not uncovered in this literature review. Therefore, the role of racer goby in non-indigenous parasite introduction, establishment, and spread within the Great Lakes is unclear.*

Does it out-compete native species for available resources (e.g., habitat, food, nutrients, light)?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species or caused critical reduction, extinction, behavioral changes including modified spawning behavior) on one or more native populations	6
Yes, and it has caused some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population	1 √
Not significantly	0
Unknown	U

- *One of the potential interactions between invasive racer gobies and native Great Lakes species is competition for food (Holcik 1991);* B. gymnotrachelus *in its native habitat has a broad benthivorous diet which consists of Polychaeta, Oligochaeta, Mollusca, Crustacea, Chironomidae larvae, fish eggs, small fishes (both larvae and juveniles), macrophytes, and algae (e.g., Gaygusuz et al. 2007, Grabowska and Grabowski 2005, within Pinchuk et al. 2003, Smirnov 1986), and it exhibits an opportunistic foraging strategy and feeding plasticity (e.g., Grabowska and Grabowski 2005, Jaroszewska et al. 2008, Kakareko et al. 2005).*
- *Though invasive fishes often compete for food with native fishes and eat their eggs and young (Witkowski and Grabowska 2012), in the Baltic basin, racer goby has been documented to avoid resource competition with native percid populations via spatial segregation during foraging (Grabowska and Grabowski 2005, Kakareko et al. 2003).*
- *Conversely, high dietary overlap was found between racer goby and native percid fishes in the Danube (Copp et al. 2008). In the Polish section of the Vistula River, racer goby has been found to be a predator of epifauna and zoobenthos, though negative impacts of invasive racer gobies to native species and ecosystem function have not yet been researched (Kakareko et al. 2005).*

- *In the Great Lakes, the related species round goby has been linked to the decline of native Great Lakes fish including several sculpin, darters, and perch (Corkum et al. 2004, Jude et al. 1995, Kornis et al. 2012). The declines have been documented to be due to round gobies eating native fish larvae and fry (e.g., Chotkowski and Marsden 1999, Corkum et al. 2004) as well as interfering with native fish spawning and displacement through habitat competition (Dubs and Corkum 1996, Janssen and Jude 2001, Kornis et al. 2012).*

Does it alter predator-prey relationships?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species, caused significant reduction or extinction of one or more native populations, creation of a dead end or any other significant alteration in the food web)	6
Yes, and it has resulted in some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population AND/OR Yes, and it has resulted in some alteration of the food web structure or processes, the effects of which have not been widespread or severe	1
Not significantly	0 √
Unknown	U

- *Round goby invasion has resulted in alterations to food web structure via diet shifts among goby predators (Corkum et al. 2004). In both its native region and in the Great Lakes, round gobies are prey items of several obligate benthivores, facultative benthivores, and even some pelagic fishes (Corkum et al. 2004). In the Great Lakes regions, these round goby predators include smallmouth bass (*Micropterus dolomieu*), stonecat (*Noturus flavus*), burbot (*Lota lota*), and yellow perch (*Perca flavens*) as well as freshwater drum (*Aplodinotus grunniens*), walleye (*Stizostedion vitreum*), and lake sturgeon (*Acipenser fulvescens*) (Corkum et al. 2004). Racer gobies may be expected to be prey for these same species in the Great Lakes, though the literature review conducted for this assessment did not uncover data as to the potential food web impacts of an invading racer goby population.*

Has it affected any native populations genetically (e.g., through hybridization, selective pressure, introgression)?

Yes, and it has caused a loss or alteration of genes that may be irreversible or has led to the decline of one or more native species (or added pressure to threatened/endangered species)	6
Yes, some genetic effects have been observed, but consequences have been limited to the individual level	1
Not significantly	0 √
Unknown	U

- *No documentation of racer or round gobies having genetic effects on native populations was uncovered in this literature review; see the complete reference list as lack of evidence for such an impact.*

Does it negatively affect water quality (e.g., increased turbidity or clarity, altered nutrient, oxygen, or other chemical levels/cycles)?

Yes, and it has had a widespread, long-term, or severe negative effect on water quality AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6

Yes, it has affected water quality to some extent, but the alterations and resulting adverse effects have been limited or inconsistent (as compared with above statement)	1
Not significantly	0 √
Unknown	U

- *Racer goby is known to eat dreissenid mussels, which also invaded the Great Lakes from the Ponto-Caspian region (Gaygusuz et al. 2007). Dreissenid mussels are widespread and abundant in the Great Lakes, and, though few native organisms eat them, they are a preferred food item of gobies in general (the study specifically included racer goby among the studied goby species) in areas in which the mussels are abundant (Gaygusuz et al. 2007). As dreissenid mussels have impacted Great Lakes water clarity and nutrient cycling regimes (e.g., Hecky et al. 2004, Johengen et al. 1995, Karatayev et al. 2002, Leach 1993), racer goby addition to the Great Lakes has the potential to decrease dreissenid mussel abundance and therefore to impact water clarity and nutrient cycling regimes.*

Does it alter physical components of the ecosystem in some way (e.g., facilitated erosion/siltation, altered hydrology, altered macrophyte/phytoplankton communities, physical or chemical changes to substrate)?

Yes, and it has had a widespread, long term, or severe negative effect on the physical ecosystem AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected the physical ecosystem to some extent, but the alterations and resulting adverse effects have been mild	1
Not significantly	0 √
Unknown	U

- Babka gymnotrachelus *in its native habitat has a broad benthivorous diet which consists of Polychaeta, Oligochaeta, Mollusca, Crustacea, Chironomidae larvae, fish eggs, small fishes (both larvae and juveniles), macrophytes, and algae (e.g., Gaygusuz et al. 2007, Grabowska and Grabowski 2005, within Pinchuk et al. 2003, Smirnov 1986); since macrophytes and algae are among its food resources, it has the potential to alter macrophyte and phytoplankton communities.*

Environmental Impact Total	**2**
Total Unknowns (U)	**0**

Scientific Name: *Calanipeda aquaedulcis*

Common Name: No common name (calanoid copepod)

Section C: Potential for Impact

IMPACT POTENTIAL RESULTS

Environmental: High
Socio-Economic: Low
Beneficial: Low

Comments: This species is a Ponto-Caspian copepod identified as having high probability of invasion if introduced to the Great Lakes (Grigorovich et al. 2003, U.S. EPA 2008). Potential pathway of introduction: ballast water or sediment. Resting stage may survive transport under harsh conditions such as in ballast tanks and ballast sediment (Wonham et al. 2005).

Due to the ability to outcompete other species for resources, *C. aquaedulcis* would have a high impact on the environment. It has been seen in other habitats when introduced. There is no significant evidence to show that there would be any impact on the socio-economic aspect. There is little potential beneficial impact as a food source to fish in the Great Lakes since a majority of freshwater fish feed on copepods.

Environmental impact has been changed from unknown to high in this updated technical memo (TM-169b, 2019).

POTENTIAL ENVIRONMENTAL IMPACT

Does the species pose some hazard or threat to the health of native species (e.g., it magnifies toxin levels; is poisonous; is a pathogen, parasite, or a vector of either)?

Yes, and it has impacted threatened/endangered species, resulted in the reduction or extinction of one or more native populations, affects multiple species, or is a reportable disease	6
Yes, but negative consequences have been small (e.g., limited number of infected individuals, limited pathogen transmissibility, mild effects on populations and ecosystems)	1
Not significantly	0 √
Unknown	U

- *There is no direct evidence of* C. aquaedulcis *having a toxic effect.*

Does it out-compete native species for available resources (e.g., habitat, food, nutrients, light)?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species or caused critical reduction, extinction, behavioral changes including modified spawning behavior) on one or more native populations	6 √
Yes, and it has caused some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population	1
Not significantly	0

Unknown	U

- *When introduced in the Aral Sea in the 1960s, it became the dominant species by the 1970s, which led to disappearance of former dominants A. salinas, C. reticulate and M. salina (Mirabdullayev et al. 2004).*
- *It also became one of the dominant species in the Bilbao estuary after potential invasion through ballast water (Albaina et al. 2009).*

Does it alter predator-prey relationships?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species, caused significant reduction or extinction of one or more native populations, creation of a dead end or any other significant alteration in the food web)	6
Yes, and it has resulted in some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population AND/OR Yes, and it has resulted in some alteration of the food web structure or processes, the effects of which have not been widespread or severe	1
Not significantly	0 √
Unknown	U

- *There has been no evidence provided that* C. aquaedulcis *alters predator-prey relationships.*

Has it affected any native populations genetically (e.g., through hybridization, selective pressure, introgression)?

Yes, and it has caused a loss or alteration of genes that may be irreversible or has led to the decline of one or more native species (or added pressure to threatened/endangered species)	6
Yes, some genetic effects have been observed, but consequences have been limited to the individual level	1
Not significantly	0 √
Unknown	U

Does it negatively affect water quality (e.g., increased turbidity or clarity, altered nutrient, oxygen, or other chemical levels/cycles)?

Yes, and it has had a widespread, long-term, or severe negative effect on water quality AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected water quality to some extent, but the alterations and resulting adverse effects have been limited or inconsistent (as compared with above statement)	1
Not significantly	0 √
Unknown	U

- Canalipeda aquaedulcis *is not known to alter its habitat, as it is known as a conformer and can adapt to different habitats (Svetlichny et al. 2012).*

Does it alter physical components of the ecosystem in some way (e.g., facilitated erosion/siltation, altered hydrology, altered macrophyte/phytoplankton communities, physical or chemical changes to substrate)?

Yes, and it has had a widespread, long term, or severe negative effect on the physical ecosystem AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected the physical ecosystem to some extent, but the alterations and resulting adverse effects have been mild	1
Not significantly	0 √
Unknown	U

- *No reports that* C. aquaedulcis *alters the physical components of an ecosystem.*

Environmental Impact Total	**6**
Total Unknowns (U)	**0**

Scientific Name: *Carassius carassius*

Common Name: Crucian carp

Section B: Potential for Establishement

ESTABLISHMENT POTENTIAL RESULTS

Status: Not established in North America, including the Great Lakes

***Carassius carassius* has a high probability of establishment if introduced to the Great Lakes (Confidence level: High).**

Carassius carassius can survive in a wide variety of water conditions and are remarkably hardy. They are omnivores. This makes them a potential invader to the Great Lakes. *C. carassius* are an open substrate spawner with eggs that adhere to twigs and macrophytes (Holopainen et al. 1997; FAO 2013a), which are plentiful in many habitat types in the Great Lakes region. This species spread occurs primarily through human release, which has been rapid due to confusing/mistaken taxonomic identification, as well as its common occurrence as a pet in Europe.

The establishment potential for this species has been changed from moderate to high at the time of this publication (TM-169b, 2019).

INVASIVE BIOLOGICAL/ECOLOGICAL ATTRIBUTES

How would the physiological tolerance of this species (survival in varying temperature, salinity, oxygen, and nutrient levels) be described?

This species has broad physiological tolerance. It has been reported to survive in wide ranges of temperature (0°C-30°C), salinity (0-16 parts per thousand), oxygen (0-saturated), AND nutrient (oligotrophic-eutrophic) levels.	9
This species has somewhat broad physiological tolerance. It has been reported to survive in a wide range of temperature, salinity, oxygen, OR nutrient levels. Tolerance to other factors is narrower, unknown, or unreported.	6
This species has narrow physiological tolerance. It has been reported to survive in limited ranges of temperature, salinity, oxygen, and nutrient levels.	3
Unknown	U
	8

- C. carassius *is remarkably hardy; they can live for hours out of water (Muus and Dahlstrom 1978).*
- *This species is tolerant of anoxic and very low oxygen conditions (Schofield et al. 2015).*
- *This species can tolerate water temperatures up to 38°C (Horoszewicz 1973).*
- *This species can tolerate pH of 4 (Holopainen and Ikari 1992).*
- *This species can survive in waters with temperatures below 0°C, and can even survive for several days with frozen integument (Schofield et al. 2013) or burrowed into mud (Holopainen et al. 1997).*
- Carassius carassius *is a freshwater species, but lab experiments have noted that this species can survive for at least 6 hours in hypersaline water (16 ppm) and in normoxic conditions* C. carassius *reduces its respiratory surface area, which likely minimizes the energetic costs of ion pumping needed to maintain homeostasis.*

How likely is it that any life stage of this species can overwinter in the Great Lakes (survive extremely low levels of oxygen, light, and temperature)?

Likely (This species is able to tolerate temperatures under 5°C and oxygen levels ≤0.5 mg/L)	9
Somewhat likely (This species is able to tolerate some of these conditions OR has adapted behaviorally to avoid them)	6
Somewhat unlikely (This species is able to tolerate conditions close to those specified, but it is not known as an overwintering species)	3
Unlikely	0
Unknown	U
	9

- C. carassius *is tolerant of anoxic and very low oxygen conditions (Schofield et al. 2013). This species can survive in waters with temperatures below 0°C, and can even survive for several days with frozen integument (Schofield et al. 2013) or burrowed into mud (Holopainen et al. 1997).*

If this species is a heterotroph, how would the flexibility of its diet be described?

This species is a dietary generalist with a broad, assorted, AND flexible diet.	9
This species is moderately a dietary generalist with a broad, assorted, OR flexible diet.	6
This species is a dietary specialist with a limited and inflexible diet.	3
This species is an autotroph.	0
Unknown	U
	9

- *This species is an omnivore that feeds on organic detritus, filamentous algae, small benthic animals, and pieces and seeds of aquatic weeds. The fry/larvae feed on zooplankton (FAO 2013a).*
- *Planktonic and benthic invertebrates form the dominant part of diet in all size classes; plant material, phytoplankon and detritus are also commonly found (Holopainen et al. 1997).*
- *Dominant items in this species' diet can vary, e.g., molluscs, chironomid larvae, or cladocera (Uspenskaja 1953).*

How likely is this species to outcompete species in the Great Lakes for available resources?

Likely (This species is known to have superior competitive abilities and has a history of outcompeting other species, AND/OR available literature predicts it might outcompete native species in the Great Lakes)	9
Somewhat likely (This species is known to have superior competitive abilities, but there are few reported cases of this species outcompeting another and no predictions regarding species in the Great Lakes)	6
Somewhat unlikely (This species has average competitive abilities, and there are no reported cases of this species outcompeting another and no predictions regarding species in the Great Lakes)	3
Unlikely (This species is known as a poor competitor that thrives only in environments with low biodiversity, AND/OR available literature predicts it might be outcompeted by a species in the Great Lakes)	0
Unknown	U
	3

- *Smaller eutrophic lakes or nutrient-rich, vegetated bays may have considerable numbers of carp (Hamrin 1979), though not likely to dominate. This species does best in monospecific ponds (Holopainen et al. 1997).*

How would the fecundity of this species be described relative to other species in the same taxonomic class?

Very high	9
High	6
Moderate	3
Low	0
Unknown	U
	3

- *Relative fecundity of* C. carassius *has been reported as 119.2 (Copp et al. 2010) and 129.2 (Holopainen et al. 1997). Relative fecundity for* Carassius auratus *has been reported at 251.7 (Copp et al. 2010) and 270 (Tarkan et al. 2010). Relative fecundity of* Carassius gibelio *has been reported at 78-251 (Leonardos et al. 2008).*

How likely are this species' reproductive strategy and habits to aid establishment in new environments, particularly the Great Lakes (e.g., parthenogenesis/self-crossing, self fertility, vegetative fragmentation)?

Likely (The reproductive strategy or habits of this species are known to aid establishment in new environments, AND available literature predicts establishment in the Great Lakes based on these attributes)	9
Somewhat likely (The reproductive strategy or habits of this species are known to aid establishment in new environments, but there is no literature available regarding establishment in the Great Lakes based on these attributes)	6
Somewhat unlikely (The reproductive strategy or habits of this species could potentially aid establishment in new environments, but there is no literature available regarding establishment in the Great Lakes based on these attributes)	3
Unlikely (The reproductive strategy or habits of this species are not known to aid establishment in new environments)	0
Unknown	U
	3

ENVIRONMENTAL COMPATIBILITY

How similar are the climatic conditions (e.g., air temperature, precipitation, seasonality) in the native and introduced ranges of this species to those in the Great Lakes region?

Very similar (The climatic conditions are practically identical to those of the Great Lakes region)	9
Similar (Many of the climatic conditions are similar to those of the Great Lakes region)	6
Somewhat similar (Few of the climatic conditions are similar to those of the Great Lakes region)	3
Not similar	0

Unknown	U
	9

- *This species is native to local areas of England, but has spread throughout England as a result of introduction. It is native to the fresh waters of the North Sea and Baltic Sea basins across the northern part of France and Germany to the Alps and throughout the Danube basin, then eastwards to Siberia (Wheeler 2000).*

How similar are other abiotic factors that are relevant to the establishment success of this species (e.g., pollution, water temperature, salinity, pH, nutrient levels, currents) in the native and introduced ranges to those in the Great Lakes?

Very similar (These factors are practically identical to those of the Great Lakes region)	9
Similar (Many of these factors are similar to those of the Great Lakes region)	6
Somewhat similar (Few of these factors are similar to those of the Great Lakes region)	3
Not similar	0
Unknown	U
	8

- *This fish is found often in smaller lakes or ponds (Wheeler 2000), which differ from the Great Lakes. Otherwise, this species tolerates a wide variety of abiotic conditions, and the Great Lakes are within this range of conditions.*

How abundant are habitats suitable for the survival, development, and reproduction of this species in the Great Lakes area (e.g., those with adequate depth, substrate, light, temperature, oxygen)?

Abundant (Suitable habitats can be easily found and readily available)	9
Somewhat abundant (Suitable habitats can be easily found but are in high demand by species already present)	6
Somewhat scarce (Suitable habitats can be found occasionally)	3
Scarce (Suitable habitats are rarely found)	0
Unknown	U
	8

- *C. carassius uses aquatic weeds for spawning (egg attachment) (FAO 2013a).*
- *This species is an open substrate spawner with eggs that adhere to twigs and macrophytes (Holopainen et al.1997).*
- *This species does not have any habitat restrictions for normal adult life.*

How likely is this species to adapt to or to benefit from the predicted effects of climate change on the Great Lakes freshwater ecosystems (e.g., warmer water temperatures, shorter duration of ice cover, altered streamflow patterns, increased salinization)?

Likely (Most of the effects described above make the Great Lakes a better environment for establishment and spread of this species OR this species could easily adapt to these changes due to its wide environmental tolerances)	9
Somewhat likely (Several of the effects described above could make the Great Lakes a better environment for establishment and spread of this species)	6
Somewhat unlikely (Few of the effects described above would make the Great Lakes a better environment for establishment and spread of this species)	3
Unlikely (Most of the effects described above would have no effect on establishment and spread of this species or would make the environment of the Great Lakes unsuitable)	0

Unknown0	U
	8

- *C. carassius is very adaptable and has already been shown to tolerate temperatures of up to 38°C (Horoszewicz 1973).*

How likely is this species to find an appropriate food source (prey or vegetation in the case of predators and herbivores, or sufficient light or nutrients in the case of autotrophs)?

Likely (All possible nutritive food items—including species in the Great Lakes that may be considered potential food items—are highly abundant and/or easily found)	9
Somewhat likely (Some nutritive food items—including species in the Great Lakes that may be considered potential food items—are abundant and/or search time is low to moderate)	6
Somewhat unlikely (Few nutritive food items—including species in the Great Lakes that may be considered potential food items—are abundant and/or search time is moderate to high)	3
Unlikely (All possible nutritive food items—including species in the Great Lakes that may be considered potential food items—are relatively scarce and/or search time is high)	0
Unknown	U
	9

- C. carassius *is an omnivore that naturally feeds on organic detritus, filamentous algae, small benthic animals, and pieces and seeds of aquatic weeds. The fry/larvae feed on zooplankton (FAO 2013a).*

Does this species require another species for critical stages in its life cycle such as growth (e.g., root symbionts), reproduction (e.g., pollinators, egg incubators), spread (e.g., seed dispersers), or transmission (e.g., vectors)?

Yes, and the critical species (or one that may provide a similar function) is common in the Great Lakes and can be easily found in environments suitable for the species being assessed; OR, No, there is no critical species required by the species being assessed	9
Yes, and the critical species (or one that may provide a similar function) is moderately abundant and relatively easily found in particular parts of the Great Lakes	6
Yes, and the critical species (or one that may provide a similar function) is relatively rare in the Great Lakes AND/OR can only be found occasionally in environments suitable for the species being assessed	3
Yes, and the critical species (or one that may provide a similar function) is not present in the Great Lakes but is likely to be introduced	0
Yes, but the critical species (or one that may provide a similar function) is not present in -80% total 144 the Great Lakes and is not likely to be introduced	-80% total points (at end)
	9

How likely is the establishment of this species to be aided by the establishment and spread of another species already in the Great Lakes?

Likely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established and spread in the Great Lakes, AND available literature predicts this previous invader might promote	9

the establishment of this species, AND/OR there have been cases reported of this species aiding the establishment of this species in other areas)	
Somewhat likely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established and spread in the Great Lakes)	6
Somewhat unlikely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established in the Great Lakes BUT it is still confined to a small area of the Lakes and the likelihood of encounter with this species assessed is hard to predict)	3
Unlikely (A non-indigenous species to the Great Lakes that facilitates the development of this species has not been established in the Great Lakes)	0
Unknown	U
	0

How likely is establishment of this species to be prevented by the herbivory, predation, or parasitism of a natural enemy this is already present in the Great Lakes and may preferentially target this species?

Likely (The ability of the natural enemy to prevent the establishment of this species in introduced ranges or limiting populations of this species in native ranges is well documented in the literature AND this natural enemy is abundant and widespread in the Great Lakes)	-80% total points (at end)
Somewhat likely (The ability of the natural enemy to prevent the establishment of this species in introduced ranges or limiting populations of this species in native ranges is suggested in the literature OR this natural enemy has limited distribution in the Great Lakes)	-60% total points (at end)
Somewhat unlikely (There are few cases reported of such a natural enemy preventing the establishment of this species in introduced ranges or limiting populations of this species in native ranges OR this natural enemy has low abundance in the Great Lakes)	-10% total points (at end)
Unlikely (Such a natural enemy is particularly rare or is not present in the Great Lakes)	0
Unknown	U
	-10%

- C. carassius *is vulnerable to predation, however, it has morphological adaptations (rapid growth to larger size) to avoid predation in waters with piscivores (Holopainen et al. 1997).*

PROPAGULE PRESSURE

On average, how large and frequent are inoculations (introduction events) from the potential vectors identified in Section A for this species? (What is the total number of individuals introduced?)

Frequent, large inocula	9
Frequent, moderate inocula	6
Frequent, small inocula OR infrequent, large inocula	3
Infrequent, small or moderate inocula	0
Unknown	U
	0

- *The main vector (aquarium release) is likely to be infrequent as* C. carassius *is not as common as the congeneric goldfish (*Carassius auratus*).*

HISTORY OF INVASION AND SPREAD

How extensively has this species established reproducing populations in areas outside its native range as a direct or indirect result of human activities?

Very extensively (many invasive populations of this species have been reported in areas widely distributed from the native range)	9
Extensively (some invasive populations of this species have been reported in areas widely distributed from the native range)	6
Somewhat extensively (few invasive populations of this species have been reported in areas widely distributed from the native range OR all invasive populations are in close proximity to each other)	3
Not extensively (no invasive populations of this species have been reported)	0
Unknown	U
	3

- C. carassius *is native to local areas of England, but has been introduced in other areas of England (Wheeler 2000).*

How rapidly has this species spread by natural means or by human activities once introduced to other locations?

Rapidly (This species has a history of rapid spread in introduced ranges)	9
Somewhat rapidly (This species has a history of moderately rapid spread in introduced ranges)	6
Somewhat slowly (This species has a history of moderately slow spread in its introduced ranges)	3
Slowly (This species has a history of slow to no spread in its introduced ranges)	0
Unknown	U
	6

- C. carassius *spread occurs primarily through human release, which has been rapid due to confusing/mistaken taxonomic identification, as well as its accidental occurrence as a pet in Europe (due to misidentification with Carassius auratus) (Wheeler 2000).*

Are there any existing control measures in the Great Lakes set to prevent the establishment and/or spread of this species?

Yes, and they are likely to prevent establishment or spread of the species. (There are no reported cases of this species adapting or avoiding current measures. These measures are highly effective in preventing the establishment and spread of this species)	-90% total points (at end)
Yes, and they are moderately likely to prevent establishment or spread of the species. (There are few reported cases of this species adapting or avoiding current measures used to control its establishment and spread)	-50% total points (at end)
Yes, but they are unlikely to prevent establishment or spread of the species. (There are many reported cases of this species adapting or avoiding current measures used to control its establishment and spread)	-20% total points (at end)
No control methods have been set to prevent the establishment and/or spread of this species	0
Unknown	U

0

Establishment Potential Scorecard				
Points	**Probability for Establishment**	Total Points (pre-adjustment)		**95**
>100	High	Adjustments		
		Critical species	A (1- 0 %)	**95**
51-99	Moderate	Natural enemy	B (1- 10 %)	**85.5**
		Control measures	C (1- 0 %)	**85.5**
0-50	Low	**Probability for Establishment**		Moderate
# of questions answered as "unable to determine"	**Confidence Level**			
0-1	High	Total # of questions unknown		0
2-5	Moderate			
6-9	Low	Confidence Level		High
>9	Very low			

Section C: Potential for Impact

IMPACT POTENTIAL RESULTS

Environmental: High
Socio-Economic: Low
Beneficial: Moderate

POTENTIAL ENVIRONMENTAL IMPACT

Does the species pose some hazard or threat to the health of native species (e.g., it magnifies toxin levels; is poisonous; is a pathogen, parasite, or a vector of either)? √

Yes, and it has impacted threatened/endangered species, resulted in the reduction or extinction of one or more native populations, affects multiple species, or is a reportable disease	6√
Yes, but negative consequences have been small (e.g., limited number of infected individuals, limited pathogen transmissibility, mild effects on populations and ecosystems)	1
Not significantly	0
Unknown	U

- *Crucian carp are viable hosts for the fatal spring viraemia of carp virus. This virus has the potential to affect native cyprinids as well as non-cyprinid species such as northern Ppike* Esox lucius, *largemouth bass* Micropterus salmoides, *and bluegill sunfish* Lepomis macrochirus *(Dixon and Stone 2017).*

Does it out-compete native species for available resources (e.g., habitat, food, nutrients, light)?

Yes, and it has resulted in significant adverse effects (e.g. critical reduction, extinction, behavioral changes, etc.) on one or more native species populations	6
Yes, and it has caused some noticeable stress to or decline of at least one native species population	1
Not significantly	0
Unknown	U √

- *Unknown.*

Does it alter predator-prey relationships?

Yes, and it has resulted in significant adverse effects (e.g. added pressure to threatened/endangered species, significant reduction or extinction of any native species populations, creation of a dead end or any other significant alteration in the food web, etc.)	6
Yes, and it has resulted in some noticeable stress to or decline of at least one native species population AND/OR It has resulted in some alteration of the food web structure or processes, the effects of which have not been widespread or severe	1
Not significantly	0
Unknown	U √

- *Unknown.*

Has it affected any native populations genetically (e.g., through hybridization, selective pressure, introgression)?

Yes, and it has caused a loss or alteration of genes which may be irreversible or has led to the decline or extinction of one or more native species	6
Yes, some genetic effects have been observed, but consequences have been limited to the individual level AND/OR It has genetically affected the same or similar species in past invasions outside of the Great Lakes	1
Not significantly	0√
Unknown	U

- *Not significantly.*

Does it negatively affect water quality (e.g., increased turbidity or clarity, altered nutrient, oxygen, or other chemical levels/cycles)?

Yes, and it has had a widespread, long-term, or severe negative effect on water quality AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected water quality to some extent, but the alterations and resulting adverse effects have been limited or inconsistent (as compared with above statement)	1 √
Not significantly	0
Unknown	U

- *Benthic feeding and disturbance of surface sediment may have an important effect on nutrient cycling and trophic dynamics (Holopainen et al. 1997).*

Does it alter physical components of the ecosystem in some way (e.g., facilitated erosion/siltation, altered hydrology, altered macrophyte/phytoplankton communities, physical or chemical changes to substrate)?

Yes, and it has had a widespread, long term, or severe negative effect on the physical ecosystem AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected the physical ecosystem to some extent, but the alterations and resulting adverse effects have been mild	1 √
Not significantly	0
Unknown	U

- *USFWS 2017 RA - Significant risk of habitat alteration, increasing turbidity (similar to common carp or goldfish).*

Environmental Impact Total	**8**
Total Unknowns (U)	**2**

POTENTIAL SOCIO-ECONOMIC IMPACT

Does the species pose some hazard or threat to human health (e.g. it magnifies toxin levels, is poisonous, a virus, bacteria, parasite, or a vector of one)?

Yes, significant effects on human health have already been observed	6
Yes, but negative consequences have not been widespread, long lasting, or severe AND/OR It has significantly affected human health in past invasions outside of the Great Lakes	1
Not significantly	0 √
Unknown	U

- *Not significantly.*

Does it cause damage to infrastructure (such as water intakes, pipes, or any other industrial or recreational infrastructure)?

Yes, it is known to cause significant damage	6
Yes, but the costs have been small and are largely reparable or preventable AND/OR It has a history of causing significant infrastructural damage in past invasions outside of the Great Lakes	1
Not significantly	0 √
Unknown	U

- *Not significantly.*

Does it negatively affect water quality?

Yes, it has significantly affected water quality, and is costly or difficult to reverse	6
Yes, but the effects are negligible and/or easily reversed	1

AND/OR It has a history of significantly affecting water quality in past invasions outside of the Great Lakes	
Not significantly	0 √
Unknown	U

- *Not significantly.*

Does it negatively affect any markets or economic sectors (e.g., commercial fisheries, aquaculture, agriculture)?

Yes, it has caused significant damage to one or more markets or economic sectors	6
Some damage to markets or sectors has been observed, but negative consequences have been small	1
Not significantly	0 √
Unknown	U

- *If crucian carp were to be used for aquaculture, they could spread spring viraemia virus to the other fishes.*

Does it inhibit recreational activities and/or associated tourism (e.g., through frequent water closures, equipment damage, decline of recreational species)?

Yes, it has caused widespread, frequent, or otherwise expensive inhibition of recreation and tourism	6
Yes, but negative consequences have been small	1
Not significantly	0
Unknown	U √

- *Crucian carp are viable hosts for the fatal spring viraemia of carp virus. This virus has the potential to affect native cyprinids as well as non-cyprinid species that are popular sportfishes such as Northern pike* Esox lucius, *largemouth bass* Micropterus salmoides, *and bluegill sunfish* Lepomis macrochirus *(Dixon and Stone 2017).*

Socio-Economic Impact Total	**0**
Total Unknowns (U)	**1**

Scientific Name: *Channa argus*

Common Name: Northern snakehead

Section C: Potential for Impact

IMPACT POTENTIAL RESULTS

Environmental: High
Socio-Economic: Moderate
Beneficial: Moderate

Comments: Environmental impact score has been changed to "high" in this updated assessment.

POTENTIAL ENVIRONMENTAL IMPACT

Does the species pose some hazard or threat to the health of native species (e.g., it magnifies toxin levels; is poisonous; is a pathogen, parasite, or a vector of either)?

Yes, and it has impacted threatened/endangered species, resulted in the reduction or extinction of one or more native populations, affects multiple species, or is a reportable disease	6
Yes, but negative consequences have been small (e.g., limited number of infected individuals, limited pathogen transmissibility, mild effects on populations and ecosystems)	1
Not significantly	0
Unknown	U √

- *A disease of snakeheads that has received broad attention is epizootic ulcerative syndrome (EUS), which causes high mortality in these fishes, particularly Channa striata and C. punctata under intensive culture. EUS involves several pathogens, including motile aeromonad bacteria. Only genus known to be affected in US is Cyprinus, but there have been no studies undertaken to examine transfer of parasites or diseases to native North American fishes (Courtenay and Williams 2004).*
- *While the pathogenicity in other fishes and the zoonotic potential of this Mycobacterium isolate infecting Northern snakehead are unknown, mycobacteriosis has potentially serious implications if introduced into the Great Lakes (Densmore et al. 2015).*

Does it out-compete native species for available resources (e.g., habitat, food, nutrients, light)?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species or caused critical reduction, extinction, behavioral changes including modified spawning behavior) on one or more native populations	6
Yes, and it has caused some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population	1 √
Not significantly	0
Unknown	U

- *Adult snakeheads show significant diet overlap with largemouth bass (Micropterus salmoides), with both consuming a large proportion of fundulids and other centrarchids in the lower Potomac River. Aquatic invertebrates were >10 times more common in native predator diets, reducing dietary overlap with northern snakehead. Competition could not be inferred as prey may not have been a limiting resource.*

Also, northern snakehead may be occupying a novel niche based on a piscivorous diet, therefore limiting competition with resident predators in the lower Potomac River. Further research into interactions between largemouth bass and northern snakehead is needed to inform management decisions and understand the ecological impacts of this non-native species. Overall, we found little evidence for potential direct competition between northern snakehead and native predators included in this study. (Saylor et al. 2012).

- *Northern snakehead are able to tolerate habitats with extremely low dissolved oxygen content which provides a competitive advantage over native species such as pike (Esox sp.) or bass (Micropterus sp.) (Sea Grant Pennsylvania 2012 in CABI).*
- *At sites where juvenile largemouth bass were collected, 10.6% were associated with northern snakehead. Using population modeling and measured predator–prey interactions, we determined that this level of co-occurrence would result in a 3.8% reduction in largemouth bass population size. This prediction is consistent with current observations that indicate there has not been a negative trend in the largemouth bass fishery. As co-occurrence was increased in the model, however, the negative impact of northern snakehead on largemouth bass monotonically increased. The time required for such increases in northern snakehead distribution is not known. If northern snakehead continues to expand its range to 100% range overlap then the population model, with its assumptions, predicts a 35.5% reduction in the abundance of largemouth bass in the Potomac River (Love and Newhard 2012).*

Does it alter predator-prey relationships?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species, caused significant reduction or extinction of one or more native populations, creation of a dead end or any other significant alteration in the food web)	6 √
Yes, and it has resulted in some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population AND/OR Yes, and it has resulted in some alteration of the food web structure or processes, the effects of which have not been widespread or severe	1
Not significantly	0
Unknown	U

- *Juveniles eat zooplankton, insect larvae, small crustaceans, and the fry of other fish. Adult snakeheads feed almost exclusively on other fishes (>97% of diet), with the remainder of their diet composed of crustaceans, frogs, small reptiles, and sometimes small birds and mammals. Northern snakeheads can eat prey up to 33% of their own body length (Courtenay and Williams 2004; Saylor et al 2012).*
- *Adverse impacts on threatened and endangered species would likely be high. Of all the taxa listed as endangered or threatened in U.S. aquatic habitats, 16 amphibians, 115 fishes, and 5 of the 21 crustaceans (surface dwelling crayfish and shrimp), would be the most likely to be affected. Based on habitat requirements and life history, amphibians and surface-dwelling crustaceans would generally be less likely to be affected by introduced snakeheads than would fishes (Courtenay and Williams 2004).*
- *Few natural enemies (CABI).*

Has it affected any native populations genetically (e.g., through hybridization, selective pressure, introgression)?

Yes, and it has caused a loss or alteration of genes that may be irreversible or has led to the decline of one or more native species (or added pressure to threatened/endangered species)	6
Yes, some genetic effects have been observed, but consequences have been limited to the individual level	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Does it negatively affect water quality (e.g., increased turbidity or clarity, altered nutrient, oxygen, or other chemical levels/cycles)?

Yes, and it has had a widespread, long-term, or severe negative effect on water quality AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected water quality to some extent, but the alterations and resulting adverse effects have been limited or inconsistent (as compared with above statement)	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Does it alter physical components of the ecosystem in some way (e.g., facilitated erosion/siltation, altered hydrology, altered macrophyte/phytoplankton communities, physical or chemical changes to substrate)?

Yes, and it has had a widespread, long term, or severe negative effect on the physical ecosystem AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected the physical ecosystem to some extent, but the alterations and resulting adverse effects have been mild	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Environmental Impact Total	**7**
Total Unknowns (U)	**1**

Scientific Name: *Chelicorophium curvispinum*

Common Name: Caspian mud shrimp

Section B: Potential for Establishment

ESTABLISHMENT POTENTIAL RESULTS

Probability of establishment if introduced to the Great Lakes: Moderate (Confidence level: Moderate)

INVASIVE BIOLOGICAL/ECOLOGICAL ATTRIBUTES

How would the physiological tolerance of this species (survival in varying temperature, salinity, oxygen, and nutrient levels) be described?

This species has broad physiological tolerance. It has been reported to survive in wide ranges of temperature (0°C-30°C), salinity (0-16 parts per thousand), oxygen (0-saturated), AND nutrient (oligotrophic-eutrophic) levels.	9
This species has somewhat broad physiological tolerance. It has been reported to survive in a wide range of temperature, salinity, oxygen, OR nutrient levels. Tolerance to other factors is narrower, unknown, or unreported.	6
This species has narrow physiological tolerance. It has been reported to survive in limited ranges of temperature, salinity, oxygen, and nutrient levels.	3
Unknown	U
	5

- Chelicorophium curvispinum *is able to tolerate temperatures from 7.0-31.8°C (Jazdzewski and Konopacka 1990).*
- Chelicorophium curvispinum *is found in salt, brackish, and fresh water (de Kluijver and Ingalsuo 1999). It is originally a brackish water species occurring in salinities of less than 6 ppt (Romanova 1975), with the ability to tolerate very low salinities (Bayliss and Harris 1988; van den Brink et al. 1993; Harris and Bayliss 1990; Taylor and Harris 1986a, b). In Black Sea lagoons and estuaries, its distribution follows the 1.5 ppt isohaline (Bortkevitch 1988).*
- *The lethal minimum oxygen concentration for* C. curvispinum *is 0.300 mg* O_2*/L (Dedyu 1980).*
- *This species is most successful in waters with relatively high ionic content and requires a minimum sodium ion (Na+) concentration of 0.5 mM (Harris and Aladin 1997).*
- *It is intolerant of heavy organic pollution levels (Harris and Musko 1999, Jazdzewski 1980).*

How likely is it that any life stage of this species can overwinter in the Great Lakes (survive extremely low levels of oxygen, light, and temperature)?

Likely (This species is able to tolerate temperatures under 5°C and oxygen levels ≤0.5 mg/L)	9
Somewhat likely (This species is able to tolerate some of these conditions OR has adapted behaviorally to avoid them)	6

Somewhat unlikely (This species is able to tolerate conditions close to those specified, but it is not known as an overwintering species)	3
Unlikely	0
Unknown	U
	6

- C. curvispinum *produces overwintering populations of smaller individuals (van den Brink et al. 1993) in waters of the Ponto-Caspian basin with very similar climatic conditions to those of the Great Lakes.*
- *The lethal minimum oxygen concentration for* C. curvispinum *is 0.300 mg O_2/L (Dedyu 1980).*

If this species is a heterotroph, how would the flexibility of its diet be described?

This species is a dietary generalist with a broad, assorted, AND flexible diet.	9
This species is moderately a dietary generalist with a broad, assorted, OR flexible diet.	6
This species is a dietary specialist with a limited and inflexible diet.	3
This species is an autotroph.	0
Unknown	U
	6

- Chelicorophium curvispinum *is a non-specific feeder (bij de Vaate et al. 2002), filtering diatoms, organic particles, and small minerals from the water column.*

How likely is this species to outcompete species in the Great Lakes for available resources?

Likely (This species is known to have superior competitive abilities and has a history of outcompeting other species, AND/OR available literature predicts it might outcompete native species in the Great Lakes)	9
Somewhat likely (This species is known to have superior competitive abilities, but there are few reported cases of this species outcompeting another and no predictions regarding species in the Great Lakes)	6
Somewhat unlikely (This species has average competitive abilities, and there are no reported cases of this species outcompeting another and no predictions regarding species in the Great Lakes)	3
Unlikely (This species is known as a poor competitor that thrives only in environments with low biodiversity, AND/OR available literature predicts it might be outcompeted by a species in the Great Lakes)	0
Unknown	U
	8

- *Its superior competitive abilities—including spatial adaptation, gregarious behavior, and relatively short lifespan and generation time—have contributed to this species' invasion success (bij de Vaate et al. 2002, van den Brink et al. 1993).*
- *Competition with other macroinvertebrate species has been well documented, most notably with the highly successful Great Lakes invader, the zebra mussel (*Dreissena polymorpha*) (van der Velde et al. 1994). In areas where these species have colonized together,* C. curvispinum *has either greatly reduced or eliminated* D. polymorpha *populations by smothering settled individuals and larvae with a thick layer of dense, muddy material used for construction of tubes (van der Velde et al. 1994). After introduction of* C. curvispinum *to the Rhine, zebra mussel populations were seen to decrease from 1000s of individuals/m^2 to 100s of individuals/m^2 within four years (Paffen et al. 1994, Rajagopal et al. 1998a, van der Velde et al. 1994, 1998).*
- *This species has outcompeted the freshwater isopod* Asellus aquaticus *and several species of chironomid larvae within their native ranges in the Rhine (Kinzelbach 1997).*

How would the fecundity of this species be described relative to other species in the same taxonomic class?

Very high	9
High	6
Moderate	3
Low	0
Unknown	U
	6

- *Bij de Vaate et al. (2002) classify* C. curvispinum *as a species with high fecundity.*
- *Reproduction in* C. curvispinum *occurs from May to October in the Black Sea (Bortkevitch 1988) and from April to September in the Baltic (van den Brink et al. 1993).*
- *The number of eggs carried by females and total female body length are correlated, ranging in the Rhine from 3 to 34 eggs (mean = 12) (van den Brink et al. 1993) and in Lake Balaton from 1 to 25 (mean = 6) (Musko 1989, 1990).*

How likely are this species' reproductive strategy and habits to aid establishment in new environments, particularly the Great Lakes (e.g., parthenogenesis/self-crossing, self fertility, vegetative fragmentation)?

Likely (The reproductive strategy or habits of this species are known to aid establishment in new environments, AND available literature predicts establishment in the Great Lakes based on these attributes)	9
Somewhat likely (The reproductive strategy or habits of this species are known to aid establishment in new environments, but there is no literature available regarding establishment in the Great Lakes based on these attributes)	6
Somewhat unlikely (The reproductive strategy or habits of this species could potentially aid establishment in new environments, but there is no literature available regarding establishment in the Great Lakes based on these attributes)	3
Unlikely (The reproductive strategy or habits of this species are not known to aid establishment in new environments)	0
Unknown	U
	6

- *Three generations of brooded offspring are produced each year, following an overwintering period—the first in April to May, the second in June to July, and the third in September to October (den Hartog et al. 1992).*

ENVIRONMENTAL COMPATIBILITY

How similar are the climatic conditions (e.g., air temperature, precipitation, seasonality) in the native and introduced ranges of this species to those in the Great Lakes region?

Very similar (The climatic conditions are practically identical to those of the Great Lakes region)	9
Similar (Many of the climatic conditions are similar to those of the Great Lakes region)	6
Somewhat similar (Few of the climatic conditions are similar to those of the Great Lakes region)	3

Not similar	0
Unknown	U
	6

- *This species is a Ponto-Caspian native, a region where climatic conditions are very similar to those of the Great Lakes.*

How similar are other abiotic factors that are relevant to the establishment success of this species (e.g., pollution, water temperature, salinity, pH, nutrient levels, currents) in the native and introduced ranges to those in the Great Lakes?

Very similar (These factors are practically identical to those of the Great Lakes region)	9
Similar (Many of these factors are similar to those of the Great Lakes region)	6
Somewhat similar (Few of these factors are similar to those of the Great Lakes region)	3
Not similar	0
Unknown	U
	6

- *The water temperature (up to 31.8°C) and salinity (<6 ppt) ranges tolerated by* C. curvispinum *are well within those of the Great Lakes and have allowed this species to be extremely successful in invasions of European rivers.*
- *This species is most successful in waters with relatively high ionic content and requires a minimum sodium ion (Na+) concentration of 0.5 mM (Harris and Aladin 1997).*
- *Individuals' ability to retain and replace Na+ and Cl- varies among populations in different locations, and some populations have adapted to freshwater by means of lower ion permeability (Harris 1991, van der Velde et al. 2000).*
- *Its physiological tolerance is restricted by other factors, such as ion concentrations, oxygen availability, chlorophyll* a *concentrations, flow rate, and organic pollution levels (van der Velde et al. 2000).*

How abundant are habitats suitable for the survival, development, and reproduction of this species in the Great Lakes area (e.g., those with adequate depth, substrate, light, temperature, oxygen)?

Abundant (Suitable habitats can be easily found and readily available)	9
Somewhat abundant (Suitable habitats can be easily found but are in high demand by species already present)	6
Somewhat scarce (Suitable habitats can be found occasionally)	3
Scarce (Suitable habitats are rarely found)	0
Unknown	U
	5

- *To sustain its high metabolism and ensure sufficient food availability, this species requires specific physical conditions including high levels of dissolved oxygen (~10mg/L) and chlorophyll a (~>10µg/L), as well as high flow rates (>1 m/s).*[AJF1]
- *Chlorophyll* a *concentrations required by this species are currently present only in Lake Erie's central basin, with less than 3 µg/L typically occurring in the other lake basins (USEPA 2012). This is consistent with the predicted distribution of* C. curvispinum *in the Great Lakes according to the Genetic Algorithm for Rule-Set Production (GARP) model, which incorporates variable chlorophyll* a *levels (USEPA 2008).*
- *However, anoxic conditions have recently been present in the central basin of Lake Erie, dropping below 0.5 mg/L at certain times of year (USEPA 2012). As a result,* C. curvispinum *distribution is likely to be restricted to areas with sufficient flow rates, high dissolved oxygen levels, and high phytoplankton productivity.*

How likely is this species to adapt to or to benefit from the predicted effects of climate change on the Great Lakes freshwater ecosystems (e.g., warmer water temperatures, shorter duration of ice cover, altered streamflow patterns, increased salinization)?

Likely (Most of the effects described above make the Great Lakes a better environment for establishment and spread of this species OR this species could easily adapt to these changes due to its wide environmental tolerances)	9
Somewhat likely (Several of the effects described above could make the Great Lakes a better environment for establishment and spread of this species)	6
Somewhat unlikely (Few of the effects described above would make the Great Lakes a better environment for establishment and spread of this species)	3
Unlikely (Most of the effects described above would have no effect on establishment and spread of this species or would make the environment of the Great Lakes unsuitable)	0
Unknown	U
	9

- *The changing conditions of the Rhine River throughout the 20th century, specifically the increases in temperature and salinity, have created more suitable conditions for the invasion of foreign species originating in brackish waters, including* C. curvispinum *(van den Brink et al. 1993, den Hartog et al. 1992).*
- *These conditions are consistent with the physical changes forecast for the Great Lakes as a result of climate change (Rahel and Olden 2008), suggesting that this species may benefit from the resulting habitat shifts if introduced.*

How likely is this species to find an appropriate food source (prey or vegetation in the case of predators and herbivores, or sufficient light or nutrients in the case of autotrophs)?

Likely (All possible nutritive food items—including species in the Great Lakes that may be considered potential food items—are highly abundant and/or easily found)	9
Somewhat likely (Some nutritive food items—including species in the Great Lakes that may be considered potential food items—are abundant and/or search time is low to moderate)	6
Somewhat unlikely (Few nutritive food items—including species in the Great Lakes that may be considered potential food items—are abundant and/or search time is moderate to high)	3
Unlikely (All possible nutritive food items—including species in the Great Lakes that may be considered potential food items—are relatively scarce and/or search time is high)	0
Unknown	U
	6

- Chelicorophium curvispinum *is a non-specific feeder (bij de Vaate et al. 2002), filtering diatoms, organic particles, and small minerals from the water column.*
- *Both average clutch size (Rajagopal 1998b) and growth rate (Rajagopal 1998a) have been positively correlated with the availability of chlorophyll* a, *which leads to increased planktonic development and greater food availability (van der Velde et al. 2000). Chlorophyll* a *concentrations required by this species are currently present only in Lake Erie's central basin, with less than 3 µg/L typically occurring in the other lake basins (USEPA 2012).*

Does this species require another species for critical stages in its life cycle such as growth (e.g., root symbionts), reproduction (e.g., pollinators, egg incubators), spread (e.g., seed dispersers), or transmission (e.g., vectors)?

Yes, and the critical species (or one that may provide a similar function) is common in the Great Lakes and can be easily found in environments suitable for the species being assessed; OR, No, there is no critical species required by the species being assessed	9
Yes, and the critical species (or one that may provide a similar function) is moderately abundant and relatively easily found in particular parts of the Great Lakes	6
Yes, and the critical species (or one that may provide a similar function) is relatively rare in the Great Lakes AND/OR can only be found occasionally in environments suitable for the species being assessed	3
Yes, and the critical species (or one that may provide a similar function) is not present in the Great Lakes but is likely to be introduced	0
Yes, but the critical species (or one that may provide a similar function) is not present in the Great Lakes and is not likely to be introduced	-80% total points (at end)
Unknown	U
	9

- *There is no critical species required by* C. curvispinum.

How likely is the establishment of this species to be aided by the establishment and spread of another species already in the Great Lakes?

Likely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established and spread in the Great Lakes, AND available literature predicts this previous invader might promote the establishment of this species, AND/OR there have been cases reported of this species aiding the establishment of this species in other areas)	9
Somewhat likely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established and spread in the Great Lakes)	6
Somewhat unlikely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established in the Great Lakes BUT it is still confined to a small area of the Lakes and the likelihood of encounter with this species assessed is hard to predict)	3
Unlikely (A non-indigenous species to the Great Lakes that facilitates the development of this species has not been established in the Great Lakes)	0
Unknown	U
	0

How likely is establishment of this species to be prevented by the herbivory, predation, or parasitism of a natural enemy this is already present in the Great Lakes and may preferentially target this species?

Likely (The ability of the natural enemy to prevent the establishment of this species in introduced ranges or limiting populations of this species in native ranges is well documented in the literature AND this natural enemy is abundant and widespread in the Great Lakes)	-80% total points (at end)

Somewhat likely (The ability of the natural enemy to prevent the establishment of this species in introduced ranges or limiting populations of this species in native ranges is suggested in the literature OR this natural enemy has limited distribution in the Great Lakes)	-60% total points (at end)
Somewhat unlikely (There are few cases reported of such a natural enemy preventing the establishment of this species in introduced ranges or limiting populations of this species in native ranges OR this natural enemy has low abundance in the Great Lakes)	-10% total points (at end)
Unlikely (Such a natural enemy is particularly rare or is not present in the Great Lakes)	0
Unknown	U
	U

- *This species is an important food source for a variety of fish species, including sculpin, eels, perch, ruffe, and pike perch, all of which are represented in the Great Lakes (van den Brink et al. 1993). Other predators include birds, crayfish, and other predatory macroinvertebrates (Biro 1974; Kelleher et al. 1998, 1999; Marguillier et al. 1998). However, the extent to which this predation will have an effect on potential populations of* C. curvispinum *in the Great Lakes is unknown.*

PROPAGULE PRESSURE

On average, how large and frequent are inoculations (introduction events) from the potential vectors identified in Section A for this species? (What is the total number of individuals introduced?)

Frequent, large inocula	9
Frequent, moderate inocula	6
Frequent, small inocula OR infrequent, large inocula	3
Infrequent, small or moderate inocula	0
Unknown	U
	U

HISTORY OF INVASION AND SPREAD

How extensively has this species established reproducing populations in areas outside its native range as a direct or indirect result of human activities?

Very extensively (many invasive populations of this species have been reported in areas widely distributed from the native range)	9
Extensively (some invasive populations of this species have been reported in areas widely distributed from the native range)	6
Somewhat extensively (few invasive populations of this species have been reported in areas widely distributed from the native range OR all invasive populations are in close proximity to each other)	3
Not extensively (no invasive populations of this species have been reported)	0
Unknown	U
	9

- *This species has been one of the most successful macroinvertebrate invaders in Europe, establishing populations much larger than those of any native invertebrate species within a few years of colonization (van den Brink et al. 1993, den Hartog et al. 1992, bij de Vaate et al. 2002). Densities have reached up to 750,000 individuals/m^2 in some areas of the Rhine (van den Brink et al. 1993). Reproducing populations* *are now established throughout all major European river systems and as far west as Great Britain (Bij de Vaate et al. 2002).*

How rapidly has this species spread by natural means or by human activities once introduced to other locations?

Rapidly (This species has a history of rapid spread in introduced ranges)	9
Somewhat rapidly (This species has a history of moderately rapid spread in introduced ranges)	6
Somewhat slowly (This species has a history of moderately slow spread in its introduced ranges)	3
Slowly (This species has a history of slow to no spread in its introduced ranges)	0
Unknown	U
	7

- *This species is able to readily disperse through ballast water transport, ship hulls fouling, passive drift, and active migration (van Riel et al. 2006, van der Velde et al. 2000), with secondary spread across Europe occurring in a pattern similar to, though at a much slower rate than, that of the zebra mussel (Tittizer et al. 1994).*

Are there any existing control measures in the Great Lakes set to prevent the establishment and/or spread of this species?

Yes, and they are likely to prevent establishment or spread of the species. (There are no reported cases of this species adapting or avoiding current measures. These measures are highly effective in preventing the establishment and spread of this species)	-90% total points (at end)
Yes, and they are moderately likely to prevent establishment or spread of the species. (There are few reported cases of this species adapting or avoiding current measures used to control its establishment and spread)	-50% total points (at end)
Yes, but they are unlikely to prevent establishment or spread of the species. (There are many reported cases of this species adapting or avoiding current measures used to control its establishment and spread)	-20% total points (at end)
No control methods have been set to prevent the establishment and/or spread of this species	0
Unknown	U
	0

Establishment Potential Scorecard				
Points	**Probability for Establishment**	A. Total Points (pre-adjustment)		94
>100	High	**Adjustments**		
		B. Critical species	A*(1- 0%)	94
51-99	Moderate	C. Natural enemy	B*(1- 0%)	94
		Control measures	C*(1- 0%)	94
0-50	Low	**Potential for Establishment**		Moderate

# of questions answered as "unable to determine"	Confidence Level		
0-1	High	Total # of questions unknown	2
2-5	Moderate		
6-9	Low	Confidence Level	Moderate
>9	Very low		

<u>Qualitative Statement for GLANSIS Fact Sheet:</u>

Chelicorophium curvispinum has a moderate probability of establishment if introduced to the Great Lakes (Confidence level: Moderate).

Scientific Name: *Clupeonella cultriventris*

Common Name: Black sea sprat, Caspian sea sprat, Azov kilka, common kilka, tyulka

Section C: Potential for Impact

IMPACT POTENTIAL RESULTS

Environmental: Low
Socio-Economic: Low
Beneficial: Low

Comments: Ponto-Caspian clupeid fish identified as having high probability of invasion if introduced to the Great Lakes (Kolar and Lodge 2002, Ricciardi and Rasmussen 1998, U.S. EPA 2008). Potential pathway of introduction: ballast water.

POTENTIAL ENVIRONMENTAL IMPACT

Does the species pose some hazard or threat to the health of native species (e.g., it magnifies toxin levels; is poisonous; is a pathogen, parasite, or a vector of either)?

Yes, and it has impacted threatened/endangered species, resulted in the reduction or extinction of one or more native populations, affects multiple species, or is a reportable disease	6
Yes, but negative consequences have been small (e.g., limited number of infected individuals, limited pathogen transmissibility, mild effects on populations and ecosystems)	1
Not significantly	0 √
Unknown	U

- *No reports of hazardous effects on native populations were found.*
- *If introduced "tulka poses the added threat of invading lakes that are currently devoid of important pelagic forage fish, which could result in increased contaminant levels in piscivores, an effect already documented for introduced smelt (Vander Zanden and Rasmussen 1996)" (Ricciardi and Rasmussen 1998); however, this effect has not been specifically documented for* Clupeonella cultriventris.

Does it out-compete native species for available resources (e.g., habitat, food, nutrients, light)?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species or caused critical reduction, extinction, behavioral changes including modified spawning behavior) on one or more native populations	6
Yes, and it has caused some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population	1 √
Not significantly	0
Unknown	U

- Clupeonella cultriventris *is successful at establishing in non-native regions, though no data on its effect on specific native species were found.*
- *It has extended its range towards the Volga and Sheksna reservoirs, where it dominates pelagic fish communities (Slynko et al. 2002). The lack of competitors and low predation pressure in these reservoirs, as well as eutrophication, retarded flow, and the creation of habitats suitable for pelagic fish may have contributed to their spread and dominance over fish communities (Kiyashko et al. 2006). The dominance of*

this species in the Volga River reservoirs may have suppressed native fish populations (Ricciardi and Rasmussen 1998; Mordukhai-Boltovskoi 1979b). However, the identity of the species that have been impacted by Clupeonella cultriventris *dominance remains unknown.*

- *In locations where* Clupeonella cultriventris *is very abundant, its diet is similar to the diets of native species, with a feeding similarity index greater than 50% (Kiyashko et al. 2007). On the other hand, where this species is less numerous, its feeding similarity with native species is less than 40%. Thus, it may compete with planktivorous fish for zooplankton if it attains a large population in the Great Lakes.*

Does it alter predator-prey relationships?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species, caused significant reduction or extinction of one or more native populations, creation of a dead end or any other significant alteration in the food web)	6
Yes, and it has resulted in some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population AND/OR Yes, and it has resulted in some alteration of the food web structure or processes, the effects of which have not been widespread or severe	1
Not significantly	0 √
Unknown	U

- *In its native range,* C. cultriventris *is important as predator and prey, but nothing was found pertaining to its role in invaded ecosystems.*

Has it affected any native populations genetically (e.g., through hybridization, selective pressure, introgression)?

Yes, and it has caused a loss or alteration of genes that may be irreversible or has led to the decline of one or more native species (or added pressure to threatened/endangered species)	6
Yes, some genetic effects have been observed, but consequences have been limited to the individual level	1
Not significantly	0 √
Unknown	U

- *A genetic effect of* C. cultriventris *on other populations is not known.*

Does it negatively affect water quality (e.g., increased turbidity or clarity, altered nutrient, oxygen, or other chemical levels/cycles)?

Yes, and it has had a widespread, long-term, or severe negative effect on water quality AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected water quality to some extent, but the alterations and resulting adverse effects have been limited or inconsistent (as compared with above statement)	1
Not significantly	0 √
Unknown	U

- *No reports of water quality alteration were found.*

Does it alter physical components of the ecosystem in some way (e.g., facilitated erosion/siltation, altered hydrology, altered macrophyte/phytoplankton communities, physical or chemical changes to substrate)?

Yes, and it has had a widespread, long term, or severe negative effect on the physical ecosystem AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected the physical ecosystem to some extent, but the alterations and resulting adverse effects have been mild	1
Not significantly	0 √
Unknown	U

- *No information about additional environmental impacts was found.*

Environmental Impact Total	**1**
Total Unknowns (U)	**0**

Scoring		
Score	# U	Impact
>5	Any	High
2-5	Any	Moderate
0	0-1	**Low**
1	0	
0	≥2	Unknown
1	≥1	

There is little or no evidence to support that *Clupeonella cultriventris* has the potential for significant environmental impacts if introduced to the Great Lakes.

Scientific Name: *Cornigerius maeoticus maeoticus*

Common Name: a cladoceran (no common name)

Section C: Potential for Impact

IMPACT POTENTIAL RESULTS

Environmental: Low
Socio-Economic: Low
Beneficial: Low

Comments: Ponto-Caspian cladoceran identified as having high probability of invasion if introduced to the Great Lakes (Grigorovich et al. 2003, U.S. EPA 2008); listed as invasive in Baltic Sea (Baltic Sea Alien Species Database 2007). Potential pathway of introduction: ballast water or sediment. Resting stage may survive transport under harsh conditions such as in ballast tanks and ballast sediment (Wonham et al. 2005).

There is little or no evidence to support that *Cornigerius maeoticus maeoticus* has the potential for significant environmental impacts if introduced to the Great Lakes.

While there is no direct evidence of *C. maeoticus maeoticus* having an effect on the food web structure in its introduced ranges, there has been such evidence for a closely related species. *Cercopagis pengoi* invaded the Great Lakes approximately 15 years ago through the same vectors that could transport *C. maeoticus maeoticus*. Since then, *C. pengoi* has disrupted predator prey relationships and in some cases outcompeted smaller planktivorous fish (Rodionova 2005, Panov et al. 2007).

There is little or no evidence to support that *Cornigerius maeoticus maeoticus* has the potential for significant socio-economic impacts if introduced to the Great Lakes.

There is little or no evidence to support that *Cornigerius maeoticus maeoticus* has the potential for significant beneficial impacts if introduced to the Great Lakes.

A possible beneficial effect that *C. maeoticus maeoticus* could have would be the control of other nonindigenous species. There is no record of this occurring, but other closely related species such as *C. pengoi* have been shown to control and be controlled by non-native species (Rodionova 2005, Panov et al. 2007).

POTENTIAL ENVIRONMENTAL IMPACT

Does the species pose some hazard or threat to the health of native species (e.g., it magnifies toxin levels; is poisonous; is a pathogen, parasite, or a vector of either)?

Yes, and it has impacted threatened/endangered species, resulted in the reduction or extinction of one or more native populations, affects multiple species, or is a reportable disease	6

Yes, but negative consequences have been small (e.g., limited number of infected individuals, limited pathogen transmissibility, mild effects on populations and ecosystems)	1
Not significantly	0 √

- *There is little literature describing the biology of this species in particular. Some papers compare* Cornigerius maeoticus maeoticus *to its relatives, which do not pose any particular threat or hazard to native species (Mordukhai-Boltovskoi and Rivier 1971, Panov et al. 2007).*

Does it out-compete native species for available resources (e.g., habitat, food, nutrients, light)?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species or caused critical reduction, extinction, behavioral changes including modified spawning behavior) on one or more native populations	6
Yes, and it has caused some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population	1 √
Not significantly	0
Unknown	U

- Cornigerius maeoticus maeoticus *is a predatory cladoceran that generally feeds on smaller planktonic crustaceans. There is no direct evidence that* C. maeoticus maeoticus *would out-compete native species for food sources, however closely related species such as* Cercopagis pengoi *have been shown to do so once introduced in the Great Lakes (Rodionova 2005, Panov et al. 2007).*

Does it alter predator-prey relationships?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species, caused significant reduction or extinction of one or more native populations, creation of a dead end or any other significant alteration in the food web)	6
Yes, and it has resulted in some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population AND/OR Yes, and it has resulted in some alteration of the food web structure or processes, the effects of which have not been widespread or severe	1
Not significantly	0 √
Unknown	U

- *There is no direct evidence of* C. maeoticus maeoticus *altering predator prey relationships.*

Has it affected any native populations genetically (e.g., through hybridization, selective pressure, introgression)?

Yes, and it has caused a loss or alteration of genes that may be irreversible or has led to the decline of one or more native species (or added pressure to threatened/endangered species)	6
Yes, some genetic effects have been observed, but consequences have been limited to the individual level	1
Not significantly	0 √
Unknown	U

- *There has been research done on the phylogeny of* C. maeoticus maeoticus *but nothing indicating that it affects populations genetically (Cristescu and Hebert 2002).*

Does it negatively affect water quality (e.g., increased turbidity or clarity, altered nutrient, oxygen, or other chemical levels/cycles)?

Yes, and it has had a widespread, long-term, or severe negative effect on water quality AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected water quality to some extent, but the alterations and resulting adverse effects have been limited or inconsistent (as compared with above statement)	1
Not significantly	0 √
Unknown	U

- *There has been some work done on the basic biology and ecology of this species but in general it is lacking. There is however no indication that* C. maeoticus maeoticus *would have any effect on water quality (Mordukhai-Boltovskoi and Rivier 1971, Panov et al. 2007).*

Does it alter physical components of the ecosystem in some way (e.g., facilitated erosion/siltation, altered hydrology, altered macrophyte/phytoplankton communities, physical or chemical changes to substrate)?

Yes, and it has had a widespread, long term, or severe negative effect on the physical ecosystem AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected the physical ecosystem to some extent, but the alterations and resulting adverse effects have been mild	1
Not significantly	0 √
Unknown	U

- *There has been some work done on the basic biology and ecology of this species but in general it is lacking. There is however no indication that* C. maeoticus maeoticus *would have any effect on the physical components of the ecosystem (Mordukhai-Boltovskoi and Rivier 1971, Panov et al. 2007).*

Environmental Impact Total	**1**
Total Unknowns (U)	**0**

Scientific Name: *Cottus gobio*

Common Name: Bullhead

Section C: Potential for Impact

IMPACT POTENTIAL RESULTS

Environmental: Low
Socio-Economic: Low
Beneficial: NA

Comments: Ponto-Caspian cottid fish have been identified as having high probability of invasion if introduced to the Great Lakes (Kolar and Lodge 2002). Potential pathway of introduction: ballast water.

Very little known about this species (EPA 2008). Predicted to be a non-nuisance fish by Kolar and Lodge (2002).

POTENTIAL ENVIRONMENTAL IMPACT

Does the species pose some hazard or threat to the health of native species (e.g., it magnifies toxin levels; is poisonous; is a pathogen, parasite, or a vector of either)?

Yes, and it has impacted threatened/endangered species, resulted in the reduction or extinction of one or more native populations, affects multiple species, or is a reportable disease	6
Yes, but negative consequences have been small (e.g., limited number of infected individuals, limited pathogen transmissibility, mild effects on populations and ecosystems)	1
Not significantly	0 √
Unknown	U

- *There is no evidence that* Cottus gobio *is a hazard or threat to the health of native species.*

Does it out-compete native species for available resources (e.g., habitat, food, nutrients, light)?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species or caused critical reduction, extinction, behavioral changes including modified spawning behavior) on one or more native populations	6
Yes, and it has caused some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population	1
Not significantly	0 √
Unknown	U

- *Some crayfish species decrease bullhead density through competition for shelter and food (Tomlinson and Perrow).*
- *Racer goby outcompetes bullhead (Kakareko et al. 2013).*

Does it alter predator-prey relationships?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species, caused significant reduction or extinction of one or more native populations, creation of a dead end or any other significant alteration in the food web)	6
Yes, and it has resulted in some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population AND/OR Yes, and it has resulted in some alteration of the food web structure or processes, the effects of which have not been widespread or severe	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Has it affected any native populations genetically (e.g., through hybridization, selective pressure, introgression)?

Yes, and it has caused a loss or alteration of genes that may be irreversible or has led to the decline of one or more native species (or added pressure to threatened/endangered species)	6
Yes, some genetic effects have been observed, but consequences have been limited to the individual level	1
Not significantly	0 √
Unknown	U

- *No data were found that show genetic effects of* Cottus gobio *on native populations.*

Does it negatively affect water quality (e.g., increased turbidity or clarity, altered nutrient, oxygen, or other chemical levels/cycles)?

Yes, and it has had a widespread, long-term, or severe negative effect on water quality AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected water quality to some extent, but the alterations and resulting adverse effects have been limited or inconsistent (as compared with above statement)	1
Not significantly	0 √
Unknown	U

- *There was no evidence of* Cottus gobio *affecting water quality.*

Does it alter physical components of the ecosystem in some way (e.g., facilitated erosion/siltation, altered hydrology, altered macrophyte/phytoplankton communities, physical or chemical changes to substrate)?

Yes, and it has had a widespread, long term, or severe negative effect on the physical ecosystem AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected the physical ecosystem to some extent, but the alterations and resulting adverse effects have been mild	1
Not significantly	0 √

Unknown	U

- *Not reported.*

Environmental Impact Total	**0**
Total Unknowns (U)	**0**

Scientific Name: *Crassula helmsii*

(A. Berger)
Common Name: Swamp stone-crop, New Zealand pygmy weed
Synonyms: *Tillaea helmsii*, *Tillaea recurva*, *Crassula recurve*

Section A: Potential for Introduction

INTRODUCTION POTENTIAL RESULTS

Dispersal: Low
Hitchhiking/fouling: Low
Unauthorized intentional release: Unknown
Stocking/planting/escape from recreational culture: Low
Escape from commercial culture: Low
Transoceanic shipping: Low

POTENTIAL INTRODUCTION VIA DISPERSAL

Does this species occur near waters (natural or artificial) connected to the Great Lakes basin* (e.g., streams, ponds, canals, or wetlands)?
(*Great Lakes basin = below the ordinary high water mark, including connecting channels, wetlands, and waters ordinarily attached to the Lakes)

Yes, this species occurs near waters connected to the Great Lakes basin and is mobile or able to be transported by wind or water.	100
No, this species does not occur near waters connected to the Great Lakes basin and/or is not mobile or able to be transported by wind or water.	0 √
Unknown	U

What is the proximity of this species to the Great Lakes basin?

This species occurs in waters within 20 kilometers of the Great Lakes basin, and no barrier (e.g., electric barrier, dam) to dispersal is present.	Score x 1
This species occurs in waters within 20 kilometers of the Great Lakes basin, but dispersal to the basin is blocked; or, this species occurs in waters within 100 kilometers of the Great Lakes basin, and no barrier to dispersal is present.	Score x 0.75
This species occurs in waters within 100 kilometers of the Great Lakes basin, but dispersal to the basin is blocked.	Score x 0.5
This species occurs in waters >100 kilometers from the Great Lakes basin.	Score x 0.25
Unknown	U

POTENTIAL INTRODUCTION VIA HITCHHIKING/FOULING

Is this species likely to attach to or be otherwise transported by, or along with, recreational gear, boats, trailers, fauna (e.g., waterfowl, fish, insects), flora (e.g., aquatic plants), or other objects (e.g., packing materials), including as parasites or pathogens, entering the Great Lakes basin?

Yes, this species is known to be able to adhere to certain surfaces or to be transported by other organisms entering the Great Lakes basin.	100
No, this species is not known to be able to adhere to certain surfaces or to be transported by other organisms entering the Great Lakes basin.	0 √
Unknown	U

What is the proximity of this species to the Great Lakes basin?

This species occurs in waters within 20 km of the Great Lakes basin.	Score x 1
This species occurs in waters within 100 km of the Great Lakes basin.	Score x 0.5
This species occurs in waters >100 km from the Great Lakes basin.	Score x 0.1
Unknown	U

POTENTIAL INTRODUCTION VIA UNAUTHORIZED INTENTIONAL RELEASE

Is this species sold at aquarium/pet/garden stores ("brick & mortar" or online), catalogs, biological supply companies, or live markets (e.g., purchased for human consumption, bait, ornamental, ethical, educational, or cultural reasons) and as a result may be released into the Great Lakes basin?

Yes, this species is available for purchase.	100 √
No, this species this species is rarely/never sold.	0
Unknown	U

- *This species has been found for sale at large outdoor stores (e.g., Lowe's Hardware mistakenly sold it under another name in Florida), as well as recommended for hobbyists online. It is unknown, however, if it is being bought and sold in Michigan or the Great Lakes region.*

How easily is this species obtained within the Great Lakes region (states/provinces)?

This species is widely popular, frequently sold, and/or easily obtained within the Great Lakes region.	Score x 1
This species is widely popular, and although trade, sale, and/or possession of this species is prohibited, it is frequently sold on the black market within the Great Lakes region.	Score x 0.5
This species is not very popular or is not easily obtained within the Great Lakes region.	Score x 0.1
Unknown	U √

- *This species has been found for sale at large outdoor stores (Lowe's Hardware), as well as recommended for hobbyists online. It is unknown, however, if it is being bought and sold in Michigan or the Great Lakes region.*

POTENTIAL INTRODUCTION VIA STOCKING/PLANTING OR ESCAPE FROM RECREATIONAL CULTURE

Is this species being stocked/planted to natural waters or outdoor water gardens around the Great Lakes region?

Yes, this species is being stocked/planted and/or has ornamental, cultural, medicinal, environmental (e.g., biocontrol, erosion control), scientific, or recreational value in the Great Lakes region.	100
No, this species cannot be stocked/planted or there is not enough interest to do so in the Great Lakes region.	0 √

Unknown	U

What is the nature and proximity of this activity to the Great Lakes basin?

This activity is authorized and/or is occurring directly in the Great Lakes.	Score x 1
This activity is occurring in Great Lakes tributaries or connecting waters, or within 20 km of the Great Lakes basin.	Score x 0.75
This activity is likely to occur within 20 km of the Great Lakes basin because of its popularity/value and there are no widespread regulations against stocking/planting.	Score x 0.5
This activity is occurring in waters >20 km from the Great Lakes basin, or despite federal or state regulations in more than half the basin (> 5 states/provinces), this activity may occur within 20 km of the basin because of the species' popularity/value.	Score x 0.25
Unknown	U

POTENTIAL INTRODUCTION VIA ESCAPE FROM COMMERCIAL CULTURE

Is this species known to be commercially cultured in or transported through the Great Lakes region?

Yes, this species is being commercially cultured in or transported through the Great Lakes region.	100
No, this species is not commercially cultured in or transported through the Great Lakes region.	0 √
Unknown	U

What is the nature and proximity of this activity to the Great Lakes basin?

This activity is unregulated or minimally regulated and is occurring directly in the Great Lakes.	Score x 1
This activity is unregulated or minimally regulated and is occurring in Great Lakes tributaries or connecting waters, or within 20 km of the Great Lakes basin.	Score x 0.75
This activity is strictly regulated but occurs directly in the Great Lakes, and/or this activity involves transport of live organisms on/across the Great Lakes.	Score x 0.5
This activity is strictly regulated but occurs in Great Lakes tributaries, connecting waters, or within 20 km of the Great Lakes basin, and/or this activity involves transport of live organisms within 20 km of the Great Lakes basin.	Score x 0.25
This activity occurs >20 km from the Great Lakes basin and typically does not involve transport of live organisms closer to the basin.	Score x 0.1
Unknown	U

POTENTIAL INTRODUCTION VIA SHIPPING

Is this species likely to be taken up in ballast, and capable of surviving adverse environments (i.e. extreme temperatures, absence of light, low oxygen levels) and partial-to-complete ballast water exchange/flushing (e.g., is euryhaline, buries in sediment, produces resistant resting stages, has other attributes or behaviors facilitating survival under these conditions)?

Yes, this species is able to survive in ballast tank environments for weeks at a time and is not substantially impacted by current regulatory requirements (e.g., exchange, flushing).	100
Yes, this species is able to survive in ballast tank environments for weeks at a time, but survival is substantially impacted by current regulatory requirements.	80
No, but this species is capable of fouling transoceanic ship structures (e.g., hull, chains, chain locker) while in its active or resting stage.	40
No, this species is unlikely to be taken up in ballast, not able to survive adverse environments, does not foul transoceanic ship structures, or is unable to survive current ballast water regulations.	0 √
Unknown	U

Does this species occur in waters from which shipping traffic to the Great Lakes originates?

Yes, and this species has been observed in ballast of or fouling ships entering the Great Lakes.	Score x 1
Yes, and this species has been observed in ports that have direct trade connections with the Great Lakes (e.g., Baltic Sea).	Score x 0.5
Yes, but this species has neither been observed in ballast/fouling ships entering the Great Lakes nor in ports in direct trade with the Great Lakes.	Score x 0.1
No, this species does not occur in waters from which shipping traffic to the Great Lakes originates.	Score x 0
Unknown	U

Vector Potential Scorecard					
Vector		**Raw Points Scored**	**Proximity Multiplier**	**Total Points Scored**	**Probability of Introduction**
Dispersal: Natural dispersal through waterbody connections or wind		**0**	x	**0**	Low
Hitchhiking/fouling: Transport via recreational gear, boats, trailers, mobile fauna, stocked/planted organisms, packing materials, host organisms, etc.		**0**	x	**0**	Low
Release: Unauthorized intentional release of organisms in trade (e.g., aquaria, water gardens, live food)		**100**	x U	**U**	Unknown
Stocking/planting/escape from recreational culture: Intentional authorized or unauthorized introduction to natural waters in the Great Lakes OR Accidental introduction to Great Lakes by escape from recreational culture (e.g., water gardens)		**0**	x	**0**	Low
Escape from commercial culture: Accidental introduction to Great Lakes by escape from commercial culture (e.g., aquaculture)		**0**	x	**0**	Low
Trans-oceanic shipping: Ballast (BOB) or no-ballast-on-board (NOBOB) water exchange/discharge, sediment discharge, hull fouling		**0**	x	**0**	Low
Total Unknowns (U)	**2**	**Confidence Level**		Moderate	

<u>Qualitative Statements for GLANSIS Fact Sheet:</u> *Crassula helmsii* has an unknown probability of introduction to the Great Lakes (Confidence level: Moderate).

Potential pathway(s) of introduction: Unauthorized intentional release

Scientific Name: *Cyclops kolensis*

Common Name: Water flea

Section C: Potential for Impact

IMPACT POTENTIAL RESULTS

Environmental: Moderate
Socio-Economic: Low
Beneficial: Low

Comments: Ponto-Caspian amphipod identified as having high probability of invasion if introduced to the Great Lakes (Grigorovich et al. 2003, U.S. EPA 2008). Potential pathway of introduction: ballast water. May survive partial to complete ballast water exchange based on natural occurrence at salinity of 17% (Grigorovich et al. 2003).

POTENTIAL ENVIRONMENTAL IMPACT

Does the species pose some hazard or threat to the health of native species (e.g., it magnifies toxin levels; is poisonous; is a pathogen, parasite, or a vector of either)?

Yes, and it has impacted threatened/endangered species, resulted in the reduction or extinction of one or more native populations, affects multiple species, or is a reportable disease	6
Yes, but negative consequences have been small (e.g., limited number of infected individuals, limited pathogen transmissibility, mild effects on populations and ecosystems)	1 √
Not significantly	0
Unknown	U

- *This species is a vector of several parasites. The rate of infection is unknown.*
- *Copepods are intermediate host for the tapeworm* Diphyllobothrium*, which can infect fish (particularly salmon) (Center for Disease Control 2013).*

Does it out-compete native species for available resources (e.g., habitat, food, nutrients, light)?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species or caused critical reduction, extinction, behavioral changes including modified spawning behavior) on one or more native populations	6
Yes, and it has caused some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population	1 √
Not significantly	0
Unknown	U

- *While its competitive effects are unknown, this species has been documented at relatively high densities (400 individuals/m^2), with higher densities than endemic copepods (Pislegina and Silow 2009).*

Does it alter predator-prey relationships?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species, caused significant reduction or extinction of one or more native populations, creation of a dead end or any other significant alteration in the food web)	6
Yes, and it has resulted in some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population AND/OR Yes, and it has resulted in some alteration of the food web structure or processes, the effects of which have not been widespread or severe	1 √
Not significantly	0
Unknown	U

- *In Baikal Lake, it was abundant years 1946 and 1950,* Cyclops *reached 80–90% of the total biomass of the zooplankton and through predation reduced the abundance and biomass of Epischura (Mazepova 1998).*

Has it affected any native populations genetically (e.g., through hybridization, selective pressure, introgression)?

Yes, and it has caused a loss or alteration of genes that may be irreversible or has led to the decline of one or more native species (or added pressure to threatened/endangered species)	6
Yes, some genetic effects have been observed, but consequences have been limited to the individual level	1
Not significantly	0 √
Unknown	U

- *No information was provided in located articles.*

Does it negatively affect water quality (e.g., increased turbidity or clarity, altered nutrient, oxygen, or other chemical levels/cycles)?

Yes, and it has had a widespread, long-term, or severe negative effect on water quality AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected water quality to some extent, but the alterations and resulting adverse effects have been limited or inconsistent (as compared with above statement)	1
Not significantly	0 √
Unknown	U

- *No information was provided in located articles.*

Does it alter physical components of the ecosystem in some way (e.g., facilitated erosion/siltation, altered hydrology, altered macrophyte/phytoplankton communities, physical or chemical changes to substrate)?

Yes, and it has had a widespread, long term, or severe negative effect on the physical ecosystem AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6

Yes, it has affected the physical ecosystem to some extent, but the alterations and resulting adverse effects have been mild	1
Not significantly	0 √
Unknown	U

- *No information was provided in located articles.*

Environmental Impact Total	**3**
Total Unknowns (U)	**0**

Scientific Name: *Daphnia cristata*

Common Name: a cladoceran

Section C: Potential for Impact

IMPACT POTENTIAL RESULTS

Environmental: Low

POTENTIAL ENVIRONMENTAL IMPACT

Does the species pose some hazard or threat to the health of native species (e.g., it magnifies toxin levels; is poisonous; is a pathogen, parasite, or a vector of either)?

Yes, and it has impacted threatened/endangered species, resulted in the reduction or extinction of one or more native populations, affects multiple species, or is a reportable disease	6
Yes, but negative consequences have been small (e.g., limited number of infected individuals, limited pathogen transmissibility, mild effects on populations and ecosystems)	1
Not significantly	0 √
Unknown	U

- Daphnia cristata *poses no natural hazard to other species.*

Does it out-compete native species for available resources (e.g., habitat, food, nutrients, light)?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species or caused critical reduction, extinction, behavioral changes including modified spawning behavior) on one or more native populations	6
Yes, and it has caused some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population	1
Not significantly	0 √
Unknown	U

- Daphnia cristata *is not a strong competitor. It generally loses out in competition and is recorded in higher abundances only in the presence of planktivorous fish (Nyberg 1998, Amundsen P. et al. 2009).*

Does it alter predator-prey relationships?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species, caused significant reduction or extinction of one or more native populations, creation of a dead end or any other significant alteration in the food web)	6
Yes, and it has resulted in some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population AND/OR Yes, and it has resulted in some alteration of the food web structure or processes, the effects of which have not been widespread or severe	1

Not significantly	0 √
Unknown	U

- Daphnia cristata *has been shown to occupy available niches when present (Wærvågen et al. 2002). It is generally is recorded only in the presence of planktivorous fish (Nyberg 1998, Wærvågen et al. 2002, Amundsen P. et al. 2009).*

Has it affected any native populations genetically (e.g., through hybridization, selective pressure, introgression)?

Yes, and it has caused a loss or alteration of genes that may be irreversible or has led to the decline of one or more native species (or added pressure to threatened/endangered species)	6
Yes, some genetic effects have been observed, but consequences have been limited to the individual level	1
Not significantly	0 √
Unknown	U

Does it negatively affect water quality (e.g., increased turbidity or clarity, altered nutrient, oxygen, or other chemical levels/cycles)?

Yes, and it has had a widespread, long-term, or severe negative effect on water quality AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected water quality to some extent, but the alterations and resulting adverse effects have been limited or inconsistent (as compared with above statement)	1
Not significantly	0 √
Unknown	U

- *There have been no reports of any environmental effects from this organism.* Daphnia cristata *is a very small organism and generally fills a specialized niche (NINA 2007, Amundsen P. et al. 2009). Its effect on water quality would be negligible.*

Does it alter physical components of the ecosystem in some way (e.g., facilitated erosion/siltation, altered hydrology, altered macrophyte/phytoplankton communities, physical or chemical changes to substrate)?

Yes, and it has had a widespread, long term, or severe negative effect on the physical ecosystem AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected the physical ecosystem to some extent, but the alterations and resulting adverse effects have been mild	1
Not significantly	0 √
Unknown	U

- *There have been no reports of any environmental effects from this organism.*

Environmental Impact Total	**0**
Total Unknowns (U)	**0**

Scientific Name: *Ectinosoma abrau*

(Kritchagin, 1877)
Common Name(s): oarsman, harpacticoid copepod
Synonyms: none

Section C: Potential for Impact

IMPACT POTENTIAL RESULTS

Environmental: Low
Socio-Economic: Low
Beneficial: Low

Comments: Ponto-Caspian copepod identified as having high probability of invasion if introduced to the Great Lakes (Grigorovich et al. 2003, U.S. EPA 2008). Potential pathway of introduction: ballast water or sediment. Resting stage may survive transport under harsh conditions such as in ballast tanks and ballast sediment (Wonham et al. 2005).

POTENTIAL ENVIRONMENTAL IMPACT

Does the species pose some hazard or threat to the health of native species (e.g., it magnifies toxin levels; is poisonous; is a pathogen, parasite, or a vector of either)?

Yes, and it has impacted threatened/endangered species, resulted in the reduction or extinction of one or more native populations, affects multiple species, or is a reportable disease	6
Yes, but negative consequences have been small (e.g., limited number of infected individuals, limited pathogen transmissibility, mild effects on populations and ecosystems)	1
Not significantly	0 √
Unknown	U

- *No information was found on whether* E. abrau *is a threat to the health of native species.*

Does it out-compete native species for available resources (e.g., habitat, food, nutrients, light)?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species or caused critical reduction, extinction, behavioral changes including modified spawning behavior) on one or more native populations	6
Yes, and it has caused some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population	1
Not significantly	0 √
Unknown	U

- *Information on species competition was not found.*

Does it alter predator-prey relationships?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species, caused significant reduction or extinction of one or more native populations, creation of a dead end or any other significant alteration in the food web)	6
Yes, and it has resulted in some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population AND/OR Yes, and it has resulted in some alteration of the food web structure or processes, the effects of which have not been widespread or severe	1
Not significantly	0 √
Unknown	U

- *Information on predator-prey relationships was not found.*

Has it affected any native populations genetically (e.g., through hybridization, selective pressure, introgression)?

Yes, and it has caused a loss or alteration of genes that may be irreversible or has led to the decline of one or more native species (or added pressure to threatened/endangered species)	6
Yes, some genetic effects have been observed, but consequences have been limited to the individual level	1
Not significantly	0 √
Unknown	U

- *Information on whether or not this species has affected any native population genetically was not found.*

Does it negatively affect water quality (e.g., increased turbidity or clarity, altered nutrient, oxygen, or other chemical levels/cycles)?

Yes, and it has had a widespread, long-term, or severe negative effect on water quality AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected water quality to some extent, but the alterations and resulting adverse effects have been limited or inconsistent (as compared with above statement)	1
Not significantly	0 √
Unknown	U

- *Information about this species' effect on water quality was not found on this subject.*

Does it alter physical components of the ecosystem in some way (e.g., facilitated erosion/siltation, altered hydrology, altered macrophyte/phytoplankton communities, physical or chemical changes to substrate)?

Yes, and it has had a widespread, long term, or severe negative effect on the physical ecosystem AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected the physical ecosystem to some extent, but the alterations and resulting adverse effects have been mild	1
Not significantly	0 √
Unknown	U

- *Information about this species' effect on the physical ecosystem was not found.*

Environmental Impact Total	**0**
Total Unknowns (U)	**0**

Scientific Name: *Eichhornia crassipes*

Common Name: Water hyacinth

Section A: Potential for Introduction

INTRODUCTION POTENTIAL RESULTS

Dispersal: High
Hitchhiking/Fouling: High
Unauthorized intentional release: High
Stocking/Planting/Escape from recreational culture: High
Escape from commercial culture: Moderate
Shipping: Unlikely

POTENTIAL INTRODUCTION VIA STOCKING/PLANTING OR ESCAPE FROM RECREATIONAL CULTURE

Is this species being stocked/planted to natural waters or outdoor water gardens around the Great Lakes region?

Yes, this species is being stocked/planted and/or has ornamental, cultural, medicinal, environmental (e.g., biocontrol, erosion control), scientific, or recreational value in the Great Lakes region.	100√
No, this species cannot be stocked/planted or there is not enough interest to do so in the Great Lakes region.	0
Unknown	U

- *Greenhouses within the Great Lakes basin (e.g., Countryside Greenhouse in Allendale, MI), sell this plant and mention its use in their outdoor water gardens.*
- *Retail advertisements also recommend this species as a good oxygenator plants for outdoor ponds.*
- *Homeowners have admitted to introducing water hyacinth in the coastal waters of Lake St. Clair (MacIsaac et al. 2016).*

What is the nature and proximity of this activity to the Great Lakes basin?

This activity is authorized and/or is occurring directly in the Great Lakes.	Score x 1√
This activity is occurring in Great Lakes tributaries or connecting waters, or within 20 km of the Great Lakes basin.	Score x 0.75
This activity is likely to occur within 20 km of the Great Lakes basin because of its popularity/value and there are no widespread regulations against stocking/planting.	Score x 0.5
This activity is occurring in waters >20 km from the Great Lakes basin, or despite federal or state regulations in more than half the basin (> 5 states/provinces), this activity may occur within 20 km of the basin because of the species' popularity/value.	Score x 0.25
Unknown	U

Vector Potential Scorecard					
Vector		**Raw Points Scored**	**Proximity Multiplier**	**Total Points Scored**	**Probability of Introduction**
Dispersal: Natural dispersal through waterbody connections or wind		**100**	x 1	**100**	High
Hitchhiking/Fouling: Transport via recreational gear, boats, trailers, mobile fauna, stocked/planted organisms, packing materials, host organisms, etc.		**100**	x 1	**100**	High
Release: Unauthorized intentional release of organisms in trade (e.g., aquaria, water gardens, live food)		**100**	x 1	**100**	High
Stocking/Planting/Escape from recreational culture: Intentional authorized or unauthorized introduction to natural waters in the Great Lakes OR Accidental introduction to Great Lakes by escape from recreational culture (e.g., water gardens)		**100**	x 1	**100**	High
Escape from commercial culture: Accidental introduction to Great Lakes by escape from commercial culture (e.g., aquaculture)		**100**	x .075	**75**	Moderate
Trans-oceanic shipping: Ballast (BOB) or no-ballast-on-board (NOBOB) water exchange/discharge, sediment discharge, hull fouling		**0**	x	**0**	Unlikely
Total Unknowns (U)	**0**	**Confidence Level**		High	

Section B: Potential for Establishment

<u>ESTABLISHMENT POTENTIAL RESULTS</u>

Comments: New information in this section has been underlined to show new citations and evidence overwintering since this species was first assessed.

Eichhornia crassipes has been reported to tolerate salinities of 0-8.8 ppt, with growth rate decreasing with increasing salinity (Rotella and Luken 2012). This species tolerates water temperatures of 5°C for short periods of time (Owens and Madsen 1995) and survives in water temperatures up to 30°C (NSW DPI 2012b). *Eichhornia crassipes* requires abundant nitrogen, phosphorus, and potassium for growth. The abiotic and climatic conditions of the introduced ranges *of E. crassipes* (e.g. Lake St. Clair, Detroit River, New York) are similar to the Great Lakes. Nutrient inputs to the Great Lakes from runoff may provide the necessary nitrogen and phosphorus levels for *E. crassipes* growth. Slow flowing fresh water bodies located in the Great Lakes basin may provide suitable habitats for this species.

Eichhornia crassipes is somewhat likely to be able to overwinter in the Great Lakes basin as rooted plants, which are more resistant to freezing temperatures than free floating mats (Owens and Madsen 1995). There is evidence that *E. crassipes* may have overwintered in private ponds in Michigan and in the coastal waters of Lake St. Clair and the Detroit River (MacIsaac et al. 2016; Ankney 2012). Annual recurrence of this species is due in most part to annual reintroduction by residents. However, 5% of collected seeds were identified as *E. crassipes* in areas where the species has recurred in Lake St. Clair and the Detroit River (MacIsaac et al. 2016). Seeds are capable of germinating in maximum water temperatures and summer light conditions (13 hours of light) in the Great Lakes. Therefore, it is possible that the production of a viable seed bank that is dormant in the winter and germinates in the summer could contribute to the prevalence and persistence of this species, in conjunction with the recurrence attributed to human introductions (MacIsaac et al. 2016). Although it is capable of producing dormant seeds that remain viable for 5-20 years, some evidence suggests that *E. crassipes* will not establish a population in the Great Lakes region via sexual reproduction due to the lack of genetic diversity (FAO 2013; Adebayo et al. 2011).

Eichhornia crassipes may experience increased mortality and reduced regrowth after long periods of near-freezing temperatures (Adebayo et al. 2011, Owens and Madsen 1995, Rixon et al. 2005). However, climate change may make the Great Lakes more suitable for this species' establishment. Shorter ice duration and warmer temperatures may improve this species' ability to survive the winter in the Great Lakes (Adebayo et al. 2011).

This plant produces seeds that can remain viable for 5-20 years (FAO 2013). Although it is capable of producing dormant seeds, evidence suggests that E. crassipes will not establish a population in the Great Lakes region via sexual reproduction due to the lack of genetic diversity (Adebayo et al. 2011). Its primary method of spread is through vegetative fragmentation (NSW DPI 2012b). This species rapidly grows and can double its biomass every 2 to 34 days (Gutiérrez et al. 2001).

Eichhornia crassipes forms dense stands, which may impact species in the Great Lakes. In San Joaquin Delta, California, insect densities where lower in patches of *E. crassipes* and there was a difference in insect composition between E. crassipes and the native pennywort (*Hydrocotyle umbellata*) (Toft 2000). Non-native introduced amphipods such as *Crangonyx floridanus* were more abundant in *E. crassipes* stands than in the native pennywort stands, and are not frequently consumed by fish. Fish preyed heavily on native amphipod *Hyalella azteca* that was more abundant in the native pennywort. It is suggested that the presence of *E. crassipes* may influence native invertebrate community assemblages. In Lake Okeechobee, *E. crassipes* displaced native bulrush and shaded out native submerged plants that provide important habitats for fish, waterfowl, and other animals (UF IFAS 2013). In Caohai and Dianchi lakes in Yunnan province, southwestern China, *E. crassipes* had competed with native plants for water, nutrients, and space, and contributed to the reduction in native plant diversity (Jianqing et al. 2001).

However, a basin-wide monitoring program is lacking (Dupre 2011). Michigan has a state management plan to prevent aquatic invasive species introductions, limit their dispersal, and control their populations (MI DEQ 2013). The Michigan Department of Natural Resources and the United States Environmental Protection Agency (USEPA) have an early detection and rapid response plant regarding the establishment of *E. crassipes* (Ankney 2012)

INVASIVE BIOLOGICAL/ECOLOGICAL ATTRIBUTES

How would the physiological tolerance of this species (survival in varying temperature, salinity, oxygen, and nutrient levels) be described?

This species has broad physiological tolerance. It has been reported to survive in wide ranges of temperature (0°C-30°C), salinity (0-16 parts per thousand), oxygen (0-saturated), AND nutrient (oligotrophic-eutrophic) levels.	9
This species has somewhat broad physiological tolerance. It has been reported to survive in a wide range of temperature, salinity, oxygen, OR nutrient levels. Tolerance to other factors is narrower, unknown, or unreported.	6
This species has narrow physiological tolerance. It has been reported to survive in limited ranges of temperature, salinity, oxygen, and nutrient levels.	3
Unknown	U
	5

- *Estimates for the lethal level of salinity for water hyacinth range from roughly 2-8 ppt (Rotella and Luken 2012).*
- *If air temperature remains at 5˚C for 2-3 weeks, water hyacinth has a significant decrease in regrowth (Owens and Madsen 1995).*
- *Optimum growth of this species occurs at temperatures between 28°C and 30°C, and requires abundant nitrogen, phosphorus, and potassium (NSW DPI 2012b).*
- *Although this plant will tolerate a wide range of growth conditions and climatic extremes including frost, it is rapidly killed by sea strength salinity and will not grow in brackish water (NSW DPI 2012b).*
- *Water hyacinth seeds can remain viable for up to 5-20 years (FAO 2013).*
- *In 2011-2012, MacIsaac et al. (2016) observed E. crassipes survived throughout most of the winter in nearshore locations around Lake St. Clair, but it eventually died by the end of March 2012. During the harsher 2012-2013 winter, E. crassipes reached complete mortality by mid-February 2013.*
- *With sufficient nutrients for growth, 67 and 53%, respectively, of moist and dry seeds germinated in a controlled environmental chamber that mimicked the light conditions (13 hours of light) and maximum water temperature (28 C) of nearshore areas during the summer (MacIsaac et al. 2016).*
- *Water hyacinth's minimum growth temperature is 12 C (Ramey et al. 2001).*

How likely is it that any life stage of this species can overwinter in the Great Lakes (survive extremely low levels of oxygen, light, and temperature)?

Likely (This species is able to tolerate temperatures under 5°C and oxygen levels ≤0.5 mg/L)	9
Somewhat likely (This species is able to tolerate some of these conditions OR has adapted behaviorally to avoid them)	6
Somewhat unlikely (This species is able to tolerate conditions close to those specified, but it is not known as an overwintering species)	3
Unlikely	0
Unknown	U
	7

- *Water hyacinth seeds can remain viable for up to 5-20 years (FAO 2013).*
- *In 2011-2012, MacIsaac et al. (2016) observed E. crassipes survived throughout most of the winter in nearshore locations around Lake St. Clair, but it eventually died by the end of March 2012. During the harsher 2012-2013 winter, E. crassipes reached complete mortality by mid-February 2013.*
- *5% of collected seeds were identified as E. crassipes in areas where the species has recurred in Lake St. Clair and the Detroit River (MacIsaac et al. 2016).*
- *With sufficient nutrients for growth, 67 and 53%, respectively, of moist and dry seeds germinated in a controlled environmental chamber that mimicked the light conditions (13 hours of light) and maximum water temperature (28 C) of nearshore areas during the summer (MacIsaac et al. 2016).*
- *Although it is capable of producing dormant seeds, evidence suggests that E. crassipes will not establish a population in the Great Lakes region via seeds due to the lack of genetic diversity of the introduced populations (Adebayo et al. 2011).*

- *There is evidence that E. crassipes has overwintered in private ponds in Michigan and in the coastal waters of Lake St. Clair and the Detroit River (MacIsaac et al. 2016; Ankney 2012). Annual recurrence of this species is due in most part to annual reintroduction by residents. However, the production of viable seed banks may supplement these introductions and contribute to the persistence of this species (MacIsaac et al. 2016).*
- *Water hyacinth's minimum growth temperature is 12 C (Ramey et al. 2001).*
- *Water hyacinth does not tolerate long exposure to temperatures lower than 0°C. Short-term exposure to temperatures at or below freezing can be tolerated (IPAMS 2013).*
- *It is not known as an overwintering species in Rixon et al. (2005).*
- *Eichhornia crassipes may experience increased mortality and reduced regrowth potential after long periods of near-freezing temperatures (Adebayo et al. 2011, Owens and Madsen 1995, Rixon et al. 2005).*
- *In Dallas, Texas, water hyacinth populations were completely killed during one winter (Owens and Madsen 1995). The winter of 1990-1991 there was a period of 11 days with the minimum air temperature below freezing.*
- *Rooted plants are more resistant to overwintering than floating mats (Owens and Madsen 1995).*

Establishment Potential Scorecard				
Points	**Probability for Establishment**	Total Points (pre-adjustment)		**103**
>100	High	Adjustments		
		Critical species	A (1- 0 %)	103
51-99	Moderate	Natural enemy	B (1- 0%)	103
		Control measures	C (1- 30 %)	72.1
0-50	Low	**Potential for Establishment**		Moderate
# of questions answered as "unable to determine"	**Confidence Level**			
0-1	High	Total # of questions unknown		
2-5	Moderate			
6-9	Low	Confidence Level		
>9	Very low			

Scientific Name: *Hypania invalida*

Common Name: Freshwater bristle-worm

Section B: Potential for Establishment

ESTABLISHMENT POTENTIAL RESULTS

Probability of establishment if introduced to the Great Lakes: Moderate (Confidence level: Moderate)

Comments: None.

INVASIVE BIOLOGICAL/ECOLOGICAL ATTRIBUTES

How would the physiological tolerance of this species (survival in varying temperature, salinity, oxygen, and nutrient levels) be described?

This species has broad physiological tolerance. It has been reported to survive in wide ranges of temperature (0°C-30°C), salinity (0-16 parts per thousand), oxygen (0-saturated), AND nutrient (oligotrophic-eutrophic) levels.	9
This species has somewhat broad physiological tolerance. It has been reported to survive in a wide range of temperature, salinity, oxygen, OR nutrient levels. Tolerance to other factors is narrower, unknown, or unreported.	6
This species has narrow physiological tolerance. It has been reported to survive in limited ranges of temperature, salinity, oxygen, and nutrient levels.	3
Unknown	U
	6

- Hypania invalida *is able to survive in a wide range of temperature (2-25°C) and salinity (0-12 PSU) (Mordukhai-Boltovskoi 1964), both of which are well within the ranges that occur in the Great Lakes.*
- *Tolerance to other physiological factors is unknown or unreported.*

How likely is it that any life stage of this species can overwinter in the Great Lakes (survive extremely low levels of oxygen, light, and temperature)?

Likely (This species is able to tolerate temperatures under 5°C and oxygen levels ≤0.5 mg/L)	9
Somewhat likely (This species is able to tolerate some of these conditions OR has adapted behaviorally to avoid them)	6
Somewhat unlikely (This species is able to tolerate conditions close to those specified, but it is not known as an overwintering species)	3
Unlikely	0
Unknown	U
	U

- *Information on the mechanisms facilitating the overwintering of this species within its native range are unreported (e.g., lower oxygen tolerance limit).*

If this species is a heterotroph, how would the flexibility of its diet be described?

This species is a dietary generalist with a broad, assorted, AND flexible diet.	9
This species is moderately a dietary generalist with a broad, assorted, OR flexible diet.	6
This species is a dietary specialist with a limited and inflexible diet.	3
This species is an autotroph.	0
Unknown	U
	9

- Hypania invalida *is an active filter and deposit feeder (Manoleli 1975), with a non-specific food preference (bij de Vaate et al. 2002).*

How likely is this species to outcompete species in the Great Lakes for available resources?

Likely (This species is known to have superior competitive abilities and has a history of outcompeting other species, AND/OR available literature predicts it might outcompete native species in the Great Lakes)	9
Somewhat likely (This species is known to have superior competitive abilities, but there are few reported cases of this species outcompeting another and no predictions regarding species in the Great Lakes)	6
Somewhat unlikely (This species has average competitive abilities, and there are no reported cases of this species outcompeting another and no predictions regarding species in the Great Lakes)	3
Unlikely (This species is known as a poor competitor that thrives only in environments with low biodiversity, AND/OR available literature predicts it might be outcompeted by a species in the Great Lakes)	0
Unknown	U
	3

- *There are currently no reported cases of* H. invalida *outcompeting another species within its invaded range in Europe and no predictions available regarding its potential competitive abilities within the Great Lakes.*

How would the fecundity of this species be described relative to other species in the same taxonomic class?

Very high	9
High	6
Moderate	3
Low	0
Unknown	U
	6

- *Females have a high net fecundity due to frequent reproductive events (every 2 weeks) throughout maturity; it is estimated that a single female could produce at least 1200 larvae during her lifespan (Norf et al. 2010).*

How likely are this species' reproductive strategy and habits to aid establishment in new environments, particularly the Great Lakes (e.g., parthenogenesis/self-crossing, self fertility, vegetative fragmentation)?

Likely (The reproductive strategy or habits of this species are known to aid establishment in new environments, AND available literature predicts establishment in the Great Lakes based on these attributes)	9
Somewhat likely (The reproductive strategy or habits of this species are known to aid establishment in new environments, but there is no literature available regarding establishment in the Great Lakes based on these attributes)	6
Somewhat unlikely (The reproductive strategy or habits of this species could potentially aid establishment in new environments, but there is no literature available regarding establishment in the Great Lakes based on these attributes)	3
Unlikely (The reproductive strategy or habits of this species are not known to aid establishment in new environments)	0
Unknown	U
	9

- *Many of the sexual and reproductive traits of* H. invalida *(short generation time, external spermcast fertilization, etc.) reflect attributes that are postulated to enhance the invasion success of aquatic invertebrates as given by Devin and Beisel (2007) and Ricciardi and Rasmussen (1998) (Norf et al. 2010).*
- *The maternal care of offspring (brooding) by this species can increase reproductive success by reducing larval mortality during early planktonic life stages (McHugh 1993, Schroeder and Hermans 1975).*
- *Increased knowledge of this species' reproductive characteristics, has led Norf et al. (2010) to highlight the potential of* H. invalida *to invade the Great Lakes (contrary to earlier suggestions that it is unlikely to disperse internationally; cf. Ricciardi and Rasmussen 1998).*

ENVIRONMENTAL COMPATIBILITY

How similar are the climatic conditions (e.g., air temperature, precipitation, seasonality) in the native and introduced ranges of this species to those in the Great Lakes region?

Very similar (The climatic conditions are practically identical to those of the Great Lakes region)	9
Similar (Many of the climatic conditions are similar to those of the Great Lakes region)	6
Somewhat similar (Few of the climatic conditions are similar to those of the Great Lakes region)	3
Not similar	0
Unknown	U
	6

- *This species is a Ponto-Caspian native, a region where climatic conditions are similar to those of the Great Lakes.*

How similar are other abiotic factors that are relevant to the establishment success of this species (e.g., pollution, water temperature, salinity, pH, nutrient levels, currents) in the native and introduced ranges to those in the Great Lakes?

Very similar (These factors are practically identical to those of the Great Lakes region)	9
Similar (Many of these factors are similar to those of the Great Lakes region)	6
Somewhat similar (Few of these factors are similar to those of the Great Lakes region)	3
Not similar	0
Unknown	U

	6

POTENTIAL BENEFICIAL

How abundant are habitats suitable for the survival, development, and reproduction of this species in the Great Lakes area (e.g., those with adequate depth, substrate, light, temperature, oxygen)?

Abundant (Suitable habitats can be easily found and readily available)	9
Somewhat abundant (Suitable habitats can be easily found but are in high demand by species already present)	6
Somewhat scarce (Suitable habitats can be found occasionally)	3
Scarce (Suitable habitats are rarely found)	0
Unknown	U
	7

- *This species is restricted to soft-bottom communities (e.g., silt, clay, fine sand) (Zoric et al. 2011).*
- *Sandy bottoms covered with zebra mussel beds also serve as potential habitat, though settlement densities here are typically lower than those in soft-bottom communities (Norf et al. 2010, Yakovleva and Yakovleva 2010).*
- Hypania invalida *is able to live at a wide range of water depths (shoreline to 960 m) (Zenkevich 1963).*

How likely is this species to adapt to or to benefit from the predicted effects of climate change on the Great Lakes freshwater ecosystems (e.g., warmer water temperatures, shorter duration of ice cover, altered streamflow patterns, increased salinization)?

Likely (Most of the effects described above make the Great Lakes a better environment for establishment and spread of this species OR this species could easily adapt to these changes due to its wide environmental tolerances)	9
Somewhat likely (Several of the effects described above could make the Great Lakes a better environment for establishment and spread of this species)	6
Somewhat unlikely (Few of the effects described above would make the Great Lakes a better environment for establishment and spread of this species)	3
Unlikely (Most of the effects described above would have no effect on establishment and spread of this species or would make the environment of the Great Lakes unsuitable)	0
Unknown	U
	8

- *Increased salinization as a predicted effect of climate change may give this species a competitive advantage over Great Lakes native polychaetes.*
- *Shorter ice cover duration and warmer water temperatures may also benefit this species by lengthening its suitable yearly spawning period; however, if water becomes too warm, this effect may be detrimental to survival. For instance, in the summer of 2003, the lower Rhine experienced the highest water temperatures on record, greatly reducing the population density of H. invalida (Norf et al. 2010).*

How likely is this species to find an appropriate food source (prey or vegetation in the case of predators and herbivores, or sufficient light or nutrients in the case of autotrophs)?

Likely (All possible nutritive food items—including species in the Great Lakes that may be considered potential food items—are highly abundant and/or easily found)	9

Somewhat likely (Some nutritive food items—including species in the Great Lakes that may be considered potential food items—are abundant and/or search time is low to moderate)	6
Somewhat unlikely (Few nutritive food items—including species in the Great Lakes that may be considered potential food items—are abundant and/or search time is moderate to high)	3
Unlikely (All possible nutritive food items—including species in the Great Lakes that may be considered potential food items—are relatively scarce and/or search time is high)	0
Unknown	U
	9

- Hypania invalida *is an active filter and deposit feeder, feeding primarily upon diatoms (Gruia and Manoleli 1974, Manoleli 1975). Hence, potential food items will likely not limit the distribution of this species within the Great Lakes.*

Does this species require another species for critical stages in its life cycle such as growth (e.g., root symbionts), reproduction (e.g., pollinators, egg incubators), spread (e.g., seed dispersers), or transmission (e.g., vectors)?

Yes, and the critical species (or one that may provide a similar function) is common in the Great Lakes and can be easily found in environments suitable for the species being assessed; OR, No, there is no critical species required by the species being assessed	9
Yes, and the critical species (or one that may provide a similar function) is moderately abundant and relatively easily found in particular parts of the Great Lakes	6
Yes, and the critical species (or one that may provide a similar function) is relatively rare in the Great Lakes AND/OR can only be found occasionally in environments suitable for the species being assessed	3
Yes, and the critical species (or one that may provide a similar function) is not present in the Great Lakes but is likely to be introduced	0
Yes, but the critical species (or one that may provide a similar function) is not present in the Great Lakes and is not likely to be introduced	-80% total points (at end)
Unknown	U
	9

- *There is no critical species required by* H. invalida.

How likely is the establishment of this species to be aided by the establishment and spread of another species already in the Great Lakes?

Likely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established and spread in the Great Lakes, AND available literature predicts this previous invader might promote the establishment of this species, AND/OR there have been cases reported of this species aiding the establishment of this species in other areas)	9
Somewhat likely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established and spread in the Great Lakes)	6

Somewhat unlikely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established in the Great Lakes BUT it is still confined to a small area of the Lakes and the likelihood of encounter with this species assessed is hard to predict)	3
Unlikely (A non-indigenous species to the Great Lakes that facilitates the development of this species has not been established in the Great Lakes)	0
Unknown	U
	0

How likely is establishment of this species to be prevented by the herbivory, predation, or parasitism of a natural enemy this is already present in the Great Lakes and may preferentially target this species?

Likely (The ability of the natural enemy to prevent the establishment of this species in introduced ranges or limiting populations of this species in native ranges is well documented in the literature AND this natural enemy is abundant and widespread in the Great Lakes)	-80% total points (at end)
Somewhat likely (The ability of the natural enemy to prevent the establishment of this species in introduced ranges or limiting populations of this species in native ranges is suggested in the literature OR this natural enemy has limited distribution in the Great Lakes)	-60% total points (at end)
Somewhat unlikely (There are few cases reported of such a natural enemy preventing the establishment of this species in introduced ranges or limiting populations of this species in native ranges OR this natural enemy has low abundance in the Great Lakes)	-10% total points (at end)
Unlikely (Such a natural enemy is particularly rare or is not present in the Great Lakes)	0
Unknown	U
	0

PROPAGULE PRESSURE

On average, how large and frequent are inoculations (introduction events) from the potential vectors identified in Section A for this species? (What is the total number of individuals introduced?)

Frequent, large inocula	9
Frequent, moderate inocula	6
Frequent, small inocula OR infrequent, large inocula	3
Infrequent, small or moderate inocula	0
Unknown	U
	U

HISTORY OF INVASION AND SPREAD

How extensively has this species established reproducing populations in areas outside its native range as a direct or indirect result of human activities?

Very extensively (many invasive populations of this species have been reported in areas widely distributed from the native range)	9
Extensively (some invasive populations of this species have been reported in areas widely distributed from the native range)	6
Somewhat extensively (few invasive populations of this species have been reported in areas widely distributed from the native range OR all invasive populations are in close proximity to each other)	3
Not extensively (no invasive populations of this species have been reported)	0
Unknown	U
	6

- Hypania invalida *has an extensive invasion history throughout Europe (Gherardi et al. 2009), with a spreading pattern that seems to suggest dispersal through a corridor connecting the Danube and Rhine rivers.*
- *Its dispersal pattern closely follows that of the European invasive isopod* Jaera istri *(bij de Vaate et al. 2002).*
- *Panov et al. (2009) described this species as being at high risk for dispersal and establishment when introduced to a new area.*

How rapidly has this species spread by natural means or by human activities once introduced to other locations?

Rapidly (This species has a history of rapid spread in introduced ranges)	9
Somewhat rapidly (This species has a history of moderately rapid spread in introduced ranges)	6
Somewhat slowly (This species has a history of moderately slow spread in its introduced ranges)	3
Slowly (This species has a history of slow to no spread in its introduced ranges)	0
Unknown	U
	6

- *Rapid expansion throughout European inland waterways has been facilitated by both human mediated (ballast water) upstream spread and natural (passive drift) downstream spread (Norf et al. 2010, bij de Vaate 2003).*
- *Within a few years of introduction to the Rhine River, it had dispersed along the entire navigable river stretch (Bernauer and Jansen 2006) and into many adjacent waterways, including the Moselle (Devin et al. 2006) and Elbe rivers (Eggers and Anlauf 2008).*

Are there any existing control measures in the Great Lakes set to prevent the establishment and/or spread of this species?

Yes, and they are likely to prevent establishment or spread of the species. (There are no reported cases of this species adapting or avoiding current measures. These measures are highly effective in preventing the establishment and spread of this species)	-90% total points (at end)

Yes, and they are moderately likely to prevent establishment or spread of the species. (There are few reported cases of this species adapting or avoiding current measures used to control its establishment and spread)	-50% total points (at end)
Yes, but they are unlikely to prevent establishment or spread of the species. (There are many reported cases of this species adapting or avoiding current measures used to control its establishment and spread)	-20% total points (at end)
No control methods have been set to prevent the establishment and/or spread of this species	0
Unknown	U
	0

Establishment Potential Scorecard				
Points	**Probability for Establishment**	**Total Points (pre-adjustment)**		**A 90**
>100	High	**Adjustments**		
		Critical species	A*(1- ___ %)	**B 90**
51-99	Moderate	Natural enemy	B*(1- ___ %)	**C 90**
		Control measures	C*(1- ___ %)	**90**
0-50	Low	**Potential for Establishment**		Moderate
# of questions answered as "unable to determine"	**Confidence Level**			
0-1	High	Total # of questions unknown		2
2-5	Moderate			
6-9	Low	Confidence Level		Moderate
>9	Very low			

Qualitative Statement for GLANSIS Fact Sheet: *Hypania invalida* has a moderate probability of establishment if introduced to the Great Lakes (Confidence level: Moderate).

Scientific Name: *Hyhpophthalmichthys molitrix*

Common Name: Silver carp

Section A: Potential for Introduction

INTRODUCTION POTENTIAL RESULTS

Dispersal: Moderate
Hitchhiking/Fouling: Unlikely
Unauthorized intentional release: Moderate
Stocking/Planting/Escape from recreational culture: Unlikely
Escape from commercial culture: Low
Shipping: Unlikely

Comments:

***Hypophthalmichthys molitrix* has a moderate probability of introduction to the Great Lakes (Confidence level: High).**

Potential pathway(s) of introduction: Dispersal, unauthorized intentional release, escape from commercial culture
Currently, large populations of this species are already established in nearby waters connected to the Great Lakes basin including the Illinois river and the Chicago Area Waterway System (Baerwaldt et al. 2013). On June 22nd, 2017, a 4-year-old male silver carp was found nine miles from Lake Michigan in the Little Calumet River of the Chicago Area Waterway System (CAWS). This was the first silver carp collected above the electrical barriers in the CAWS. The autopsy revealed that this fish originated in the Illinois/Middle Mississippi watershed and spent a quarter of its life in the Des Plaines River watershed before being caught and removed from the Little Calumet River. It is not known how the fish arrived above the electric barriers, but the autopsy revealed that the fish spent anywhere from a few weeks to a few months in the stretch of river where it was collected (Asian Carp Regional Coordinating Committee 2017). Prior to this record, the closest location to Lake Michigan at which a silver carp has been collected was in the Des Plaines River (river mile 290.2) at the confluence with the CSSC, north of Joliet, IL and downstream of the electric barriers (USGS 2013).

Live silver carp are sometimes available in live food fish markets in several major U.S. and Canadian cities, including Toronto (Kolar et al. 2005).

POTENTIAL INTRODUCTION VIA DISPERSAL

Does this species occur near waters (natural or artificial) connected to the Great Lakes basin* (e.g., streams, ponds, canals, or wetlands)?
*(*Great Lakes basin = below the ordinary high water mark, including connecting channels, wetlands, and waters ordinarily attached to the Lakes)*

Yes, this species occurs near waters connected to the Great Lakes basin and is mobile or able to be transported by wind or water.	100√
No, this species does not occur near waters connected to the Great Lakes basin and/or is not mobile or able to be transported by wind or water.	0

Unknown	U

- *Currently, large populations of this species are already established in nearby waters connected to the Great Lakes basin including the Illinois river and the Chicago Area Waterway System (Baerwaldt et al. 2013).*

What is the proximity of this species to the Great Lakes basin?

This species occurs in waters within 20 kilometers of the Great Lakes basin, and no barrier (e.g., electric barrier, dam) to dispersal is present.	Score x 1
This species occurs in waters within 20 kilometers of the Great Lakes basin, but dispersal to the basin is blocked; or, this species occurs in waters within 100 kilometers of the Great Lakes basin, and no barrier to dispersal is present.	Score x 0.75√
This species occurs in waters within 100 kilometers of the Great Lakes basin, but dispersal to the basin is blocked.	Score x 0.5
This species occurs in waters >100 kilometers from the Great Lakes basin.	Score x 0.25
Unknown	U

- *On June 22nd, 2017 a 4-year-old male silver carp was found nine miles from Lake Michigan in the Little Calumet River of the Chicago Area Waterway System (CAWS). This was the first silver carp collected above the electrical barriers in the CAWS. The autopsy revealed that this fish originated in the Illinois/Middle Mississippi watershed and spent a quarter of its life in the Des Plaines River watershed before being caught and removed from the Little Calumet River. It is not known how the fish arrived above the electric barriers, but the autopsy revealed that the fish spent anywhere from a few weeks to a few months in the stretch of river where it was collected (Asian Carp Regional Coordinating Committee 2017).*
- *Prior to this record, the closest location to Lake Michigan at which a silver carp has been collected was in the Des Plaines River (river mile 290.2) at the confluence with the CSSC, north of Joliet, IL and downstream of the electric barriers (USGS 2013).*

POTENTIAL INTRODUCTION VIA HITCHHIKING/FOULING

Is this species likely to attach to or be otherwise transported by, or along with, recreational gear, boats, trailers, fauna (e.g., waterfowl, fish, insects), flora (e.g., aquatic plants), or other objects (e.g., packing materials), including as parasites or pathogens, entering the Great Lakes basin?

Yes, this species is known to be able to adhere to certain surfaces or to be transported by other organisms entering the Great Lakes basin.	100
No, this species is not known to be able to adhere to certain surfaces or to be transported by other organisms entering the Great Lakes basin.	0 √
Unknown	U

- *Not reported.*

What is the proximity of this species to the Great Lakes basin?

This species occurs in waters within 20 km of the Great Lakes basin.	Score x 1
This species occurs in waters within 100 km of the Great Lakes basin.	Score x 0.5
This species occurs in waters >100 km from the Great Lakes basin.	Score x 0.1
Unknown	U

POTENTIAL INTRODUCTION VIA UNAUTHORIZED INTENTIONAL RELEASE

Is this species sold at aquarium/pet/garden stores ("brick & mortar" or online), catalogs, biological supply companies, or live markets (e.g., purchased for human consumption, bait, ornamental, ethical, educational, or cultural reasons) and as a result may be released into the Great Lakes basin?

Yes, this species is available for purchase.	100√
No, this species this species is rarely/never sold.	0
Unknown	U

- *Live silver carp are sometimes available in live food fish markets in several major U.S. and Canadian cities, including Toronto (Kolar et al. 2005).*

How easily is this species obtained within the Great Lakes region (states/provinces)?

This species is widely popular, frequently sold, and/or easily obtained within the Great Lakes region.	Score x 1
This species is widely popular, and although trade, sale, and/or possession of this species is prohibited, it is frequently sold on the black market within the Great Lakes region.	Score x 0.5√
This species is not very popular or is not easily obtained within the Great Lakes region.	Score x 0.1
Unknown	U

POTENTIAL INTRODUCTION VIA STOCKING/PLANTING OR ESCAPE FROM RECREATIONAL CULTURE

Is this species being stocked/planted to natural waters or outdoor water gardens around the Great Lakes region?

Yes, this species is being stocked/planted and/or has ornamental, cultural, medicinal, environmental (e.g., biocontrol, erosion control), scientific, or recreational value in the Great Lakes region.	100
No, this species cannot be stocked/planted or there is not enough interest to do so in the Great Lakes region.	0 √
Unknown	U

- *Not reported.*

What is the nature and proximity of this activity to the Great Lakes basin?

This activity is authorized and/or is occurring directly in the Great Lakes.	Score x 1
This activity is occurring in Great Lakes tributaries or connecting waters, or within 20 km of the Great Lakes basin.	Score x 0.75
This activity is likely to occur within 20 km of the Great Lakes basin because of its popularity/value and there are no widespread regulations against stocking/planting.	Score x 0.5
This activity is occurring in waters >20 km from the Great Lakes basin, or despite federal or state regulations in more than half the basin (> 5 states/provinces), this activity may occur within 20 km of the basin because of the species' popularity/value.	Score x 0.25
Unknown	U

POTENTIAL INTRODUCTION VIA ESCAPE FROM COMMERCIAL CULTURE

Is this species known to be commercially cultured in or transported through the Great Lakes region?

Yes, this species is being commercially cultured in or transported through the Great Lakes region.	100√
No, this species is not commercially cultured in or transported through the Great Lakes region.	0
Unknown	U

- *Live silver carp are sometimes available in live food fish markets in several major U.S. and Canadian cities, including Toronto (Kolar et al. 2005). These fish are sometimes transported through the region.*

What is the nature and proximity of this activity to the Great Lakes basin?

This activity is unregulated or minimally regulated and is occurring directly in the Great Lakes.	Score x 1
This activity is unregulated or minimally regulated and is occurring in Great Lakes tributaries or connecting waters, or within 20 km of the Great Lakes basin.	Score x 0.75
This activity is strictly regulated but occurs directly in the Great Lakes, and/or this activity involves transport of live organisms on/across the Great Lakes.	Score x 0.5
This activity is strictly regulated but occurs in Great Lakes tributaries, connecting waters, or within 20 km of the Great Lakes basin, and/or this activity involves transport of live organisms within 20 km of the Great Lakes basin.	Score x 0.25√
This activity occurs >20 km from the Great Lakes basin and typically does not involve transport of live organisms closer to the basin.	Score x 0.1
Unknown	U

POTENTIAL INTRODUCTION VIA SHIPPING

Is this species capable of surviving adverse environments (i.e. extreme temperatures, absence of light, low oxygen levels) and partial-to-complete ballast water exchange/BWE (e.g., is euryhaline, buries in sediment, produces resistant resting stages, has other attributes or behaviors facilitating survival under these conditions)?

Yes, this species is able to survive in ballast tank environments for weeks at a time and may be suspended in ballast water.	100
Yes, this species is able to survive in ballast tank environments for weeks at a time and is able to survive BWE by burial in ballast sediment.	80
Yes, this species is able to survive in ballast tank environments for weeks at a time and may be suspended in ballast water, but this species is not able to survive BWE.	60
No, but this species is capable of fouling transoceanic ship structures (e.g., hull, chains, chain locker) while in its active or resting stage.	40
No, this species is not able to survive adverse environments, does not foul transoceanic ship structures, or is unlikely to be taken up with ballast.	0√
Unknown	U

- *Not reported.*

Does this species occur in waters from which shipping traffic to the Great Lakes originates?

Yes, and this species has been observed in ballast of or fouling ships entering the Great Lakes.	Score x 1

Yes, and this species has been observed in ports that have direct trade connections with the Great Lakes (e.g., Baltic Sea).	Score x 0. 5
Yes, but this species has neither been observed in ballast/fouling ships entering the Great Lakes nor in ports in direct trade with the Great Lakes.	Score x 0.1
No, this species does not occur in waters from which shipping traffic to the Great Lakes originates.	Score x 0
Unknown	U

Vector Potential Scorecard				
Vector	**Raw Points Scored**	**Proximity Multiplier**	**Total Points Scored**	**Probability of Introduction**
Dispersal: Natural dispersal through waterbody connections or wind	**100**	x	**0.75**	Moderate
Hitchhiking/Fouling: Transport via recreational gear, boats, trailers, mobile fauna, stocked/planted organisms, packing materials, host organisms, etc.	**0**	x		0
Release: Unauthorized intentional release of organisms in trade (e.g., aquaria, water gardens, live food)	**100**	x	**0.5**	Moderate
Stocking/Planting/Escape from recreational culture: Intentional authorized or unauthorized introduction to natural waters in the Great Lakes OR Accidental introduction to Great Lakes by escape from recreational culture (e.g., water gardens)	**0**	x		0
Escape from commercial culture: Accidental introduction to Great Lakes by escape from commercial culture (e.g., aquaculture)	**100**	x	**0.25**	Low
Trans-oceanic shipping: Ballast (BOB) or no-ballast-on-board (NOBOB) water exchange/discharge, sediment discharge, hull fouling	**0**	x		0
Total Unknowns (U)	**0**	**Confidence Level**	High	

<u>Qualitative Statements for GLANSIS Fact Sheet:</u>
Hypophthalmichthys molitrix has a moderate probability of introduction to the Great Lakes (Confidence level: high).

Potential pathway(s) of introduction: Dispersal, Release, Escape from Commercial Culture

Section B: Potential for Establishment

INVASIVE BIOLOGICAL/ECOLOGICAL ATTRIBUTES

How would the physiological tolerance of this species (survival in varying temperature, salinity, oxygen, and nutrient levels) be described?

This species has broad physiological tolerance. It has been reported to survive in wide ranges of temperature (0°C-30°C), salinity (0-16 parts per thousand), oxygen (0-saturated), AND nutrient (oligotrophic-eutrophic) levels.	9
This species has somewhat broad physiological tolerance. It has been reported to survive in a wide range of temperature, salinity, oxygen, OR nutrient levels. Tolerance to other factors is narrower, unknown, or unreported.	6
This species has narrow physiological tolerance. It has been reported to survive in limited ranges of temperature, salinity, oxygen, and nutrient levels.	3
Unknown	U
	7

- *Silver carp are freshwater fish, preferring large river systems, lakes, or impoundments with flowing water, which they need to spawn. They can feed in temperatures as low as 2.5°C (36.5°F) and can withstand low levels of oxygen (PA Sea Grant 2013).*

How likely is it that any life stage of this species can overwinter in the Great Lakes (survive extremely low levels of oxygen, light, and temperature)?

Likely (This species is able to tolerate temperatures under 5°C and oxygen levels ≤0.5 mg/L)	9
Somewhat likely (This species is able to tolerate some of these conditions OR has adapted behaviorally to avoid them)	6
Somewhat unlikely (This species is able to tolerate conditions close to those specified, but it is not known as an overwintering species)	3
Unlikely	0
Unknown	U
	8

- *Overwinter mortality is correlated to length of winter and becomes more important with increasing latitude. It is not known to be an issue for bighead and silver carp (collectively bigheaded carp) in the Mississippi River basin; bigheaded carp fingerlings have been collected from floodplain wetlands in spring in years when the wetlands were not connected to the river. Overwinter mortality may influence the northern limits of the native range of bigheaded carp, but has not been modelled specifically for these species in North America. Ecological niche modeling predicting the potential North American distribution of bigheaded carp indicated that they could survive well north of the Great Lakes basin (Herborg et al. 2007); therefore, overwinter mortality will likely not be a limiting factor in most years (Cudmore B. et al. 2012).*

If this species is a heterotroph, how would the flexibility of its diet be described?

This species is a dietary generalist with a broad, assorted, AND flexible diet.	9
This species is moderately a dietary generalist with a broad, assorted, OR flexible diet.	6
This species is a dietary specialist with a limited and inflexible diet.	3

This species is an autotroph.	0
Unknown	U
	5

- *The silver carp has unique, sponge-like and porous gill rakers capable of straining phytoplankton down to 4 microns in diameter (Robison and Buchanan 1988).*
- *Adults feed primarily on phytoplankton, but silver carp larvae feed on zooplankton (Chen et al. 2006).*
- *It would be highly likely for the silver carp to find an appropriate food source but the amount they eat might not be sufficiently found in the Great Lakes. Recent bioenergetics modelling efforts suggest that plankton concentrations could support silver carp growth in productive nearshore areas and embayments (e.g. Green Bay and the Western Basin of Lake Erie), but the fish would likely be food-limited in the oligotrophic offshore regions (Cooke and Hill 2010; Anderson et al. 2015; Anderson et al. 2017).*

How likely is this species to outcompete species in the Great Lakes for available resources?

Likely (This species is known to have superior competitive abilities and has a history of outcompeting other species, AND/OR available literature predicts it might outcompete native species in the Great Lakes)	9
Somewhat likely (This species is known to have superior competitive abilities, but there are few reported cases of this species outcompeting another and no predictions regarding species in the Great Lakes)	6
Somewhat unlikely (This species has average competitive abilities, and there are no reported cases of this species outcompeting another and no predictions regarding species in the Great Lakes)	3
Unlikely (This species is known as a poor competitor that thrives only in environments with low biodiversity, AND/OR available literature predicts it might be outcompeted by a species in the Great Lakes)	0
Unknown	U
	9

- *Silver carp are thought to deplete plankton stocks for native larval fishes and mussels (Laird and Page 1996).*
- *The invasion of bigheaded carp in the Illinois river has reduced the growth condition and populations of native planktivorous fishes including bigmouth buffalo (Ictiobus bubalus) and the gizzard shad (Dorosoma cepedianum) (Pendleton et al., 2017; Irons et al. 2007).*

How would the fecundity of this species be described relative to other species in the same taxonomic class?

Very high	9
High	6
Moderate	3
Low	0
Unknown	U
	6

- *Bigheaded carp are known to spawn in rivers and it is believed that flood events are a primary spawning cue (Kolar et al. 2007). In its native range, silver carp has a fecundity ranging from 299,000-5.4 million eggs (Kolar et al. 2007). In North America, it has ranged from 26,650- 3.7 million eggs (Kipp et al. 2011).*

How likely are this species' reproductive strategy and habits to aid establishment in new environments, particularly the Great Lakes (e.g., parthenogenesis/self-crossing, self fertility, vegetative fragmentation)?

Likely (The reproductive strategy or habits of this species are known to aid establishment in new environments, AND available literature predicts establishment in the Great Lakes based on these attributes)	9
Somewhat likely (The reproductive strategy or habits of this species are known to aid establishment in new environments, but there is no literature available regarding establishment in the Great Lakes based on these attributes)	6
Somewhat unlikely (The reproductive strategy or habits of this species could potentially aid establishment in new environments, but there is no literature available regarding establishment in the Great Lakes based on these attributes)	3
Unlikely (The reproductive strategy or habits of this species are not known to aid establishment in new environments)	0
Unknown	U
	0

ENVIRONMENTAL COMPATIBILITY

How similar are the climatic conditions (e.g., air temperature, precipitation, seasonality) in the native and introduced ranges of this species to those in the Great Lakes region?

Very similar (The climatic conditions are practically identical to those of the Great Lakes region)	9
Similar (Many of the climatic conditions are similar to those of the Great Lakes region)	6
Somewhat similar (Few of the climatic conditions are similar to those of the Great Lakes region)	3
Not similar	0
Unknown	U
	8

- *Ecological niche modeling predicting the potential North American distribution of bigheaded carp indicated that they could survive well north of the Great Lakes basin (Herborg et al. 2007); therefore, overwinter mortality will likely not be a limiting factor in most years (Cudmore et al. 2012).*

How similar are other abiotic factors that are relevant to the establishment success of this species (e.g., pollution, water temperature, salinity, pH, nutrient levels, currents) in the native and introduced ranges to those in the Great Lakes?

Very similar (These factors are practically identical to those of the Great Lakes region)	9
Similar (Many of these factors are similar to those of the Great Lakes region)	6
Somewhat similar (Few of these factors are similar to those of the Great Lakes region)	3
Not similar	0
Unknown	U
	8

- *Ecological niche modeling predicting the potential North American distribution of bigheaded carp indicated that they could survive well north of the Great Lakes basin (Herborg et al. 2007); therefore, overwinter mortality will likely not be a limiting factor in most years (Cudmore et al. 2012).*

How abundant are habitats suitable for the survival, development, and reproduction of this species in the Great Lakes area (e.g., those with adequate depth, substrate, light, temperature, oxygen)?

Abundant (Suitable habitats can be easily found and readily available)	9
Somewhat abundant (Suitable habitats can be easily found but are in high demand by species already present)	6
Somewhat scarce (Suitable habitats can be found occasionally)	3
Scarce (Suitable habitats are rarely found)	0
Unknown	U
	5

- *Recent studies have examined the suitability of Great Lakes tributaries for bigheaded carp spawning based on more detailed considerations of reproductive biology. Kocovsky et al. (2012) examined eight American tributaries in the central and western basins of Lake Erie. They concluded that the three larger tributaries were thermally and hydrologically suitable to support spawning of bigheaded carp, four tributaries were less suited, and that one was ill suited. Mandrak et al. (2011) conducted a similar analysis for the 25 Canadian tributaries of the Great Lakes. They concluded suitable spawning conditions were present in nine of 14 tributaries to Lake Superior with sufficient data; however, only one of the nine tributaries had a mean annual total degree-days exceeding 2,685. Therefore, bigheaded carp are unlikely to mature within Lake Superior tributaries, but may encounter sufficient growing degree-days to mature in some parts of Lake Superior such as near shore and bays. Mandrak et al. (2011) concluded suitable spawning conditions, including growing degreedays required for maturation, were present in 23 of 27 tributaries to Lake Huron, nine of 10 tributaries to Lake Erie, and 16 of 28 tributaries to Lake Ontario. Studies have not been conducted for United States tributaries in lakes Michigan, Huron, Superior, Ontario, nor the eastern basin of Lake Erie, but the analyses of Kocovsky et al. (2012) and Mandrak et al. (2011) suggest that access to tributaries with suitable thermal and hydrologic regimes in the Great Lakes should not limit spawning by bigheaded carp (Cudmore et al. 2012).*

How likely is this species to adapt to or to benefit from the predicted effects of climate change on the Great Lakes freshwater ecosystems (e.g., warmer water temperatures, shorter duration of ice cover, altered streamflow patterns, increased salinization)?

Likely (Most of the effects described above make the Great Lakes a better environment for establishment and spread of this species OR this species could easily adapt to these changes due to its wide environmental tolerances)	9
Somewhat likely (Several of the effects described above could make the Great Lakes a better environment for establishment and spread of this species)	6
Somewhat unlikely (Few of the effects described above would make the Great Lakes a better environment for establishment and spread of this species)	3
Unlikely (Most of the effects described above would have no effect on establishment and spread of this species or would make the environment of the Great Lakes unsuitable)	0
Unknown	U
	9

- *Bigheaded carp exist across a wide range of latitudes with optimum consumption temperatures approximated to be between 25 – 30 C (Cooke 2016). In the Illinois River, bigheaded carp have been found in habitats characterized by temperatures 21.7-32.0 C (DeGrandchamp et al. 2008).*

How likely is this species to find an appropriate food source (prey or vegetation in the case of predators and herbivores, or sufficient light or nutrients in the case of autotrophs)?

Likely (All possible nutritive food items—including species in the Great Lakes that may be considered potential food items—are highly abundant and/or easily found)	9
Somewhat likely (Some nutritive food items—including species in the Great Lakes that may be considered potential food items—are abundant and/or search time is low to moderate)	6
Somewhat unlikely (Few nutritive food items—including species in the Great Lakes that may be considered potential food items—are abundant and/or search time is moderate to high)	3
Unlikely (All possible nutritive food items—including species in the Great Lakes that may be considered potential food items—are relatively scarce and/or search time is high)	0
Unknown	U
	8

- *Silver carp feed on both phytoplankton and zooplankton (Radke and Kahl 2002) but in contrast to the bighead carp (*Hypophthalmichthys nobilis*), which is more effective at filtering larger plankton (zooplankton), the silver carp's dense gill rakers allow it to be more efficient at filtering smaller prey (typically phytoplankton) (Dong and Li 1994). While they are primarily planktivores, bighead and silver carp have broad, flexible diets and in some cases have been observed to feed on detritus and biodeposits (Anderson et al. 2016; Boros et al. 2014; Calkins et al. 2012)*

Does this species require another species for critical stages in its life cycle such as growth (e.g., root symbionts), reproduction (e.g., pollinators, egg incubators), spread (e.g., seed dispersers), or transmission (e.g., vectors)?

Yes, and the critical species (or one that may provide a similar function) is common in the Great Lakes and can be easily found in environments suitable for the species being assessed; OR, No, there is no critical species required by the species being assessed	9
Yes, and the critical species (or one that may provide a similar function) is moderately abundant and relatively easily found in particular parts of the Great Lakes	6
Yes, and the critical species (or one that may provide a similar function) is relatively rare in the Great Lakes AND/OR can only be found occasionally in environments suitable for the species being assessed	3
Yes, and the critical species (or one that may provide a similar function) is not present in the Great Lakes but is likely to be introduced	0
Yes, but the critical species (or one that may provide a similar function) is not present in the Great Lakes and is not likely to be introduced	-80% total points (at end)
Unknown	U
	9

- *This species does not require another species for critical stages.*

How likely is the establishment of this species to be aided by the establishment and spread of another species already in the Great Lakes?

Likely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established and spread in the Great Lakes, AND available literature predicts this previous invader might promote the establishment of this species, AND/OR there have been cases reported of this species aiding the establishment of this species in other areas)	9
Somewhat likely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established and spread in the Great Lakes)	6
Somewhat unlikely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established in the Great Lakes BUT it is still confined to a small area of the Lakes and the likelihood of encounter with this species assessed is hard to predict)	3
Unlikely (A non-indigenous species to the Great Lakes that facilitates the development of this species has not been established in the Great Lakes)	0
Unknown	U
	0

- *Silver carp will not be aided by the establishment of any other species.*

How likely is establishment of this species to be prevented by the herbivory, predation, or parasitism of a natural enemy this is already present in the Great Lakes and may preferentially target this species?

Likely (The ability of the natural enemy to prevent the establishment of this species in introduced ranges or limiting populations of this species in native ranges is well documented in the literature AND this natural enemy is abundant and widespread in the Great Lakes)	-80% total points (at end)
Somewhat likely (The ability of the natural enemy to prevent the establishment of this species in introduced ranges or limiting populations of this species in native ranges is suggested in the literature OR this natural enemy has limited distribution in the Great Lakes)	-60% total points (at end)
Somewhat unlikely (There are few cases reported of such a natural enemy preventing the establishment of this species in introduced ranges or limiting populations of this species in native ranges OR this natural enemy has low abundance in the Great Lakes)	-10% total points (at end)
Unlikely (Such a natural enemy is particularly rare or is not present in the Great Lakes)	0
Unknown	U
	0

- *Silver carp are not found to have any predators or enemies.*

PROPAGULE PRESSURE

On average, how large and frequent are inoculations (introduction events) from the potential vectors identified in Section A for this species? (What is the total number of individuals introduced?)

Frequent, large inocula	9
Frequent, moderate inocula	6
Frequent, small inocula OR infrequent, large inocula	3
Infrequent, small or moderate inocula	0
Unknown	U

	2

HISTORY OF INVASION AND SPREAD

How extensively has this species established reproducing populations in areas outside its native range as a direct or indirect result of human activities?

Very extensively (many invasive populations of this species have been reported in areas widely distributed from the native range)	9
Extensively (some invasive populations of this species have been reported in areas widely distributed from the native range)	6
Somewhat extensively (few invasive populations of this species have been reported in areas widely distributed from the native range OR all invasive populations are in close proximity to each other)	3
Not extensively (no invasive populations of this species have been reported)	0
Unknown	U
	9

- *Bigheaded carp were imported in the 1970s for aquaculture and as a biocontrol in sewage treatment. They escaped from captivity, and by the late 1990s had become extremely abundant in parts of the Mississippi River drainage (Kolar et al. 2007).*

How rapidly has this species spread by natural means or by human activities once introduced to other locations?

Rapidly (This species has a history of rapid spread in introduced ranges)	9
Somewhat rapidly (This species has a history of moderately rapid spread in introduced ranges)	6
Somewhat slowly (This species has a history of moderately slow spread in its introduced ranges)	3
Slowly (This species has a history of slow to no spread in its introduced ranges)	0
Unknown	U
	9

- *Bigheaded carp were imported in the 1970s for aquaculture and as a biocontrol in sewage treatment. They escaped from captivity, and by the late 1990s had become extremely abundant in parts of the Mississippi River drainage (Kolar et al. 2007).*

Are there any existing control measures in the Great Lakes set to prevent the establishment and/or spread of this species?

Yes, and they are likely to prevent establishment or spread of the species. (There are no reported cases of this species adapting or avoiding current measures. These measures are highly effective in preventing the establishment and spread of this species)	-90% total points (at end)
Yes, and they are moderately likely to prevent establishment or spread of the species. (There are few reported cases of this species adapting or avoiding current measures used to control its establishment and spread)	-50% total points (at end)

Yes, but they are unlikely to prevent establishment or spread of the species. (There are many reported cases of this species adapting or avoiding current measures used to control its establishment and spread)	-20% total points (at end)
No control methods have been set to prevent the establishment and/or spread of this species	0
Unknown	U
	-40%

- *Asian Carp management and control plans can be used for silver carp.*
- *Asian Carp Control Strategy Framework can be used for silver carp.*
- *Asian Carp Regional Coordinating Committee can be used for silver carp.*
- *Asian Carp Monitoring and Rapid Response Plan can be used for silver carp.*
- *eDNA monitoring can be used for silver carp.*

Establishment Potential Scorecard				
Points	**Probability for Establishment**	Total Points (pre-adjustment)		**102**
>100	High	Adjustments		
		Critical species	A (1- _0 %)	**102**
51-99	Moderate	Natural enemy	B (1- __0 %)	**102**
		Control measures	C (1- _40 %)	**61.2**
0-50	Low	**Probability for Establishment**		Moderate
# of questions answered as "unable to determine"	**Confidence Level**			
0-1	High	Total # of questions unknown		0
2-5	Moderate			
6-9	Low	Confidence Level		High
>9	Very low			

<u>Qualitative Statements for GLANSIS Fact Sheet:</u>
H. molithrix has a moderate probability of establishment if introduced to the Great Lakes (Confidence level: high).

Section C: Potential for Impact

IMPACT POTENTIAL RESULTS

Environmental: High
Socio-Economic: High
Beneficial: High

POTENTIAL ENVIRONMENTAL IMPACT

Does the species pose some hazard or threat to the health of native species (e.g., it magnifies toxin levels; is poisonous; is a pathogen, parasite, or a vector of either)?

Yes, and it has impacted threatened/endangered species, resulted in the reduction or extinction of one or more native populations, affects multiple species, or is a reportable disease	6√
Yes, but negative consequences have been small (e.g., limited number of infected individuals, limited pathogen transmissibility, mild effects on populations and ecosystems)	1
Not significantly	0
Unknown	U

- *The silver carp has been known to be a carrier of the Asian tapeworm after the pathogen was found in silver carp stocks in the former U.S.S.R. and Philippines (Kolar et al. 2007). The Asian tapeworm, a cestode capable of being transferred to other fishes of several different orders, has minimal effects on silver carp but can cause severe or even lethal intestinal damage to novel hosts (Kolar et al. 2005). In addition, Kolar et al. (2005) points out that this parasite has been found in several species of native North American fishes, including several endangered species.*

Does it out-compete native species for available resources (e.g., habitat, food, nutrients, light)?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species or caused critical reduction, extinction, behavioral changes including modified spawning behavior) on one or more native populations	6
Yes, and it has caused some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population	1 √
Not significantly	0
Unknown	U

- *Silver carp is a filter feeder. Being efficient consumers of phytoplankton, cyanobacteria, and zooplankton, the silver carp competes with virtually every fish species in the Mississippi River basin that forage on planktonic organisms (Chick and Pegg 2001). Furthermore, silver carp has been found to have an overlapping diet with two native Great Lakes filter-feeder species, the gizzard shad and the bigmouth buffalo (Sampson et al. 2009). The interspecific competition for resources resulting from this overlap is known to cause pronounced and frequent declines in the physical condition of these native fish if plankton resources are limited. Ultimately, declines in body condition may decrease potential fitness and the long-term sustainability of gizzard shad, bigmouth buffalo, and other native riverine fishes (Irons et al. 2007).*

Does it alter predator-prey relationships?

Yes, and it has resulted in significant adverse effects (e.g.,impacted threatened/endangered species, caused significant reduction or extinction of one or more native populations, creation of a dead end or any other significant alteration in the food web)	6√
Yes, and it has resulted in some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population AND/OR Yes, and it has resulted in some alteration of the food web structure or processes, the effects of which have not been widespread or severe	1
Not significantly	0
Unknown	U

- *Mesocosmic and microcosmic studies carried out in lakes in France, Brazil, and Israel (Domaizon and Devaux 1999b, Spataru and Gophen 1985, Starling 1993) provide supporting evidence that high consumption caused by the superior filter efficiency and large size (>35 kg) of silver carp, may disproportionately deplete plankton and/or alter the assemblage of zooplankton communities, consequently modifying food web structure (Irons et al. 2007, Pongruktham et al. 2010).*
- *Hypophthalmichthys spp. also can alter species composition in phytoplankton communities by promoting the dominance of species that can resist digestion (Görgényi et al. 2016).*

- *Food web models of Lake Ontario and Lake Erie have suggested that Asian carp impacts on the Great Lakes ecosystem might be mitigated by several factors such as the availability of unused production that might be exploited by the carp, increased production at lower trophic levels due to high nutrients, and the potential for native piscivores to feed on larval Asian carp (Zhang et al. 2016; Currie et al. 2012).*

Has it affected any native populations genetically (e.g., through hybridization, selective pressure, introgression)?

Yes, and it has caused a loss or alteration of genes that may be irreversible or has led to the decline of one or more native species (or added pressure to threatened/endangered species)	6
Yes, some genetic effects have been observed, but consequences have been limited to the individual level	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Does it negatively affect water quality (e.g., increased turbidity or clarity, altered nutrient, oxygen, or other chemical levels/cycles)?

Yes, and it has had a widespread, long-term, or severe negative effect on water quality AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected water quality to some extent, but the alterations and resulting adverse effects have been limited or inconsistent (as compared with above statement)	1 √
Not significantly	0
Unknown	U

- *The possibility of silver carp as a bio-tool for improving water quality (by filtering phytoplankton and detritus) is still disputed. Some of the most recent studies (Lieberman 1996, Starling 1993) demonstrated that high biomass of silver carp causes increases in inorganic nitrogen and phosphorus levels. Decreases in zooplankton populations were shown, which in turn cause increases in microphytoplankton and consequently increases in chlorophyll a and turbidity. The increase in nutrient levels can be explained by the amount of feces excreted by silver carp. These fish can excrete their own weight in 10 days (Herodek et al. 1989). This sediment enrichment has an ultimate negative effect on water quality.*
- *Studies (Lieberman 1996; Starling 1993) demonstrated that high biomass of silver carp causes increases in inorganic nitrogen and phosphorus levels. Decreases in zooplankton populations resulted in consequent increases in chlorophyll a and turbidity.*

Does it alter physical components of the ecosystem in some way (e.g., facilitated erosion/siltation, altered hydrology, altered macrophyte/phytoplankton communities, physical or chemical changes to substrate)?

Yes, and it has had a widespread, long term, or severe negative effect on the physical ecosystem AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected the physical ecosystem to some extent, but the alterations and resulting adverse effects have been mild	1 √
Not significantly	0
Unknown	U

Environmental Impact Total	**15**
Total Unknowns (U)	**0**

POTENTIAL SOCIO-ECONOMIC IMPACT

Does the species pose some hazard or threat to human health (e.g., it magnifies toxin levels, is poisonous, a virus, bacteria, parasite, or a vector of one)?

Yes, significant effects on human health have already been observed	6
Yes, but negative consequences have not been widespread, long lasting, or severe	1√
Not significantly	0
Unknown	U

- *Silver carp is known to harbor several disease-causing agents that pose health risks to humans. These pathogens have been mostly found in carp from different parts of Iran. They include Listeria monocytogenes (found in market and fish farm samples), Clostridium botulinum (found in 1.1% of fresh and smoked samples from the Mazandaran Province), the toxigenic fungi Aspergillus flavus, Alternaria, Penicillium, and Fusarium (found from silver carp and from pond water in which they were raised) (USFWS 2006). Furthermore, silver carp can be considered a potential carrier for Salmonella (S. typhimumium) (USFWS 2006).*
- *It should also be noted that the jumping of silver carp (at least 10 feet out of the water) can result in serious injuries to boaters and it is probable that collisions between boaters and jumping silver carp will eventually result in human fatalities (Hoff 2004). Reported injuries include cuts from fins, black eyes, broken bones, neck and back injuries, and concussions. Silver carp also causes property damage including broken radios, depth finders, fishing equipment, and antennae (USFWS 2006).*

Does it cause damage to infrastructure (e.g., water intakes, pipes, or any other industrial or recreational infrastructure)?

Yes, it is known to cause significant damage	6
Yes, but the costs have been small and are largely reparable or preventable	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Does it negatively affect water quality (i.e. in terms of being less suitable for human use)?

Yes, it has significantly affected water quality, and is costly or difficult to reverse	6
Yes, but the effects are negligible and/or easily reversed	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Does it negatively affect any markets or economic sectors (e.g., commercial fisheries, aquaculture, agriculture)?

Yes, it has caused significant damage to one or more markets or economic sectors	6
Some damage to markets or sectors has been observed, but negative consequences have been small	1
Not significantly	0
Unknown	U√

- *While the increased competition and habitat disruption may impact commercially-fished species, there has never been any formal analysis of this impact.*

Does it inhibit recreational activities and/or associated tourism (e.g., through frequent water closures, equipment damage, decline of recreational species)?

Yes, it has caused widespread, frequent, or otherwise expensive inhibition of recreation and tourism	6√
Yes, but negative consequences have been small	1
Not significantly	0
Unknown	U

- *Silver carp regularly jump out of the water, particularly in response to outboard motors. These leaps cause collisions between boaters and fish and have been the source of numerous reports of injuries to human beings and damage to boats and boating equipment. Reported injuries include cuts from fins, black eyes, broken bones, neck and back injuries, and concussions. Silver carp also causes property damage including broken radios, depth finders, fishing equipment, and antennae (USFWS 2006). Additionally, when a silver carp lands in a boat, it often leaves slime, scales, feces, and blood for boaters to contend with (Kolar et al. 2005). These fish also compete with native species that are important as sport and food species and whose decline could result in a negative economic impact on recreational angling and other industries that benefit from sport fishing, such as tourism (Kolar et al. 2005).*
- T*hese fish compete with native species that are important as sport and food species and whose decline could result in a negative economic impact on recreational angling and other industries that benefit from sport fishing, such as tourism (Kolar et al. 2005).*

Does it diminish the perceived aesthetic or natural value of the areas it inhabits?

Yes, the species has received significant attention from the media/public, significantly diminished the natural or cultural character of the area, or significantly reduced the area's value for future generations	6
Yes, but negative consequences have been small	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Socio-Economic Impact Total	**7**
Total Unknowns (U)	**1**

POTENTIAL BENEFICIAL EFFECT

Does it act as a biological control agent for aquatic weeds or other harmful nonindigenous organisms?

Yes, it has succeeded significantly as a control agent	6
Yes, it has had some success as a control agent, but may be inconsistent or lack a desired level of effectiveness	1 √
Not significantly	0
Unknown	U

- *Silver carp are frequently subjects of biomanipulation research with the purpose of cleaning wastewaters and eutrophic lakes (e.g., Domaizon and Devaux 1999b, Henderson 1978, Spataru and Gophen 1985, Starling 1993). These filter feeding fish were utilized in Henderson's (1978) field tests in order to determine their capabilities in controlling excessive plankton blooms and converting nutrients into usable proteins. Henderson found that the presence of the fish did affect plankton removal and stimulate nutrient* *uptake. Nonetheless, more recent studies (Domaizon and Devaux 1999, Spataru and Gophen 1985, Starling 1993) had contradictory results. The ability of silver carp to control water quality remains unknown.*

- *Silver carp's ability as a biological agent for controlling cyanobacteria blooms has been widely debated. Although cyanobacteria produce toxins that can be noxious to animals and humans, silver carp possess natural defenses against these microcystins and are known to consume blue-green algae (Xie et al. 2004, as cited in Kolar et al. 2005). Miura (1990) has attributed phytoplankton community shifts from blue-green algae domination towards green algae to grazing by Silver carp (as cited in Kolar 2005). On the other hand, Kucklentz (1985) found that blue-green algae, as well as total phytoplankton, increased rather than decreased after stocking silver carp (as cited in Kolar 2005).*

Is it commercially valuable (e.g., for fisheries, aquaculture, agriculture, bait, ornamental trade)?

Yes, it is economically important to at least one of these industries	6√
Yes, but its economic contribution is small	1
Not significantly	0
Unknown	U

- *Silver carp are of high commercial importance in many parts of the world. According to Kolar (2005) more silver carp are produced than any other species of freshwater fish in the world, especially in China where it continues to grow in importance. In the US, commercial harvest of Silver carp is increasing in parts of the Mississippi River basin (Conover et al. 2007). The combined annual commercial harvest of bighead and silver carps from the Mississippi and Illinois rivers within Illinois increased from less than 600 kg per year between 1988 and 1992 to in excess of 50,000 kg per year since 1997 (Chick and Pegg 2001).*
- *A consumer market for Asian carp species is being investigated in the US.*

Is it recreationally valuable (e.g., for sport or leisurely fishing, as a pet, or for any other personal activity)?

Yes, it is commonly employed recreationally and has some perceived value for local communities and/or tourism	6
It is sometimes employed recreationally, but adds little value to local communities or tourism	1 √
Not significantly	0
Unknown	U

- *Fishing tournaments for silver carp are starting to develop in the US.*

Does the species have some medicinal or research value (i.e. outside of research geared towards its control)?

Yes, it has significant medicinal or research value	6
It has some medicinal or research value, but is not of high priority OR It is potentially important to medicine or research and is currently being or scheduled to be studied	1√
Not significantly	0
Unknown	U

- *Silver carp are frequently subjects of biomanipulation research with the purpose of cleaning wastewaters and eutrophic lakes (Domaizon and Devaux 1999b, Henderson 1978, Spataru and Gophen 1985, Starling 1993).*

Does the species remove toxins or pollutants from the water or otherwise increase water quality?

Yes, it reduces water treatment costs or has a significant positive impact for the health of humans and/or native species	6
Yes, but positive impact for humans or native species is considered negligible	1
Not significantly	0
Unknown	U √

- *The feeding habits of silver carp make this species capable of converting primary production into fish flesh without supplemental feeding. These filter feeding fish were utilized in Henderson's (1978) field tests in order to determine their capabilities in controlling excessive plankton blooms and converting nutrients into usable proteins. Henderson found that the presence of the fish did affect plankton removal and stimulate nutrient uptake. Nonetheless, more recent studies (Domaizon and Devaux 1999, Spataru and Gophen 1985, Starling 1993) had contradictory results; therefore, the ability of Silver carp to control water quality remains unknown.*

Does the species have a positive ecological impact outside of biological control (e.g., increases the growth or reproduction rates of other species, fills an important gap in the food web, supports the survival of a species that is threatened, endangered species, or commercially valuable)?

Yes, it significantly contributes to the ecosystem in one or more of these ways	6
Yes, it provides some positive contribution to the ecosystem, but is not vital	1
Not significantly	0 √
Unknown	U

- *According to Opuszynski 1981 and Yashouv 1971, culturing silver carp with other species can be an efficient method of increasing fishery production. It has been reported that the presence of Silver carp in polyculture improves growth of common carp and tilapias because benthic fishes cause resuspension of organic matter (Kolar et al. 2005). However, these species are not native to the Great Lakes.*

Beneficial Effect Total	**9**
Total Unknowns (U)	**1**

Scientific Name: *Hypophthalmichthys nobilis*

Common Name: Bighead carp

Section A: Potential for Introduction

INTRODUCTION POTENTIAL RESULTS

Dispersal: Moderate
Hitchhiking/Fouling: Unlikely
Unauthorized intentional release: Moderate
Stocking/Planting/Escape from recreational culture: Low
Escape from commercial culture: Low
Shipping: Unlikely

Comments:
***Hypophthalmichthys nobilis* has a moderate probability of introduction to the Great Lakes (Confidence level: High).**

Potential pathway(s) of introduction: Dispersal, unauthorized release, and escape from commercial culture

Established nonindigenous populations of bighead carp are found in close proximity to the Great Lakes in locations which do not preclude dispersal, and which would provide an easy source population for unauthorized release. Large populations of bighead carp are established in the middle and lower segments of the Illinois River, the upper Illinois River (Waterway), and the Chicago Area Waterway System (CAWS) (Baerwaldt et al. 2013). Three bighead carp adults were collected in Lake Erie between 1995 and 2000, but they are not thought to represent an established population (Cudmore et al. 2012). "The body condition of these individuals was healthy, but for those individuals dissected, their reproductive organs were not viable (B. Cudmore, Fisheries and Oceans, pers. comm.)." Bighead carp individuals have also been collected in isolated Chicago lagoons (e.g., Schiller Park Pond, Columbus Park Lagoon, Garfield Park Lagoon, McKinley Park Lake, Flatfoot Lake) closer to Lake Michigan. In 2008, a bighead carp was found in Lincoln Park South Lagoon, which connects to Lake Michigan via a screened overflow drain; this pond was poisoned and drained in late 2008 (Willink 2010).

The U.S. Army Corps of Engineers constructed a set of three electrical barriers, the first of which opened in 2002, on the Chicago Sanitary and Shipping Canal to prevent the spread of aquatic invasive species between the Great Lakes and Mississippi River basins; only one live bighead carp has been found (Lake Calumet in 2010) in the waterway above the barrier and a dead individual was found on the shore of Lake George, Indiana (Baerwaldt et al. 2013).

POTENTIAL INTRODUCTION VIA DISPERSAL

Does this species occur near waters (natural or artificial) connected to the Great Lakes basin* (e.g., streams, ponds, canals, or wetlands)? (*Great Lakes basin = below the ordinary high water mark, including connecting channels, wetlands, and waters ordinarily attached to the Lakes) √

Yes, this species occurs near waters connected to the Great Lakes basin and is mobile or able to be transported by wind or water.	100 √
No, this species does not occur near waters connected to the Great Lakes basin and/or is not mobile or able to be transported by wind or water.	0
Unknown	U

- *Three bighead carp adults were collected in Lake Erie between 1995 and 2000 (Baerwaldt et al. 2013), but they are not thought to represent an established population. The body condition of these individuals were healthy, but the individuals had reproductive organs that were not viable (Cudmore et al. 2012).*
- *Large populations of bighead carp are established in the middle and lower segments of the Illinois River, the upper Illinois River (Waterway), and the Chicago Area Waterway System (CAWS) (Baerwaldt et al. 2013).*

What is the proximity of this species to the Great Lakes basin?

This species occurs in waters within 20 kilometers of the Great Lakes basin, and no barrier (e.g., electric barrier, dam) to dispersal is present.	Score x 1
This species occurs in waters within 20 kilometers of the Great Lakes basin, but dispersal to the basin is blocked; or, this species occurs in waters within 100 kilometers of the Great Lakes basin, and no barrier to dispersal is present.	Score x 0.75 √
This species occurs in waters within 100 kilometers of the Great Lakes basin, but dispersal to the basin is blocked.	Score x 0.5
This species occurs in waters >100 kilometers from the Great Lakes basin.	Score x 0.25
Unknown	U

- *Large populations of bighead carp are established in the middle and lower segments of the Illinois River, the upper Illinois River (Waterway), and the Chicago Area Waterway System (CAWS) (Baerwaldt et al. 2013). Bighead carp individuals have also been collected in isolated Chicago lagoons (e.g., Schiller Park Pond, Columbus Park Lagoon, Garfield Park Lagoon, McKinley Park Lake, Flatfoot Lake) closer to Lake Michigan (Baerwaldt et al. 2013). In 2008, a Bighead carp was found in Lincoln Park South Lagoon, which connects to Lake Michigan via a screened overflow drain; this pond was poisoned and drained in late 2008 (Willink 2009).*
- *Bighead carp are found in ponds that could connect with the Lake Michigan watershed during flooding events, which provides a source of individuals in close proximity for illegal movement (Cudmore et al. 2012).*
- *The United States Army Corps of Engineers (USACE) constructed a set of three electrical barriers, the first of which opened in 2002, on the Chicago Sanitary and Shipping Canal to prevent the spread of aquatic invasive species between the Great Lakes and Mississippi River basins; only one live Bighead carp has been found (Lake Calumet in 2010) in the waterway above the barrier (Baerwaldt et al. 2013). A dead individual was found on the shore of Lake George, Indiana (Baerwaldt et al. 2013).*
- *While not indicative of live fish, environmental DNA (eDNA) of bighead carp was been found in water samples collected above the electric barriers (i.e., closer to Lake Michigan) in 2012 from Lake Calumet (USACE 2012). Additional eDNA of silver carp has been found in Sandusky Bay, Lake Erie (OH) (MI DNR 2012).*
- *There are no known bighead carp in or near the St. Lawrence River. Should they gain access to the St. Lawrence River, through ballast water or via natural dispersal, they would have a direct route to Lake Ontario (Cudmore et al. 2012).*

POTENTIAL INTRODUCTION VIA HITCHHIKING/FOULING

Is this species likely to attach to or be otherwise transported by, or along with, recreational gear, boats, trailers, fauna (e.g., waterfowl, fish, insects), flora (e.g., aquatic plants), or other objects (e.g., packing materials), including as parasites or pathogens, entering the Great Lakes basin?

Yes, this species is known to be able to adhere to certain surfaces or to be transported by other organisms entering the Great Lakes basin.	100
No, this species is not known to be able to adhere to certain surfaces or to be transported by other organisms entering the Great Lakes basin.	0 √
Unknown	U

- *Not reported.*

What is the proximity of this species to the Great Lakes basin?

This species occurs in waters within 20 km of the Great Lakes basin.	Score x 1
This species occurs in waters within 100 km of the Great Lakes basin.	Score x 0.5
This species occurs in waters >100 km from the Great Lakes basin.	Score x 0.1
Unknown	U

POTENTIAL INTRODUCTION VIA UNAUTHORIZED INTENTIONAL RELEASE

Is this species sold at aquarium/pet/garden stores ("brick & mortar" or online), catalogs, biological supply companies, or live markets (e.g., purchased for human consumption, bait, ornamental, ethical, educational, or cultural reasons) and as a result may be released into the Great Lakes basin?

Yes, this species is available for purchase.	100√
No, this species this species is rarely/never sold.	0
Unknown	U

- *The potential for purposeful, human-mediated releases of bighead carp into the Great Lakes basin does exist. Humans have illegally released freshwater fishes for sport opportunities (Crossman and Cudmore 1999a, Bradford et al. 2008) or spiritual/ethical reasons (Crossman and Cudmore 1999b, Severinghaus and Chi 1999, Shiu and Stokes 2008). This human behavior of illegally releasing nonnative fishes into the aquatic environment is difficult to characterize and quantify (Bradford et al. 2008), therefore, it is difficult to qualify the risk of intentional release, but it should be noted as a potential source of introduction for bighead carp into the Great Lakes basin (Cudmore et al. 2012).*
- *Being used as a live baitfish is a potential pathway for the arrival of small bighead carp into the Great Lakes (Cudmore et al. 2012).*
- *Feeder fishes (typically goldfish (Carassius auratus) or the "rosy red" color variant of fathead minnow (Pimephales promelas) shipped into the Great Lakes basin could be contaminated with bighead carp if they originated from fish farms in the Mississippi River basin. Fathead minnows found in the bait industry in Michigan are known to originate from culture in Arkansas, Minnesota, North Dakota, and South. However, the volume of such movement and the extent of contamination remains unknown (Cudmore et al. 2012). Based on a subsample of live fish import records for 2006-2007, fathead minnows (likely rosy reds) imported for the aquarium trade originated primarily from Missouri and secondarily from North Carolina (Cudmore et al. 2012).*
- *It is currently illegal to possess or sell live Asian carp in Ontario; however, despite this legislation, bighead carp and grass carp have been documented in shipments for import into Ontario (Cudmore et al. 2012). Eight entry records were recorded from January 2010 to August 2011 that listed grass (9.8 mt) and bighead (16.8 mt) carps as species descriptions. All of the shipments originated in Arkansas." (Cudmore et al. 2012)*

How easily is this species obtained within the Great Lakes region (states/provinces)?

This species is widely popular, frequently sold, and/or easily obtained within the Great Lakes region.	Score x 1
This species is widely popular, and although trade, sale, and/or possession of this species is prohibited, it is frequently sold on the black market within the Great Lakes region.	Score x 0.5√
This species is not very popular or is not easily obtained within the Great Lakes region.	Score x 0.1
Unknown	U

- *Most states prohibit the use of carp as baitfish. Michigan and Ontario specifically prohibiting the use of Asian carp (Cudmore et al. 2012)*
- *There is prohibition against using carp for bait in MN, WI, IN, MI, NY, Ontario, Quebec (Cudmore et al. 2012)*
- *Drake (2011) conducted a study of the baitfish industry and AIS in Ontario the results suggested that the entry route of bighead carp into the Great Lakes basin through the baitfish pathway will be largely dependent on the specifics of baitfish activity within each jurisdiction such as: characteristics of harvest activity in relation to bighead carp source populations; angler use, movement patterns, release rates; and, the yearly volume and spatial distribution of angling events within and outside of the Great Lakes basin (Cudmore et al. 2012)*
- *A survey of bait shops in the Chicago area was conducted in 2010 to determine presence of bighead carp in bait tanks using both visual and eDNA surveillance methods (Jerde et al. 2012). No bighead or silver carp were observed or detected by visual inspections or eDNA analysis (Cudmore et al. 2012).*
- *The possession and sale of live Asian carps within the province of Quebec is currently legal, but there are prohibition regulations for the public (Cudmore et al. 2012).*
- *There is also no international trade of bighead carp identified with the Lake Superior watershed. Lake Michigan was ranked low for human-mediated release; higher than for Lake Superior given the proximity of established populations as a source of available individuals. Lakes Huron and Ontario are associated with a low risk, taking into consideration the lack of movement of bait and trade from Bighead carp. However, these lakes are exposed to stronger fisheries from American anglers compared to Lake Superior, and Lake Ontario is also the location of live markets that could be involved in illegal trade. The risk of direct arrival to Lake Erie is also low, taking into consideration the presence of a higher number of anglers in lakes St. Clair and Erie, the frequent use of live bait in the area, and the potential for accidental release from illegal shipping of bighead carp coming from Windsor towards Toronto. (Cudmore et al. 2012).*

POTENTIAL INTRODUCTION VIA STOCKING/PLANTING OR ESCAPE FROM RECREATIONAL CULTURE

Is this species being stocked/planted to natural waters or outdoor water gardens around the Great Lakes region?

Yes, this species is being stocked/planted and/or has ornamental, cultural, medicinal, environmental (e.g., biocontrol, erosion control), scientific, or recreational value in the Great Lakes region.	100√
No, this species cannot be stocked/planted or there is not enough interest to do so in the Great Lakes region.	0
Unknown	U

- *There are many ponds and artificial lakes in the Chicago metropolitan area. They are commonly stocked for fishing with channel catfish (Ictalurus punctatus). Channel catfish are often purchased from southern fish farmers, where it is possible for the stock to be contaminated with small bighead carp (Cudmore et al. 2012).*

- *For instance, in September 2011, 17 large bighead carp were collected from Flatfoot Lake in the Beaubien Forest Preserve (K. Irons, Illinois Department of Natural Resources, pers. comm.). Three bighead carp were also found from Schiller Pond. Escapes of another Asian carp, grass carp, have occurred in similar circumstances.*
- *Fewer catfish farmers are raising Bighead carp since the species was listed as 'injurious' under the Injurious Wildlife provisions of the Lacey Act. The Act prohibits interstate transport of live bighead carp (Cudmore et al. 2012).*

What is the nature and proximity of this activity to the Great Lakes basin?

This activity is authorized and/or is occurring directly in the Great Lakes.	Score x 1
This activity is occurring in Great Lakes tributaries or connecting waters, or within 20 km of the Great Lakes basin.	Score x 0.75
This activity is likely to occur within 20 km of the Great Lakes basin because of its popularity/value and there are no widespread regulations against stocking/planting.	Score x 0.5
This activity is occurring in waters >20 km from the Great Lakes basin, or despite federal or state regulations in more than half the basin (> 5 states/provinces), this activity may occur within 20 km of the basin because of the species' popularity/value.	Score x 0.25√
Unknown	U

POTENTIAL INTRODUCTION VIA ESCAPE FROM COMMERCIAL CULTURE

Is this species known to be commercially cultured in or transported through the Great Lakes region?

Yes, this species is being commercially cultured in or transported through the Great Lakes region.	100 √
No, this species is not commercially cultured in or transported through the Great Lakes region.	0
Unknown	U

- *Bighead carp are listed under the injurious wildlife provisions of the Lacey Act and cannot be legally imported into the United States or moved interstate live without a permit. Since 2005, the eight Great Lakes states have amended their rules and regulations to prohibit movement and/or possession of live bighead carp across their jurisdictions. Even with these regulations, fishes were seized in Canada in 2010-2011 (Cudmore et al. 2012).*
- *In Canada, there is no federal legislation in place regarding import of aquatic species that may pose an invasion risk. The Ontario Ministry of Natural Resources (OMNR) has banned the live sale of Asian Carps through the Fish and Wildlife Conservation Act in 2004 and banned the live possession of Asian Carps through the Ontario Fishery Regulations in 2005 (Cudmore et al. 2012).*
- *Some illegal shipment attempts into Ontario have been stopped by Canadian enforcement officers. In November 2010, there was a seizure at the Bluewater Bridge, Sarnia of 1,136 kg of Bighead carp and 727 kg of Grass Carp after officers from both Canada Border Services Agency and OMNR inspected incoming shipments of live and fresh fishes. In March 2011, a fish importer was fined $50,000 for transporting live bighead carp (nearly 2,500 kg) from the United States across the Windsor- Detroit border. A few days later, an Indiana company was caught bringing live Bighead carp (2,727 kg) into Canada and was fined $20,000. All fishes originated in Arkansas and were headed to live fish markets in the Toronto area (Cudmore et al. 2012).*

What is the nature and proximity of this activity to the Great Lakes basin?

This activity is unregulated or minimally regulated and is occurring directly in the Great Lakes.	Score x 1

This activity is unregulated or minimally regulated and is occurring in Great Lakes tributaries or connecting waters, or within 20 km of the Great Lakes basin.	Score x 0.75
This activity is strictly regulated but occurs directly in the Great Lakes, and/or this activity involves transport of live organisms on/across the Great Lakes.	Score x 0.5
This activity is strictly regulated but occurs in Great Lakes tributaries, connecting waters, or within 20 km of the Great Lakes basin, and/or this activity involves transport of live organisms within 20 km of the Great Lakes basin.	Score x 0.25 √
This activity occurs >20 km from the Great Lakes basin and typically does not involve transport of live organisms closer to the basin.	Score x 0.1
Unknown	U

POTENTIAL INTRODUCTION VIA SHIPPING

Is this species capable of surviving adverse environments (i.e. extreme temperatures, absence of light, low oxygen levels) and partial-to-complete ballast water exchange/BWE (e.g., is euryhaline, buries in sediment, produces resistant resting stages, has other attributes or behaviors facilitating survival under these conditions)?

Yes, this species is able to survive in ballast tank environments for weeks at a time and may be suspended in ballast water.	100
Yes, this species is able to survive in ballast tank environments for weeks at a time and is able to survive BWE by burial in ballast sediment.	80
Yes, this species is able to survive in ballast tank environments for weeks at a time and may be suspended in ballast water, but this species is not able to survive BWE.	60
No, but this species is capable of fouling transoceanic ship structures (e.g., hull, chains, chain locker) while in its active or resting stage.	40
No, this species is not able to survive adverse environments, does not foul transoceanic ship structures, or is unlikely to be taken up with ballast.	0 √
Unknown	U

- *Unlike the ballast water in freighters that originate outside of the Great Lakes, ballast water in freighters that remain in the St. Lawrence River basin are not treated for AIS in any way. If bighead carp were to become established first in the St. Lawrence River, the freighter movement may facilitate the arrival of the species into the Great Lakes basin (Cudmore et al. 2012).*

Does this species occur in waters from which shipping traffic to the Great Lakes originates?

Yes, and this species has been observed in ballast of or fouling ships entering the Great Lakes.	Score x 1
Yes, and this species has been observed in ports that have direct trade connections with the Great Lakes (e.g., Baltic Sea).	Score x 0. 5
Yes, but this species has neither been observed in ballast/fouling ships entering the Great Lakes nor in ports in direct trade with the Great Lakes.	Score x 0.1
No, this species does not occur in waters from which shipping traffic to the Great Lakes originates.	Score x 0
Unknown	U

Vector Potential Scorecard					
Vector		**Raw Points Scored**	**Proximity Multiplier**	**Total Points Scored**	**Probability of Introduction**
Dispersal: Natural dispersal through waterbody connections or wind		**100**	x	**0.75**	Moderate
Hitchhiking/Fouling: Transport via recreational gear, boats, trailers, mobile fauna, stocked/planted organisms, packing materials, host organisms, etc.		**0**	x		Unlikely
Release: Unauthorized intentional release of organisms in trade (e.g., aquaria, water gardens, live food)		**100**	x	**0.5**	Moderate
Stocking/Planting/Escape from recreational culture: Intentional authorized or unauthorized introduction to natural waters in the Great Lakes OR Accidental introduction to Great Lakes by escape from recreational culture (e.g., water gardens)		**100**	x	**0.25**	Low
Escape from commercial culture: Accidental introduction to Great Lakes by escape from commercial culture (e.g., aquaculture)		**100**	x	**0.25**	Low
Trans-oceanic shipping: Ballast (BOB) or no-ballast-on-board (NOBOB) water exchange/discharge, sediment discharge, hull fouling		**0**	x		Unlikely
Total Unknowns (U)	**0**	**Confidence Level**		High	

Qualitative Statements for GLANSIS Fact Sheet:
SPECIES X has a moderate probability of introduction to the Great Lakes (Confidence level: high).

Potential pathway(s) of introduction: Dispersal, unauthorized intentional release.

Section B: Potential for Establishment

ESTABLISHMENT POTENTIAL RESULTS

Hypophthalmichthys nobilis has a moderate probability of establishment if introduced to the Great Lakes (Confidence level: High).

INVASIVE BIOLOGICAL/ECOLOGICAL ATTRIBUTES

How would the physiological tolerance of this species (survival in varying temperature, salinity, oxygen, and nutrient levels) be described?

This species has broad physiological tolerance. It has been reported to survive in wide ranges of temperature (0°C-30°C), salinity (0-16 parts per thousand), oxygen (0-saturated), AND nutrient (oligotrophic-eutrophic) levels.	9
This species has somewhat broad physiological tolerance. It has been reported to survive in a wide range of temperature, salinity, oxygen, OR nutrient levels. Tolerance to other factors is narrower, unknown, or unreported.	6
This species has narrow physiological tolerance. It has been reported to survive in limited ranges of temperature, salinity, oxygen, and nutrient levels.	3
Unknown	U
	7

- *Bighead carp have been able to establish themselves in a wide range of environments with a wide range of temperatures and lower salinity levels.*

How likely is it that any life stage of this species can overwinter in the Great Lakes (survive extremely low levels of oxygen, light, and temperature)?

Likely (This species is able to tolerate temperatures under 5°C and oxygen levels ≤0.5 mg/L)	9
Somewhat likely (This species is able to tolerate some of these conditions OR has adapted behaviorally to avoid them)	6
Somewhat unlikely (This species is able to tolerate conditions close to those specified, but it is not known as an overwintering species)	3
Unlikely	0
Unknown	U
	8

- *Bighead carp are known to be able to tolerate a wide variety of temperature but their locations in Asia suggest their ability to withstand the Great Lake waters during the winter period.*
- *Winter mortality is not known to be an issue for bighead carp in the Mississippi River basin; bighead carp fingerlings are collected from floodplain wetlands in the spring in years when those wetlands were not connected to the river (D. Chapman, USGS, pers. obs.).*
- *Overwinter mortality is correlated to length of winter and becomes more important with increasing latitudes. Overwinter mortality may influence the northern limits of the native range of Bighead carp, but this has not been modelled for these species in North America. Ecological niche modeling in their native range predicts the potential for North American distribution of bighead carp and indicated that they could survive well north of the Great Lakes basin (Herborg et al. 2007); therefore, overwinter mortality would likely not be a limiting factor in most years (Cudmore B. et al. 2012).*

If this species is a heterotroph, how would the flexibility of its diet be described?

This species is a dietary generalist with a broad, assorted, AND flexible diet.	9
This species is moderately a dietary generalist with a broad, assorted, OR flexible diet.	6
This species is a dietary specialist with a limited and inflexible diet.	3
This species is an autotroph.	0
Unknown	U
	5

- *They are moderately dietary generalists feeding on a variety of zooplankton and algae (Gollasch et al 2008).*

How likely is this species to outcompete species in the Great Lakes for available resources?

Likely (This species is known to have superior competitive abilities and has a history of outcompeting other species, AND/OR available literature predicts it might outcompete native species in the Great Lakes)	9
Somewhat likely (This species is known to have superior competitive abilities, but there are few reported cases of this species outcompeting another and no predictions regarding species in the Great Lakes)	6
Somewhat unlikely (This species has average competitive abilities, and there are no reported cases of this species outcompeting another and no predictions regarding species in the Great Lakes)	3
Unlikely (This species is known as a poor competitor that thrives only in environments with low biodiversity, AND/OR available literature predicts it might be outcompeted by a species in the Great Lakes)	0
Unknown	U
	9

- *Bighead carp have been demonstrated to outcompete both native larval fishes and mussels (Laird and Page 1996). It would be highly likely for the bighead carp to find an appropriate food source but the amount they eat might not be sufficiently found in the Great Lakes. Recent bioenergetics models suggest that productive nearshore areas and embayments (e.g. Green Bay and the Western Basin of Lake Erie) would be able to sustain growth of bighead and silver carp, but these species would likely be food-limited in the oligotrophic offshore regions (Anderson et al. 2017; Anderson et al. 2015; Cooke and Hill 2010).*

How would the fecundity of this species be described relative to other species in the same taxonomic class?

Very high	9
High	6
Moderate	3
Low	0
Unknown	U
	5

- *The fecundity of bighead carp seems comparable to other species in the same taxonomic group. Bighead carp are known to spawn in rivers and it is believed that a flood event is the primary spawning cue (Kolar et al. 2007). In its native range, bighead carp has a fecundity ranging from 280,000-1.1 million eggs (Kolar et al. 2007). In North America, fecundity ranged from 4,792-1.6 million eggs (Kipp et al. 2011). In its native range, silver carp has a fecundity ranging from 299,000-5.4 million eggs (Kolar et al. 2007). In North America, it has ranged from 26,650- 3.7 million eggs (Kipp et al. 2011).*

How likely are this species' reproductive strategy and habits to aid establishment in new environments, particularly the Great Lakes (e.g., parthenogenesis/self-crossing, self fertility, vegetative fragmentation)?

Likely (The reproductive strategy or habits of this species are known to aid establishment in new environments, AND available literature predicts establishment in the Great Lakes based on these attributes)	9
Somewhat likely (The reproductive strategy or habits of this species are known to aid establishment in new environments, but there is no literature available regarding establishment in the Great Lakes based on these attributes)	6

Somewhat unlikely (The reproductive strategy or habits of this species could potentially aid establishment in new environments, but there is no literature available regarding establishment in the Great Lakes based on these attributes)	3
Unlikely (The reproductive strategy or habits of this species are not known to aid establishment in new environments)	0
Unknown	U
	0

- *Kolar et al. (2007) stated that the limiting factor for Asian carp establishment in most regions of United States would be access to a river in which Asian carp could successfully spawn. Bighead carp need large, turbulent rivers and higher temperatures to spawn. The eggs float for 40-60 hours before hatching. Only some rivers emptying into the Great Lakes are sufficient of this characteristic and at only parts of the year. Two studies have examined the suitability of Great Lakes tributaries for bighead carp spawning based on more detailed considerations of reproductive biology. Kocovsky et al. (2012) examined eight American tributaries in the central and western basins of Lake Erie. They considered: the thermal conditions of the tributaries and Lake Erie, the minimum total degree-days required for maturation, onset of spawning and mass spawning, timing of flood events as triggers for spawning, and length of stream required for egg hatching based on stream velocity and estimated incubation time. They concluded that the three larger tributaries were thermally and hydrologically suitable to support spawning of bighead carp, four tributaries were less suited, and that one was ill suited.*
- *Mandrak et al. (2011) conducted a similar analysis for the 25 Canadian tributaries of the Great Lakes. They concluded suitable spawning conditions were present in nine of 14 tributaries to Lake Superior with sufficient data; however, only one of the nine tributaries had mean annual total degree-days exceeding 2,685. Therefore, bighead carp are unlikely to mature within Lake Superior tributaries, but may encounter sufficient growing degree-days to mature in some parts of Lake Superior such as near shore and bays. Further analysis is required to identify such areas. Mandrak et al. concluded suitable spawning conditions, including growing degree-days required for maturation, were present in 23 of 27 tributaries to Lake Huron, nine of 10 tributaries to Lake Erie, and 16 of 28 tributaries to Lake Ontario. These analyses suggest that access to tributaries with suitable thermal and hydrologic regimes in the Great Lakes should not limit spawning by bighead carp (Cudmore et al. 2012). Additionally, Cuddington et al. (2014) found that establishment would be likely for a small number of founding individuals (<20 fish) despite environmental stochasticity. Furthermore, the presence of only a few suitable spawning rivers on each lake may promote the establishment success given that the carp would have an increased chance of finding a mate in the relatively few nearby spawning rivers. However, establishment becomes less likely if age of first sexual reproduction is substantially delayed.*

ENVIRONMENTAL COMPATIBILITY

How similar are the climatic conditions (e.g., air temperature, precipitation, seasonality) in the native and introduced ranges of this species to those in the Great Lakes region?

Very similar (The climatic conditions are practically identical to those of the Great Lakes region)	9
Similar (Many of the climatic conditions are similar to those of the Great Lakes region)	6
Somewhat similar (Few of the climatic conditions are similar to those of the Great Lakes region)	3
Not similar	0
Unknown	U
	8

- *Bighead carp's native regions are quite compatible to many regions in the United States and have already been found in areas surrounding the Great Lakes basin.*
- *Ecological niche modeling has predicted the potential for North American distribution of bighead carp and has indicated that they could survive well north of the Great Lakes basin (Herborg et al. 2007); therefore, overwinter mortality will likely not be a limiting factor (Cudmore B. et al. 2012).*

How similar are other abiotic factors that are relevant to the establishment success of this species (e.g., pollution, water temperature, salinity, pH, nutrient levels, currents) in the native and introduced ranges to those in the Great Lakes?

Very similar (These factors are practically identical to those of the Great Lakes region)	9
Similar (Many of these factors are similar to those of the Great Lakes region)	6
Somewhat similar (Few of these factors are similar to those of the Great Lakes region)	3
Not similar	0
Unknown	U
	8

- *Ecological niche modeling has predicted the potential for North American distribution of bighead carp and has indicated that they could survive well north of the Great Lakes basin (Herborg et al. 2007); therefore, overwinter mortality will likely not be a limiting factor (Cudmore B. et al. 2012).*

How abundant are habitats suitable for the survival, development, and reproduction of this species in the Great Lakes area (e.g., those with adequate depth, substrate, light, temperature, oxygen)?

Abundant (Suitable habitats can be easily found and readily available)	9
Somewhat abundant (Suitable habitats can be easily found but are in high demand by species already present)	6
Somewhat scarce (Suitable habitats can be found occasionally)	3
Scarce (Suitable habitats are rarely found)	0
Unknown	U
	5

- *The habitats needed for reproduction are more commonly found in rivers than in lakes. Bighead carp need large, turbulent rivers and higher temperatures to spawn. The eggs float for 40-60 hours before hatching. Only some rivers emptying into the Great Lakes are sufficient of this characteristic and at only parts of the year.*
- *Two recent studies examined the suitability of Great Lakes tributaries for bighead carp spawning based on detailed considerations of reproductive biology. Kocovsky et al. (2012) examined eight American tributaries in the central and western basins of Lake Erie. They concluded that the three larger tributaries were thermally and hydrologically suitable to support spawning of bighead carp, four tributaries were less suited, and that one was ill suited. Mandrak et al. (2011) conducted a similar analysis for the 25 Canadian tributaries of the Great Lakes. They concluded suitable spawning conditions were present in nine of 14 tributaries to Lake Superior with sufficient data; however, only one of the nine tributaries had a mean annual total degree-days exceeding 2,685. Therefore, bighead carp are unlikely to mature within Lake Superior tributaries, but may encounter sufficient growing degree-days to mature in some parts of Lake Superior such as near shore areas and bays. Mandrak et al. (2011) concluded suitable spawning conditions, including growing degree-days required for maturation, were present in 23 of 27 tributaries to Lake Huron, nine of 10 tributaries to Lake Erie, and 16 of 28 tributaries to Lake Ontario. Similar studies have not been conducted for United States tributaries in lakes Michigan, Huron, Superior, Ontario, nor the eastern basin of Lake Erie, but the analyses of Kocovsky et al. (2012) and Mandrak et al. (2011) suggest that access to tributaries with suitable thermal and hydrologic regimes in the Great Lakes should not limit spawning by bighead carp (Cudmore B. et al. 2012).*

How likely is this species to adapt to or to benefit from the predicted effects of climate change on the Great Lakes freshwater ecosystems (e.g., warmer water temperatures, shorter duration of ice cover, altered streamflow patterns, increased salinization)?

Likely (Most of the effects described above make the Great Lakes a better environment for establishment and spread of this species OR this species could easily adapt to these changes due to its wide environmental tolerances)	9
Somewhat likely (Several of the effects described above could make the Great Lakes a better environment for establishment and spread of this species)	6
Somewhat unlikely (Few of the effects described above would make the Great Lakes a better environment for establishment and spread of this species)	3
Unlikely (Most of the effects described above would have no effect on establishment and spread of this species or would make the environment of the Great Lakes unsuitable)	0
Unknown	U
	9

- *This species would be able to adapt to the effects of climate change and would allow for longer periods of reproduction.*

How likely is this species to find an appropriate food source (prey or vegetation in the case of predators and herbivores, or sufficient light or nutrients in the case of autotrophs)?

Likely (All possible nutritive food items—including species in the Great Lakes that may be considered potential food items—are highly abundant and/or easily found)	9
Somewhat likely (Some nutritive food items—including species in the Great Lakes that may be considered potential food items—are abundant and/or search time is low to moderate)	6
Somewhat unlikely (Few nutritive food items—including species in the Great Lakes that may be considered potential food items—are abundant and/or search time is moderate to high)	3
Unlikely (All possible nutritive food items—including species in the Great Lakes that may be considered potential food items—are relatively scarce and/or search time is high)	0
Unknown	U
	8

- *Bioenergetic models indicate that bighead carp would be able to survive on planktonic resources in nearshore areas and eutophic embayments in the Great Lakes (Cooke and Hill 2010; Anderson et al. 2015, 2017)*
- *Bighead carp could also supplement their planktivorous diet with dreissenid biodeposits (Anderson et al. 2016).*

Does this species require another species for critical stages in its life cycle such as growth (e.g., root symbionts), reproduction (e.g., pollinators, egg incubators), spread (e.g., seed dispersers), or transmission (e.g., vectors)?

Yes, and the critical species (or one that may provide a similar function) is common in the Great Lakes and can be easily found in environments suitable for the species being assessed; OR, No, there is no critical species required by the species being assessed	9

Yes, and the critical species (or one that may provide a similar function) is moderately abundant and relatively easily found in particular parts of the Great Lakes	6
Yes, and the critical species (or one that may provide a similar function) is relatively rare in the Great Lakes AND/OR can only be found occasionally in environments suitable for the species being assessed	3
Yes, and the critical species (or one that may provide a similar function) is not present in the Great Lakes but is likely to be introduced	0
Yes, but the critical species (or one that may provide a similar function) is not present in the Great Lakes and is not likely to be introduced	-80% total points (at end)
Unknown	U
	9

- *This species does not require another species for critical stages.*

How likely is the establishment of this species to be aided by the establishment and spread of another species already in the Great Lakes?

Likely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established and spread in the Great Lakes, AND available literature predicts this previous invader might promote the establishment of this species, AND/OR there have been cases reported of this species aiding the establishment of this species in other areas)	9
Somewhat likely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established and spread in the Great Lakes)	6
Somewhat unlikely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established in the Great Lakes BUT it is still confined to a small area of the Lakes and the likelihood of encounter with this species assessed is hard to predict)	3
Unlikely (A non-indigenous species to the Great Lakes that facilitates the development of this species has not been established in the Great Lakes)	0
Unknown	U
	0

- *Bighead carp will not be aided by the establishment of any other species.*

How likely is establishment of this species to be prevented by the herbivory, predation, or parasitism of a natural enemy this is already present in the Great Lakes and may preferentially target this species?

Likely (The ability of the natural enemy to prevent the establishment of this species in introduced ranges or limiting populations of this species in native ranges is well documented in the literature AND this natural enemy is abundant and widespread in the Great Lakes)	-80% total points (at end)
Somewhat likely (The ability of the natural enemy to prevent the establishment of this species in introduced ranges or limiting populations of this species in native ranges is suggested in the literature OR this natural enemy has limited distribution in the Great Lakes)	-60% total points (at end)

Somewhat unlikely (There are few cases reported of such a natural enemy preventing the establishment of this species in introduced ranges or limiting populations of this species in native ranges OR this natural enemy has low abundance in the Great Lakes)	-10% total points (at end)
Unlikely (Such a natural enemy is particularly rare or is not present in the Great Lakes)	0
Unknown	U
	0

- *Bighead carp are not found to have any predators or enemies.*

PROPAGULE PRESSURE

On average, how large and frequent are inoculations (introduction events) from the potential vectors identified in Section A for this species? (What is the total number of individuals introduced?)

Frequent, large inocula	9
Frequent, moderate inocula	6
Frequent, small inocula OR infrequent, large inocula	3
Infrequent, small or moderate inocula	0
Unknown	U
	1

- *There are control measures to try to stop the introduction of bighead into the Great Lakes.*

HISTORY OF INVASION AND SPREAD

How extensively has this species established reproducing populations in areas outside its native range as a direct or indirect result of human activities?

Very extensively (many invasive populations of this species have been reported in areas widely distributed from the native range)	9
Extensively (some invasive populations of this species have been reported in areas widely distributed from the native range)	6
Somewhat extensively (few invasive populations of this species have been reported in areas widely distributed from the native range OR all invasive populations are in close proximity to each other)	3
Not extensively (no invasive populations of this species have been reported)	0
Unknown	U
	9

- *Bighead carp have established in Europe and the Mississippi River.*

How rapidly has this species spread by natural means or by human activities once introduced to other locations?

Rapidly (This species has a history of rapid spread in introduced ranges)	9
Somewhat rapidly (This species has a history of moderately rapid spread in introduced ranges)	6

Somewhat slowly (This species has a history of moderately slow spread in its introduced ranges)	3
Slowly (This species has a history of slow to no spread in its introduced ranges)	0
Unknown	U
	9

- *Bighead carp were able to establish themselves rapidly once introduced into habitats with the right conditions.*

Are there any existing control measures in the Great Lakes set to prevent the establishment and/or spread of this species?

Yes, and they are likely to prevent establishment or spread of the species. (There are no reported cases of this species adapting or avoiding current measures. These measures are highly effective in preventing the establishment and spread of this species)	-90% total points (at end)
Yes, and they are moderately likely to prevent establishment or spread of the species. (There are few reported cases of this species adapting or avoiding current measures used to control its establishment and spread)	-50% total points (at end)
Yes, but they are unlikely to prevent establishment or spread of the species. (There are many reported cases of this species adapting or avoiding current measures used to control its establishment and spread)	-20% total points (at end)
No control methods have been set to prevent the establishment and/or spread of this species	0
Unknown	U
	-40%

- *Asian Carp management and control plans can be used for bighead carp.*
- *Asian Carp Control Strategy Framework can be used for bighead carp.*
- *Asian Carp Regional Coordinating Committee can be used for bighead carp.*
- *Asian Carp Monitoring and Rapid Response Plan can be used for bighead carp.*
- *eDNA monitoring can be used for bighead carp.*

Establishment Potential Scorecard				
Points	**Probability for Establishment**	Total Points (pre-adjustment)		**100**
>100	High	Adjustments		
		Critical species	A (1- __0_ %)	**100**
51-99	Moderate	Natural enemy	B (1- __0_ %)	**100**
		Control measures	C (1- 40 %)	**60**
0-50	Low	**Probability for Establishment**		Moderate
# of questions answered as "unable to determine"	**Confidence Level**			
0-1	High	Total # of questions unknown		0
2-5	Moderate			
6-9	Low	Confidence Level		High
>9	Very low			

<u>Qualitative Statements for GLANSIS Fact Sheet:</u>
Hypophthalmichthys nobilis has a moderate probability of establishment if introduced to the Great Lakes (Confidence level: High).

Section C: Potential for Impact

<u>IMPACT POTENTIAL RESULTS</u>

Environmental: High
Socio-Economic: High
Beneficial: High

<u>POTENTIAL ENVIRONMENTAL IMPACT</u>

NOTE: In this section, a "Not significantly" response should be selected if the species has been studied but there have been no reports of a particular impact. An "Unknown" response is appropriate if the species is poorly studied.

Does the species pose some hazard or threat to the health of native species (e.g., it magnifies toxin levels; is poisonous; is a pathogen, parasite, or a vector of either)?

Yes, and it has impacted threatened/endangered species, resulted in the reduction or extinction of one or more native populations, affects multiple species, or is a reportable disease	6√
Yes, but negative consequences have been small (e.g., limited number of infected individuals, limited pathogen transmissibility, mild effects on populations and ecosystems)	1
Not significantly	0
Unknown	U

- *Bighead carp is host to two pathogens that have the potential of affecting and native fish species. One of these parasites, the gill-damaging Lernaea cyprinacea, known as anchorworm, was found in channel catfish being cultured with Bighead carp (Goodwin 1999). This parasite is also known to affect salmonids and eels. Anchorworm occurs worldwide, is known from 40 cyprinid species, and completes its life history on a single host (Hoole et al. 2001). Bighead carp is also known to be host of Bothriocephalus acheilognathi, known as the Asian Carp Tapeworm. This cestode parasite, introduced into United States waters from Grass Carp, erodes mucus membranes and intestinal tissues, often leading to death of the host (Hoole et al. 2001, Humpback Chub Ad Hoc Advisory Committee 2003). However, these adverse effects are minimal on bighead carp (Kolar et al. 2005). The Asian Carp Tapeworm is known to have infected native fishes of concern in five states: Arizona, Colorado, Nevada, New Mexico, and Utah (Kolar et al. 2005). As the introduced range of bighead and silver carps grows in United States waters, a number of native fishes, particularly, but not limited to, cyprinids, percids, and centrarchids, will probably become hosts of the Asian carp tapeworm (Kolar et al. 2005).*

Does it out-compete native species for available resources (e.g., habitat, food, nutrients, light)?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species or caused critical reduction, extinction, behavioral changes including modified spawning behavior) on one or more native populations	6

Yes, and it has caused some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population	1 √
Not significantly	0
Unknown	U

- *Bighead carp is a powerful filter-feeder with a wide food spectrum that grows fast and reproduces quickly (Xie and Chen 2001), which makes this species a strong competitor. Within its native China, bighead carp are considered invasive and are associated with declines in native planktivorous fishes when translocated outside their natural range (Li and Xie 2002). Xie and Chen (2001) found that stocking of bighead carp into the plateau lakes of China had disastrous effects on endemic fishes, especially filter-feeding, endemic barbless carp (Cyprinus pellegrini). The catch of barbless carp, that once represented 50% of yield of total fishes caught, declined to 20% in the 1960s, to 10% in the early 1970s, and plummeted to <1% in the 1980s.*
- *Bighead carp also pose a threat to the ecology of the Mississippi River basin and connecting aquatic ecosystems. These fish are capable of significantly reducing zooplankton abundance, which adversely affects all fish in their early life stages when their diets are strictly planktonic (Chick and Pegg 2001, Xie and Chen 2001). Furthermore, bighead carp compete with fish that are filter-feeders as adults, such as paddlefish. Several studies have showed that when zooplankton is limited, bighead carp has a competitive advantage over paddlefish, negatively affecting the relative growth of the latter (Chick and Pegg 2001, Schrank et al. 2003, Schrank and Guy 2002).*

Does it alter predator-prey relationships?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species, caused significant reduction or extinction of one or more native populations, creation of a dead end or any other significant alteration in the food web)	6
Yes, and it has resulted in some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population AND/OR Yes, and it has resulted in some alteration of the food web structure or processes, the effects of which have not been widespread or severe	1 √
Not significantly	0
Unknown	U

- *Bighead carp have considerable effects on zooplankton communities. This fish is known to decrease the size of zooplankton within a species (Kim et al. 2003, Radke and Kahl 2002), possibly removing a species from the size category that will be consumed effectively by paddlefish. It seems likely that Hypophthalmichthys have the potential to alter the food web in ways that could negatively affect fishes such as paddlefish that feed on large crustacean zooplankton (Kolar et al. 2005).*
- *Hypophthalmichthys spp. also can alter species composition in phytoplankton communities by promoting the dominance of species that can resist digestion (Görgényi et al. 2016).*
- *Food web models of Lake Ontario and Lake Erie have suggested that Asian carp impacts on the Great Lakes ecosystem might be mitigated by several factors and trophic interactions such as the availability of unused production that might be exploited by the carp, increased production at lower trophic levels due to high nutrients, and the potential for native piscivores to feed on larval Asian carp (Zhang et al. 2016; Currie et al. 2012).*

Has it affected any native populations genetically (e.g., through hybridization, selective pressure, introgression)?

Yes, and it has caused a loss or alteration of genes that may be irreversible or has led to the decline of one or more native species (or added pressure to threatened/endangered species)	6
Yes, some genetic effects have been observed, but consequences have been limited to the individual level	1

Not significantly	0 √
Unknown	U

- *Not reported.*

Does it negatively affect water quality (e.g., increased turbidity or clarity, altered nutrient, oxygen, or other chemical levels/cycles)?

Yes, and it has had a widespread, long-term, or severe negative effect on water quality AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected water quality to some extent, but the alterations and resulting adverse effects have been limited or inconsistent (as compared with above statement)	1
Not significantly	0
Unknown	U√

- *Unknown.*

Does it alter physical components of the ecosystem in some way (e.g., facilitated erosion/siltation, altered hydrology, altered macrophyte/phytoplankton communities, physical or chemical changes to substrate)?

Yes, and it has had a widespread, long term, or severe negative effect on the physical ecosystem AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected the physical ecosystem to some extent, but the alterations and resulting adverse effects have been mild	1
Not significantly	0
Unknown	U√

Environmental Impact Total	**8**
Total Unknowns (U)	**2**

<u>POTENTIAL SOCIO-ECONOMIC IMPACT</u>

Does the species pose some hazard or threat to human health (e.g., it magnifies toxin levels, is poisonous, a virus, bacteria, parasite, or a vector of one)?

Yes, significant effects on human health have already been observed	6
Yes, but negative consequences have not been widespread, long lasting, or severe	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Does it cause damage to infrastructure (e.g., water intakes, pipes, or any other industrial or recreational infrastructure)?

Yes, it is known to cause significant damage	6
Yes, but the costs have been small and are largely reparable or preventable	1
Not significantly	0 √

Unknown	U

- *Not reported.*

Does it negatively affect water quality (i.e. in terms of being less suitable for human use)?

Yes, it has significantly affected water quality, and is costly or difficult to reverse	6
Yes, but the effects are negligible and/or easily reversed	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Does it negatively affect any markets or economic sectors (e.g., commercial fisheries, aquaculture, agriculture)?

Yes, it has caused significant damage to one or more markets or economic sectors	6√
Some damage to markets or sectors has been observed, but negative consequences have been small	1
Not significantly	0
Unknown	U

- *The spread of this species adversely affects commercial fishery in parts of the Mississippi River basin (Maher 2005). Bighead carp has become a substantial portion of commercial catch, significantly outnumbering the catch of native species sought after commercially in several waters of the Midwest (Conover et al. 2007, Kolar et al. 2005). Commercial fishers on the Illinois River reported a 124% increase in the harvest of bighead and silver carps (reported together) and a 35% decrease in buffalo harvest during 2002 (Conover et al. 2007). In the lower Missouri River, between 2002 and 2004, more than twice as many Hypophthalmichthys were caught than all other commercial species combined. Furthermore, the average weight of individual Hypophthalmichthys was estimated to be at least double that of the individual commercial species caught (Kolar et al. 2005). Unless economically viable markets develop, the establishment of large self-sustaining populations of bighead carp in the United States may compromise commercial fishing (Conover et al. 2007).*

Does it inhibit recreational activities and/or associated tourism (e.g., through frequent water closures, equipment damage, decline of recreational species)?

Yes, it has caused widespread, frequent, or otherwise expensiv inhibition of recreation and tourism	6√
Yes, but negative consequences have been small	1
Not significantly	0
Unknown	U

- *The diet of this species overlaps with that of planktivorous species (fish and invertebrates) and to some extent with that of the young of virtually all native fishes. If food resources become limiting, bighead carp may compete directly with these native species. The decline of native species that are important as sport and food species are bound to have a negative economic impact on recreational angling and other industries that benefit from sport fishing, such as tourism (Kolar et al. 2005).*

Does it diminish the perceived aesthetic or natural value of the areas it inhabits?

Yes, the species has received significant attention from the media/public, significantly diminished the natural or cultural character of the area, or significantly reduced the area's value for future generations	6
Yes, but negative consequences have been small	1

Not significantly	0 √
Unknown	U

- *Not reported.*

Socio-Economic Impact Total	**12**
Total Unknowns (U)	**0**

POTENTIAL BENEFICIAL EFFECT

NOTE: In this section, a "Not significantly" response should be selected if there have been no reports of a particular effect. An "Unknown" response is appropriate if the potential for a particular effect might be inferred but has not been explicitly reported or if there is an unresolved debate about a particular effect.

Does it act as a biological control agent for aquatic weeds or other harmful nonindigenous organisms?

Yes, it has succeeded significantly as a control agent	6
Yes, it has had some success as a control agent, but may be inconsistent or lack a desired level of effectiveness	1 √
Not significantly	0
Unknown	U

- *The role of bighead carp as a biological control agent for plankton control and removal is largely debated. While Henderson (1978, 1983) suggested that both bighead and silver carp would stimulate phytoplankton blooms that would result in removal of nutrients by phytoplankton, Opuszynski (1980) found that organic carbon, nitrogen, and total phosphorous increased in bottom sediments, despite the decrease in nitrogen, phosphorous, and dissolved. When those bottom sediments were disturbed by activities of other fishes, phytoplankton populations increased. Furthermore, Lieberman (1996) stocked bighead and silver carps and found that total phosphorus and total inorganic nitrogen increased as a result.*

Is it commercially valuable (e.g., for fisheries, aquaculture, agriculture, bait, ornamental trade)?

Yes, it is economically important to at least one of these industries	6√
Yes, but its economic contribution is small	1
Not significantly	0
Unknown	U

- *Bighead carp is a popular food fish in its native China and several other countries, ranking fourth in 1999 in world aquaculture production (FAO 1999). Although not so popular, North American commercial fisheries for bighead carp exist on the Mississippi, Missouri, and Illinois rivers and are sold from small specialty food markets to consumers of various Asian cultures in major North American cities (Conover et al. 2007, Kolar et al. 2005, Stone et al. 2000). Nonetheless, the market for live bighead carp in the United States is limited (the typical consumer will buy only enough fish for the current day's meal) and easily saturated (Stone et al. 2000). After bighead carp fry are produced by hatcheries and grown to market size by fish farmers, they are transported to live markets in Toronto, Chicago, New York, Boston, Montreal, and other cities (Conover et al. 2007).*
- *Furthermore, bighead carp are frequently used in polyculture with other fish, such as common carp, various tilapias, largemouth bass, and bigmouth buffalo (Jennings 1988) to control zooplankton and phytoplankton populations. In the United States, bighead carp are cultured in ponds with channel catfish and sometimes with grass carp to control macrophytes (Conover et al. 2007).*
- *Additionally, bighead carp can be an important source of revenue for catfish farmers during times of low catfish prices (Stone et al. 2000). Engle and Brown (1998) estimated that the net benefit of stocking Bighead carp with catfish was substantially higher. Net benefits ranged from $1,628 to $2,743 annually from a 6-ha (15-acre) pond.*

Is it recreationally valuable (e.g., for sport or leisurely fishing, as a pet, or for any other personal activity)?

Yes, it is commonly employed recreationally and has some perceived value for local communities and/or tourism	6
It is sometimes employed recreationally, but adds little value to local communities or tourism	1
Not significantly	0√
Unknown	U

- *There is evidence of bighead carp used as sport fish in Oklahoma. Relatively numerous sport fishing catches have been recorded downstream from a low-water dam in the Neosho River at Miami, Oklahoma (Jester et al. 1992).*

Does the species have some medicinal or research value (i.e. outside of research geared towards its control)?

Yes, it has significant medicinal or research value	6
It has some medicinal or research value, but is not of high priority OR It is potentially important to medicine or research and is currently being or scheduled to be studied	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Does the species remove toxins or pollutants from the water or otherwise increase water quality?

Yes, it reduces water treatment costs or has a significant positive impact for the health of humans and/or native species	6
Yes, but positive impact for humans or native species is considered negligible	1
Not significantly	0
Unknown	U √

- *The effects of bighead carp on water quality in culture ponds is highly debated due to conflicting results from various studies (Kolar et al. 2007, Stickney 1996). However, some studies have reported that bighead carp is able to improve water quality by continually removing plankton, especially blue-green algae. This stabilizes plankton and lessens the probability of die-offs in production ponds (Kolar et al. 2007, Schofield et al. 2005).*

Does the species have a positive ecological impact outside of biological control (e.g., increases the growth or reproduction rates of other species, fills an important gap in the food web, supports the survival of a species that is threatened, endangered species, or commercially valuable)?

Yes, it significantly contributes to the ecosystem in one or more of these ways	6
Yes, it provides some positive contribution to the ecosystem, but is not vital	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Beneficial Effect Total	**7**
Total Unknowns (U)	**1**

Scientific Name: *Knipowitschia caucasica*

Common Name: Caucasian dwarf goby

Section A: Potential for Introduction

INTRODUCTION POTENTIAL RESULTS

Dispersal: Unlikely
Hitchhiking/Fouling: Unlikely
Unauthorized intentional release: Unlikely
Stocking/Planting/Escape from recreational culture: Unlikely
Escape from commercial culture: Unlikely
Shipping: Low

Comments:
Means of Introduction: *Knipowitschia caucasica* has a low probability of introduction to the Great Lakes (Confidence level: High).

Potential pathway(s) of introduction: Transoceanic shipping (ballast water)

Knipowitschia caucasica does not occur near waters connected to the Great Lakes basin. This species is not known to hitchhike or foul. *Knipowitschia caucasica* is not stocked, commercially cultured, or sold in the Great Lakes region. It occurs in the Mediterranean Sea, which has shipping traffic that goes directly to the Great Lakes; however, there is insufficient information to determine if this species occurs in the Mediterranean ports that are in direct trade with the Great Lakes. Due to its euryhaline nature, *Knipowitschia caucasica* may be able to survive ballast water management practices, but survival through full exchange and sediment flushing is doubtful.

POTENTIAL INTRODUCTION VIA DISPERSAL

Does this species occur near waters (natural or artificial) connected to the Great Lakes basin* (e.g., streams, ponds, canals, or wetlands)?

(*Great Lakes basin = below the ordinary high water mark, including connecting channels, wetlands, and waters ordinarily attached to the Lakes) √

Yes, this species occurs near waters connected to the Great Lakes basin and is mobile or able to be transported by wind or water.	100
No, this species does not occur near waters connected to the Great Lakes basin and/or is not mobile or able to be transported by wind or water.	0 √
Unknown	U

- *There have been no reports of* K. caucasica *near or in waters connected to the Great Lakes; however, the species has been accidently introduced to other European bodies of water from its original source in the Ponto- Caspian region.* K. caucasica *has been identified in several bodies of water in Greece (Economidis and Miller 1990, Kevrekidis et al. 1990, Daoulas et al. 1993, Kovačić and Pallaoro 2003, Leonardos et al. 2008), Hungary (Halasi-Kovács et al. 2011), and Turkey (Van Neer et al. 1999).*
- Knipowitschia caucasica *has only been identified in European waters (Economidis and Miller 1990,*

Kevrekidis et al. 1990, Daoulas et al. 1993, Van Neer et al. 1999, Kovačić and Pallaoro 2003, Leonardos et al. 2008, Halasi-Kovács et al. 2011).

What is the proximity of this species to the Great Lakes basin?

This species occurs in waters within 20 kilometers of the Great Lakes basin, and no barrier (e.g., electric barrier, dam) to dispersal is present.	Score x 1
This species occurs in waters within 20 kilometers of the Great Lakes basin, but dispersal to the basin is blocked; or, this species occurs in waters within 100 kilometers of the Great Lakes basin, and no barrier to dispersal is present.	Score x 0.75
This species occurs in waters within 100 kilometers of the Great Lakes basin, but dispersal to the basin is blocked.	Score x 0.5
This species occurs in waters >100 kilometers from the Great Lakes basin.	Score x 0.25
Unknown	U

POTENTIAL INTRODUCTION VIA HITCHHIKING/FOULING

Is this species likely to attach to or be otherwise transported by, or along with, recreational gear, boats, trailers, fauna (e.g., waterfowl, fish, insects), flora (e.g., aquatic plants), or other objects (e.g., packing materials), including as parasites or pathogens, entering the Great Lakes basin?

Yes, this species is known to be able to adhere to certain surfaces or to be transported by other organisms entering the Great Lakes basin.	100
No, this species is not known to be able to adhere to certain surfaces or to be transported by other organisms entering the Great Lakes basin.	0 √
Unknown	U

- *Invasion of* K. caucasica *into Turkish lakes was attributed to involuntary introduction by man through fish stocking or recreational fishing (Van Neer et al. 1999).*
- Knipowitschia caucasica *larvae were found in aquatic vegetation hauls in Greek lakes (Daoulas et al. 1993).*
- *Eggs are usually found attached to the underside of small gravel, mollusk shells, or reeds (Baimov 1963).*
- *In Europe,* K. caucasica *have been found in fish stocks of common carp (Van Neer et al. 1999).*
- *However*, K. caucasica *has only been identified in European waters (Economidis and Miller 1990, Kevrekidis et al. 1990, Daoulas et al. 1993, Van Neer et al. 1999, Kovačić and Pallaoro 2003, Leonardos et al. 2008, Halasi-Kovács et al. 2011).*

What is the proximity of this species to the Great Lakes basin?

This species occurs in waters within 20 km of the Great Lakes basin.	Score x 1
This species occurs in waters within 100 km of the Great Lakes basin.	Score x 0.5
This species occurs in waters >100 km from the Great Lakes basin.	Score x 0.1
Unknown	U

POTENTIAL INTRODUCTION VIA UNAUTHORIZED INTENTIONAL RELEASE

Is this species sold at aquarium/pet/garden stores ("brick & mortar" or online), catalogs, biological supply companies, or live markets (e.g., purchased for human consumption, bait, ornamental, ethical, educational, or cultural reasons) and as a result may be released into the Great Lakes basin?

Yes, this species is available for purchase.	100
No, this species this species is rarely/never sold.	0 √
Unknown	U

- *Performing an online search of aquaria, catalogs, and biological supply companies (including Carolina Biological, Aquatic Biosystems, and Fisher-Scientific) did not yield any listings or information for* K. caucasica *or the common name (Caucasian dwarf goby).*
- Knipowitschia caucasica *is listed on the IUCN Redlist of Threatened Species, although as a low concern species with no known major threats (Freyhof and Kottelat 2008c). With this in mind, it may be difficult to acquire these species for market sales.*

How easily is this species obtained within the Great Lakes region (states/provinces)?

This species is widely popular, frequently sold, and/or easily obtained within the Great Lakes region.	Score x 1
This species is widely popular, and although trade, sale, and/or possession of this species is prohibited, it is frequently sold on the black market within the Great Lakes region.	Score x 0.5
This species is not very popular or is not easily obtained within the Great Lakes region.	Score x 0.1
Unknown	U

POTENTIAL INTRODUCTION VIA STOCKING/PLANTING OR ESCAPE FROM RECREATIONAL CULTURE

Is this species being stocked/planted to natural waters or outdoor water gardens around the Great Lakes region?

Yes, this species is being stocked/planted and/or has ornamental, cultural, medicinal, environmental (e.g., biocontrol, erosion control), scientific, or recreational value in the Great Lakes region.	100
No, this species cannot be stocked/planted or there is not enough interest to do so in the Great Lakes region.	0 √
Unknown	U

- *An online search did not yield any listings or information for* K. caucasica *or the common name (Caucasian dwarf goby).*
- Knipowitschia caucasica *is listed on the IUCN Redlist of Threatened Species, although as a low concern species with no known major threats (Freyhof and Kottelat 2008c). With this in mind, it may be difficult to acquire these species for market sales.*
- *Moreover,* K. caucasica *has only been identified in European waters (Economidis and Miller 1990, Kevrekidis et al. 1990, Daoulas et al. 1993, Van Neer et al. 1999, Kovačić and Pallaoro 2003, Leonardos et al. 2008, Halasi-Kovács et al. 2011).*

What is the nature and proximity of this activity to the Great Lakes basin?

This activity is authorized and/or is occurring directly in the Great Lakes.	Score x 1
This activity is occurring in Great Lakes tributaries or connecting waters, or within 20 km of the Great Lakes basin.	Score x 0.75
This activity is likely to occur within 20 km of the Great Lakes basin because of its popularity/value and there are no widespread regulations against stocking/planting.	Score x 0.5
This activity is occurring in waters >20 km from the Great Lakes basin, or despite federal or state regulations in more than half the basin (> 5 states/provinces), this activity may occur within 20 km of the basin because of the species' popularity/value.	Score x 0.25
Unknown	U

POTENTIAL INTRODUCTION VIA ESCAPE FROM COMMERCIAL CULTURE

Is this species known to be commercially cultured in or transported through the Great Lakes region?

Yes, this species is being commercially cultured in or transported through the Great Lakes region.	100
No, this species is not commercially cultured in or transported through the Great Lakes region.	0 √
Unknown	U

- *Although* K. caucasica *is not transported or sold commercially in the Great Lakes region according to an online search, there is potential for the species to accidentally enter the basin illegally or through ballast water. Van Neer et al. (1999) and Daoulas et al. (1993) argue that* K. caucasica *has been accidently introduced into some European waters by stocks of other fish or recreational fishing.*
- *However,* K. caucasica *has only been identified in European waters (Economidis and Miller 1990, Kevrekidis et al. 1990, Daoulas et al. 1993, Van Neer et al. 1999, Kovačić and Pallaoro 2003, Leonardos et al. 2008, Halasi- Kovács et al. 2011).*
- *Furthermore,* K. caucasica *is listed on the IUCN Redlist of Threatened Species, although as a low concern species with no known major threats (Freyhof and Kottelat 2008c). With this in mind, it may be difficult to acquire this species for market sales.*

What is the nature and proximity of this activity to the Great Lakes basin?

This activity is unregulated or minimally regulated and is occurring directly in the Great Lakes.	Score x 1
This activity is unregulated or minimally regulated and is occurring in Great Lakes tributaries or connecting waters, or within 20 km of the Great Lakes basin.	Score x 0.75
This activity is strictly regulated but occurs directly in the Great Lakes, and/or this activity involves transport of live organisms on/across the Great Lakes.	Score x 0.5
This activity is strictly regulated but occurs in Great Lakes tributaries, connecting waters, or within 20 km of the Great Lakes basin, and/or this activity involves transport of live organisms within 20 km of the Great Lakes basin.	Score x 0.25
This activity occurs >20 km from the Great Lakes basin and typically does not involve transport of live organisms closer to the basin.	Score x 0.1
Unknown	U

POTENTIAL INTRODUCTION VIA SHIPPING

Is this species capable of surviving adverse environments (i.e. extreme temperatures, absence of light, low oxygen levels) and partial-to-complete ballast water exchange/BWE (e.g., is euryhaline, buries in sediment, produces resistant resting stages, has other attributes or behaviors facilitating survival under these conditions)?

Yes, this species is able to survive in ballast tank environments for weeks at a time and may be suspended in ballast water.	100
Yes, this species is able to survive in ballast tank environments for weeks at a time and is able to survive BWE by burial in ballast sediment.	80 √
Yes, this species is able to survive in ballast tank environments for weeks at a time and may be suspended in ballast water, but this species is not able to survive BWE.	60
No, but this species is capable of fouling transoceanic ship structures (e.g., hull, chains, chain locker) while in its active or resting stage.	40
No, this species is not able to survive adverse environments, does not foul transoceanic ship structures, or is unlikely to be taken up with ballast.	0
Unknown	U

- *Due to its small size (30-40mm) (Kevrekidis et al. 1990),* K. caucasica *can be easily taken up by ballast water systems.*
- Knipowitschia caucasica *has been found in other fish stocks, which has contributed to their introduction in Turkish and Greek water bodies (Van Neer et al. 1999). In addition, they have shown the ability to develop freshwater populations in European riverine and lake systems (Halasi-Kovács et al. 2011).*
- Knipowitschia caucasica *has wide ecological tolerances. They are a euryhaline species and can survive in both hypersaline and fresh water, allowing them to easy survive introduction to the Great Lakes from a saline source (Kevrekidis et al. 1990).*
- *Since it feeds primarily on benthic amphipods and polychaetes,* K. caucasica *prefers to inhabit sandy, muddy or gravel substrata (Kevrekidis et al. 1990, Daoulas et al. 1993) which may facilitate its survival during ballast water flushing.*
- *However, the species may have difficulty surviving adverse environments for long periods of time in ballast tanks. Typical environments they have been found in have a dissolved oxygen (DO) range of 5.3-8.4ppm and pH range of 7.3-8.3 (Kevrekidis et al. 1990). Low DO levels or acidic/basic conditions in ballast tanks may have adverse effects on their survival. Also, they can survive temperatures of 3.4°C up to 27°C, but temperatures above 15°C are ideal (Baimov 1963, Kevrekidis et al. 1990).*
- Knipowitschia caucasica *is found in the freshwater Lake Trichonis of Greece, and the Evros delta that has 24- 36‰ salinity (Daoulas et al. 1993, Kevrekidis et al. 1993). This species occurs in waters with temperatures of 1.6-26.9°C and oxygen levels of 5.3-8.96 ppm (Kevrekidis et al. 1993, Gülle et al. 2008).*

Does this species occur in waters from which shipping traffic to the Great Lakes originates?

Yes, and this species has been observed in ballast of or fouling ships entering the Great Lakes.	Score x 1
Yes, and this species has been observed in ports that have direct trade connections with the Great Lakes (e.g., Baltic Sea).	Score x 0. 5
Yes, but this species has neither been observed in ballast/fouling ships entering the Great Lakes nor in ports in direct trade with the Great Lakes.	Score x 0.1√
No, this species does not occur in waters from which shipping traffic to the Great Lakes originates.	Score x 0
Unknown	U

- Knipowitschia caucasica *originates from the Ponto-Caspian region and has been confirmed in Aegean waters (Economidis and Miller 1990). Also, it has been identified in the Caspian, Azov, Aral, Black (Daoulas et al. 1993), and Adriatic (Kovačić and Pallaoro 2003) seas, as well as several localities in northern Greece and Turkey. Since ships coming from these locations have brought other invasive species (i.e. dreissenid mussels from Ponto-Caspian region), we know that ships have the potential to bring* K. caucasica *from these areas.*
- *However, documentation of* K. caucasica *in ballast water from these areas was not found. It occurs in the Mediterranean Sea (Kevrekidis et al. 1990), which has shipping traffic that goes directly to the*

- *Great Lakes; however, there is insufficient information to determine if this species occurs in the Mediterranean ports that are in direct trade with the Great Lakes.*

Vector Potential Score					
Vector		**Raw Points Scored**	**Proximity Multiplier**	**Total Points Scored**	**Probability of Introduction**
Dispersal: Natural dispersal through waterbody connections or wind		0	x		Unlikely
Hitchhiking/Fouling: Transport via recreational gear, boats, trailers, mobile fauna, stocked/planted organisms, packing materials, host organisms, etc.		0	x		Unlikely
Release: Unauthorized intentional release of organisms in trade (e.g., aquaria, water gardens, live food)		0	x		Unlikely
Stocking/Planting/Escape from recreational culture: Intentional authorized or unauthorized introduction to natural waters in the Great Lakes OR Accidental introduction to Great Lakes by escape from Unlikely recreational culture (e.g., water gardens)		0	x		Unlikely
Escape from commercial culture: Accidental introduction to Great Lakes by escape from commercial culture (e.g., aquaculture)		0	x		Unlikely
Trans-oceanic shipping: Ballast (BOB) or no-ballast-on-board (NOBOB) water exchange/discharge, sediment discharge, hull fouling		80	x	0.1	Low
Total Unknowns (U)	**0**	**Confidence Level**		**High**	

<u>Qualitative Statements for GLANSIS Fact Sheet:</u>
SPECIES X has a low probability of introduction to the Great Lakes (Confidence level: High).

Potential pathway(s) of introduction: Shipping

Scientific Name: *Lepomis auritus*

Common Name: Redbreast sunfish

Section A: Potential for Introduction

INTRODUCTION POTENTIAL RESULTS

Dispersal: High
Hitchhiking/Fouling: Unlikely
Unauthorized intentional release: High
Stocking/Planting/Escape from recreational culture: Unknown
Escape from commercial culture: Unknown
Shipping: Unlikely

Comments:
Records of *Lepomis auritus* in the Great Lakes basin have been attributed to stocking for sport fishing purposes (USGS 2010). However, there is no evidence that suggests stocking is occurring or has ever occurred. A single *Lepomis auritus* in the Rocky River in Cuyahoga County, Ohio was reportedly collected in 2013 but it is believed to be a misidentification and there are no records of redbreast sunfish being stocked in Ohio's public waters (K. Kayle, pers. comm.). Recent records denoted by Carlson et al. (2016) refer to occurrences in the part of the St. Lawrence drainage (HUC 415) that does not drain into the Great Lakes portion of the drainage.

POTENTIAL INTRODUCTION VIA DISPERSAL

Does this species occur near waters (natural or artificial) connected to the Great Lakes basin* (e.g., streams, ponds, canals, or wetlands)?
(*Great Lakes basin = below the ordinary high water mark, including connecting channels, wetlands, and waters ordinarily attached to the Lakes)

Yes, this species occurs near waters connected to the Great Lakes basin and is mobile or able to be transported by wind or water.	100√
No, this species does not occur near waters connected to the Great Lakes basin and/or is not mobile or able to be transported by wind or water.	0
Unknown	U

- *This species was found in Little Conneaut Creek (Ashtabula, PA) in the Rocky River (Cuyahoga County, OH), and in several New York waterways within the Great Lakes-St. Lawrence HUC (Carlson et al. 2016). However, the Ohio record is believed to be misidentified (K. Kayle, pers. comm.) and other records are not below the ordinary high water mark.*

What is the proximity of this species to the Great Lakes basin?

This species occurs in waters within 20 kilometers of the Great Lakes basin, and no barrier (e.g., electric barrier, dam) to dispersal is present.	Score x 1√
This species occurs in waters within 20 kilometers of the Great Lakes basin, but dispersal to the basin is blocked; or, this species occurs in waters within 100 kilometers of the Great Lakes basin, and no barrier to dispersal is present.	Score x 0.75

This species occurs in waters within 100 kilometers of the Great Lakes basin, but dispersal to the basin is blocked.	Score x 0.5
This species occurs in waters >100 kilometers from the Great Lakes basin.	Score x 0.25
Unknown	U

POTENTIAL INTRODUCTION VIA HITCHHIKING/FOULING

Is this species likely to attach to or be otherwise transported by, or along with, recreational gear, boats, trailers, fauna (e.g., waterfowl, fish, insects), flora (e.g., aquatic plants), or other objects (e.g., packing materials), including as parasites or pathogens, entering the Great Lakes basin?

Yes, this species is known to be able to adhere to certain surfaces or to be transported by other organisms entering the Great Lakes basin.	100
No, this species is not known to be able to adhere to certain surfaces or to be transported by other organisms entering the Great Lakes basin.	0 √
Unknown	U

What is the proximity of this species to the Great Lakes basin?

This species occurs in waters within 20 km of the Great Lakes basin.	Score x 1
This species occurs in waters within 100 km of the Great Lakes basin.	Score x 0.5
This species occurs in waters >100 km from the Great Lakes basin.	Score x 0.1
Unknown	U

POTENTIAL INTRODUCTION VIA UNAUTHORIZED INTENTIONAL RELEASE

Is this species sold at aquarium/pet/garden stores ("brick & mortar" or online), catalogs, biological supply companies, or live markets (e.g., purchased for human consumption, bait, ornamental, ethical, educational, or cultural reasons) and as a result may be released into the Great Lakes basin?

Yes, this species is available for purchase.	100√
No, this species this species is rarely/never sold.	0
Unknown	U

- *Redbreast sunfish are sold online in North America (http://www.aquaculturestore.com/Redbreast.html.)*

How easily is this species obtained within the Great Lakes region (states/provinces)?

This species is widely popular, frequently sold, and/or easily obtained within the Great Lakes region.	Score x 1√
This species is widely popular, and although trade, sale, and/or possession of this species is prohibited, it is frequently sold on the black market within the Great Lakes region.	Score x 0.5
This species is not very popular or is not easily obtained within the Great Lakes region.	Score x 0.1
Unknown	U

- *This species can be bought online from aquaculture facilities outside of the Great Lakes region and shipped into the region since there are no regulations banning the importation of this species in the Great Lakes states and provinces.*

POTENTIAL INTRODUCTION VIA STOCKING/PLANTING OR ESCAPE FROM RECREATIONAL CULTURE

Is this species being stocked/planted to natural waters or outdoor water gardens around the Great Lakes region?

Yes, this species is being stocked/planted and/or has ornamental, cultural, medicinal, environmental (e.g., biocontrol, erosion control), scientific, or recreational value in the Great Lakes region.	100
No, this species cannot be stocked/planted or there is not enough interest to do so in the Great Lakes region.	0
Unknown	U√

- *USGS NAS records indicate that this species has been stocked within the basin for sport fishing. However, Ohio DNR believes the record in the Rocky River was a misidentification (K. Kayle, pers. comm.).*

What is the nature and proximity of this activity to the Great Lakes basin?

This activity is authorized and/or is occurring directly in the Great Lakes.	Score x 1
This activity is occurring in Great Lakes tributaries or connecting waters, or within 20 km of the Great Lakes basin.	Score x 0.75
This activity is likely to occur within 20 km of the Great Lakes basin because of its popularity/value and there are no widespread regulations against stocking/planting.	Score x 0.5
This activity is occurring in waters >20 km from the Great Lakes basin, or despite federal or state regulations in more than half the basin (> 5 states/provinces), this activity may occur within 20 km of the basin because of the species' popularity/value.	Score x 0.25
Unknown	U√

POTENTIAL INTRODUCTION VIA ESCAPE FROM COMMERCIAL CULTURE

Is this species known to be commercially cultured in or transported through the Great Lakes region?

Yes, this species is being commercially cultured in or transported through the Great Lakes region.	100
No, this species is not commercially cultured in or transported through the Great Lakes region.	0
Unknown	U√

What is the nature and proximity of this activity to the Great Lakes basin?

This activity is unregulated or minimally regulated and is occurring directly in the Great Lakes.	Score x 1
This activity is unregulated or minimally regulated and is occurring in Great Lakes tributaries or connecting waters, or within 20 km of the Great Lakes basin.	Score x 0.75
This activity is strictly regulated but occurs directly in the Great Lakes, and/or this activity involves transport of live organisms on/across the Great Lakes.	Score x 0.5
This activity is strictly regulated but occurs in Great Lakes tributaries, connecting waters, or within 20 km of the Great Lakes basin, and/or this activity involves transport of live organisms within 20 km of the Great Lakes basin.	Score x 0.25

This activity occurs >20 km from the Great Lakes basin and typically does not involve transport of live organisms closer to the basin.	Score x 0.1
Unknown	U√

- *Stocking near Lake Erie suggests that this species was (or is) commercially cultured in or transported through the Great Lakes region. Whether this practice is still occurring is not certain.*

POTENTIAL INTRODUCTION VIA SHIPPING

Is this species capable of surviving adverse environments (i.e. extreme temperatures, absence of light, low oxygen levels) and partial-to-complete ballast water exchange/BWE (e.g., is euryhaline, buries in sediment, produces resistant resting stages, has other attributes or behaviors facilitating survival under these conditions)?

Yes, this species is able to survive in ballast tank environments for weeks at a time and may be suspended in ballast water.	100
Yes, this species is able to survive in ballast tank environments for weeks at a time and is able to survive BWE by burial in ballast sediment.	80
Yes, this species is able to survive in ballast tank environments for weeks at a time and may be suspended in ballast water, but this species is not able to survive BWE.	60
No, but this species is capable of fouling transoceanic ship structures (e.g., hull, chains, chain locker) while in its active or resting stage.	40
No, this species is not able to survive adverse environments, does not foul transoceanic ship structures, or is unlikely to be taken up with ballast.	0√
Unknown	U

- *The critical thermal maxima of L. auritus is believed to be 36 C (Aho & Terrell 1986)*

Does this species occur in waters from which shipping traffic to the Great Lakes originates?

Yes, and this species has been observed in ballast of or fouling ships entering the Great Lakes.	Score x 1
Yes, and this species has been observed in ports that have direct trade connections with the Great Lakes (e.g., Baltic Sea).	Score x 0. 5
Yes, but this species has neither been observed in ballast/fouling ships entering the Great Lakes nor in ports in direct trade with the Great Lakes.	Score x 0.1
No, this species does not occur in waters from which shipping traffic to the Great Lakes originates.	Score x 0
Unknown	U

Vector Potential Scorecard

Vector	**Raw Points Scored**	**Proximity Multiplier**	**Total Points Scored**	**Probability of Introduction**
Dispersal: Natural dispersal through waterbody connections or wind	**100**	x 1	**100**	High
Hitchhiking/Fouling: Transport via recreational gear, boats, trailers, mobile fauna, stocked/planted organisms, packing materials, host organisms, etc.	**0**	x	**0**	Unlikely

Release: Unauthorized intentional release of organisms in trade (e.g., aquaria, water gardens, live food)	**100**	x 1	**100**	High
Stocking/Planting/Escape from recreational culture: Intentional authorized or unauthorized introduction to natural waters in the Great Lakes OR Accidental introduction to Great Lakes by escape from recreational culture (e.g., water gardens)	**U**	x	**U**	Unknown
Escape from commercial culture: Accidental introduction to Great Lakes by escape from commercial culture (e.g., aquaculture)	**U**	x	**U**	Unknown
Trans-oceanic shipping: Ballast (BOB) or no-ballast-on-board (NOBOB) water exchange/discharge, sediment discharge, hull fouling	**0**	x	**0**	Unlikely
Total Unknowns (U)	**2**	**Confidence Level**	Moderate	

Qualitative Statements for GLANSIS Fact Sheet:
***Lepomis auritus* has a high probability of introduction to the Great Lakes (Confidence level: Moderate).**

Potential pathway(s) of introduction: Dispersal, Unauthorized Intentional Release

Section B: Potential for Establishment

ESTABLISHMENT POTENTIAL RESULTS

Lepomis auritus has a moderate probability of establishment if introduced to the Great Lakes (Confidence level: High).

Comments: Redbreast sunfish are known to exist at latitudes similar to the Great Lakes, and their broad temperature range suggests that overwintering will not hinder this species establishment. Native *Lepomis* spp. with similar life history traits suggest that *L. auritus* will likely be able to establish in the Great Lakes.

INVASIVE BIOLOGICAL/ECOLOGICAL ATTRIBUTES

How would the physiological tolerance of this species (survival in varying temperature, salinity, oxygen, and nutrient levels) be described?

This species has broad physiological tolerance. It has been reported to survive in wide ranges of temperature (0°C-30°C), salinity (0-16 parts per thousand), oxygen (0-saturated), AND nutrient (oligotrophic-eutrophic) levels.	9

This species has somewhat broad physiological tolerance. It has been reported to survive in a wide range of temperature, salinity, oxygen, OR nutrient levels. Tolerance to other factors is narrower, unknown, or unreported.	6
This species has narrow physiological tolerance. It has been reported to survive in limited ranges of temperature, salinity, oxygen, and nutrient levels.	3
Unknown	U
	6

- *Redbreast sunfish are believed to prefer temperatures of 27-29 C (Aho & Terrell 1986), however this species has been observed in thermally impacted reservoirs where temperatures were as high as 33-35 C (Siler 1975).*

How likely is it that any life stage of this species can overwinter in the Great Lakes (survive extremely low levels of oxygen, light, and temperature)?

Likely (This species is able to tolerate temperatures under 5°C and oxygen levels ≤0.5 mg/L)	9
Somewhat likely (This species is able to tolerate some of these conditions OR has adapted behaviorally to avoid them)	6
Somewhat unlikely (This species is able to tolerate conditions close to those specified, but it is not known as an overwintering species)	3
Unlikely	0
Unknown	U
	9

- Lepomis auritus *occurrences in New York, USA (Carlson et al. 2016) and New Brunswick, Canada (Gautreau & Curry 2012) demonstrate that this species is capable of surviving throughout the year in northern temperate climates.*
- *Lab observations noted that Redbreast Sunfish aggregate in a quiescent state during winter when temperatures are around 5 C (Breder and Nigrelli 1935)*

If this species is a heterotroph, how would the flexibility of its diet be described?

This species is a dietary generalist with a broad, assorted, AND flexible diet.	9
This species is moderately a dietary generalist with a broad, assorted, OR flexible diet.	6
This species is a dietary specialist with a limited and inflexible diet.	3
This species is an autotroph.	0
Unknown	U
	9

- *This species is an opportunistic feeder known to eat a variety of aquatic and terrestrial invertebrates (Sandlow et al. 1975; Gautreau and Curry 2012; Thorp et al. 1989).*

How likely is this species to outcompete species in the Great Lakes for available resources?

Likely (This species is known to have superior competitive abilities and has a history of outcompeting other species, AND/OR available literature predicts it might outcompete native species in the Great Lakes)	9
Somewhat likely (This species is known to have superior competitive abilities, but there are few reported cases of this species outcompeting another and no predictions regarding species in the Great Lakes)	6

Somewhat unlikely (This species has average competitive abilities, and there are no reported cases of this species outcompeting another and no predictions regarding species in the Great Lakes)	3
Unlikely (This species is known as a poor competitor that thrives only in environments with low biodiversity, AND/OR available literature predicts it might be outcompeted by a species in the Great Lakes)	0
Unknown	U
	4

- *Circumstantial evidence in Tennessee suggests that redbreast sunfish are displacing native longear sunfish in Tennessee. In addition, redbreast sunfish are generally more aggressive, more surface-oriented, and more active in cool waters than bluegill (Etnier & Starnes 1993).*

How would the fecundity of this species be described relative to other species in the same taxonomic class?

Very high	9
High	6
Moderate	3
Low	0
Unknown	U
	3

- Lepomis auritus *produces an average of 3300 eggs, with a range of 322-9206 depending on the size of the fish (Sandow et al. 1975).*
- Lepomis macrochirus *in South Carolina were estimated to produce 571 to 27,027 eggs per female.* Lepomis gulosus *were estimated to produce 798 to 34,257 eggs per female (Panek & Cofield 2011)*
- Lepomis gibbosus *is capable of producing 660-3000 eggs during the spawning season (Etnier & Starnes 1993).*
- Lepomis megalotis *fecundity is believed to approach 4000 eggs per female (Etnier & Starnes 1993).*
- Lepomis microlophus *fecundity was reported to range from 15,000-30,000 mature ova (Etnier & Starnes 1993).*

How likely are this species' reproductive strategy and habits to aid establishment in new environments, particularly the Great Lakes (e.g., parthenogenesis/self-crossing, self fertility, vegetative fragmentation)?

Likely (The reproductive strategy or habits of this species are known to aid establishment in new environments, AND available literature predicts establishment in the Great Lakes based on these attributes)	9
Somewhat likely (The reproductive strategy or habits of this species are known to aid establishment in new environments, but there is no literature available regarding establishment in the Great Lakes based on these attributes)	6
Somewhat unlikely (The reproductive strategy or habits of this species could potentially aid establishment in new environments, but there is no literature available regarding establishment in the Great Lakes based on these attributes)	3
Unlikely (The reproductive strategy or habits of this species are not known to aid establishment in new environments)	0
Unknown	U
	3

- *Nest guarding may aid establishment.*

ENVIRONMENTAL COMPATIBILITY

How similar are the climatic conditions (e.g., air temperature, precipitation, seasonality) in the native and introduced ranges of this species to those in the Great Lakes region?

Very similar (The climatic conditions are practically identical to those of the Great Lakes region)	9
Similar (Many of the climatic conditions are similar to those of the Great Lakes region)	6
Somewhat similar (Few of the climatic conditions are similar to those of the Great Lakes region)	3
Not similar	0
Unknown	U
	9

- *Exists in New Brunswick, Canada and in the St. Lawrence drainage (Carlson et al. 2016; Gautreau and Curry 2012), which have similar climatic conditions to that of the Great Lakes.*

How similar are other abiotic factors that are relevant to the establishment success of this species (e.g., pollution, water temperature, salinity, pH, nutrient levels, currents) in the native and introduced ranges to those in the Great Lakes?

Very similar (These factors are practically identical to those of the Great Lakes region)	9
Similar (Many of these factors are similar to those of the Great Lakes region)	6
Somewhat similar (Few of these factors are similar to those of the Great Lakes region)	3
Not similar	0
Unknown	U
	9

How abundant are habitats suitable for the survival, development, and reproduction of this species in the Great Lakes area (e.g., those with adequate depth, substrate, light, temperature, oxygen)?

Abundant (Suitable habitats can be easily found and readily available)	9
Somewhat abundant (Suitable habitats can be easily found but are in high demand by species already present)	6
Somewhat scarce (Suitable habitats can be found occasionally)	3
Scarce (Suitable habitats are rarely found)	0
Unknown	U
	9

- *Redbreast sunfish can be found in rocky and sandy pools of creeks, small- to medium-sized rivers, and rocky and vegetated lake margins (Page and Burr 1991).*
- *This species would likely inhabit habitat similar to native* Lepomis spp.

How likely is this species to adapt to or to benefit from the predicted effects of climate change on the Great Lakes freshwater ecosystems (e.g., warmer water temperatures, shorter duration of ice cover, altered streamflow patterns, increased salinization)?

Likely (Most of the effects described above make the Great Lakes a better environment for establishment and spread of this species OR this species could easily adapt to these changes due to its wide environmental tolerances)	9
Somewhat likely (Several of the effects described above could make the Great Lakes a better environment for establishment and spread of this species)	6
Somewhat unlikely (Few of the effects described above would make the Great Lakes a better environment for establishment and spread of this species)	3
Unlikely (Most of the effects described above would have no effect on establishment and spread of this species or would make the environment of the Great Lakes unsuitable)	0
Unknown	U
	7

- *Redbreast sunfish tolerate a wide range of temperature (4-36°C) (Froese & Casal 2017; Aho & Terrell 1986)*
- *Maximum growth occurs in temperatures of 25-30° C. Reduced growth and survival are expected at temperatures less than 15°C and greater than 33° C (Aho &Terrell 1986)*
- Lepomis auritus *growth was positively related to river flows in Georgia, USA (Sammons and MacEina 2009). The increasing amount of heavy rains and floods due to climate change (Hayhoe et al. 2010) may benefit* L. auritus *growth.*

How likely is this species to find an appropriate food source (prey or vegetation in the case of predators and herbivores, or sufficient light or nutrients in the case of autotrophs)?

Likely (All possible nutritive food items—including species in the Great Lakes that may be considered potential food items—are highly abundant and/or easily found)	9
Somewhat likely (Some nutritive food items—including species in the Great Lakes that may be considered potential food items—are abundant and/or search time is low to moderate)	6
Somewhat unlikely (Few nutritive food items—including species in the Great Lakes that may be considered potential food items—are abundant and/or search time is moderate to high)	3
Unlikely (All possible nutritive food items—including species in the Great Lakes that may be considered potential food items—are relatively scarce and/or search time is high)	0
Unknown	U
	9

- Lepomis auritus *feeds primarily on aquatic and terrestrial invertebrates, but also is known to feed on small fish (Sandow et al. 1975)*

Does this species require another species for critical stages in its life cycle such as growth (e.g., root symbionts), reproduction (e.g., pollinators, egg incubators), spread (e.g., seed dispersers), or transmission (e.g., vectors)?

Yes, and the critical species (or one that may provide a similar function) is common in the Great Lakes and can be easily found in environments suitable for the species being assessed; OR, No, there is no critical species required by the species being assessed	9
Yes, and the critical species (or one that may provide a similar function) is moderately abundant and relatively easily found in particular parts of the Great Lakes	6

Yes, and the critical species (or one that may provide a similar function) is relatively rare in the Great Lakes AND/OR can only be found occasionally in environments suitable for the species being assessed	3
Yes, and the critical species (or one that may provide a similar function) is not present in the Great Lakes but is likely to be introduced	0
Yes, but the critical species (or one that may provide a similar function) is not present in the Great Lakes and is not likely to be introduced	-80% total points (at end)
Unknown	U
	9

- *There is no evidence of another species needed for any stage of the* Lepomis auritus *life cycle.*

How likely is the establishment of this species to be aided by the establishment and spread of another species already in the Great Lakes?

Likely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established and spread in the Great Lakes, AND available literature predicts this previous invader might promote the establishment of this species, AND/OR there have been cases reported of this species aiding the establishment of this species in other areas)	9
Somewhat likely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established and spread in the Great Lakes)	6
Somewhat unlikely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established in the Great Lakes BUT it is still confined to a small area of the Lakes and the likelihood of encounter with this species assessed is hard to predict)	3
Unlikely (A non-indigenous species to the Great Lakes that facilitates the development of this species has not been established in the Great Lakes)	0
Unknown	U
	0

- *There is no evidence that another species facilitates the establishment of* L. auritus.

How likely is establishment of this species to be prevented by the herbivory, predation, or parasitism of a natural enemy this is already present in the Great Lakes and may preferentially target this species?

Likely (The ability of the natural enemy to prevent the establishment of this species in introduced ranges or limiting populations of this species in native ranges is well documented in the literature AND this natural enemy is abundant and widespread in the Great Lakes)	-80% total points (at end)
Somewhat likely (The ability of the natural enemy to prevent the establishment of this species in introduced ranges or limiting populations of this species in native ranges is suggested in the literature OR this natural enemy has limited distribution in the Great Lakes)	-60% total points (at end)
Somewhat unlikely (There are few cases reported of such a natural enemy preventing the establishment of this species in introduced ranges or limiting populations of this species in native ranges OR this natural enemy has low abundance in the Great Lakes)	-10% total points (at end)
Unlikely (Such a natural enemy is particularly rare or is not present in the Great Lakes)	0
Unknown	U

	0

- *Natural predators are abundant in the Great Lakes, but there is no indication in the literature that they will limit* L. auritus *establishment*
- *Studies have suggested that gape-limited piscivores (e.g. largemouth bass) may constrain prey selectivity. This suggests that all sizes of shallow-bodied prey fish are vulnerable to piscivory, whereas predation on deep-bodied fish like,* L. auritus*, will be concentrated on smaller juveniles (Hambright 1991).*

PROPAGULE PRESSURE

On average, how large and frequent are inoculations (introduction events) from the potential vectors identified in Section A for this species? (What is the total number of individuals introduced?)

Frequent, large inocula	9
Frequent, moderate inocula	6
Frequent, small inocula OR infrequent, large inocula	3
Infrequent, small or moderate inocula	0
Unknown	U
	U

- *This would depend on the frequency of stocking events, which is unknown.*
- *The most likely pathways for* Lepomis auritus *to enter the Great Lakes would be via dispersal or unauthorized intentional release.*

HISTORY OF INVASION AND SPREAD

How extensively has this species established reproducing populations in areas outside its native range as a direct or indirect result of human activities?

Very extensively (many invasive populations of this species have been reported in areas widely distributed from the native range)	9
Extensively (some invasive populations of this species have been reported in areas widely distributed from the native range)	6
Somewhat extensively (few invasive populations of this species have been reported in areas widely distributed from the native range OR all invasive populations are in close proximity to each other)	3
Not extensively (no invasive populations of this species have been reported)	0
Unknown	U
	7

- Lepomis auritus *has expanded its range westward due to stocking. Nonindigenous occurrences have been noted in 15 states including recent occurrences in Ohio and Pennsylvania (Fuller et al. 1999).*

How rapidly has this species spread by natural means or by human activities once introduced to other locations?

Rapidly (This species has a history of rapid spread in introduced ranges)	9
Somewhat rapidly (This species has a history of moderately rapid spread in introduced ranges)	6
Somewhat slowly (This species has a history of moderately slow spread in its introduced ranges)	3

Slowly (This species has a history of slow to no spread in its introduced ranges)	0
Unknown	U
	2

- Lepomis auritus *does not move far except during spawning (Etnier & Starnes 1993).*
- *Rate of spread is likely dependent on stocking frequency, which might explain the extent of its non-native range.*
- *The non-native range includes Texas, Oklahoma, Louisiana, Arkansas, Tennessee, Kentucky, West Virginia, the Coosa and Tennessee drainages in Georgia, several drainages in Alabama, the northern Adirondack Mountains in New York, parts of Virginia, parts of North Carolina, and the Susquehanna drainage in south central Pennsylvania (Fuller et al. 1999).*

Are there any existing control measures in the Great Lakes set to prevent the establishment and/or spread of this species?

Yes, and they are likely to prevent establishment or spread of the species. (There are no reported cases of this species adapting or avoiding current measures. These measures are highly effective in preventing the establishment and spread of this species)	-90% total points (at end)
Yes, and they are moderately likely to prevent establishment or spread of the species. (There are few reported cases of this species adapting or avoiding current measures used to control its establishment and spread)	-50% total points (at end)
Yes, but they are unlikely to prevent establishment or spread of the species. (There are many reported cases of this species adapting or avoiding current measures used to control its establishment and spread)	-20% total points (at end)
No control methods have been set to prevent the establishment and/or spread of this species	0
Unknown	U
	0

Establishment Potential Scorecard				
Points	**Probability for Establishment**	Total Points (pre-adjustment)		**95**
>100	High	**Adjustments**		
		Critical species	A (1- 0%)	**95**
51-99	Moderate	Natural enemy	B (1- 0 %)	**95**
		Control measures	C (1- 0%)	
0-50	Low	**Probability for Establishment**		**Moderate**
# of questions answered as “unable to determine”	**Confidence Level**			
0-1	High	Total # of questions unknown		1
2-5	Moderate			
6-9	Low	Confidence Level		High
>9	Very low			

Qualitative Statements for GLANSIS Fact Sheet:

Lepomis auritus has a high probability of establishment if introduced to the Great Lakes (Confidence level: High).

Section C: Potential for Impact

IMPACT POTENTIAL RESULTS

Environmental: Moderate
Socio-Economic: Low
Beneficial: Moderate

POTENTIAL ENVIRONMENTAL IMPACT

Does the species pose some hazard or threat to the health of native species (e.g., it magnifies toxin levels, is poisonous, a virus, bacteria, parasite, or a vector of one)? √

Yes, and it has resulted in the reduction or extinction of one or more native species populations, affects multiple species, or is a reportable disease	6
Yes, but negative consequences have been small (e.g., limited number of infected individuals, limited pathogen transmissibility, mild effects on populations and ecosystems) AND/OR It has significantly affected similar species in past invasions outside of the Great Lakes	1
Not significantly	0 √
Unknown	U

- Lepomis auritus *is susceptible to parasites that infect other freshwater fish like the white sucker (*Catostomus commerson*i) and other* Lepomis spp. *(Bauer & Whipps 2013; Moravec et al. 2008; Anderson et al. 2015).*
- Lepomis auritus *is a viable host for the nematode* Philometroides wellborni*, which can also infect* L. macrochirus*,* L. microlophus*, and* L. gulosus *(Moravec et al. 2008).*
- *Bluegill and redbreast sunfish in the Bull and Upatoi Creeks watershed in Muskogee County, GA were found to share 10 of the 12 parasitic helminths (Anderson et al. 2015).*
- *Despite being another host for freshwater parasites, there is no indication of any potential impacts related to the capacity of* L. auritus *to carry parasites.*

Does it out-compete native species for available resources (e.g., habitat, food, nutrients, light)?

Yes, and it has resulted in significant adverse effects (e.g., critical reduction, extinction, behavioral changes) on one or more native species populations	6
Yes, and it has caused some noticeable stress to or decline of at least one native species population	1 √
Not significantly	0
Unknown	U

- *Circumstantial evidence indicates that redbreast sunfish are displacing native longear sunfish in eastern Tennessee (Etnier & Starnes 1993).*

Does it alter predator-prey relationships?

Yes, and it has resulted in significant adverse effects (e.g., added pressure to threatened/endangered species, significant reduction or extinction of any native species populations, creation of a dead end or any other significant alteration in the food web)	6
Yes, and it has resulted in some noticeable stress to or decline of at least one native species population	1 √

AND/OR Yes, and it has resulted in some alteration of the food web structure or processes, the effects of which have not been widespread or severe	
Not significantly	0
Unknown	U

- *Circumstantial evidence indicates that redbreast sunfish are displacing native longear sunfish in eastern Tennessee (Etnier & Starnes 1993).*

Has it affected any native populations genetically (e.g., through hybridization, selective pressure, introgression)?

Yes, and it has caused a loss or alteration of genes which may be irreversible or has led to the decline or extinction of one or more native species	6
Yes, some genetic effects have been observed, but consequences have been limited to the individual level AND/OR It has genetically affected the same or similar species in past invasions outside of the Great Lakes	1 √
Not significantly	0
Unknown	U

- *In Tennessee,* L. auritus *hybridizes occasionally with* L. macrochirus *(Etnier & Starnes 1993).*
- Lepomis auritus *is known to be able to hybridize with:* L. macrochirus*, bluegill;* L. gulosus*, warmouth;* L. cyanellus*, green sunfish;* L. gibbosus*, pumpkinseed;* L. microlophus*, redear sunfish; and* Stizostedion vitreum*, walleye (Schwartz 1981).*

Does it negatively affect water quality (e.g., increased turbidity or clarity, altered nutrient, oxygen, or other chemical levels/cycles)?

Yes, and it has had a widespread, long term, or severe negative effect on water quality AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected water quality to some extent, but the alterations and resulting adverse effects have been mild AND/OR It has significantly affected water quality in past invasions outside of the Great Lakes	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Does it alter the physical ecosystem in some way (e.g., facilitated erosion/siltation, altered hydrology, altered macrophyte/phytoplankton communities, changes to substrate (physical or chemical))?

Yes, and it has had a widespread, long term, or severe negative effect on the physical ecosystem AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected the physical ecosystem to some extent, but the alterations and resulting adverse effects have been mild AND/OR It has significantly altered physical ecosystems in past invasions outside of the Great Lakes	1
Not significantly	0 √

Unknown	U

Environmental Impact Total	**3**
Total Unknowns (U)	**0**

SOCIO-ECONOMIC IMPACT

Does the species pose some hazard or threat to human health (e.g., it magnifies toxin levels, is poisonous, a virus, bacteria, parasite, or a vector of one).

Yes, significant effects on human health have already been observed	6
Yes, but negative consequences have not been widespread, long lasting, or severe AND/OR It has significantly affected human health in past invasions outside of the Great Lakes	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Does it cause damage to infrastructure (such as water intakes, pipes, or any other industrial or recreational infrastructure)?

Yes, it is known to cause significant damage	6
Yes, but the costs have been small and are largely reparable or preventable AND/OR It has a history of causing significant infrastructural damage in past invasions outside of the Great Lakes	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Does it negatively affect water quality?

Yes, it has significantly affected water quality, and is costly or difficult to reverse	6
Yes, but the effects are negligible and/or easily reversed AND/OR It has a history of significantly affecting water quality in past invasions outside of the Great Lakes	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Does it harm any markets or economic sectors (e.g., commercial fisheries, aquaculture, agriculture)?

Yes, it has caused significant damage to one or more markets or economic sectors	6
Yes, some damage to markets or sectors has been observed, but negative consequences have been small AND/OR It has a history of harming markets or economic sectors in past invasions outside of the Great Lakes	1
Not significantly	0 √

Unknown	U

- *Not reported.*

Does it inhibit recreational activities and/or associated tourism (e.g., through frequent water closures, equipment damage, decline of recreational species)?

Yes, it has caused widespread, frequent, or otherwise expensive inhibition of recreation and tourism	6
Yes, but negative consequences have been small	1
Not significantly	0 √
Unknown	U

- L. auritus *may compete with native panfish, which are popular recreational sportfishes, but no significant economic damage to recreational fishing has been reported.*

Does it diminish the perceived aesthetic or natural value of the areas it inhabits?

Yes, the species has received significant attention from the media/public, significantly diminished the natural or cultural character of the area, or significantly reduced the area's value for future generations	6
Yes, but negative consequences have been small	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Socio-Economic Impact Total	**0**
Total Unknowns (U)	**0**

BENEFICIAL EFFECT

Does it act as a biological control agent for aquatic weeds or other harmful nonindigenous organisms?

Yes, it has succeeded significantly as a control agent	6
Yes, it has had some success as a control agent, but may be inconsistent or lack a desired level of effectiveness	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Is it commercially valuable (e.g., for fisheries, aquaculture, agriculture, bait, ornamental trade)?

Yes, it is economically important to at least one of these industries	6
Yes, but its economic contribution is small	1 √
Not significantly	0
Unknown	U

- *Sunfish (*Lepomis spp.*) are popular as food fish, research specimens, recreational sport fishes, and forage fishes for other popular sportfishes such as largemouth bass (*Micropterus salmoides*) (Morris & Mischke 2003).*
- *Hybrid sunfish are popular aquaculture specimens because of their broad appeal to different markets, vigor (higher growth rates), higher acceptance of artificial feeds, reduced reproductive capacity, greater*

tolerance to cooler water and poor environmental conditions, and high vulnerability to angling (Morris et al. 2002).
- *Native* Lepomis spp. *are abundant and hybridization between bluegill and green sunfish, and bluegill and redear sunfish are the most common (Morris et al. 2002).*

Is it recreationally valuable (e.g., for sport or leisurely fishing, as a pet, or for any other personal activity)?

Yes, it is commonly employed recreationally and has some perceived value for local communities and/or tourism	6
Yes, it is sometimes employed recreationally, but adds little value to local communities or tourism	1 √
Not significantly	0
Unknown	U

- *More than half of the sport fish harvest in Illinois consists of fishes from* Lepomis *or* Pomoxis *genera (Morris & Mischke 2003)*

Does the species have some medicinal or research value (outside of research geared towards its control)?

Yes, it has significant medicinal or research value	6
It has some medicinal or research value, but is not of high priority OR It is potentially important to medicine or research and is currently being or scheduled to be studied	1 √
Not significantly	0
Unknown	U

- *Redbreast sunfish and other* Lepomis spp. *have been used in ecotoxicology research (Theodorakis et al. 2006; Morris et al. 2002).*

Does the species remove toxins or pollutants from the water or otherwise increase water quality?

Yes, it reduces water treatment costs or has a significant positive impact for the health of humans and/or native species	6
Yes, but positive impact for humans or native species is considered negligible	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Does the species have a positive ecological impact outside of biological control (e.g., increases the growth or reproduction rates of other species, fills an important gap in the food web, supports the survival of a species which is threatened, endangered species, or commercially valuable)?

Yes, it significantly contributes to the ecosystem in one or more of these ways	6
Yes, it provides some positive contribution to the ecosystem, but is not vital	1 √
Not significantly	0
Unknown	U

- Lepomis auritus *is an important game fish and a keystone species in many rivers across the southeastern U.S.A. and often supports important fisheries (Morris & Mischke 2003; Sammons and MacEina 2009)*

Beneficial Effect Total	**4**
Total Unknowns (U)	**0**

Scientific Name: *Paraleptastacus spinicaudus triseta*

Common Name: Oarsman, Harpacticoid Copepod

Section B: Potential for Establishment

ESTABLISHMENT POTENTIAL RESULTS

Comments: *Paraleptastacus spinicaudus triseta* has a moderate probability of establishment if introduced to the Great Lakes (Confidence level: Moderate).

The native and introduced ranges of *Paraleptastacus spinicaudus triseta* have similar climatic and abiotic conditions as the Great Lakes (Grigorovich et al. 2003, Reid and Orlova 2002, US EPA 2008). *Paraleptastacus spinicaudus* primarily inhabits sand and sediments of coastal marine and estuarine environments, but it has been introduced to inland fresh waters before (Alexandrov et al. 2007); there are habitats available for this species in the Great Lakes region. *Paraleptastacus spinicaudus* has a moderately broad physiological tolerance. This species can tolerate a somewhat wide range of salinity, water temperatures, and oxygen levels. As a coastal marine and estuarine organism, increased salinization and warmer water temperatures due to climate change may make the Great Lakes more habitable for *P. spinicaudus*.

Paraleptastacus spinicaudus feeds on bacteria (Cnudde 2013), so it is likely that this species will find an appropriate food source in the Great Lakes. Little is known about the competitive abilities and fecundity of *P. spinicaudus*.

This species has established extensively outside its native range and occurs through much of Europe and on the coasts of British Columbia. The rate of its spread is unknown.

INVASIVE BIOLOGICAL/ECOLOGICAL ATTRIBUTES

How would the physiological tolerance of this species (survival in varying temperature, salinity, oxygen, and nutrient levels) be described?

This species has broad physiological tolerance. It has been reported to survive in wide ranges of temperature (0°C-30°C), salinity (0-16 parts per thousand), oxygen (0-saturated), AND nutrient (oligotrophic-eutrophic) levels.	9
This species has somewhat broad physiological tolerance. It has been reported to survive in a wide range of temperature, salinity, oxygen, OR nutrient levels. Tolerance to other factors is narrower, unknown, or unreported.	6
This species has narrow physiological tolerance. It has been reported to survive in limited ranges of temperature, salinity, oxygen, and nutrient levels.	3
Unknown	U
	6

- *The native and introduced ranges of Paraleptastacus spinicaudus triseta have similar climatic and abiotic conditions as the Great Lakes (Grigorovich et al. 2003, Reid and Orlova 2002, US EPA 2008).*
- *Paraleptastacus spinicaudus has a moderately broad physiological tolerance. This species can tolerate a somewhat wide range of salinity, water temperatures, and oxygen levels. As a coastal marine and estuarine organism, increased salinization and warmer water temperatures due to climate change may make the Great Lakes more habitable for P. spinicaudus.*

How likely is it that any life stage of this species can overwinter in the Great Lakes (survive extremely low levels of oxygen, light, and temperature)?

Likely (This species is able to tolerate temperatures under 5°C and oxygen levels ≤0.5 mg/L)	9
Somewhat likely (This species is able to tolerate some of these conditions OR has adapted behaviorally to avoid them)	6
Somewhat unlikely (This species is able to tolerate conditions close to those specified, but it is not known as an overwintering species)	3
Unlikely	0
Unknown	U
	8

- *Due to the climatic similarities between the Great Lakes and Ponto-Caspian regions (Reid and Orlova 2002) this species most likely endures similar overwintering conditions in its native range.*
- Paraleptastacus spinicaudus triseta *is predicted to be able to survive in the Great Lakes region (Grigorovich et al. 2003).*

If this species is a heterotroph, how would the flexibility of its diet be described?

This species is a dietary generalist with a broad, assorted, AND flexible diet.	9
This species is moderately a dietary generalist with a broad, assorted, OR flexible diet.	6
This species is a dietary specialist with a limited and inflexible diet.	3
This species is an autotroph.	0
Unknown	U
	6

- Paraleptastacus spinicaudus *feeds on bacteria (Cnudde 2013), so it is likely that this species will find an appropriate food source in the Great Lakes.*

How likely is this species to outcompete species in the Great Lakes for available resources?

Likely (This species is known to have superior competitive abilities and has a history of outcompeting other species, AND/OR available literature predicts it might outcompete native species in the Great Lakes)	9
Somewhat likely (This species is known to have superior competitive abilities, but there are few reported cases of this species outcompeting another and no predictions regarding species in the Great Lakes)	6
Somewhat unlikely (This species has average competitive abilities, and there are no reported cases of this species outcompeting another and no predictions regarding species in the Great Lakes)	3
Unlikely (This species is known as a poor competitor that thrives only in environments with low biodiversity, AND/OR available literature predicts it might be outcompeted by a species in the Great Lakes)	0
Unknown	U
	3

- *No information was found about the species' ability to outcompete native species, but as a copepod, it is unlikely to pose a major threat.*

How would the fecundity of this species be described relative to other species in the same taxonomic class?

Very high	9
High	6
Moderate	3
Low	0
Unknown	U
	U

- *Information on the fecundity of* P. spinicaudus triseta *was not found.*

How likely are this species' reproductive strategy and habits to aid establishment in new environments, particularly the Great Lakes (e.g., parthenogenesis/self-crossing, self fertility, vegetative fragmentation)?

Likely (The reproductive strategy or habits of this species are known to aid establishment in new environments, AND available literature predicts establishment in the Great Lakes based on these attributes)	9
Somewhat likely (The reproductive strategy or habits of this species are known to aid establishment in new environments, but there is no literature available regarding establishment in the Great Lakes based on these attributes)	6
Somewhat unlikely (The reproductive strategy or habits of this species could potentially aid establishment in new environments, but there is no literature available regarding establishment in the Great Lakes based on these attributes)	3
Unlikely (The reproductive strategy or habits of this species are not known to aid establishment in new environments)	0
Unknown	U
	0

- *Information on this species' reproductive strategy was not found, but it is unlikely to aid establishment.*

ENVIRONMENTAL COMPATIBILITY

How similar are the climatic conditions (e.g., air temperature, precipitation, seasonality) in the native and introduced ranges of this species to those in the Great Lakes region?

Very similar (The climatic conditions are practically identical to those of the Great Lakes region)	9
Similar (Many of the climatic conditions are similar to those of the Great Lakes region)	6
Somewhat similar (Few of the climatic conditions are similar to those of the Great Lakes region)	3
Not similar	0
Unknown	U
	8

- *Grigorovich et al. (2003) stated that conditions were similar enough to allow survival in the Great Lakes.*
- *The Great Lakes and Ponto-Caspian region are climatically compatible, which is one of the attributing factors to the success of Ponto-Caspian species in the Great Lakes (Reid and Orlova 2002).*

How similar are other abiotic factors that are relevant to the establishment success of this species (e.g., pollution, water temperature, salinity, pH, nutrient levels, currents) in the native and introduced ranges to those in the Great Lakes?

Very similar (These factors are practically identical to those of the Great Lakes region)	9
Similar (Many of these factors are similar to those of the Great Lakes region)	6
Somewhat similar (Few of these factors are similar to those of the Great Lakes region)	3
Not similar	0
Unknown	U
	8

- *Abiotic factors and climatic conditions in the Ponto-Caspian region are quite similar to the Great Lakes, making the region compatible (Grigorovich et al. 2003, Reid and Orlova 2002).*
- *Great Lakes underwent similar anthropogenic eutrophication as the Ponto-Caspian region (Reid and Orlova 2002). Surface water temperature is similar between the Great Lakes and Ponto-Caspian seas (Grigorovich et al. 2003, Reid and Orlova 2002, USEPA 2008).*

How abundant are habitats suitable for the survival, development, and reproduction of this species in the Great Lakes area (e.g., those with adequate depth, substrate, light, temperature, oxygen)?

Abundant (Suitable habitats can be easily found and readily available)	9
Somewhat abundant (Suitable habitats can be easily found but are in high demand by species already present)	6
Somewhat scarce (Suitable habitats can be found occasionally)	3
Scarce (Suitable habitats are rarely found)	0
Unknown	U
	8

- Paraleptastacus spinicaudus *primarily inhabits sand and sediments of coastal marine and estuarine environments, but it has been introduced to inland fresh waters before (Alexandrov et al. 2007); there are habitats available for this species in the Great Lakes region.*

How likely is this species to adapt to or to benefit from the predicted effects of climate change on the Great Lakes freshwater ecosystems (e.g., warmer water temperatures, shorter duration of ice cover, altered streamflow patterns, increased salinization)?

Likely (Most of the effects described above make the Great Lakes a better environment for establishment and spread of this species OR this species could easily adapt to these changes due to its wide environmental tolerances)	9
Somewhat likely (Several of the effects described above could make the Great Lakes a better environment for establishment and spread of this species)	6
Somewhat unlikely (Few of the effects described above would make the Great Lakes a better environment for establishment and spread of this species)	3
Unlikely (Most of the effects described above would have no effect on establishment and spread of this species or would make the environment of the Great Lakes unsuitable)	0
Unknown	U
	8

- *As a coastal marine and estuarine organism, increased salinization and warmer water temperatures due to climate change may make the Great Lakes more habitable for* P. spinicaudus.

How likely is this species to find an appropriate food source (prey or vegetation in the case of predators and herbivores, or sufficient light or nutrients in the case of autotrophs)?

Likely (All possible nutritive food items—including species in the Great Lakes that may be considered potential food items—are highly abundant and/or easily found)	9
Somewhat likely (Some nutritive food items—including species in the Great Lakes that may be considered potential food items—are abundant and/or search time is low to moderate)	6
Somewhat unlikely (Few nutritive food items—including species in the Great Lakes that may be considered potential food items—are abundant and/or search time is moderate to high)	3
Unlikely (All possible nutritive food items—including species in the Great Lakes that may be considered potential food items—are relatively scarce and/or search time is high)	0
Unknown	U
	U

- *Information on this subject is unknown.*

Does this species require another species for critical stages in its life cycle such as growth (e.g., root symbionts), reproduction (e.g., pollinators, egg incubators), spread (e.g., seed dispersers), or transmission (e.g., vectors)?

Yes, and the critical species (or one that may provide a similar function) is common in the Great Lakes and can be easily found in environments suitable for the species being assessed; OR, No, there is no critical species required by the species being assessed	9
Yes, and the critical species (or one that may provide a similar function) is moderately abundant and relatively easily found in particular parts of the Great Lakes	6
Yes, and the critical species (or one that may provide a similar function) is relatively rare in the Great Lakes AND/OR can only be found occasionally in environments suitable for the species being assessed	3
Yes, and the critical species (or one that may provide a similar function) is not present in the Great Lakes but is likely to be introduced	0
Yes, but the critical species (or one that may provide a similar function) is not present in the Great Lakes and is not likely to be introduced	-80% total points (at end)
Unknown	U
	9

- *No information on this subject could be found; from that it can be inferred that this species does not require other critical species.*

How likely is the establishment of this species to be aided by the establishment and spread of another species already in the Great Lakes?

Likely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established and spread in the Great Lakes, AND available literature predicts this previous invader might promote	9

the establishment of this species, AND/OR there have been cases reported of this species aiding the establishment of this species in other areas)	
Somewhat likely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established and spread in the Great Lakes)	6
Somewhat unlikely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established in the Great Lakes BUT it is still confined to a small area of the Lakes and the likelihood of encounter with this species assessed is hard to predict)	3
Unlikely (A non-indigenous species to the Great Lakes that facilitates the development of this species has not been established in the Great Lakes)	0
Unknown	U
	0

- *No information was found on this subject. It is unlikely that the establishment of this species will be aided by another species.*

How likely is establishment of this species to be prevented by the herbivory, predation, or parasitism of a natural enemy this is already present in the Great Lakes and may preferentially target this species?

Likely (The ability of the natural enemy to prevent the establishment of this species in introduced ranges or limiting populations of this species in native ranges is well documented in the literature AND this natural enemy is abundant and widespread in the Great Lakes)	-80% total points (at end)
Somewhat likely (The ability of the natural enemy to prevent the establishment of this species in introduced ranges or limiting populations of this species in native ranges is suggested in the literature OR this natural enemy has limited distribution in the Great Lakes)	-60% total points (at end)
Somewhat unlikely (There are few cases reported of such a natural enemy preventing the establishment of this species in introduced ranges or limiting populations of this species in native ranges OR this natural enemy has low abundance in the Great Lakes)	-10% total points (at end)
Unlikely (Such a natural enemy is particularly rare or is not present in the Great Lakes)	0
Unknown	U
	0

- *No natural predators of this species were found.*

PROPAGULE PRESSURE

On average, how large and frequent are inoculations (introduction events) from the potential vectors identified in Section A for this species? (What is the total number of individuals introduced?)

Frequent, large inocula	9
Frequent, moderate inocula	6
Frequent, small inocula OR infrequent, large inocula	3
Infrequent, small or moderate inocula	0
Unknown	U
	U

- *The size and frequency of potential introductions of this species are unknown.*

HISTORY OF INVASION AND SPREAD

How extensively has this species established reproducing populations in areas outside its native range as a direct or indirect result of human activities?

Very extensively (many invasive populations of this species have been reported in areas widely distributed from the native range)	9
Extensively (some invasive populations of this species have been reported in areas widely distributed from the native range)	6
Somewhat extensively (few invasive populations of this species have been reported in areas widely distributed from the native range OR all invasive populations are in close proximity to each other)	3
Not extensively (no invasive populations of this species have been reported)	0
Unknown	U
	6

- *This species has established extensively outside its native range and occurs through much of Europe and on the coasts of British Columbia. The rate of its spread is unknown.*

How rapidly has this species spread by natural means or by human activities once introduced to other locations?

Rapidly (This species has a history of rapid spread in introduced ranges)	9
Somewhat rapidly (This species has a history of moderately rapid spread in introduced ranges)	6
Somewhat slowly (This species has a history of moderately slow spread in its introduced ranges)	3
Slowly (This species has a history of slow to no spread in its introduced ranges)	0
Unknown	U
	U

- *No information has been found regarding spread via human activities.*

Are there any existing control measures in the Great Lakes set to prevent the establishment and/or spread of this species?

Yes, and they are likely to prevent establishment or spread of the species. (There are no reported cases of this species adapting or avoiding current measures. These measures are highly effective in preventing the establishment and spread of this species)	-90% total points (at end)
Yes, and they are moderately likely to prevent establishment or spread of the species. (There are few reported cases of this species adapting or avoiding current measures used to control its establishment and spread)	-50% total points (at end)
Yes, but they are unlikely to prevent establishment or spread of the species. (There are many reported cases of this species adapting or avoiding current measures used to control its establishment and spread)	-20% total points (at end)
No control methods have been set to prevent the establishment and/or spread of this species	0
Unknown	U

0

- *There are no control measures for this species.*

Establishment Potential Scorecard				
Points	**Probability for Establishment**	Total Points (pre-adjustment)		**70**
>100	High	Adjustments		
		Critical species	70(1- __0_ %)	**70**
51-99	Moderate	Natural enemy	70 (1- _0_ %)	**70**
		Control measures	70 (1- __0 %)	**70**
0-50	Low	**Probability for Establishment**		Moderate
# of questions answered as "unable to determine"	**Confidence Level**			
0-1	High	Total # of questions unknown		4
2-5	Moderate			
6-9	Low	Confidence Level		Moderate
>9	Very low			

Scientific Name: *Paraleptastacus wilsonii*

Common Name: Harpacticoid copepod

Section A: Potential for Introduction

INTRODUCTION POTENTIAL RESULTS

Dispersal: Low
Hitchhiking/Fouling: Unknown
Unauthorized intentional release: Low
Stocking/Planting/Escape from recreational culture: Low
Escape from commercial culture: Low
Shipping: High

Comments: Little information available about this species specifically

POTENTIAL INTRODUCTION VIA DISPERSAL

Does this species occur near waters (natural or artificial) connected to the Great Lakes basin* (e.g., streams, ponds, canals, or wetlands)?
*(*Great Lakes basin = below the ordinary high water mark, including connecting channels, wetlands, and waters ordinarily attached to the Lakes)*

Yes, this species occurs near waters connected to the Great Lakes basin and is mobile or able to be transported by wind or water.	100
No, this species does not occur near waters connected to the Great Lakes basin and/or is not mobile or able to be transported by wind or water.	0 √
Unknown	U

- *Native to Atlantic Coast, not mobile enough to disperse into the Great Lakes*

What is the proximity of this species to the Great Lakes basin?

This species occurs in waters within 20 kilometers of the Great Lakes basin, and no barrier (e.g., electric barrier, dam) to dispersal is present.	Score x 1
This species occurs in waters within 20 kilometers of the Great Lakes basin, but dispersal to the basin is blocked; or, this species occurs in waters within 100 kilometers of the Great Lakes basin, and no barrier to dispersal is present.	Score x 0.75
This species occurs in waters within 100 kilometers of the Great Lakes basin, but dispersal to the basin is blocked.	Score x 0.5
This species occurs in waters >100 kilometers from the Great Lakes basin.	Score x 0.25√
Unknown	U

POTENTIAL INTRODUCTION VIA HITCHHIKING/FOULING

Is this species likely to attach to or be otherwise transported by, or along with, recreational gear, boats, trailers, fauna (e.g., waterfowl, fish, insects), flora (e.g., aquatic plants), or other objects (e.g., packing materials), including as parasites or pathogens, entering the Great Lakes basin?

Yes, this species is known to be able to adhere to certain surfaces or to be transported by other organisms entering the Great Lakes basin.	100
No, this species is not known to be able to adhere to certain surfaces or to be transported by other organisms entering the Great Lakes basin.	0
Unknown	U√

- *No reports of fouling. Could possibly be transported with sediment or water on recreational gear being transported into the Great Lakes*

What is the proximity of this species to the Great Lakes basin?

This species occurs in waters within 20 km of the Great Lakes basin.	Score x 1
This species occurs in waters within 100 km of the Great Lakes basin.	Score x 0.5
This species occurs in waters >100 km from the Great Lakes basin.	Score x 0.1
Unknown	U

POTENTIAL INTRODUCTION VIA UNAUTHORIZED INTENTIONAL RELEASE

Is this species sold at aquarium/pet/garden stores ("brick & mortar" or online), catalogs, biological supply companies, or live markets (e.g., purchased for human consumption, bait, ornamental, ethical, educational, or cultural reasons) and as a result may be released into the Great Lakes basin?

Yes, this species is available for purchase.	100
No, this species this species is rarely/never sold.	0 √
Unknown	U

- *No reports of this species being for sale*

How easily is this species obtained within the Great Lakes region (states/provinces)?

This species is widely popular, frequently sold, and/or easily obtained within the Great Lakes region.	Score x 1
This species is widely popular, and although trade, sale, and/or possession of this species is prohibited, it is frequently sold on the black market within the Great Lakes region.	Score x 0.5
This species is not very popular or is not easily obtained within the Great Lakes region.	Score x 0.1
Unknown	U

POTENTIAL INTRODUCTION VIA STOCKING/PLANTING OR ESCAPE FROM RECREATIONAL CULTURE

Is this species being stocked/planted to natural waters or outdoor water gardens around the Great Lakes region?

Yes, this species is being stocked/planted and/or has ornamental, cultural, medicinal, environmental (e.g., biocontrol, erosion control), scientific, or recreational value in the Great Lakes region.	100

No, this species cannot be stocked/planted or there is not enough interest to do so in the Great Lakes region.	0 √
Unknown	U

- *Not reported.*

What is the nature and proximity of this activity to the Great Lakes basin?

This activity is authorized and/or is occurring directly in the Great Lakes.	Score x 1
This activity is occurring in Great Lakes tributaries or connecting waters, or within 20 km of the Great Lakes basin.	Score x 0.75
This activity is likely to occur within 20 km of the Great Lakes basin because of its popularity/value and there are no widespread regulations against stocking/planting.	Score x 0.5
This activity is occurring in waters >20 km from the Great Lakes basin, or despite federal or state regulations in more than half the basin (> 5 states/provinces), this activity may occur within 20 km of the basin because of the species' popularity/value.	Score x 0.25
Unknown	U

POTENTIAL INTRODUCTION VIA ESCAPE FROM COMMERCIAL CULTURE

Is this species known to be commercially cultured in or transported through the Great Lakes region?

Yes, this species is being commercially cultured in or transported through the Great Lakes region.	100
No, this species is not commercially cultured in or transported through the Great Lakes region.	0 √
Unknown	U

- *Not commercially cultured*

What is the nature and proximity of this activity to the Great Lakes basin?

This activity is unregulated or minimally regulated and is occurring directly in the Great Lakes.	Score x 1
This activity is unregulated or minimally regulated and is occurring in Great Lakes tributaries or connecting waters, or within 20 km of the Great Lakes basin.	Score x 0.75
This activity is strictly regulated but occurs directly in the Great Lakes, and/or this activity involves transport of live organisms on/across the Great Lakes.	Score x 0.5
This activity is strictly regulated but occurs in Great Lakes tributaries, connecting waters, or within 20 km of the Great Lakes basin, and/or this activity involves transport of live organisms within 20 km of the Great Lakes basin.	Score x 0.25
This activity occurs >20 km from the Great Lakes basin and typically does not involve transport of live organisms closer to the basin.	Score x 0.1
Unknown	U

POTENTIAL INTRODUCTION VIA SHIPPING

Is this species capable of surviving adverse environments (i.e. extreme temperatures, absence of light, low oxygen levels) and partial-to-complete ballast water exchange/BWE (e.g., is euryhaline, buries in sediment, produces resistant resting stages, has other attributes or behaviors facilitating survival under these conditions)?

Yes, this species is able to survive in ballast tank environments for weeks at a time and may be suspended in ballast water.	100√
Yes, this species is able to survive in ballast tank environments for weeks at a time and is able to survive BWE by burial in ballast sediment.	80
Yes, this species is able to survive in ballast tank environments for weeks at a time and may be suspended in ballast water, but this species is not able to survive BWE.	60
No, but this species is capable of fouling transoceanic ship structures (e.g., hull, chains, chain locker) while in its active or resting stage.	40
No, this species is not able to survive adverse environments, does not foul transoceanic ship structures, or is unlikely to be taken up with ballast.	0
Unknown	U

- *Native to Atlantic Ocean, can tolerate high salinities.*
- *Inhabits interstitial spaces in aquatic sediment (Light 2007).*

Does this species occur in waters from which shipping traffic to the Great Lakes originates?

Yes, and this species has been observed in ballast of or fouling ships entering the Great Lakes.	Score x 1√
Yes, and this species has been observed in ports that have direct trade connections with the Great Lakes (e.g., Baltic Sea).	Score x 0. 5
Yes, but this species has neither been observed in ballast/fouling ships entering the Great Lakes nor in ports in direct trade with the Great Lakes.	Score x 0.1
No, this species does not occur in waters from which shipping traffic to the Great Lakes originates.	Score x 0
Unknown	U

- *Already found in ballast water in Great Lakes (Cangelosi et al., 2018)*

Vector Potential Scorecard				
Vector	**Raw Points Scored**	**Proximity Multiplier**	**Total Points Scored**	**Probability of Introduction**
Dispersal: Natural dispersal through waterbody connections or wind	**0**	x 0.25	**0**	Low
Hitchhiking/Fouling: Transport via recreational gear, boats, trailers, mobile fauna, stocked/planted organisms, packing materials, host organisms, etc.	**U**	x -	**U**	Unknown
Release: Unauthorized intentional release of organisms in trade (e.g., aquaria, water gardens, live food)	**0**	x 0	**0**	High
Stocking/Planting/Escape from recreational culture: Intentional authorized or unauthorized introduction to natural waters in the Great Lakes OR Accidental introduction to Great Lakes by escape from recreational culture (e.g., water gardens)	**0**	X 0	**0**	Low

Escape from commercial culture: Accidental introduction to Great Lakes by escape from commercial culture (e.g., aquaculture)	**0**	x 0	**0**	Low
Trans-oceanic shipping: Ballast (BOB) or no-ballast-on-board (NOBOB) water exchange/discharge, sediment discharge, hull fouling	**100**	x 1	**100**	High

Total Unknowns (U)	1	**Confidence Level**	Low

Section B: Potential for Establishment

ESTABLISHMENT POTENTIAL RESULTS

***Paraleptastacus wilsonii* has a Moderate probability of establishment if introduced to the Great Lakes (Confidence level: Moderate).**

INVASIVE BIOLOGICAL/ECOLOGICAL ATTRIBUTES

How would the physiological tolerance of this species (survival in varying temperature, salinity, oxygen, and nutrient levels) be described?

This species has broad physiological tolerance. It has been reported to survive in wide ranges of temperature (0°C-30°C), salinity (0-16 parts per thousand), oxygen (0-saturated), AND nutrient (oligotrophic-eutrophic) levels.	9
This species has somewhat broad physiological tolerance. It has been reported to survive in a wide range of temperature, salinity, oxygen, OR nutrient levels. Tolerance to other factors is narrower, unknown, or unreported.	6 √
This species has narrow physiological tolerance. It has been reported to survive in limited ranges of temperature, salinity, oxygen, and nutrient levels.	3
Unknown	U
	6

- *Native to atlantic coast, found in estuaries (Wilson, 1932). Tolerant to broad range of temperatures and salinities.*
- *Unreported tolerance to varied oxygen levels.*

How likely is it that any life stage of this species can overwinter in the Great Lakes (survive extremely low levels of oxygen, light, and temperature)?

Likely (This species is able to tolerate temperatures under 5°C and oxygen levels ≤0.5 mg/L)	9√
Somewhat likely (This species is able to tolerate some of these conditions OR has adapted behaviorally to avoid them)	6
Somewhat unlikely (This species is able to tolerate conditions close to those specified, but it is not known as an overwintering species)	3

Unlikely	0
Unknown	U
	9

- *Native range experiences long cold winters.*

If this species is a heterotroph, how would the flexibility of its diet be described?

This species is a dietary generalist with a broad, assorted, AND flexible diet.	9 √
This species is moderately a dietary generalist with a broad, assorted, OR flexible diet.	6
This species is a dietary specialist with a limited and inflexible diet.	3
This species is an autotroph.	0
Unknown	U
	9

- *Characterized by broad diet (Cnudde, 2013).*

How likely is this species to outcompete species in the Great Lakes for available resources?

Likely (This species is known to have superior competitive abilities and has a history of outcompeting other species, AND/OR available literature predicts it might outcompete native species in the Great Lakes)	9
Somewhat likely (This species is known to have superior competitive abilities, but there are few reported cases of this species outcompeting another and no predictions regarding species in the Great Lakes)	6
Somewhat unlikely (This species has average competitive abilities, and there are no reported cases of this species outcompeting another and no predictions regarding species in the Great Lakes)	3√
Unlikely (This species is known as a poor competitor that thrives only in environments with low biodiversity, AND/OR available literature predicts it might be outcompeted by a species in the Great Lakes)	0
Unknown	U
	3

- *Broad diet and physical tolerances, however there are no reports of this species outcompeting others.*

How would the fecundity of this species be described relative to other species in the same taxonomic class?

Very high	9
High	6
Moderate	3
Low	0
Unknown	U√
	U

- *Unknown.*

How likely are this species' reproductive strategy and habits to aid establishment in new environments, particularly the Great Lakes (e.g., parthenogenesis/self-crossing, self fertility, vegetative fragmentation)?

Likely (The reproductive strategy or habits of this species are known to aid establishment in new environments, AND available literature predicts establishment in the Great Lakes based on these attributes)	9
Somewhat likely (The reproductive strategy or habits of this species are known to aid establishment in new environments, but there is no literature available regarding establishment in the Great Lakes based on these attributes)	6
Somewhat unlikely (The reproductive strategy or habits of this species could potentially aid establishment in new environments, but there is no literature available regarding establishment in the Great Lakes based on these attributes)	3
Unlikely (The reproductive strategy or habits of this species are not known to aid establishment in new environments)	0
Unknown	U√
	U

- *Unknown.*

ENVIRONMENTAL COMPATIBILITY

How similar are the climatic conditions (e.g., air temperature, precipitation, seasonality) in the native and introduced ranges of this species to those in the Great Lakes region?

Very similar (The climatic conditions are practically identical to those of the Great Lakes region)	9
Similar (Many of the climatic conditions are similar to those of the Great Lakes region)	6 √
Somewhat similar (Few of the climatic conditions are similar to those of the Great Lakes region)	3
Not similar	0
Unknown	U
	6

- *Atlantic coast has similar climatic conditions to the Great Lakes Region.*
- *First described off the coast of Massachusetts (Wilson, 1932)*

How similar are other abiotic factors that are relevant to the establishment success of this species (e.g., pollution, water temperature, salinity, pH, nutrient levels, currents) in the native and introduced ranges to those in the Great Lakes?

Very similar (These factors are practically identical to those of the Great Lakes region)	9
Similar (Many of these factors are similar to those of the Great Lakes region)	6 √
Somewhat similar (Few of these factors are similar to those of the Great Lakes region)	3
Not similar	0
Unknown	U
	6

- *Abiotic factors are similar, except that it occupies oceans and estuaries in its native range (Cnudde, 2013).*

How abundant are habitats suitable for the survival, development, and reproduction of this species in the Great Lakes area (e.g., those with adequate depth, substrate, light, temperature, oxygen)?

Abundant (Suitable habitats can be easily found and readily available)	9 √
Somewhat abundant (Suitable habitats can be easily found but are in high demand by species already present)	6
Somewhat scarce (Suitable habitats can be found occasionally)	3
Scarce (Suitable habitats are rarely found)	0
Unknown	U
	9

- *Occupies interstitial spaces in sediment (Wilson 1932).*

How likely is this species to adapt to or to benefit from the predicted effects of climate change on the Great Lakes freshwater ecosystems (e.g., warmer water temperatures, shorter duration of ice cover, altered streamflow patterns, increased salinization)?

Likely (Most of the effects described above make the Great Lakes a better environment for establishment and spread of this species OR this species could easily adapt to these changes due to its wide environmental tolerances)	9
Somewhat likely (Several of the effects described above could make the Great Lakes a better environment for establishment and spread of this species)	6
Somewhat unlikely (Few of the effects described above would make the Great Lakes a better environment for establishment and spread of this species)	3√
Unlikely (Most of the effects described above would have no effect on establishment and spread of this species or would make the environment of the Great Lakes unsuitable)	0
Unknown	U
	3

- *May benefit from increased salinity in the Great Lakes.*

How likely is this species to find an appropriate food source (prey or vegetation in the case of predators and herbivores, or sufficient light or nutrients in the case of autotrophs)?

Likely (All possible nutritive food items—including species in the Great Lakes that may be considered potential food items—are highly abundant and/or easily found)	9 √
Somewhat likely (Some nutritive food items—including species in the Great Lakes that may be considered potential food items—are abundant and/or search time is low to moderate)	6
Somewhat unlikely (Few nutritive food items—including species in the Great Lakes that may be considered potential food items—are abundant and/or search time is moderate to high)	3
Unlikely (All possible nutritive food items—including species in the Great Lakes that may be considered potential food items—are relatively scarce and/or search time is high)	0
Unknown	U
	9

- *Broad, flexible diet (Cnudde, 2013).*

Does this species require another species for critical stages in its life cycle such as growth (e.g., root symbionts), reproduction (e.g., pollinators, egg incubators), spread (e.g., seed dispersers), or transmission (e.g., vectors)?

Yes, and the critical species (or one that may provide a similar function) is common in the Great Lakes and can be easily found in environments suitable for the species being assessed; OR, No, there is no critical species required by the species being assessed	9 √
Yes, and the critical species (or one that may provide a similar function) is moderately abundant and relatively easily found in particular parts of the Great Lakes	6
Yes, and the critical species (or one that may provide a similar function) is relatively rare in the Great Lakes AND/OR can only be found occasionally in environments suitable for the species being assessed	3
Yes, and the critical species (or one that may provide a similar function) is not present in the Great Lakes but is likely to be introduced	0
Yes, but the critical species (or one that may provide a similar function) is not present in the Great Lakes and is not likely to be introduced	-80% total points (at end)
Unknown	U
	9

- *No, this species does not require the presence of any other species to grow, reproduce, or spread.*

How likely is the establishment of this species to be aided by the establishment and spread of another species already in the Great Lakes?

Likely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established and spread in the Great Lakes, AND available literature predicts this previous invader might promote the establishment of this species, AND/OR there have been cases reported of this species aiding the establishment of this species in other areas)	9
Somewhat likely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established and spread in the Great Lakes)	6
Somewhat unlikely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established in the Great Lakes BUT it is still confined to a small area of the Lakes and the likelihood of encounter with this species assessed is hard to predict)	3
Unlikely (A non-indigenous species to the Great Lakes that facilitates the development of this species has not been established in the Great Lakes)	0 √
Unknown	U
	0

- *No species reported to aid the establishment or spread of this species.*

How likely is establishment of this species to be prevented by the herbivory, predation, or parasitism of a natural enemy this is already present in the Great Lakes and may preferentially target this species?

Likely (The ability of the natural enemy to prevent the establishment of this species in introduced ranges or limiting populations of this species in native ranges is well documented in the literature AND this natural enemy is abundant and widespread in the Great Lakes)	-80% total points (at end)
Somewhat likely (The ability of the natural enemy to prevent the establishment of this species in introduced ranges or limiting populations of this species in native ranges is suggested in the literature OR this natural enemy has limited distribution in the Great Lakes)	-60% total points (at end)
Somewhat unlikely (There are few cases reported of such a natural enemy preventing the establishment of this species in introduced ranges or limiting populations of this species in native ranges OR this natural enemy has low abundance in the Great Lakes)	-10% total points (at end)
Unlikely (Such a natural enemy is particularly rare or is not present in the Great Lakes)	0 √
Unknown	U
	0

- *No natural predators reported in Great Lakes. There are species present that eat copepods, however they are unlikely to prevent establishment entirely.*

PROPAGULE PRESSURE

On average, how large and frequent are inoculations (introduction events) from the potential vectors identified in Section A for this species? (What is the total number of individuals introduced?)

Frequent, large inocula	9
Frequent, moderate inocula	6
Frequent, small inocula OR infrequent, large inocula	3
Infrequent, small or moderate inocula	0
Unknown	U√
	U

- *Occasional aquarium releases by pet owners are the likely vector, and would not occur with great frequency or in high numbers (Souty-Grosset et al., 2006).*

HISTORY OF INVASION AND SPREAD

How extensively has this species established reproducing populations in areas outside its native range as a direct or indirect result of human activities?

Very extensively (many invasive populations of this species have been reported in areas widely distributed from the native range)	9
Extensively (some invasive populations of this species have been reported in areas widely distributed from the native range)	6
Somewhat extensively (few invasive populations of this species have been reported in areas widely distributed from the native range OR all invasive populations are in close proximity to each other)	3
Not extensively (no invasive populations of this species have been reported)	0√
Unknown	U
	0

- *No reports of spreading outside of its native range.*

How rapidly has this species spread by natural means or by human activities once introduced to other locations?

Rapidly (This species has a history of rapid spread in introduced ranges)	9
Somewhat rapidly (This species has a history of moderately rapid spread in introduced ranges)	6
Somewhat slowly (This species has a history of moderately slow spread in its introduced ranges)	3
Slowly (This species has a history of slow to no spread in its introduced ranges)	0√
Unknown	U
	0

- *Not reported.*

Are there any existing control measures in the Great Lakes set to prevent the establishment and/or spread of this species?

Yes, and they are likely to prevent establishment or spread of the species. (There are no reported cases of this species adapting or avoiding current measures. These measures are highly effective in preventing the establishment and spread of this species)	-90% total points (at end)
Yes, and they are moderately likely to prevent establishment or spread of the species. (There are few reported cases of this species adapting or avoiding current measures used to control its establishment and spread)	-50% total points (at end)
Yes, but they are unlikely to prevent establishment or spread of the species. (There are many reported cases of this species adapting or avoiding current measures used to control its establishment and spread)	-20% total points (at end) √
No control methods have been set to prevent the establishment and/or spread of this species	0
Unknown	U
	-20%

- *Ballast water regulations should prevent this species entering the Great Lakes; however, they were found in sediment from ballast tanks in a ship traveling within the Great Lakes (Cangelosi et al, 2018).*

Establishment Potential Scorecard				
Points	**Probability for Establishment**	Total Points (pre-adjustment)		**A: 69**
>100	High	Adjustments		
		Critical species	A (69- 0 %)	**B:69**
51-99	Moderate	Natural enemy	B (69- 0 %)	**C: 69**
		Control measures	C (69- 20 %)	**55.2**
0-50	Low	Probability for Establishment		Moderate
# of questions answered as “unable to determine”	**Confidence Level**			
0-1	High	Total # of questions unknown		3
2-5	Moderate			
6-9	Low	Confidence Level		Moderate
>9	Very low			

Scientific Name: *Paraleptastacus wilsoni*

Common Name: Harpacticoid copepod

Section C: Potential Organism Impact Assessment

IMPACT POTENTIAL RESULTS

Environmental: Unknown
Socio-Economic: Low
Beneficial: Low

Comments: Little information about *P. wilsoni* in particular. Much of this is based on general information about harpacticoid copepods.

POTENTIAL ENVIRONMENTAL IMPACT

Does the species pose some hazard or threat to the health of native species (e.g., it magnifies toxin levels; is poisonous; is a pathogen, parasite, or a vector of either)? √

Yes, and it has impacted threatened/endangered species, resulted in the reduction or extinction of one or more native populations, affects multiple species, or is a reportable disease	6
Yes, but negative consequences have been small (e.g., limited number of infected individuals, limited pathogen transmissibility, mild effects on populations and ecosystems)	1
Not significantly	0
Unknown	U√

- *No reports exist of threats to native species.*

Does it out-compete native species for available resources (e.g., habitat, food, nutrients, light)?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species or caused critical reduction, extinction, behavioral changes including modified spawning behavior) on one or more native populations	6
Yes, and it has caused some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population	1√
Not significantly	0
Unknown	U

- *No record of P. wilsoni outcompeting native species elsewhere, but Cnudde (2013) classifies harpacticoid copepods as "indiscriminate feeders".*

Does it alter predator-prey relationships?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species, caused significant reduction or extinction of one or more native populations, creation of a dead end or any other significant alteration in the food web)	6

Yes, and it has resulted in some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population AND/OR Yes, and it has resulted in some alteration of the food web structure or processes, the effects of which have not been widespread or severe	1
Not significantly	0
Unknown	U √

- *No reports. Could alter lower food web if it outcompetes other benthic invertebrates.*

Has it affected any native populations genetically (e.g., through hybridization, selective pressure, introgression)?

Yes, and it has caused a loss or alteration of genes that may be irreversible or has led to the decline of one or more native species (or added pressure to threatened/endangered species)	6
Yes, some genetic effects have been observed, but consequences have been limited to the individual level	1
Not significantly	0 √
Unknown	U

- *No reports of hybridization.*

Does it negatively affect water quality (e.g., increased turbidity or clarity, altered nutrient, oxygen, or other chemical levels/cycles)?

Yes, and it has had a widespread, long-term, or severe negative effect on water quality AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected water quality to some extent, but the alterations and resulting adverse effects have been limited or inconsistent (as compared with above statement)	1
Not significantly	0 √
Unknown	U

- *P. wilsoni is an interstitial copepod, so it is unlikely to have much effect on turbidity/water clarity.*

Does it alter physical components of the ecosystem in some way (e.g., facilitated erosion/siltation, altered hydrology, altered macrophyte/phytoplankton communities, physical or chemical changes to substrate)?

Yes, and it has had a widespread, long term, or severe negative effect on the physical ecosystem AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected the physical ecosystem to some extent, but the alterations and resulting adverse effects have been mild	1
Not significantly	0 √
Unknown	U

Environmental Impact Total	**1**
Total Unknowns (U)	**2**

POTENTIAL SOCIO-ECONOMIC IMPACT

Does the species pose some hazard or threat to human health (e.g., it magnifies toxin levels, is poisonous, a virus, bacteria, parasite, or a vector of one)?

Yes, significant effects on human health have already been observed	6
Yes, but negative consequences have not been widespread, long lasting, or severe	1
Not significantly	0
Unknown	U√

- *No reports.*

Does it cause damage to infrastructure (e.g., water intakes, pipes, or any other industrial or recreational infrastructure)?

Yes, it is known to cause significant damage	6
Yes, but the costs have been small and are largely reparable or preventable	1
Not significantly	0 √
Unknown	U

- *Not reported to affect infrastructure.*

Does it negatively affect water quality (i.e. in terms of being less suitable for human use)?

Yes, it has significantly affected water quality, and is costly or difficult to reverse	6
Yes, but the effects are negligible and/or easily reversed	1
Not significantly	0 √
Unknown	U

- *No reports of effects on water quality.*

Does it negatively affect any markets or economic sectors (e.g., commercial fisheries, aquaculture, agriculture)?

Yes, it has caused significant damage to one or more markets or economic sectors	6
Some damage to markets or sectors has been observed, but negative consequences have been small	1
Not significantly	0 √
Unknown	U

- *No reports. Could possibly disrupt lower food web and harm fisheries.*

Does it inhibit recreational activities and/or associated tourism (e.g., through frequent water closures, equipment damage, decline of recreational species)?

Yes, it has caused widespread, frequent, or otherwise expensive inhibition of recreation and tourism	6
Yes, but negative consequences have been small	1
Not significantly	0√
Unknown	U

- *Not reported.*

Does it diminish the perceived aesthetic or natural value of the areas it inhabits?

Yes, the species has received significant attention from the media/public, significantly diminished the natural or cultural character of the area, or significantly reduced the area's value for future generations	6
Yes, but negative consequences have been small	1
Not significantly	0 √
Unknown	U

- *Wilson (1932) noted that they spend their life cycle in interstitial spaces of sandy beaches below the waterline.*

Socio-Economic Impact Total	**0**
Total Unknowns (U)	**1**

POTENTIAL BENEFICIAL EFFECT

NOTE: In this section, a "Not significantly" response should be selected if there have been no reports of a particular effect. An "Unknown" response is appropriate if the potential for a particular effect might be inferred but has not been explicitly reported or if there is an unresolved debate about a particular effect.

Does it act as a biological control agent for aquatic weeds or other harmful nonindigenous organisms?

Yes, it has succeeded significantly as a control agent	6
Yes, it has had some success as a control agent, but may be inconsistent or lack a desired level of effectiveness	1
Not significantly	0√
Unknown	U

- *Cnudde (2013) mentions that harpacticoid copepods eat cyanobacteria, no mention of specific use as a control agent.*

Is it commercially valuable (e.g., for fisheries, aquaculture, agriculture, bait, ornamental trade)?

Yes, it is economically important to at least one of these industries	6
Yes, but its economic contribution is small	1
Not significantly	0√
Unknown	U

- *Not cultured or traded for any commercial purpose.*

Is it recreationally valuable (e.g., for sport or leisurely fishing, as a pet, or for any other personal activity)?

Yes, it is commonly employed recreationally and has some perceived value for local communities and/or tourism	6
It is sometimes employed recreationally, but adds little value to local communities or tourism	1
Not significantly	0√
Unknown	U

- *No recreational purpose.*

Does the species have some medicinal or research value (i.e. outside of research geared towards its control)?

Yes, it has significant medicinal or research value	6

It has some medicinal or research value, but is not of high priority OR It is potentially important to medicine or research and is currently being or scheduled to be studied	1
Not significantly	0 √
Unknown	U

- *Not used for any research applications.*

Does the species remove toxins or pollutants from the water or otherwise increase water quality?

Yes, it reduces water treatment costs or has a significant positive impact for the health of humans and/or native species	6
Yes, but positive impact for humans or native species is considered negligible	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Does the species have a positive ecological impact outside of biological control (e.g., increases the growth or reproduction rates of other species, fills an important gap in the food web, supports the survival of a species that is threatened, endangered species, or commercially valuable)?

Yes, it significantly contributes to the ecosystem in one or more of these ways	6
Yes, it provides some positive contribution to the ecosystem, but is not vital	1
Not significantly	0 √
Unknown	U

- Not reported.

Beneficial Effect Total	**0**
Total Unknowns (U)	**0**

Scientific Name: *Paramysis ullskyi*

Common Name: Mysid shrimp

Section A: Potential for Introduction

INTRODUCTION POTENTIAL RESULTS

Dispersal: Unlikely
Hitchhiking/Fouling: Unlikely
Unauthorized intentional release: Unlikely
Stocking/Planting/Escape from recreational culture: Unlikely
Escape from commercial culture: Unlikely
Shipping: Moderate

Comments: *Paramysis ullskyi* has a moderate probability of introduction to the Great Lakes (Confidence level: High).

Potential pathway(s) of introduction: Transoceanic shipping (ballast water)

Very little information is available for this species. Most scores are based on extrapolation from the conspecific Paramysis intermedia.

POTENTIAL INTRODUCTION VIA DISPERSAL

Does this species occur near waters (natural or artificial) connected to the Great Lakes basin* (e.g., streams, ponds, canals, or wetlands)?
*(*Great Lakes basin = below the ordinary high water mark, including connecting channels, wetlands, and waters ordinarily attached to the Lakes)*

Yes, this species occurs near waters connected to the Great Lakes basin and is mobile or able to be transported by wind or water.	100
No, this species does not occur near waters connected to the Great Lakes basin and/or is not mobile or able to be transported by wind or water.	0 √
Unknown	U

- *This species occurs in European part of Russia, Baltic Sea, Caspian Sea, North Atlantic near Russia.*
- *The species is indigenous to waters surrounding the western part of Russia, as well as the Baltic, Caspian, and North Atlantic near Russia.*

What is the proximity of this species to the Great Lakes basin?

This species occurs in waters within 20 kilometers of the Great Lakes basin, and no barrier (e.g., electric barrier, dam) to dispersal is present.	Score x 1
This species occurs in waters within 20 kilometers of the Great Lakes basin, but dispersal to the basin is blocked; or, this species occurs in waters within 100 kilometers of the Great Lakes basin, and no barrier to dispersal is present.	Score x 0.75

This species occurs in waters within 100 kilometers of the Great Lakes basin, but dispersal to the basin is blocked.	Score x 0.5
This species occurs in waters >100 kilometers from the Great Lakes basin.	Score x 0.25
Unknown	U

POTENTIAL INTRODUCTION VIA HITCHHIKING/FOULING

Is this species likely to attach to or be otherwise transported by, or along with, recreational gear, boats, trailers, fauna (e.g., waterfowl, fish, insects), flora (e.g., aquatic plants), or other objects (e.g., packing materials), including as parasites or pathogens, entering the Great Lakes basin?

Yes, this species is known to be able to adhere to certain surfaces or to be transported by other organisms entering the Great Lakes basin.	100
No, this species is not known to be able to adhere to certain surfaces or to be transported by other organisms entering the Great Lakes basin.	0 √
Unknown	U

- Paramysis ullskyi *is indigenous to the European part of Russia in the Ponto-Caspian basin.*

What is the proximity of this species to the Great Lakes basin?

This species occurs in waters within 20 km of the Great Lakes basin.	Score x 1
This species occurs in waters within 100 km of the Great Lakes basin.	Score x 0.5
This species occurs in waters >100 km from the Great Lakes basin.	Score x 0.1
Unknown	U

POTENTIAL INTRODUCTION VIA UNAUTHORIZED INTENTIONAL RELEASE

Is this species sold at aquarium/pet/garden stores ("brick & mortar" or online), catalogs, biological supply companies, or live markets (e.g., purchased for human consumption, bait, ornamental, ethical, educational, or cultural reasons) and as a result may be released into the Great Lakes basin?

Yes, this species is available for purchase.	100
No, this species this species is rarely/never sold.	0 √
Unknown	U

- *While the specific species is not stated, similar mysid shrimp indigenous to the same area has been used as fish food for fauna enrichment in the Soviet Union back in the 1970s. However, it is unknown whether this is still in practice today, or if particular mysids are used for fish farms in the United States.*
- *No evidence was shown that this particular species has arrived in the Great Lakes nor is there any recent evidence of this species being used currently in either Russia or the United States.*

How easily is this species obtained within the Great Lakes region (states/provinces)?

This species is widely popular, frequently sold, and/or easily obtained within the Great Lakes region.	Score x 1

This species is widely popular, and although trade, sale, and/or possession of this species is prohibited, it is frequently sold on the black market within the Great Lakes region.	Score x 0.5
This species is not very popular or is not easily obtained within the Great Lakes region.	Score x 0.1
Unknown	U

POTENTIAL INTRODUCTION VIA STOCKING/PLANTING OR ESCAPE FROM RECREATIONAL CULTURE

Is this species being stocked/planted to natural waters or outdoor water gardens around the Great Lakes region?

Yes, this species is being stocked/planted and/or has ornamental, cultural, medicinal, environmental (e.g., biocontrol, erosion control), scientific, or recreational value in the Great Lakes region.	100
No, this species cannot be stocked/planted or there is not enough interest to do so in the Great Lakes region.	0 √
Unknown	U

- *It is only known to be used for fish and fauna enrichment around the Ponto-Caspian area around Russia.*

What is the nature and proximity of this activity to the Great Lakes basin?

This activity is authorized and/or is occurring directly in the Great Lakes.	Score x 1
This activity is occurring in Great Lakes tributaries or connecting waters, or within 20 km of the Great Lakes basin.	Score x 0.75
This activity is likely to occur within 20 km of the Great Lakes basin because of its popularity/value and there are no widespread regulations against stocking/planting.	Score x 0.5
This activity is occurring in waters >20 km from the Great Lakes basin, or despite federal or state regulations in more than half the basin (> 5 states/provinces), this activity may occur within 20 km of the basin because of the species' popularity/value.	Score x 0.25
Unknown	U

POTENTIAL INTRODUCTION VIA ESCAPE FROM COMMERCIAL CULTURE

Is this species known to be commercially cultured in or transported through the Great Lakes region?

Yes, this species is being commercially cultured in or transported through the Great Lakes region.	100
No, this species is not commercially cultured in or transported through the Great Lakes region.	0 √
Unknown	U

- *While there has been history of transport, similar species have been transported only throughout Russia, and not to the Great Lakes.*

What is the nature and proximity of this activity to the Great Lakes basin?

This activity is unregulated or minimally regulated and is occurring directly in the Great Lakes.	Score x 1

This activity is unregulated or minimally regulated and is occurring in Great Lakes tributaries or connecting waters, or within 20 km of the Great Lakes basin.	Score x 0.75
This activity is strictly regulated but occurs directly in the Great Lakes, and/or this activity involves transport of live organisms on/across the Great Lakes.	Score x 0.5
This activity is strictly regulated but occurs in Great Lakes tributaries, connecting waters, or within 20 km of the Great Lakes basin, and/or this activity involves transport of live organisms within 20 km of the Great Lakes basin.	Score x 0.25
This activity occurs >20 km from the Great Lakes basin and typically does not involve transport of live organisms closer to the basin.	Score x 0.1
Unknown	U

POTENTIAL INTRODUCTION VIA SHIPPING

Is this species capable of surviving adverse environments (i.e. extreme temperatures, absence of light, low oxygen levels) and partial-to-complete ballast water exchange/BWE (e.g., is euryhaline, buries in sediment, produces resistant resting stages, has other attributes or behaviors facilitating survival under these conditions)?

Yes, this species is able to survive in ballast tank environments for weeks at a time and may be suspended in ballast water.	100
Yes, this species is able to survive in ballast tank environments for weeks at a time and is able to survive BWE by burial in ballast sediment.	80 √
Yes, this species is able to survive in ballast tank environments for weeks at a time and may be suspended in ballast water, but this species is not able to survive BWE.	60
No, but this species is capable of fouling transoceanic ship structures (e.g., hull, chains, chain locker) while in its active or resting stage.	40
No, this species is not able to survive adverse environments, does not foul transoceanic ship structures, or is unlikely to be taken up with ballast.	0
Unknown	U

- *While* Paramysis *has a broad range in salinity tolerance, Ovcarenko (2006) has shown that there is high mortality when the salinity change is sudden, such as when changing ballast water. Mortality occurs when they approach 15 PSU.*

Does this species occur in waters from which shipping traffic to the Great Lakes originates?

Yes, and this species has been observed in ballast of or fouling ships entering the Great Lakes.	Score x 1
Yes, and this species has been observed in ports that have direct trade connections with the Great Lakes (e.g., Baltic Sea).	Score x 0. 5√
Yes, but this species has neither been observed in ballast/fouling ships entering the Great Lakes nor in ports in direct trade with the Great Lakes.	Score x 0.1
No, this species does not occur in waters from which shipping traffic to the Great Lakes originates.	Score x 0
Unknown	U

- *The species is indigenous to the European part of Russia in the Ponto-Caspian basin.*
- *This species occurs in European part of Russia, Baltic Sea, Caspian Sea, North Atlantic near Russia.*
- *The species is indigenous to waters surrounding the western part of Russia, as well as the Baltic, Caspian, and north Atlantic near Russia.*

Vector Potential Scorecard				
Vector	**Raw Points Scored**	**Proximity Multiplier**	**Total Points Scored**	**Probability of Introduction**
Dispersal: Natural dispersal through waterbody connections or wind	**0**	x		Unlikely
Hitchhiking/Fouling: Transport via recreational gear, boats, trailers, mobile fauna, stocked/planted organisms, packing materials, host organisms, etc.	**0**	x		Unlikely
Release: Unauthorized intentional release of organisms in trade (e.g., aquaria, water gardens, live food)	**0**	x		Unlikely
Stocking/Planting/Escape from recreational culture: Intentional authorized or unauthorized introduction to natural waters in the Great Lakes OR Accidental introduction to Great Lakes by escape from recreational culture (e.g., water gardens)	**0**	x		Unlikely
Escape from commercial culture: Accidental introduction to Great Lakes by escape from commercial culture (e.g., aquaculture)	**0**	x		Unlikely
Trans-oceanic shipping: Ballast (BOB) or no-ballast-on-board (NOBOB) water exchange/discharge, sediment discharge, hull fouling	**80**	x	**0.5**	Moderate
Total Unknowns (U)	**0**	**Confidence Level**	High	

<u>Qualitative Statements for GLANSIS Fact Sheet:</u>
SPECIES X has a moderate probability of introduction to the Great Lakes (Confidence level: high).

Potential pathway(s) of introduction: Shipping

Section B: Potential for Establishment

<u>ESTABLISHMENT POTENTIAL RESULTS</u>

Status: **Not established in North America, including the Great Lakes**

***Paramysis ullskyi* has a moderate probability of establishment if introduced to the Great Lakes (Confidence level: moderate)**

Comments: Very little direct information is available for this species. Some information has been extrapolated from the conspecific *Paramysis intermedia*.

INVASIVE BIOLOGICAL/ECOLOGICAL ATTRIBUTES

How would the physiological tolerance of this species (survival in varying temperature, salinity, oxygen, and nutrient levels) be described?

This species has broad physiological tolerance. It has been reported to survive in wide ranges of temperature (0°C-30°C), salinity (0-16 parts per thousand), oxygen (0-saturated), AND nutrient (oligotrophic-eutrophic) levels.	9
This species has somewhat broad physiological tolerance. It has been reported to survive in a wide range of temperature, salinity, oxygen, OR nutrient levels. Tolerance to other factors is narrower, unknown, or unreported.	6
This species has narrow physiological tolerance. It has been reported to survive in limited ranges of temperature, salinity, oxygen, and nutrient levels.	3
Unknown	U
	7

- *The Ponto-Caspian region, where* P. ullskyi *originates, is quite similar to the Great Lakes. The spatial temperature mean is 13.7 degrees with a range of 12.1 to 16.1.*
- Paramysis ullskyi *cannot tolerate a sudden salinity change to 18 PSU levels of salinities, and its natural salinity environment was 3 psu. (Ovcarenko 2006).*

How likely is it that any life stage of this species can overwinter in the Great Lakes (survive extremely low levels of oxygen, light, and temperature)?

Likely (This species is able to tolerate temperatures under 5°C and oxygen levels ≤0.5 mg/L)	9
Somewhat likely (This species is able to tolerate some of these conditions OR has adapted behaviorally to avoid them)	6
Somewhat unlikely (This species is able to tolerate conditions close to those specified, but it is not known as an overwintering species)	3
Unlikely	0
Unknown	U
	8

- *Given their origins around northern Russia, mysid shrimp can survive long periods of time within colder and deeper waters.*
- Parmysis ullskyi *exist in reservoirs that have ice cover over winter, reproduce at 6-7*℃ *(Borodich and Havlena 1973).*
- *Due to the climatic similarities between the Great Lakes and Ponto-Caspian regions (Reid and Orlova 2002) this species most likely endures similar overwintering conditions in its native range.*

If this species is a heterotroph, how would the flexibility of its diet be described?

This species is a dietary generalist with a broad, assorted, AND flexible diet.	9
This species is moderately a dietary generalist with a broad, assorted, OR flexible diet.	6
This species is a dietary specialist with a limited and inflexible diet.	3
This species is an autotroph.	0
Unknown	U
	7

- Paramysis ullskyi *mainly consumes the detritus of surface ground layers (Borodich and Havlena 1973).*

How likely is this species to outcompete species in the Great Lakes for available resources?

Likely (This species is known to have superior competitive abilities and has a history of outcompeting other species, AND/OR available literature predicts it might outcompete native species in the Great Lakes)	9
Somewhat likely (This species is known to have superior competitive abilities, but there are few reported cases of this species outcompeting another and no predictions regarding species in the Great Lakes)	6
Somewhat unlikely (This species has average competitive abilities, and there are no reported cases of this species outcompeting another and no predictions regarding species in the Great Lakes)	3
Unlikely (This species is known as a poor competitor that thrives only in environments with low biodiversity, AND/OR available literature predicts it might be outcompeted by a species in the Great Lakes)	0
Unknown	U
	3

- *Mysids can cause a lowering of zooplankton abundance (Ketelaars et al. 1999).*

How would the fecundity of this species be described relative to other species in the same taxonomic class?

Very high	9
High	6
Moderate	3
Low	0
Unknown	U
	5

- *Nothing specific has been shown to differentiate the reproductive ability from other similar species within the same taxa.*
- *The number of embryos ranges from a mean of 17-55, based on female body size (2 generations). This is slightly more than* P. intermedia*, which has mean range from 7-30 embryos (3 generations) (Borodich and Havlena 1973).*

How likely are this species' reproductive strategy and habits to aid establishment in new environments, particularly the Great Lakes (e.g., parthenogenesis/self-crossing, self fertility, vegetative fragmentation)?

Likely (The reproductive strategy or habits of this species are known to aid establishment in new environments, AND available literature predicts establishment in the Great Lakes based on these attributes)	9
Somewhat likely (The reproductive strategy or habits of this species are known to aid establishment in new environments, but there is no literature available regarding establishment in the Great Lakes based on these attributes)	6
Somewhat unlikely (The reproductive strategy or habits of this species could potentially aid establishment in new environments, but there is no literature available regarding establishment in the Great Lakes based on these attributes)	3
Unlikely (The reproductive strategy or habits of this species are not known to aid establishment in new environments)	0

Unknown	U
	3

- *This species is a brooder.*
- Paramysis ullskyi *abilities and tolerances make it likely, but only literature found on invasions of other European lakes have been found.*

ENVIRONMENTAL COMPATIBILITY

How similar are the climatic conditions (e.g., air temperature, precipitation, seasonality) in the native and introduced ranges of this species to those in the Great Lakes region?

Very similar (The climatic conditions are practically identical to those of the Great Lakes region)	9
Similar (Many of the climatic conditions are similar to those of the Great Lakes region)	6
Somewhat similar (Few of the climatic conditions are similar to those of the Great Lakes region)	3
Not similar	0
Unknown	U
	7

- *The Great Lakes are known to change seasons, having an average temperature of less than 5 ℃ on the surface in the winter months, then 5 – 15 degrees with the onset of spring, and up to 25 degrees in the summer (data from the NOAA Coastwatch Great Lakes website, specifically to Lake Ontario.*
- *The Ponto-Caspian region, where* P. ullskyi *originates, is quite similar. The spatial temperature mean is 13.7 degrees with a range of 12.1 to 16.1. This is warmer, but climate change would cause the Great Lakes to be more similar (USEPA 2008).*

How similar are other abiotic factors that are relevant to the establishment success of this species (e.g., pollution, water temperature, salinity, pH, nutrient levels, currents) in the native and introduced ranges to those in the Great Lakes?

Very similar (These factors are practically identical to those of the Great Lakes region)	9
Similar (Many of these factors are similar to those of the Great Lakes region)	6
Somewhat similar (Few of these factors are similar to those of the Great Lakes region)	3
Not similar	0
Unknown	U
	8

- Paramysis ullskyi *is known to live in 0-4% salinity (Audzijonytė et al. 2006), and their native lake salinities have a wide range, with the Black Sea reaching salinities of 22 ppt, the Azov up to 12 ppt, and the Caspian reaching 13 ppt. The Great Lakes salinities tend to be close to 0. The Great Lakes and Ponto-Caspian region are climatically compatible, which is one of the attributing factors to the success of Ponto-Caspian species in the Great Lakes (Reid and Orlova 2002).*

How abundant are habitats suitable for the survival, development, and reproduction of this species in the Great Lakes area (e.g., those with adequate depth, substrate, light, temperature, oxygen)?

Abundant (Suitable habitats can be easily found and readily available)	9
Somewhat abundant (Suitable habitats can be easily found but are in high demand by species already present)	6
Somewhat scarce (Suitable habitats can be found occasionally)	3
Scarce (Suitable habitats are rarely found)	0
Unknown	U
	8

- Paramysis intermedia *prefers sandy shallow-water habitat (Borodich and Havlena 1973).*
- *Abiotic factors and climatic conditions in the Ponto-Caspian region are quite similar to the Great Lakes, making the region compatible (Grigorovich et al. 2003, Reid and Orlova 2002).*
- *Great Lakes underwent similar anthropogenic eutrophication as the Ponto-Caspian region (Reid and Orlova 2002). Surface water temperature is similar between the Great Lakes and Ponto-Caspian seas (Grigorovich et al. 2003, Reid and Orlova 2002, USEPA 2008).*

How likely is this species to adapt to or to benefit from the predicted effects of climate change on the Great Lakes freshwater ecosystems (e.g., warmer water temperatures, shorter duration of ice cover, altered streamflow patterns, increased salinization)?

Likely (Most of the effects described above make the Great Lakes a better environment for establishment and spread of this species OR this species could easily adapt to these changes due to its wide environmental tolerances)	9
Somewhat likely (Several of the effects described above could make the Great Lakes a better environment for establishment and spread of this species)	6
Somewhat unlikely (Few of the effects described above would make the Great Lakes a better environment for establishment and spread of this species)	3
Unlikely (Most of the effects described above would have no effect on establishment and spread of this species or would make the environment of the Great Lakes unsuitable)	0
Unknown	U
	7

- *The Ponto-Caspian region, where* P. ullskyi *originates, is actually quite similar to the Great Lakes. The spatial temperature mean is 13.7 degrees with a range of 12.1 to 16.1. This is warmer, but climate change would cause the Great Lakes to be more similar (USEPA 2008).*
- *Due to their wider temperature tolerances,* Paramysis ullskyi *can be very adaptable to warmer temperatures and shallower waters. Even though the Great Lakes may be slightly colder in the winters than what the species may be used to, climate change would adjust that factor in the future (USEPA 2008).*

How likely is this species to find an appropriate food source (prey or vegetation in the case of predators and herbivores, or sufficient light or nutrients in the case of autotrophs)?

Likely (All possible nutritive food items—including species in the Great Lakes that may be considered potential food items—are highly abundant and/or easily found)	9
Somewhat likely (Some nutritive food items—including species in the Great Lakes that may be considered potential food items—are abundant and/or search time is low to moderate)	6
Somewhat unlikely (Few nutritive food items—including species in the Great Lakes that may be considered potential food items—are abundant and/or search time is moderate to high)	3
Unlikely (All possible nutritive food items—including species in the Great Lakes that may be considered potential food items—are relatively scarce and/or search time is high)	0

Unknown	U
	9

- *Much of the sustenance of* Paramysis ullskyi *can be found both in their native waters and in the Great Lakes. They survive on algae and zooplankton (Ketelaars et al. 1999).*

Does this species require another species for critical stages in its life cycle such as growth (e.g., root symbionts), reproduction (e.g., pollinators, egg incubators), spread (e.g., seed dispersers), or transmission (e.g., vectors)?

Yes, and the critical species (or one that may provide a similar function) is common in the Great Lakes and can be easily found in environments suitable for the species being assessed; OR, No, there is no critical species required by the species being assessed	9
Yes, and the critical species (or one that may provide a similar function) is moderately abundant and relatively easily found in particular parts of the Great Lakes	6
Yes, and the critical species (or one that may provide a similar function) is relatively rare in the Great Lakes AND/OR can only be found occasionally in environments suitable for the species being assessed	3
Yes, and the critical species (or one that may provide a similar function) is not present in the Great Lakes but is likely to be introduced	0
Yes, but the critical species (or one that may provide a similar function) is not present in the Great Lakes and is not likely to be introduced	-80% total points (at end)
Unknown	U
	9

How likely is the establishment of this species to be aided by the establishment and spread of another species already in the Great Lakes?

Likely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established and spread in the Great Lakes, AND available literature predicts this previous invader might promote the establishment of this species, AND/OR there have been cases reported of this species aiding the establishment of this species in other areas)	9
Somewhat likely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established and spread in the Great Lakes)	6
Somewhat unlikely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established in the Great Lakes BUT it is still confined to a small area of the Lakes and the likelihood of encounter with this species assessed is hard to predict)	3
Unlikely (A non-indigenous species to the Great Lakes that facilitates the development of this species has not been established in the Great Lakes)	0
Unknown	U
	0

- *There was no indication of this species that would facilitate their establishment.*

How likely is establishment of this species to be prevented by the herbivory, predation, or parasitism of a natural enemy this is already present in the Great Lakes and may preferentially target this species?

Likely (The ability of the natural enemy to prevent the establishment of this species in introduced ranges or limiting populations of this species in native ranges is well documented in the literature AND this natural enemy is abundant and widespread in the Great Lakes)	-80% total points (at end)
Somewhat likely (The ability of the natural enemy to prevent the establishment of this species in introduced ranges or limiting populations of this species in native ranges is suggested in the literature OR this natural enemy has limited distribution in the Great Lakes)	-60% total points (at end)
Somewhat unlikely (There are few cases reported of such a natural enemy preventing the establishment of this species in introduced ranges or limiting populations of this species in native ranges OR this natural enemy has low abundance in the Great Lakes)	-10% total points (at end)
Unlikely (Such a natural enemy is particularly rare or is not present in the Great Lakes)	0
Unknown	U
	0

- *Larger fish have always been the main predator of mysid shrimp, though a specific one is not mentioned. This has not really controlled the native mysid shrimp in the Great Lakes region.*

PROPAGULE PRESSURE

On average, how large and frequent are inoculations (introduction events) from the potential vectors identified in Section A for this species? (What is the total number of individuals introduced?)

Frequent, large inocula	9
Frequent, moderate inocula	6
Frequent, small inocula OR infrequent, large inocula	3
Infrequent, small or moderate inocula	0
Unknown	U
	U

- *There were multiple reports of invasions in Europe outside the Ponto-Caspian, but they did not mention anything on frequency (Ketelaars 1997).*

HISTORY OF INVASION AND SPREAD

How extensively has this species established reproducing populations in areas outside its native range as a direct or indirect result of human activities?

Very extensively (many invasive populations of this species have been reported in areas widely distributed from the native range)	9
Extensively (some invasive populations of this species have been reported in areas widely distributed from the native range)	6
Somewhat extensively (few invasive populations of this species have been reported in areas widely distributed from the native range OR all invasive populations are in close proximity to each other)	3

Not extensively (no invasive populations of this species have been reported)	0
Unknown	U
	8

- Paramysis ullskyi *was spread via ballast water to other Baltic lakes throughout Europe. This was shown through actual physical observation and mitochondrial DNA tracking of migrating species. (Audzijonytė 2008, bij de Vaate et al. 2002)*

How rapidly has this species spread by natural means or by human activities once introduced to other locations?

Rapidly (This species has a history of rapid spread in introduced ranges)	9
Somewhat rapidly (This species has a history of moderately rapid spread in introduced ranges)	6
Somewhat slowly (This species has a history of moderately slow spread in its introduced ranges)	3
Slowly (This species has a history of slow to no spread in its introduced ranges)	0
Unknown	U
	U

- *In the 1950s*, H. anomala*, a similar species with nearly the same origins in the Ponto-Caspian area, were intentionally introduced in fisheries in the Dnieper River, and in the Dubossart reservoir in Moldovia. Throughout the 70s and onward, mysids distributed through Europe vie rivers and tributaries (bij de Vaate et al. 2002)*

Are there any existing control measures in the Great Lakes set to prevent the establishment and/or spread of this species?

Yes, and they are likely to prevent establishment or spread of the species. (There are no reported cases of this species adapting or avoiding current measures. These measures are highly effective in preventing the establishment and spread of this species)	-90% total points (at end)
Yes, and they are moderately likely to prevent establishment or spread of the species. (There are few reported cases of this species adapting or avoiding current measures used to control its establishment and spread)	-50% total points (at end)
Yes, but they are unlikely to prevent establishment or spread of the species. (There are many reported cases of this species adapting or avoiding current measures used to control its establishment and spread)	-20% total points (at end)
No control methods have been set to prevent the establishment and/or spread of this species	0
Unknown	U
	0

Establishment Potential Scorecard				
Points	**Probability for Establishment**	Total Points (pre-adjustment)		**89**
>100	High	**Adjustments**		
		Critical species	A (1- ___ %)	**89**

51-99	Moderate	Natural enemy	B (1- ___ %)	**89**
		Control measures	C (1- ___ %)	**89**
0-50	Low	**Probability for Establishment**		Moderate
# of questions answered as "unable to determine"	**Confidence Level**			
0-1	High	Total # of questions unknown		2
2-5	Moderate			
6-9	Low	Confidence Level		Moderate
>9	Very low			

Qualitative Statements for GLANSIS Fact Sheet:
SPECIES X has a moderate probability of establishment if introduced to the Great Lakes (Confidence level: moderate).

Section B: Potential for Impact

IMPACT POTENTIAL RESULTS

Environmental: Unknown
Socio-Economic: Low
Beneficial: Low

Comments: Very little information is available for this species. Most information is extrapolated from the conspecific *Paramysis intermedia*.

POTENTIAL ENVIRONMENTAL IMPACT

Does the species pose some hazard or threat to the health of native species (e.g., it magnifies toxin levels; is poisonous; is a pathogen, parasite, or a vector of either)?

Yes, and it has impacted threatened/endangered species, resulted in the reduction or extinction of one or more native populations, affects multiple species, or is a reportable disease	6
Yes, but negative consequences have been small (e.g., limited number of infected individuals, limited pathogen transmissibility, mild effects on populations and ecosystems)	1
Not significantly	0
Unknown	U√

- *Unknown.*

Does it out-compete native species for available resources (e.g., habitat, food, nutrients, light)?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species or caused critical reduction, extinction, behavioral changes including modified spawning behavior) on one or more native populations	6
Yes, and it has caused some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population	1

Not significantly	0
Unknown	U√

- *Unknown.*

Does it alter predator-prey relationships?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species, caused significant reduction or extinction of one or more native populations, creation of a dead end or any other significant alteration in the food web)	6
Yes, and it has resulted in some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population AND/OR Yes, and it has resulted in some alteration of the food web structure or processes, the effects of which have not been widespread or severe	1 √
Not significantly	0
Unknown	U

- *Ketelaars (1997) mentions an almost absent population of in zooplankton and phytoplankton biomass as a result of invasion, in a span of almost a decade. While this is referencing* Hemimysis anomola*, this reference also indicates that* Paramysis *is part of the most frequent Ponto-Caspian invaders they are researching, and it is known that* H. anomala *and* Paramysis *are part of the same taxonomic subfamily, only differing in genus (Mees 2015).*
- *Mysid shrimp tend to be the preferred choice of prey for many fish species, but this does not impact their invasiveness significantly.*

Has it affected any native populations genetically (e.g., through hybridization, selective pressure, introgression)?

Yes, and it has caused a loss or alteration of genes that may be irreversible or has led to the decline of one or more native species (or added pressure to threatened/endangered species)	6
Yes, some genetic effects have been observed, but consequences have been limited to the individual level	1
Not significantly	0 √
Unknown	U

- *There was no mention of any alteration to species.*

Does it negatively affect water quality (e.g., increased turbidity or clarity, altered nutrient, oxygen, or other chemical levels/cycles)?

Yes, and it has had a widespread, long-term, or severe negative effect on water quality AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected water quality to some extent, but the alterations and resulting adverse effects have been limited or inconsistent (as compared with above statement)	1
Not significantly	0
Unknown	U√

- *It can be speculated that it can, considering that colonies of paramysis and feed on vast quantities of algae as well as reduce populations of zooplankton and phytoplankton (Porter et al. 2008). Theoretically, it can increase clarity and alter certain chemical content.*

Does it alter physical components of the ecosystem in some way (e.g., facilitated erosion/siltation, altered hydrology, altered macrophyte/phytoplankton communities, physical or chemical changes to substrate)?

Yes, and it has had a widespread, long term, or severe negative effect on the physical ecosystem AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected the physical ecosystem to some extent, but the alterations and resulting adverse effects have been mild	1
Not significantly	0
Unknown	U√

Environmental Impact Total	**1**
Total Unknowns (U)	**4**

POTENTIAL SOCIO-ECONOMIC IMPACT

Does the species pose some hazard or threat to human health (e.g., it magnifies toxin levels, is poisonous, a virus, bacteria, parasite, or a vector of one)?

Yes, significant effects on human health have already been observed	6
Yes, but negative consequences have not been widespread, long-lasting, or severe	1
Not significantly	0 √
Unknown	U

- *There was no mention other than possible ecological effects.*

Does it cause damage to infrastructure (e.g., water intakes, pipes, or any other industrial or recreational infrastructure)?

Yes, it is known to cause significant damage	6
Yes, but the costs have been small and are largely reparable or preventable	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Does it negatively affect water quality (i.e. in terms of being less suitable for human use)?

Yes, it has significantly affected water quality, and is costly or difficult to reverse	6
Yes, but the effects are negligible and/or easily reversed	1
Not significantly	0 √
Unknown	U

- *It has only been reported to have decreased alga levels as well as overall diversity of the food web.*

Does it negatively affect any markets or economic sectors (e.g., commercial fisheries, aquaculture, agriculture)?

Yes, it has caused significant damage to one or more markets or economic sectors	6

Some damage to markets or sectors has been observed, but negative consequences have been small	1
Not significantly	0 √
Unknown	U

- *Not negatively, but a related paramysis species have been a frequent choice of commercial fisheries since they are prime food sources for new fauna.*

Does it inhibit recreational activities and/or associated tourism (e.g., through frequent water closures, equipment damage, decline of recreational species)?

Yes, it has caused widespread, frequent, or otherwise expensive inhibition of recreation and tourism	6
Yes, but negative consequences have been small	1
Not significantly	0√
Unknown	U

- *Not reported.*

Does it diminish the perceived aesthetic or natural value of the areas it inhabits?

Yes, the species has received significant attention from the media/public, significantly diminished the natural or cultural character of the area, or significantly reduced the area's value for future generations	6
Yes, but negative consequences have been small	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Socio-Economic Impact Total	**0**
Total Unknowns (U)	**0**

POTENTIAL BENEFICIAL EFFECT

NOTE: In this section, a "Not significantly" response should be selected if there have been no reports of a particular effect. An "Unknown" response is appropriate if the potential for a particular effect might be inferred but has not been explicitly reported or if there is an unresolved debate about a particular effect.

Does it act as a biological control agent for aquatic weeds or other harmful nonindigenous organisms?

Yes, it has succeeded significantly as a control agent	6
Yes, it has had some success as a control agent, but may be inconsistent or lack a desired level of effectiveness	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Is it commercially valuable (e.g., for fisheries, aquaculture, agriculture, bait, ornamental trade)?

Yes, it is economically important to at least one of these industries	6
Yes, but its economic contribution is small	1√

Not significantly	0
Unknown	U

- *Mysid shrimp has been used extensively to feed fisheries, mainly because they are relatively easy to culture because to their wide habitat tolerances (Marini and Moe 2003).*

Is it recreationally valuable (e.g., for sport or leisurely fishing, as a pet, or for any other personal activity)?

Yes, it is commonly employed recreationally and has some perceived value for local communities and/or tourism	6
It is sometimes employed recreationally, but adds little value to local communities or tourism	1
Not significantly	0√
Unknown	U

- *Not reported.*

Does the species have some medicinal or research value (i.e. outside of research geared towards its control)?

Yes, it has significant medicinal or research value	6
It has some medicinal or research value, but is not of high priority OR It is potentially important to medicine or research and is currently being or scheduled to be studied	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Does the species remove toxins or pollutants from the water or otherwise increase water quality?

Yes, it reduces water treatment costs or has a significant positive impact for the health of humans and/or native species	6
Yes, but positive impact for humans or native species is considered negligible	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Does the species have a positive ecological impact outside of biological control (e.g., increases the growth or reproduction rates of other species, fills an important gap in the food web, supports the survival of a species that is threatened, endangered species, or commercially valuable)?

Yes, it significantly contributes to the ecosystem in one or more of these ways	6
Yes, it provides some positive contribution to the ecosystem, but is not vital	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Beneficial Effect Total	**1**
Total Unknowns (U)	**0**

Scientific Name: *Procambarus fallax f. virginalis*

Common Name: Marbled crayfish, Marmorkrebs

Section A: Potential for Introduction

<u>INTRODUCTION POTENTIAL RESULTS</u>

Dispersal: Low
Hitchhiking/Fouling: Low
Unauthorized intentional release: High
Stocking/Planting/Escape from recreational culture: Unknown
Escape from commercial culture: Unknown
Shipping: Low

Comments: *Procambarus fallax f. virginalis* has a high probability of introduction to the Great Lakes (Confidence level: low).

<u>POTENTIAL INTRODUCTION VIA DISPERSAL</u>

Does this species occur near waters (natural or artificial) connected to the Great Lakes basin* (e.g., streams, ponds, canals, or wetlands)?
*(*Great Lakes basin = below the ordinary high water mark, including connecting channels, wetlands, and waters ordinarily attached to the Lakes)*

Yes, this species occurs near waters connected to the Great Lakes basin and is mobile or able to be transported by wind or water.	100
No, this species does not occur near waters connected to the Great Lakes basin and/or is not mobile or able to be transported by wind or water.	0 √
Unknown	U

- *No free-living populations have been reported in North America, but they are readily available for purchase as lab or aquarium specimens and as fishing bait in the US (Chucholl 2010).*

What is the proximity of this species to the Great Lakes basin?

This species occurs in waters within 20 kilometers of the Great Lakes basin, and no barrier (e.g., electric barrier, dam) to dispersal is present.	Score x 1
This species occurs in waters within 20 kilometers of the Great Lakes basin, but dispersal to the basin is blocked; or, this species occurs in waters within 100 kilometers of the Great Lakes basin, and no barrier to dispersal is present.	Score x 0.75
This species occurs in waters within 100 kilometers of the Great Lakes basin, but dispersal to the basin is blocked.	Score x 0.5
This species occurs in waters >100 kilometers from the Great Lakes basin.	Score x 0.25
Unknown	U√

- *As of 2018, specimens have only been found in captivity in the US.*

POTENTIAL INTRODUCTION VIA HITCHHIKING/FOULING

Is this species likely to attach to or be otherwise transported by, or along with, recreational gear, boats, trailers, fauna (e.g., waterfowl, fish, insects), flora (e.g., aquatic plants), or other objects (e.g., packing materials), including as parasites or pathogens, entering the Great Lakes basin?

Yes, this species is known to be able to adhere to certain surfaces or to be transported by other organisms entering the Great Lakes basin.	100
No, this species is not known to be able to adhere to certain surfaces or to be transported by other organisms entering the Great Lakes basin.	0
Unknown	U√

- *Waterbird-mediated dispersal is possible and has been documented in other species of invasive crayfish (Ferreira 2010), but has not been observed with marbled crayfish.*

What is the proximity of this species to the Great Lakes basin?

This species occurs in waters within 20 km of the Great Lakes basin.	Score x 1
This species occurs in waters within 100 km of the Great Lakes basin.	Score x 0.5
This species occurs in waters >100 km from the Great Lakes basin.	Score x 0.1√
Unknown	U

- *As of 2018, specimens have only been found in captivity in the US.*

POTENTIAL INTRODUCTION VIA UNAUTHORIZED INTENTIONAL RELEASE

Is this species sold at aquarium/pet/garden stores ("brick & mortar" or online), catalogs, biological supply companies, or live markets (e.g., purchased for human consumption, bait, ornamental, ethical, educational, or cultural reasons) and as a result may be released into the Great Lakes basin?

Yes, this species is available for purchase.	100√
No, this species this species is rarely/never sold.	0
Unknown	U

- *Aquarist and bait stores frequently sell these species at very low prices and ship them around the country, as they make for popular pets. Crayfish enthusiasts may also send specimens to each other, facilitating their spread (Chucholl 2010).*

How easily is this species obtained within the Great Lakes region (states/provinces)?

This species is widely popular, frequently sold, and/or easily obtained within the Great Lakes region.	Score x 1 √
This species is widely popular, and although trade, sale, and/or possession of this species is prohibited, it is frequently sold on the black market within the Great Lakes region.	Score x 0.5
This species is not very popular or is not easily obtained within the Great Lakes region.	Score x 0.1
Unknown	U

- *Marbled crayfish are readily available for purchase online in the United States, and will ship within the Great Lakes region (Faulkes 2010).*

POTENTIAL INTRODUCTION VIA STOCKING/PLANTING OR ESCAPE FROM RECREATIONAL CULTURE

Is this species being stocked/planted to natural waters or outdoor water gardens around the Great Lakes region?

Yes, this species is being stocked/planted and/or has ornamental, cultural, medicinal, environmental (e.g., biocontrol, erosion control), scientific, or recreational value in the Great Lakes region.	100
No, this species cannot be stocked/planted or there is not enough interest to do so in the Great Lakes region.	0
Unknown	U√

- *In Europe, marbled crayfish are a popular food source for ornamental turtles (Chucholl, 2010). Since ornamental turtles may be kept in open ponds, this use of marbled crayfish may facilitate accidental introductions, but no records exist of this phenomenon in the United States.*

What is the nature and proximity of this activity to the Great Lakes basin?

This activity is authorized and/or is occurring directly in the Great Lakes.	Score x 1
This activity is occurring in Great Lakes tributaries or connecting waters, or within 20 km of the Great Lakes basin.	Score x 0.75
This activity is <u>likely</u> to occur within 20 km of the Great Lakes basin because of its popularity/value and there are no widespread regulations against stocking/planting.	Score x 0.5
This activity is occurring in waters >20 km from the Great Lakes basin, or despite federal or state regulations in more than half the basin (> 5 states/provinces), this activity <u>may</u> occur within 20 km of the basin because of the species' popularity/value.	Score x 0.25
Unknown	U√

- *No records of deliberate stocking exist in the Great Lakes region.*

POTENTIAL INTRODUCTION VIA ESCAPE FROM COMMERCIAL CULTURE

Is this species known to be commercially cultured in or transported through the Great Lakes region?

Yes, this species is being commercially cultured in or transported through the Great Lakes region.	100
No, this species is not commercially cultured in or transported through the Great Lakes region.	0
Unknown	U√

- *Commercial culture for aquaria does exist in the US, but typically in the southern states: the frequency of transportation of marbled crayfish through the Great Lakes is unknown.*

What is the nature and proximity of this activity to the Great Lakes basin?

This activity is unregulated or minimally regulated and is occurring directly in the Great Lakes.	Score x 1
This activity is unregulated or minimally regulated and is occurring in Great Lakes tributaries or connecting waters, or within 20 km of the Great Lakes basin.	Score x 0.75
This activity is strictly regulated but occurs directly in the Great Lakes, and/or this activity involves transport of live organisms on/across the Great Lakes.	Score x 0.5

This activity is strictly regulated but occurs in Great Lakes tributaries, connecting waters, or within 20 km of the Great Lakes basin, and/or this activity involves transport of live organisms within 20 km of the Great Lakes basin.	Score x 0.25
This activity occurs >20 km from the Great Lakes basin and typically does not involve transport of live organisms closer to the basin.	Score x 0.1
Unknown	U √

- *The frequency of transportation of marbled crayfish through the Great Lakes is unknown.*

POTENTIAL INTRODUCTION VIA SHIPPING

Is this species capable of surviving adverse environments (i.e. extreme temperatures, absence of light, low oxygen levels) and partial-to-complete ballast water exchange/BWE (e.g., is euryhaline, buries in sediment, produces resistant resting stages, has other attributes or behaviors facilitating survival under these conditions)?

Yes, this species is able to survive in ballast tank environments for weeks at a time and may be suspended in ballast water.	100
Yes, this species is able to survive in ballast tank environments for weeks at a time and is able to survive BWE by burial in ballast sediment.	80
Yes, this species is able to survive in ballast tank environments for weeks at a time and may be suspended in ballast water, but this species is not able to survive BWE.	60
No, but this species is capable of fouling transoceanic ship structures (e.g., hull, chains, chain locker) while in its active or resting stage.	40
No, this species is not able to survive adverse environments, does not foul transoceanic ship structures, or is unlikely to be taken up with ballast.	0 √
Unknown	U

- *This freshwater species is highly unlikely to be able to survive ballast water exchange.*

Does this species occur in waters from which shipping traffic to the Great Lakes originates?

Yes, and this species has been observed in ballast of or fouling ships entering the Great Lakes.	Score x 1
Yes, and this species has been observed in ports that have direct trade connections with the Great Lakes (e.g., Baltic Sea).	Score x 0. 5
Yes, but this species has neither been observed in ballast/fouling ships entering the Great Lakes nor in ports in direct trade with the Great Lakes.	Score x 0.1
No, this species does not occur in waters from which shipping traffic to the Great Lakes originates.	Score x 0
Unknown	U√

- *This species lives in streams and sloughs, not the deeper water environments necessary for shipping (Chucholl 2010).*

Potential Vector Ranking and Points				
Vector	**Raw Points Scored**	**Proximity Multiplier**	**Total Points Scored**	**Probability of Introduction**
Dispersal: Natural dispersal through waterbody connections or wind	**0**	x U	**0**	Low
Hitchhiking/Fouling: Transport via recreational gear, boats, trailers, mobile	**U**	x 0.1	**U (<10)**	Low

fauna, stocked/planted organisms, packing materials, host organisms, etc.				
Release: Unauthorized intentional release of organisms in trade (e.g., aquaria, water gardens, live food)	**100**	x 1	**100**	High
Stocking/Planting/Escape from recreational culture: Intentional authorized or unauthorized introduction to natural waters in the Great Lakes OR Accidental introduction to Great Lakes by escape from recreational culture (e.g., water gardens)	**U**	x U	**U**	Unknown
Escape from commercial culture: Accidental introduction to Great Lakes by escape from commercial culture (e.g., aquaculture)	**U**	x U	**U**	Unknown
Trans-oceanic shipping: Ballast (BOB) or no-ballast-on-board (NOBOB) water exchange/discharge, sediment discharge, hull fouling	**0**	x U	**0**	Low

Total Unknowns (U)	**3**	**Confidence Level**	Low

Section B: Potential for Establishment

ESTABLISHMENT POTENTIAL RESULTS

***Procambarus fallax f. virginalis* has a moderate probability of establishment if introduced to the Great Lakes (Confidence level: moderate).**

Comments: This species in unlikely to be able to overwinter in the Great Lakes region, but if it manages to do so, it may pose a significant threat because of its flexible diet and environmental tolerances along with its rapid, unusual reproductive strategy.

INVASIVE BIOLOGICAL/ECOLOGICAL ATTRIBUTES

How would the physiological tolerance of this species (survival in varying temperature, salinity, oxygen, and nutrient levels) be described?

This species has broad physiological tolerance. It has been reported to survive in wide ranges of temperature (0°C-30°C), salinity (0-16 parts per thousand), oxygen (0-saturated), AND nutrient (oligotrophic-eutrophic) levels.	9
This species has somewhat broad physiological tolerance. It has been reported to survive in a wide range of temperature, salinity, oxygen, OR nutrient levels. Tolerance to other factors is narrower, unknown, or unreported.	6 √
This species has narrow physiological tolerance. It has been reported to survive in limited ranges of temperature, salinity, oxygen, and nutrient levels.	3
Unknown	U

	6

- *Temperature tolerance: 8-30ºC tolerated, does best between 18-25. Can survive ice cover in laboratory experiments, but opinions are mixed as to the potential for overwintering ability (Seitz et al., 2005; Souty-Grosset et al., 2006; Feria and Faulkes, 2011).*
- *Found in both lentic and lotic conditions as well as temporary wetlands (Kawai et al., 2009).*
- *Aquarium hobbyists indicate that this species can tolerate variance in pH and oxygen, and can even tolerate water "straight from the tap" (Robbins, 2018).*

How likely is it that any life stage of this species can overwinter in the Great Lakes (survive extremely low levels of oxygen, light, and temperature)?

Likely (This species is able to tolerate temperatures under 5°C and oxygen levels ≤0.5 mg/L)	9
Somewhat likely (This species is able to tolerate some of these conditions OR has adapted behaviorally to avoid them)	6
Somewhat unlikely (This species is able to tolerate conditions close to those specified, but it is not known as an overwintering species)	3
Unlikely	0 √
Unknown	U
	0

- *This species' non-mutant form* P. fallax *originated from the southern US, and the marbled crayfish has mainly been found in tropical Madagascar and southern Europe. While laboratory specimens have been able to survive brief exposure to freezing temperatures, their apparent preference for warmer conditions may make overwintering unlikely.*

If this species is a heterotroph, how would the flexibility of its diet be described?

This species is a dietary generalist with a broad, assorted, AND flexible diet.	9 √
This species is moderately a dietary generalist with a broad, assorted, OR flexible diet.	6
This species is a dietary specialist with a limited and inflexible diet.	3
This species is an autotroph.	0
Unknown	U
	9

- *Like many crayfish species,* P. fallax f. virginalis *is a polytrophic omnivore, and feeds on detritus, algae, plants, and invertebrates (Souty-Grosset et al., 2006).*

How likely is this species to outcompete species in the Great Lakes for available resources?

Likely (This species is known to have superior competitive abilities and has a history of outcompeting other species, AND/OR available literature predicts it might outcompete native species in the Great Lakes)	9 √
Somewhat likely (This species is known to have superior competitive abilities, but there are few reported cases of this species outcompeting another and no predictions regarding species in the Great Lakes)	6
Somewhat unlikely (This species has average competitive abilities, and there are no reported cases of this species outcompeting another and no predictions regarding species in the Great Lakes)	3

Unlikely (This species is known as a poor competitor that thrives only in environments with low biodiversity, AND/OR available literature predicts it might be outcompeted by a species in the Great Lakes)	0
Unknown	U
	9

- *This species may pose a threat to indigenous crayfish due to competition for food and rapid reproduction (Jones et al., 2009; Chucholl and Pfeiffer, 2010).*

How would the fecundity of this species be described relative to other species in the same taxonomic class?

Very high	9 √
High	6
Moderate	3
Low	0
Unknown	U
	9

- *This species is parthenogenetic and single individuals can reproduce without a mate, making them exceptionally fecund (Kawai et al., 2009).*

How likely are this species' reproductive strategy and habits to aid establishment in new environments, particularly the Great Lakes (e.g., parthenogenesis/self-crossing, self fertility, vegetative fragmentation)?

Likely (The reproductive strategy or habits of this species are known to aid establishment in new environments, AND available literature predicts establishment in the Great Lakes based on these attributes)	9
Somewhat likely (The reproductive strategy or habits of this species are known to aid establishment in new environments, but there is no literature available regarding establishment in the Great Lakes based on these attributes)	6 √
Somewhat unlikely (The reproductive strategy or habits of this species could potentially aid establishment in new environments, but there is no literature available regarding establishment in the Great Lakes based on these attributes)	3
Unlikely (The reproductive strategy or habits of this species are not known to aid establishment in new environments)	0
Unknown	U
	6

- *Parthenogenic reproduction means a single individual can establish a new population without the need for a mate (Chucholl, 2010).*

ENVIRONMENTAL COMPATIBILITY

How similar are the climatic conditions (e.g., air temperature, precipitation, seasonality) in the native and introduced ranges of this species to those in the Great Lakes region?

Very similar (The climatic conditions are practically identical to those of the Great Lakes region)	9
Similar (Many of the climatic conditions are similar to those of the Great Lakes region)	6

Somewhat similar (Few of the climatic conditions are similar to those of the Great Lakes region)	3
Not similar	0
Unknown	U√
	U

- *The marbled crayfish originates from* P. fallax*, which is native to Florida and Georgia (Dorn and Violin, 2009). No indigenous marbled crayfish has been reported, however, which makes it difficult to assess "native" environmental conditions to compare them to the Great Lakes region.*

How similar are other abiotic factors that are relevant to the establishment success of this species (e.g., pollution, water temperature, salinity, pH, nutrient levels, currents) in the native and introduced ranges to those in the Great Lakes?

Very similar (These factors are practically identical to those of the Great Lakes region)	9
Similar (Many of these factors are similar to those of the Great Lakes region)	6
Somewhat similar (Few of these factors are similar to those of the Great Lakes region)	3
Not similar	0
Unknown	U√
	U

- *Water temperature is significantly colder in many parts of the Great Lakes, but other abiotic factors may be fairly compatible -- however, because no indigenous marbled crayfish has ever been observed, further detailed assessment is unavailable.*

How abundant are habitats suitable for the survival, development, and reproduction of this species in the Great Lakes area (e.g., those with adequate depth, substrate, light, temperature, oxygen)?

Abundant (Suitable habitats can be easily found and readily available)	9
Somewhat abundant (Suitable habitats can be easily found but are in high demand by species already present)	6
Somewhat scarce (Suitable habitats can be found occasionally)	3√
Scarce (Suitable habitats are rarely found)	0
Unknown	U
	3

- *Based on reported temperature tolerances (Seitz et al., 2005; Souty-Grosset et al., 2006; Feria and Faulkes, 2011) this species may be restricted to the warmest, southernmost ranges of the Great Lakes basin if it is able to establish at all.*

How likely is this species to adapt to or to benefit from the predicted effects of climate change on the Great Lakes freshwater ecosystems (e.g., warmer water temperatures, shorter duration of ice cover, altered streamflow patterns, increased salinization)?

Likely (Most of the effects described above make the Great Lakes a better environment for establishment and spread of this species OR this species could easily adapt to these changes due to its wide environmental tolerances)	9
Somewhat likely (Several of the effects described above could make the Great Lakes a better environment for establishment and spread of this species)	6√
Somewhat unlikely (Few of the effects described above would make the Great Lakes a better environment for establishment and spread of this species)	3

Unlikely (Most of the effects described above would have no effect on establishment and spread of this species or would make the environment of the Great Lakes unsuitable)	0
Unknown	U
	6

- *Warming of the Great Lakes and shorter duration of ice cover would be highly beneficial to this species, and may allow it to overwinter.*

How likely is this species to find an appropriate food source (prey or vegetation in the case of predators and herbivores, or sufficient light or nutrients in the case of autotrophs)?

Likely (All possible nutritive food items—including species in the Great Lakes that may be considered potential food items—are highly abundant and/or easily found)	9 √
Somewhat likely (Some nutritive food items—including species in the Great Lakes that may be considered potential food items—are abundant and/or search time is low to moderate)	6
Somewhat unlikely (Few nutritive food items—including species in the Great Lakes that may be considered potential food items—are abundant and/or search time is moderate to high)	3
Unlikely (All possible nutritive food items—including species in the Great Lakes that may be considered potential food items—are relatively scarce and/or search time is high)	0
Unknown	U
	9

- *This species is omnivorous and will readily eat freshwater plants, detritus, and invertebrates (Souty-Grosset et al., 2006).*

Does this species require another species for critical stages in its life cycle such as growth (e.g., root symbionts), reproduction (e.g., pollinators, egg incubators), spread (e.g., seed dispersers), or transmission (e.g., vectors)?

Yes, and the critical species (or one that may provide a similar function) is common in the Great Lakes and can be easily found in environments suitable for the species being assessed; OR, No, there is no critical species required by the species being assessed	9 √
Yes, and the critical species (or one that may provide a similar function) is moderately abundant and relatively easily found in particular parts of the Great Lakes	6
Yes, and the critical species (or one that may provide a similar function) is relatively rare in the Great Lakes AND/OR can only be found occasionally in environments suitable for the species being assessed	3
Yes, and the critical species (or one that may provide a similar function) is not present in the Great Lakes but is likely to be introduced	0
Yes, but the critical species (or one that may provide a similar function) is not present in the Great Lakes and is not likely to be introduced	-80% total points (at end)
Unknown	U
	9

- *No, this species does not require the presence of any other species to grow, reproduce, or spread.*

How likely is the establishment of this species to be aided by the establishment and spread of another species already in the Great Lakes?

Likely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established and spread in the Great Lakes, AND available literature predicts this previous invader might promote the establishment of this species, AND/OR there have been cases reported of this species aiding the establishment of this species in other areas)	9
Somewhat likely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established and spread in the Great Lakes)	6
Somewhat unlikely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established in the Great Lakes BUT it is still confined to a small area of the Lakes and the likelihood of encounter with this species assessed is hard to predict)	3
Unlikely (A non-indigenous species to the Great Lakes that facilitates the development of this species has not been established in the Great Lakes)	0 √
Unknown	U
	0

- *A non-indigenous species in the Great Lakes has not been established that would facilitate the spread of the marbled crayfish.*

How likely is establishment of this species to be prevented by the herbivory, predation, or parasitism of a natural enemy this is already present in the Great Lakes and may preferentially target this species?

Likely (The ability of the natural enemy to prevent the establishment of this species in introduced ranges or limiting populations of this species in native ranges is well documented in the literature AND this natural enemy is abundant and widespread in the Great Lakes)	-80% total points (at end)
Somewhat likely (The ability of the natural enemy to prevent the establishment of this species in introduced ranges or limiting populations of this species in native ranges is suggested in the literature OR this natural enemy has limited distribution in the Great Lakes)	-60% total points (at end)
Somewhat unlikely (There are few cases reported of such a natural enemy preventing the establishment of this species in introduced ranges or limiting populations of this species in native ranges OR this natural enemy has low abundance in the Great Lakes)	-10% total points (at end)√
Unlikely (Such a natural enemy is particularly rare or is not present in the Great Lakes)	0
Unknown	U
	-10%

- *Eels and other predatory fish prey on crayfish, but are unlikely to be able to control a rapidly reproducing population (Aquiloni et al., 2010).*

PROPAGULE PRESSURE

On average, how large and frequent are inoculations (introduction events) from the potential vectors identified in Section A for this species? (What is the total number of individuals introduced?)

Frequent, large inocula	9
Frequent, moderate inocula	6

Frequent, small inocula OR infrequent, large inocula	3
Infrequent, small or moderate inocula	0 √
Unknown	U
	0

- *Occasional aquarium releases by pet owners are the likely vector, and would not occur with great frequency or in high numbers (Souty-Grosset et al., 2006).*

HISTORY OF INVASION AND SPREAD

How extensively has this species established reproducing populations in areas outside its native range as a direct or indirect result of human activities?

Very extensively (many invasive populations of this species have been reported in areas widely distributed from the native range)	9
Extensively (some invasive populations of this species have been reported in areas widely distributed from the native range)	6√
Somewhat extensively (few invasive populations of this species have been reported in areas widely distributed from the native range OR all invasive populations are in close proximity to each other)	3
Not extensively (no invasive populations of this species have been reported)	0
Unknown	U
	6

- *The spread of this species has been somewhat limited (and may be temperature-dependent) in Europe, but populations in Madagascar are massive and can severely disrupt the ecosystem (Jones et al., 2009; Chucholl and Pfeiffer, 2010).*

How rapidly has this species spread by natural means or by human activities once introduced to other locations?

Rapidly (This species has a history of rapid spread in introduced ranges)	9 √
Somewhat rapidly (This species has a history of moderately rapid spread in introduced ranges)	6
Somewhat slowly (This species has a history of moderately slow spread in its introduced ranges)	3
Slowly (This species has a history of slow to no spread in its introduced ranges)	0
Unknown	U
	9

- *This species' rapid rate of asexual reproduction has allowed it to colonize many waterways in Madagascar, and because crayfish can travel by land the risk is compounded. Human activity in Madagascar has also helped spread the marbled crayfish because it is used for food (Jones et al., 2009).*

Are there any existing control measures in the Great Lakes set to prevent the establishment and/or spread of this species?

Yes, and they are likely to prevent establishment or spread of the species. (There are no reported cases of this species adapting or avoiding current measures. These measures are highly effective in preventing the establishment and spread of this species)	-90% total points (at end)

Yes, and they are moderately likely to prevent establishment or spread of the species. (There are few reported cases of this species adapting or avoiding current measures used to control its establishment and spread)	-50% total points (at end)
Yes, but they are unlikely to prevent establishment or spread of the species. (There are many reported cases of this species adapting or avoiding current measures used to control its establishment and spread)	-20% total points (at end) √
No control methods have been set to prevent the establishment and/or spread of this species	0
Unknown	U
	-20%

- *Methods used for other invasive crayfish may be applicable to this species (to limited effect), but no specific legislation yet exists in the Great Lakes. Once control measures are ceased, the population is likely to return to its former level (Gherardi et al., 2011).*

Establishment Potential Scorecard				
Points	**Probability for Establishment**	Total Points (pre-adjustment)		**84**
>100	High	**Adjustments**		
		Critical species	A (84- 0 %)	**84**
51-99	Moderate	Natural enemy	B (84- 10 %)	**75.6**
		Control measures	C (75.6- 20 %)	**60.48**
0-50	Low	Probability for Establishment		Moderate
# of questions answered as “unable to determine”	**Confidence Level**			
0-1	High	Total # of questions unknown		2
2-5	Moderate			
6-9	Low	Confidence Level		Moderate
>9	Very low			

Section C: Potential for Impact

IMPACT POTENTIAL RESULTS

Environmental: *P. fallax f. virginalis* has the potential for high environmental impact if introduced to the Great Lakes.
Socio-Economic: *P. fallax f. virginalis* has the potential for moderate socio-economic impact if introduced to the Great Lakes.
Beneficial: *P. fallax f. virginalis* has the potential for high beneficial impact if introduced to the Great Lakes.

POTENTIAL ENVIRONMENTAL IMPACT

Does the species pose some hazard or threat to the health of native species (e.g., it magnifies toxin levels; is poisonous; is a pathogen, parasite, or a vector of either)?

Yes, and it has impacted threatened/endangered species, resulted in the reduction or extinction of one or more native populations, affects multiple species, or is a reportable disease	6√
Yes, but negative consequences have been small (e.g., limited number of infected individuals, limited pathogen transmissibility, mild effects on populations and ecosystems)	1
Not significantly	0
Unknown	U

- *As a crayfish of North American origin, the marbled crayfish is likely a carrier of* Aphanomyces astaci*, the crayfish plague (Souty-Grosset et al., 2006).*
- *Rickettsiosis and coccidiosis have both been found in marbled crayfish, and* Psorospermium sp. *is known to infect* P. fallax *in its indigenous range (Souty-Grosset et al., 2006).*

Does it out-compete native species for available resources (e.g., habitat, food, nutrients, light)?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species or caused critical reduction, extinction, behavioral changes including modified spawning behavior) on one or more native populations	6 √
Yes, and it has caused some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population	1
Not significantly	0
Unknown	U

- *Marbled crayfish pose a threat to indigenous crayfish species in Madagascar and Europe due to competition for food and space and crayfish plague transmission (Jones et al., 2009; Kawai et al., 2009; Chucholl and Pfeiffer, 2010).*
- *Marbled crayfish reproduce by parthenogenesis, which makes the risk of release resulting in a reproducing population considerably greater than for sexually reproducing species: a single individual is sufficient to create a new population (Kawai et al 2009).*
- *Current data suggests that the marbled crayfish is a fast-growing species that exhibits r-selected life history traits like early maturation, an extended breeding period, and high fecundity, giving it a competitive advantage over other species (Seitz et al., 2005; Jones et al., 2009; Chucholl and Pfeiffer, 2010).*

Does it alter predator-prey relationships?

Yes, and it has resulted in significant adverse effects	6

(e.g., impacted threatened/endangered species, caused significant reduction or extinction of one or more native populations, creation of a dead end or any other significant alteration in the food web)	
Yes, and it has resulted in some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population AND/OR Yes, and it has resulted in some alteration of the food web structure or processes, the effects of which have not been widespread or severe	1
Not significantly	0
Unknown	U √

- *Unknown.*

Has it affected any native populations genetically (e.g., through hybridization, selective pressure, introgression)?

Yes, and it has caused a loss or alteration of genes that may be irreversible or has led to the decline of one or more native species (or added pressure to threatened/endangered species)	6
Yes, some genetic effects have been observed, but consequences have been limited to the individual level	1
Not significantly	0 √
Unknown	U

- *The marbled crayfish is triploid, and attempted crossbreeding experiments with* P. fallax *and* P. alleni *indicate that they are incapable of hybridization: all offspring produced even after mating with males are identical female marbled crayfish with no genetic contribution from the males (Vogt et al., 2015).*

Does it negatively affect water quality (e.g., increased turbidity or clarity, altered nutrient, oxygen, or other chemical levels/cycles)?

Yes, and it has had a widespread, long-term, or severe negative effect on water quality AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected water quality to some extent, but the alterations and resulting adverse effects have been limited or inconsistent (as compared with above statement)	1 √
Not significantly	0
Unknown	U

- *This species is a tertiary burrower (Kouba et al, 2016), and while only anecdotal evidence exists of how the marbled crayfish in particular may alter water quality, the related species* Procambarus clarkii *has had major impacts on native ecosystems and degraded shallow wetlands on the Iberian Peninsular within a few years. In Lake Chozas, the invasion by* P. clarkii *led to a switch from a clear water state to a turbid one, followed by a severe biodiversity reduction (Rodríguez et al., 2005).*

Does it alter physical components of the ecosystem in some way (e.g., facilitated erosion/siltation, altered hydrology, altered macrophyte/phytoplankton communities, physical or chemical changes to substrate)?

Yes, and it has had a widespread, long term, or severe negative effect on the physical ecosystem AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected the physical ecosystem to some extent, but the alterations and resulting adverse effects have been mild	1 √
Not significantly	0

Unknown	U

- *Marbled crayfish are polytrophic omnivores and were found at very high densities in Madagascar (Jones et al., 2009). Given that, they may have a very significant impact on ecosystem functioning and integrity, although specific and quantified information is currently lacking.*

Environmental Impact Total	**14**
Total Unknowns (U)	**2**

POTENTIAL SOCIO-ECONOMIC IMPACT

Does the species pose some hazard or threat to human health (e.g., it magnifies toxin levels, is poisonous, a virus, bacteria, parasite, or a vector of one)?

Yes, significant effects on human health have already been observed	6
Yes, but negative consequences have not been widespread, long lasting, or severe	1
Not significantly	0 √
Unknown	U

- *The marbled crayfish does not appear to have negative impacts on human health.*

Does it cause damage to infrastructure (e.g., water intakes, pipes, or any other industrial or recreational infrastructure)?

Yes, it is known to cause significant damage	6
Yes, but the costs have been small and are largely reparable or preventable	1 √
Not significantly	0
Unknown	U

- *This species digs burrows which may cause damage to irrigation systems and dams (Souty-Grosset et al., 2006).*

Does it negatively affect water quality (i.e. in terms of being less suitable for human use)?

Yes, it has significantly affected water quality, and is costly or difficult to reverse	6
Yes, but the effects are negligible and/or easily reversed	1
Not significantly	0
Unknown	U√

- *This species may cause increased turbidity, but other factors impacting water quality are unknown.*

Does it negatively affect any markets or economic sectors (e.g., commercial fisheries, aquaculture, agriculture)?

Yes, it has caused significant damage to one or more markets or economic sectors	6
Some damage to markets or sectors has been observed, but negative consequences have been small	1 √
Not significantly	0
Unknown	U

- *Anecdotal observations from Madagascar suggest a significant impact on fish populations. Local fishermen reported that marbled crayfish have destroyed fishing in their area (Jones et al., 2009; Heimer, 2010).*
- *There is serious concern in Madagascar that the invasion of marbled crayfish will negatively impact rice culture by feeding on and destroying young plants (Jones et al., 2009; Kawai et al., 2009; Heimer, 2010), which suggests that they may also have the potential to negatively impact wild rice cultivation in the Great Lakes if introduced to paddies.*

Does it inhibit recreational activities and/or associated tourism (e.g., through frequent water closures, equipment damage, decline of recreational species)?

Yes, it has caused widespread, frequent, or otherwise expensive inhibition of recreation and tourism	6
Yes, but negative consequences have been small	1
Not significantly	0
Unknown	U √

- *May increase turbidity, but current research is inconclusive.*

Does it diminish the perceived aesthetic or natural value of the areas it inhabits?

Yes, the species has received significant attention from the media/public, significantly diminished the natural or cultural character of the area, or significantly reduced the area's value for future generations	6
Yes, but negative consequences have been small	1
Not significantly	0 √
Unknown	U

- *Significant media coverage in February 2018 around the globe has led to increased public awareness of this species, but no significant impacts on natural or aesthetic value have been observed.*

Socio-Economic Impact Total	**2**
Total Unknowns (U)	**2**

POTENTIAL BENEFICIAL EFFECT

Does it act as a biological control agent for aquatic weeds or other harmful nonindigenous organisms?

Yes, it has succeeded significantly as a control agent	6
Yes, it has had some success as a control agent, but may be inconsistent or lack a desired level of effectiveness	1
Not significantly	0
Unknown	U√

- *This species is omnivorous but any impacts on weeds or other harmful organisms is unknown.*

Is it commercially valuable (e.g., for fisheries, aquaculture, agriculture, bait, ornamental trade)?

Yes, it is economically important to at least one of these industries	6
Yes, but its economic contribution is small	1√
Not significantly	0
Unknown	U

- *In Madagascar, marbled crayfish are sold in markets for human consumption (Jones et al., 2009, Kawai et al., 2009; Heimer, 2010). However, Heimer (2010) and Jones et al. (2009) both indicate that marbled crayfish are of low economic value, and their popularity as a food source is limited by their small size and the subsequent amount of work it takes to clean them for eating.*
- *This species is a popular and inexpensive aquarium pet: they are available for purchase from hobbyists in the United States for about $10-15 per specimen (Aquatic Arts, 2018).*

Is it recreationally valuable (e.g., for sport or leisurely fishing, as a pet, or for any other personal activity)?

Yes, it is commonly employed recreationally and has some perceived value for local communities and/or tourism	6
It is sometimes employed recreationally, but adds little value to local communities or tourism	1 √
Not significantly	0
Unknown	U

- *The marbled crayfish remains a popular pet species in Europe and North America (Chucholl, 2010; Faulkes, 2010).*
- *This species is also used as fishing bait.*

Does the species have some medicinal or research value (i.e. outside of research geared towards its control)?

Yes, it has significant medicinal or research value	6√
It has some medicinal or research value, but is not of high priority OR It is potentially important to medicine or research and is currently being or scheduled to be studied [I think this second half qualifies as unknown]	1
Not significantly	0
Unknown	U

- *The marbled crayfish is a useful laboratory model organism for developmental physiology, epigenetics and toxicology. Its large numbers of genetically identical offspring, fast reproductive rate, and simple care requirements make it an ideal species for lab research (Vogt, 2008; 2010). Recent publications document its increasing use as model organism (e.g. Jirikowski et al., 2010; Rubach et al., 2011).*

Does the species remove toxins or pollutants from the water or otherwise increase water quality?

Yes, it reduces water treatment costs or has a significant positive impact for the health of humans and/or native species	6
Yes, but positive impact for humans or native species is considered negligible	1
Not significantly	0 √
Unknown	U

- *To the contrary, this species may increase turbidity.*

Does the species have a positive ecological impact outside of biological control (e.g., increases the growth or reproduction rates of other species, fills an important gap in the food web, supports the survival of a species that is threatened, endangered species, or commercially valuable)?

Yes, it significantly contributes to the ecosystem in one or more of these ways	6
Yes, it provides some positive contribution to the ecosystem, but is not vital	1
Not significantly	0 √
Unknown	U

- *Any benefits this species may provide as a food source for large fish or other organisms are likely cancelled out by its competition with native crayfish and other disruptive behaviors.*

Beneficial Effect Total	**8**
Total Unknowns (U)	**1**

Scientific Name: *Pseudorasbora parva*

Notable change: Overall economic impact potential score changed from Unknown (1 pt, 1 U) to High (6 pts, 1 U) due to revision in question S4.

Section C: Potential for Impact

IMPACT POTENTIAL RESULTS

Socio-Economic: High
***Pseudorasbora parva* has a high potential socio-economic impact in the Great Lakes.**

It is unknown whether *P. parva* poses hazards or threats to human health. *P. parva* does carry parasites that are able to infect humans (Zhou et al. 2008, Pak et al. 2009, Xu et al. 2010, Bao 2012) but there are no documentations of *P. parva* directly transferring these to humans (Gozlan et al. 2010a). A series of three (successful) eradication exercises from United Kingdom lakes has cost approximately £130,000 in public funds (Britton et al. 2008).

P. parva poses a threat to commercial and recreational fisheries. *P. parva* may outcompete native prey species and carry pathogens/parasites that are known to affect salmonids and Northern pike (Gozlan et al. 2010a). Three fish species in Europe have declined by 80-90% following the invasion of *P. parva*. This trend coincided with increased prevalence of *Sphareothecum destruens*, a pathogen known to be carried by *P. parva*, in fish populations and specifically in the three declining species. *P. parva* is considered a major threat to the sea bass aquaculture industry in Europe (Ercan et al. 2015). In the United States, *S. destruens* has caused mass mortality in farmed and wild Chinook salmon in California where it caused >80% mortality of smolts (Harrell et al. 1986).

POTENTIAL SOCIO-ECONOMIC IMPACT

Does it negatively affect any markets or economic sectors (e.g., commercial fisheries, aquaculture, agriculture)?

Yes, it has caused significant damage to one or more markets or economic sectors	6 √
Some damage to markets or sectors has been observed, but negative consequences have been small	1
Not significantly	0
Unknown	U

- *P. parva may outcompete native prey species and carry pathogens/parasites that are known to affect salmonids and Northern pike (Gozlan et al. 2010a). Ercan et al. (2015) noted that three species endemic to Europe have declined by 80-90% three years following the invasion of P. parva. This trend coincided with increased prevalence of Sphareothecum destruens, a pathogen known to be carried by P. parva, in fish populations and specifically in the three declining species. P. parva is also considered a major threat to the sea bass aquaculture industry in Europe. In the US, S. destruens has caused mass mortality in farmed and wild Chinook salmon in California where it caused >80% mortality of smolts (Harrell et al. 1986).*
- *The prevalence of* Pseudocapillaria tomentosa *in topmouth gudgeon was 45.1%.* Pseudocapillaria tomentosa *infection was associated with mortality in captive tiger barbs,* Puntius tetrazona, *and other ornamental fish (Moravec et al. 1984). Heavy infections of* P. tomentosa *in pond-reared carp or other fish species of economic importance can cause economic problems with fish production (Mihok et al. 2011).*
- *In the native range,* P. parva *is the second intermediate host for cosmopolitan ligulid tapeworms and to species of the* Digramma *genus that have been the cause of high mortalities in freshwater commercial*

fisheries in China and Russia. These species have not been reported in introduced range (Gozlan et al. 2010b).

- *A series of three (successful) eradication exercises from United Kingdom lakes that has cost approximately £130,000 of public funds (Britton et al. 2008).*

Socio-Economic Impact Total	**6**
Total Unknowns (U)	**1**

Scientific Name: *Sinelobus stanfordi*

Common Name: none

Section C: Potential for Impact

IMPACT POTENTIAL RESULTS

Environmental: Unknown
Socio-Economic: Low
Beneficial: Low

Comments:

Current research on the potential environmental impacts to result from *Sinelobus stanfordi* if introduced to the Great Lakes is inadequate to support proper assessment.
There is little or no evidence to support that *Sinelobus stanfordi* has the potential for significant socio-economic impacts if introduced to the Great Lakes.

There is little or no evidence to support that *Sinelobus stanfordi* has the potential for significant beneficial impacts if introduced to the Great Lakes.

POTENTIAL ENVIRONMENTAL IMPACT

Does the species pose some hazard or threat to the health of native species (e.g., it magnifies toxin levels; is poisonous; is a pathogen, parasite, or a vector of either)? √

Yes, and it has impacted threatened/endangered species, resulted in the reduction or extinction of one or more native populations, affects multiple species, or is a reportable disease	6
Yes, but negative consequences have been small (e.g., limited number of infected individuals, limited pathogen transmissibility, mild effects on populations and ecosystems)	1
Not significantly	0√
Unknown	U

- *As a small benthic crustacean, not likely.*

Does it out-compete native species for available resources (e.g., habitat, food, nutrients, light)?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species or caused critical reduction, extinction, behavioral changes including modified spawning behavior) on one or more native populations	6
Yes, and it has caused some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population	1
Not significantly	0
Unknown	U√

- *A paucity of data exists for this species.*

Does it alter predator-prey relationships?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species, caused significant reduction or extinction of one or more native populations, creation of a dead end or any other significant alteration in the food web)	6
Yes, and it has resulted in some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population AND/OR Yes, and it has resulted in some alteration of the food web structure or processes, the effects of which have not been widespread or severe	1
Not significantly	0√
Unknown	U

- *As a small benthic crustacean, not likely.*

Has it affected any native populations genetically (e.g., through hybridization, selective pressure, introgression)?

Yes, and it has caused a loss or alteration of genes that may be irreversible or has led to the decline of one or more native species (or added pressure to threatened/endangered species)	6
Yes, some genetic effects have been observed, but consequences have been limited to the individual level	1
Not significantly	0
Unknown	U√

- *As a small benthic crustacean, not likely.*

Does it negatively affect water quality (e.g., increased turbidity or clarity, altered nutrient, oxygen, or other chemical levels/cycles)?

Yes, and it has had a widespread, long-term, or severe negative effect on water quality AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected water quality to some extent, but the alterations and resulting adverse effects have been limited or inconsistent (as compared with above statement)	1
Not significantly	0
Unknown	U√

- *As a small benthic crustacean, not likely.*

Does it alter physical components of the ecosystem in some way (e.g., facilitated erosion/siltation, altered hydrology, altered macrophyte/phytoplankton communities, physical or chemical changes to substrate)?

Yes, and it has had a widespread, long term, or severe negative effect on the physical ecosystem AND/OR	6

Yes, and it has resulted in significant negative consequences for at least one native species	
Yes, it has affected the physical ecosystem to some extent, but the alterations and resulting adverse effects have been mild	1
Not significantly	0 √
Unknown	U

- *As a small benthic crustacean, not likely.*

Environmental Impact Total	**0**
Total Unknowns (U)	**3**

POTENTIAL SOCIO-ECONOMIC IMPACT

Does the species pose some hazard or threat to human health (e.g., it magnifies toxin levels, is poisonous, a virus, bacteria, parasite, or a vector of one)?

Yes, significant effects on human health have already been observed	6
Yes, but negative consequences have not been widespread, long lasting, or severe	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Does it cause damage to infrastructure (e.g., water intakes, pipes, or any other industrial or recreational infrastructure)?

Yes, it is known to cause significant damage	6
Yes, but the costs have been small and are largely reparable or preventable	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Does it negatively affect water quality (i.e. in terms of being less suitable for human use)?

Yes, it has significantly affected water quality, and is costly or difficult to reverse	6
Yes, but the effects are negligible and/or easily reversed	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Does it negatively affect any markets or economic sectors (e.g., commercial fisheries, aquaculture, agriculture)?

Yes, it has caused significant damage to one or more markets or economic sectors	6
Some damage to markets or sectors has been observed, but negative consequences have been small	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Does it inhibit recreational activities and/or associated tourism (e.g., through frequent water closures, equipment damage, decline of recreational species)?

Yes, it has caused widespread, frequent, or otherwise expensive inhibition of recreation and tourism	6
Yes, but negative consequences have been small	1
Not significantly	0√
Unknown	U

- *Not reported.*

Does it diminish the perceived aesthetic or natural value of the areas it inhabits?

Yes, the species has received significant attention from the media/public, significantly diminished the natural or cultural character of the area, or significantly reduced the area's value for future generations	6
Yes, but negative consequences have been small	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Socio-Economic Impact Total	**0**
Total Unknowns (U)	**0**

POTENTIAL BENEFICIAL EFFECT

Does it act as a biological control agent for aquatic weeds or other harmful nonindigenous organisms?

Yes, it has succeeded significantly as a control agent	6
Yes, it has had some success as a control agent, but may be inconsistent or lack a desired level of effectiveness	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Is it commercially valuable (e.g., for fisheries, aquaculture, agriculture, bait, ornamental trade)?

Yes, it is economically important to at least one of these industries	6
Yes, but its economic contribution is small	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Is it recreationally valuable (e.g., for sport or leisurely fishing, as a pet, or for any other personal activity)?

Yes, it is commonly employed recreationally and has some perceived value for local communities and/or tourism	6
It is sometimes employed recreationally, but adds little value to local communities or tourism	1

Not significantly	0√
Unknown	U

- *Not reported.*

Does the species have some medicinal or research value (i.e. outside of research geared towards its control)?

Yes, it has significant medicinal or research value	6
It has some medicinal or research value, but is not of high priority OR It is potentially important to medicine or research and is currently being or scheduled to be studied	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Does the species remove toxins or pollutants from the water or otherwise increase water quality?

Yes, it reduces water treatment costs or has a significant positive impact for the health of humans and/or native species	6
Yes, but positive impact for humans or native species is considered negligible	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Does the species have a positive ecological impact outside of biological control (e.g., increases the growth or reproduction rates of other species, fills an important gap in the food web, supports the survival of a species that is threatened, endangered species, or commercially valuable)?

Yes, it significantly contributes to the ecosystem in one or more of these ways	6
Yes, it provides some positive contribution to the ecosystem, but is not vital	1
Not significantly	0 √
Unknown	U

- *No evidence that Tanais stanfordi is utilized as a food source for juvenile salmonids at estuarine environments (Levings and Rafi 1978).*

Beneficial Effect Total	**0**
Total Unknowns (U)	**0**

Scientific Name: *Sparganium erectum*

Common Name: Exotic bur-reed

Section A: Potential for Introduction

INTRODUCTION POTENTIAL RESULTS

Dispersal: Low
Hitchhiking/Fouling: Low
Unauthorized intentional release: Moderate
Stocking/Planting/Escape from recreational culture: Unknown
Escape from commercial culture: Low
Shipping: Low

POTENTIAL INTRODUCTION VIA DISPERSAL

Does this species occur near waters (natural or artificial) connected to the Great Lakes basin* (e.g., streams, ponds, canals, or wetlands)?
*(*Great Lakes basin = below the ordinary high water mark, including connecting channels, wetlands, and waters ordinarily attached to the Lakes)*

Yes, this species occurs near waters connected to the Great Lakes basin and is mobile or able to be transported by wind or water.	100√
No, this species does not occur near waters connected to the Great Lakes basin and/or is not mobile or able to be transported by wind or water.	0
Unknown	U

- *Closest population appears to be Devil's Lake State Park/ Sauk County Wisconsin (Lange, 1998) This area is in Mississippi River Drainage; however, seeds may be wind-dispersed*

What is the proximity of this species to the Great Lakes basin?

This species occurs in waters within 20 kilometers of the Great Lakes basin, and no barrier (e.g., electric barrier, dam) to dispersal is present.	Score x 1
This species occurs in waters within 20 kilometers of the Great Lakes basin, but dispersal to the basin is blocked; or, this species occurs in waters within 100 kilometers of the Great Lakes basin, and no barrier to dispersal is present.	Score x 0.75
This species occurs in waters within 100 kilometers of the Great Lakes basin, but dispersal to the basin is blocked.	Score x 0.5
This species occurs in waters >100 kilometers from the Great Lakes basin.	Score x 0.25√
Unknown	U

- *Devil's Lake State Park is 100 miles from Lake Michigan.*

POTENTIAL INTRODUCTION VIA HITCHHIKING/FOULING

Is this species likely to attach to or be otherwise transported by, or along with, recreational gear, boats, trailers, fauna (e.g., waterfowl, fish, insects), flora (e.g., aquatic plants), or other objects (e.g., packing materials), including as parasites or pathogens, entering the Great Lakes basin?

Yes, this species is known to be able to adhere to certain surfaces or to be transported by other organisms entering the Great Lakes basin.	100
No, this species is not known to be able to adhere to certain surfaces or to be transported by other organisms entering the Great Lakes basin.	0 √
Unknown	U

- *Tucker et al., (2018) scores it as 0/100 for risk of hitchhiking/fouling*

What is the proximity of this species to the Great Lakes basin?

This species occurs in waters within 20 km of the Great Lakes basin.	Score x 1
This species occurs in waters within 100 km of the Great Lakes basin.	Score x 0.5
This species occurs in waters >100 km from the Great Lakes basin.	Score x 0.1√
Unknown	U

- *Closest population is Sauk County, WI (Lange, 1998).*

POTENTIAL INTRODUCTION VIA UNAUTHORIZED INTENTIONAL RELEASE

Is this species sold at aquarium/pet/garden stores ("brick & mortar" or online), catalogs, biological supply companies, or live markets (e.g., purchased for human consumption, bait, ornamental, ethical, educational, or cultural reasons) and as a result may be released into the Great Lakes basin?

Yes, this species is available for purchase.	100√
No, this species this species is rarely/never sold.	0
Unknown	U

- *Stratford and Hoyle (2001) found that it was readily available through online retailers.*

How easily is this species obtained within the Great Lakes region (states/provinces)?

This species is widely popular, frequently sold, and/or easily obtained within the Great Lakes region.	Score x 1
This species is widely popular, and although trade, sale, and/or possession of this species is prohibited, it is frequently sold on the black market within the Great Lakes region.	Score x 0.5√
This species is not very popular or is not easily obtained within the Great Lakes region.	Score x 0.1
Unknown	U

- *Federally listed as a noxious weed (USDA, 2001)*
- *Most commonly found commercial species after Hygro via Yahoo search (Kay and Hoyle, 2001)*

POTENTIAL INTRODUCTION VIA STOCKING/PLANTING OR ESCAPE FROM RECREATIONAL CULTURE

Is this species being stocked/planted to natural waters or outdoor water gardens around the Great Lakes region?

Yes, this species is being stocked/planted and/or has ornamental, cultural, medicinal, environmental (e.g., biocontrol, erosion control), scientific, or recreational value in the Great Lakes region.	100
No, this species cannot be stocked/planted or there is not enough interest to do so in the Great Lakes region.	0
Unknown	U√

- *No reports of planting in outdoor water gardens in the Great Lakes, but it is available for sale online.*

What is the nature and proximity of this activity to the Great Lakes basin?

This activity is authorized and/or is occurring directly in the Great Lakes.	Score x 1
This activity is occurring in Great Lakes tributaries or connecting waters, or within 20 km of the Great Lakes basin.	Score x 0.75
This activity is likely to occur within 20 km of the Great Lakes basin because of its popularity/value and there are no widespread regulations against stocking/planting.	Score x 0.5
This activity is occurring in waters >20 km from the Great Lakes basin, or despite federal or state regulations in more than half the basin (> 5 states/provinces), this activity may occur within 20 km of the basin because of the species' popularity/value.	Score x 0.25
Unknown	U√

- *Unknown.*

POTENTIAL INTRODUCTION VIA ESCAPE FROM COMMERCIAL CULTURE

Is this species known to be commercially cultured in or transported through the Great Lakes region?

Yes, this species is being commercially cultured in or transported through the Great Lakes region.	100
No, this species is not commercially cultured in or transported through the Great Lakes region.	0 √
Unknown	U

- *Not reported to be commercially cultured anywhere.*

What is the nature and proximity of this activity to the Great Lakes basin?

This activity is unregulated or minimally regulated and is occurring directly in the Great Lakes.	Score x 1
This activity is unregulated or minimally regulated and is occurring in Great Lakes tributaries or connecting waters, or within 20 km of the Great Lakes basin.	Score x 0.75
This activity is strictly regulated but occurs directly in the Great Lakes, and/or this activity involves transport of live organisms on/across the Great Lakes.	Score x 0.5
This activity is strictly regulated but occurs in Great Lakes tributaries, connecting waters, or within 20 km of the Great Lakes basin, and/or this activity involves transport of live organisms within 20 km of the Great Lakes basin.	Score x 0.25
This activity occurs >20 km from the Great Lakes basin and typically does not involve transport of live organisms closer to the basin.	Score x 0.1
Unknown	U

POTENTIAL INTRODUCTION VIA SHIPPING

Is this species capable of surviving adverse environments (i.e. extreme temperatures, absence of light, low oxygen levels) and partial-to-complete ballast water exchange/BWE (e.g., is euryhaline, buries in sediment, produces resistant resting stages, has other attributes or behaviors facilitating survival under these conditions)?

Yes, this species is able to survive in ballast tank environments for weeks at a time and may be suspended in ballast water.	100
Yes, this species is able to survive in ballast tank environments for weeks at a time and is able to survive BWE by burial in ballast sediment.	80
Yes, this species is able to survive in ballast tank environments for weeks at a time and may be suspended in ballast water, but this species is not able to survive BWE.	60
No, but this species is capable of fouling transoceanic ship structures (e.g., hull, chains, chain locker) while in its active or resting stage.	40
No, this species is not able to survive adverse environments, does not foul transoceanic ship structures, or is unlikely to be taken up with ballast.	0 √
Unknown	U

- *Rated 0 for risk of spread via shipping by Tucker et al. (2018).*

Does this species occur in waters from which shipping traffic to the Great Lakes originates?

Yes, and this species has been observed in ballast of or fouling ships entering the Great Lakes.	Score x 1
Yes, and this species has been observed in ports that have direct trade connections with the Great Lakes (e.g., Baltic Sea).	Score x 0. 5
Yes, but this species has neither been observed in ballast/fouling ships entering the Great Lakes nor in ports in direct trade with the Great Lakes.	Score x 0.1
No, this species does not occur in waters from which shipping traffic to the Great Lakes originates.	Score x 0√
Unknown	U

Vector Potential Scorecard				
Vector	**Raw Points Scored**	**Proximity Multiplier**	**Total Points Scored**	**Probability of Introduction**
Dispersal: Natural dispersal through waterbody connections or wind	**100**	x	**0.25**	25
Hitchhiking/Fouling: Transport via recreational gear, boats, trailers, mobile fauna, stocked/planted organisms, packing materials, host organisms, etc.	**0**	x	**0.1**	0
Release: Unauthorized intentional release of organisms in trade (e.g., aquaria, water gardens, live food)	**100**	x	**0.5**	50
Stocking/Planting/Escape from recreational culture: Intentional authorized or unauthorized introduction to natural waters in the Great Lakes OR Accidental introduction to Great Lakes by	**U**	x	**U**	Unknown

escape from recreational culture (e.g., water gardens)					
Escape from commercial culture: Accidental introduction to Great Lakes by escape from commercial culture (e.g., aquaculture)		**0**	x	**0**	0
Trans-oceanic shipping: Ballast (BOB) or no-ballast-on-board (NOBOB) water exchange/discharge, sediment discharge, hull fouling		**0**	x	**0**	0
Total Unknowns (U)	**1**	**Confidence Level**		Moderate	

Section B: Potential for Establishment

ESTABLISHMENT POTENTIAL RESULTS

Sparganium erectum **has a Moderate probability of establishment if introduced to the Great Lakes (Confidence level: Moderate).**

INVASIVE BIOLOGICAL/ECOLOGICAL ATTRIBUTES

How would the physiological tolerance of this species (survival in varying temperature, salinity, oxygen, and nutrient levels) be described?

This species has broad physiological tolerance. It has been reported to survive in wide ranges of temperature (0°C-30°C), salinity (0-16 parts per thousand), oxygen (0-saturated), AND nutrient (oligotrophic-eutrophic) levels.	9
This species has somewhat broad physiological tolerance. It has been reported to survive in a wide range of temperature, salinity, oxygen, OR nutrient levels. Tolerance to other factors is narrower, unknown, or unreported.	6
This species has narrow physiological tolerance. It has been reported to survive in limited ranges of temperature, salinity, oxygen, and nutrient levels.	3√
Unknown	U
	3

- *Prefers full sun but can tolerate some shade (Favorite, 2002).*
- *Found primarily in mesotrophic to eutrophic waters (IUCN, 2014).*
- *Adapted to low energy, low gradient streams (Pollen Bankhead et al., 2011).*
- *Prefer nutrient-rich clayey soils (Asaeda, 2010).*

How likely is it that any life stage of this species can overwinter in the Great Lakes (survive extremely low levels of oxygen, light, and temperature)?

Likely (This species is able to tolerate temperatures under 5°C and oxygen levels ≤0.5 mg/L)	9
Somewhat likely (This species is able to tolerate some of these conditions OR has adapted behaviorally to avoid them)	6√

Somewhat unlikely (This species is able to tolerate conditions close to those specified, but it is not known as an overwintering species)	3
Unlikely	0
Unknown	U
	6

- *Widespread in temperate regions of Europe and Asia (O'hare et al., 2013).*
- *Populations reported in Wisconsin (Lange, 1998).*

If this species is a heterotroph, how would the flexibility of its diet be described?

This species is a dietary generalist with a broad, assorted, AND flexible diet.	9
This species is moderately a dietary generalist with a broad, assorted, OR flexible diet.	6
This species is a dietary specialist with a limited and inflexible diet.	3
This species is an autotroph.	0√
Unknown	U
	0

- *Not reported.*

How likely is this species to outcompete species in the Great Lakes for available resources?

Likely (This species is known to have superior competitive abilities and has a history of outcompeting other species, AND/OR available literature predicts it might outcompete native species in the Great Lakes)	9
Somewhat likely (This species is known to have superior competitive abilities, but there are few reported cases of this species outcompeting another and no predictions regarding species in the Great Lakes)	6
Somewhat unlikely (This species has average competitive abilities, and there are no reported cases of this species outcompeting another and no predictions regarding species in the Great Lakes)	3√
Unlikely (This species is known as a poor competitor that thrives only in environments with low biodiversity, AND/OR available literature predicts it might be outcompeted by a species in the Great Lakes)	0
Unknown	U
	3

- *Listed as a noxious federal weed. Forms monocultures in its current range, however has somewhat narrow tolerances. No reports of outcompeting natives.*
- *Populations in Wisconsin listed as "rare" (Lange, 1998).*

How would the fecundity of this species be described relative to other species in the same taxonomic class?

Very high	9
High	6√
Moderate	3
Low	0

Unknown	U
	6

- *Subspecies* S. emersum *is described as having high rates of production, however mortality rate was 50% of production rate (Nielsen et al., 1985).*

How likely are this species' reproductive strategy and habits to aid establishment in new environments, particularly the Great Lakes (e.g., parthenogenesis/self-crossing, self fertility, vegetative fragmentation)?

Likely (The reproductive strategy or habits of this species are known to aid establishment in new environments, AND available literature predicts establishment in the Great Lakes based on these attributes)	9
Somewhat likely (The reproductive strategy or habits of this species are known to aid establishment in new environments, but there is no literature available regarding establishment in the Great Lakes based on these attributes)	6
Somewhat unlikely (The reproductive strategy or habits of this species could potentially aid establishment in new environments, but there is no literature available regarding establishment in the Great Lakes based on these attributes)	3√
Unlikely (The reproductive strategy or habits of this species are not known to aid establishment in new environments)	0
Unknown	U
	3

- *Can reproduce through vegetative fragmentation.*
- *No literature on Great Lakes establishment potential.*

ENVIRONMENTAL COMPATIBILITY

How similar are the climatic conditions (e.g., air temperature, precipitation, seasonality) in the native and introduced ranges of this species to those in the Great Lakes region?

Very similar (The climatic conditions are practically identical to those of the Great Lakes region)	9
Similar (Many of the climatic conditions are similar to those of the Great Lakes region)	6 √
Somewhat similar (Few of the climatic conditions are similar to those of the Great Lakes region)	3
Not similar	0
Unknown	U
	6

- *Widespread throughout Europe, Japan, Korean Peninsula, China, Mongolia, and the Mediterranean (IUCN, 2014). Many of these areas have similar climates to the Great Lakes region.*
- *Reported populations in Wisconsin (Lange, 1998) and New York (USDA plants, 2001).*

How similar are other abiotic factors that are relevant to the establishment success of this species (e.g., pollution, water temperature, salinity, pH, nutrient levels, currents) in the native and introduced ranges to those in the Great Lakes?

Very similar (These factors are practically identical to those of the Great Lakes region)	9

Similar (Many of these factors are similar to those of the Great Lakes region)	6 √
Somewhat similar (Few of these factors are similar to those of the Great Lakes region)	3
Not similar	0
Unknown	U
	6

- *Widespread throughout Europe, Japan, Korean Peninsula, China, Mongolia, and the Mediterranean (IUCN, 2014). Many of these areas have similar climates to the Great Lakes region.*

How abundant are habitats suitable for the survival, development, and reproduction of this species in the Great Lakes area (e.g., those with adequate depth, substrate, light, temperature, oxygen)?

Abundant (Suitable habitats can be easily found and readily available)	9 √
Somewhat abundant (Suitable habitats can be easily found but are in high demand by species already present)	6
Somewhat scarce (Suitable habitats can be found occasionally)	3
Scarce (Suitable habitats are rarely found)	0
Unknown	U
	9

- *Prefers slow-moving or still water between 10-20 cm (Newman, 2005).*

How likely is this species to adapt to or to benefit from the predicted effects of climate change on the Great Lakes freshwater ecosystems (e.g., warmer water temperatures, shorter duration of ice cover, altered streamflow patterns, increased salinization)?

Likely (Most of the effects described above make the Great Lakes a better environment for establishment and spread of this species OR this species could easily adapt to these changes due to its wide environmental tolerances)	9
Somewhat likely (Several of the effects described above could make the Great Lakes a better environment for establishment and spread of this species)	6√
Somewhat unlikely (Few of the effects described above would make the Great Lakes a better environment for establishment and spread of this species)	3
Unlikely (Most of the effects described above would have no effect on establishment and spread of this species or would make the environment of the Great Lakes unsuitable)	0
Unknown	U
	6

- *Warmer temperatures and shorter ice cover may prolong growing season. Increased salinization and altered streamflow patterns probably would not benefit S. erectum.*

How likely is this species to find an appropriate food source (prey or vegetation in the case of predators and herbivores, or sufficient light or nutrients in the case of autotrophs)?

Likely (All possible nutritive food items—including species in the Great Lakes that may be considered potential food items—are highly abundant and/or easily found)	9 √
Somewhat likely (Some nutritive food items—including species in the Great Lakes that may be considered potential food items—are abundant and/or search time is low to moderate)	6

Somewhat unlikely (Few nutritive food items—including species in the Great Lakes that may be considered potential food items—are abundant and/or search time is moderate to high)	3
Unlikely (All possible nutritive food items—including species in the Great Lakes that may be considered potential food items—are relatively scarce and/or search time is high)	0
Unknown	U
	9

- *Autotroph.*
- *Shade tolerant, but prefers full sun (Favorite, 2005).*
- *Prefers mesotrophic to Eutrophic waters which are prevalent in the nearshore of the Great Lakes.*

Does this species require another species for critical stages in its life cycle such as growth (e.g., root symbionts), reproduction (e.g., pollinators, egg incubators), spread (e.g., seed dispersers), or transmission (e.g., vectors)?

Yes, and the critical species (or one that may provide a similar function) is common in the Great Lakes and can be easily found in environments suitable for the species being assessed; OR, No, there is no critical species required by the species being assessed	9 √
Yes, and the critical species (or one that may provide a similar function) is moderately abundant and relatively easily found in particular parts of the Great Lakes	6
Yes, and the critical species (or one that may provide a similar function) is relatively rare in the Great Lakes AND/OR can only be found occasionally in environments suitable for the species being assessed	3
Yes, and the critical species (or one that may provide a similar function) is not present in the Great Lakes but is likely to be introduced	0
Yes, but the critical species (or one that may provide a similar function) is not present in the Great Lakes and is not likely to be introduced	-80% total points (at end)
Unknown	U
	9

- *No, this species does not require the presence of any other species to grow, reproduce, or spread.*

How likely is the establishment of this species to be aided by the establishment and spread of another species already in the Great Lakes?

Likely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established and spread in the Great Lakes, AND available literature predicts this previous invader might promote the establishment of this species, AND/OR there have been cases reported of this species aiding the establishment of this species in other areas)	9
Somewhat likely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established and spread in the Great Lakes)	6
Somewhat unlikely (A non-indigenous species to the Great Lakes that facilitates the development of this species—a major host, food item, pollinator—has already established in the Great Lakes BUT it is still confined to a small area of the Lakes and the likelihood of encounter with this species assessed is hard to predict)	3

Unlikely (A non-indigenous species to the Great Lakes that facilitates the development of this species has not been established in the Great Lakes)	0 √
Unknown	U
	0

- *No reports of its establishment being aided by other species.*

How likely is establishment of this species to be prevented by the herbivory, predation, or parasitism of a natural enemy this is already present in the Great Lakes and may preferentially target this species?

Likely (The ability of the natural enemy to prevent the establishment of this species in introduced ranges or limiting populations of this species in native ranges is well documented in the literature AND this natural enemy is abundant and widespread in the Great Lakes)	-80% total points (at end)
Somewhat likely (The ability of the natural enemy to prevent the establishment of this species in introduced ranges or limiting populations of this species in native ranges is suggested in the literature OR this natural enemy has limited distribution in the Great Lakes)	-60% total points (at end)
Somewhat unlikely (There are few cases reported of such a natural enemy preventing the establishment of this species in introduced ranges or limiting populations of this species in native ranges OR this natural enemy has low abundance in the Great Lakes)	-10% total points (at end)√
Unlikely (Such a natural enemy is particularly rare or is not present in the Great Lakes)	0
Unknown	U
	-10%

- *Eaten by waterfowl (Wagner, 2005) However, there are no reports of* S. erectum *limitation by waterfowl predation.*

PROPAGULE PRESSURE

On average, how large and frequent are inoculations (introduction events) from the potential vectors identified in Section A for this species? (What is the total number of individuals introduced?)

Frequent, large inocula	9
Frequent, moderate inocula	6
Frequent, small inocula OR infrequent, large inocula	3
Infrequent, small or moderate inocula	0
Unknown	U√
	U

- *Unknown.*

HISTORY OF INVASION AND SPREAD

How extensively has this species established reproducing populations in areas outside its native range as a direct or indirect result of human activities?

Very extensively (many invasive populations of this species have been reported in areas widely distributed from the native range)	9

Extensively (some invasive populations of this species have been reported in areas widely distributed from the native range)	6√
Somewhat extensively (few invasive populations of this species have been reported in areas widely distributed from the native range OR all invasive populations are in close proximity to each other)	3
Not extensively (no invasive populations of this species have been reported)	0
Unknown	U
	6

- *USDA plants reports introduced populations in California, Wisconsin, and New York. Also considered invasive in Australia.*
- *Native range is unclear, may be more introduced populations.*

How rapidly has this species spread by natural means or by human activities once introduced to other locations?

Rapidly (This species has a history of rapid spread in introduced ranges)	9
Somewhat rapidly (This species has a history of moderately rapid spread in introduced ranges)	6
Somewhat slowly (This species has a history of moderately slow spread in its introduced ranges)	3
Slowly (This species has a history of slow to no spread in its introduced ranges)	0
Unknown	U√
	U

- *Unknown.*

Are there any existing control measures in the Great Lakes set to prevent the establishment and/or spread of this species?

Yes, and they are likely to prevent establishment or spread of the species. (There are no reported cases of this species adapting or avoiding current measures. These measures are highly effective in preventing the establishment and spread of this species)	-90% total points (at end)
Yes, and they are moderately likely to prevent establishment or spread of the species. (There are few reported cases of this species adapting or avoiding current measures used to control its establishment and spread)	-50% total points (at end)
Yes, but they are unlikely to prevent establishment or spread of the species. (There are many reported cases of this species adapting or avoiding current measures used to control its establishment and spread)	-20% total points (at end) √
No control methods have been set to prevent the establishment and/or spread of this species	0
Unknown	U
	-20

- *Prohibited in Illinois, Indiana, and Minnesota. Listed as a noxious weed federally. However,* S. erectum *is still available through online retailers.*

Establishment Potential Scorecard				
Points	**Probability for Establishment**	Total Points (pre-adjustment)		**72**
>100	High	Adjustments		
		Critical species	A (72- 0%)	**71**
51-99	Moderate	Natural enemy	B (72- 10 %)	**64.8**
		Control measures	C (64.8- 20%)	**51.84**
0-50	Low	**Probability for Establishment**		Moderate
# of questions answered as "unable to determine"	**Confidence Level**			
0-1	High	Total # of questions unknown		2
2-5	Moderate			
6-9	Low	Confidence Level		Moderate
>9	Very low			

Section C: Potential for Impact

IMPACT POTENTIAL RESULTS

Environmental: High
Socio-Economic: Moderate
Beneficial: Moderate

POTENTIAL ENVIRONMENTAL IMPACT

Does the species pose some hazard or threat to the health of native species (e.g., it magnifies toxin levels; is poisonous; is a pathogen, parasite, or a vector of either)?

Yes, and it has impacted threatened/endangered species, resulted in the reduction or extinction of one or more native populations, affects multiple species, or is a reportable disease	6
Yes, but negative consequences have been small (e.g., limited number of infected individuals, limited pathogen transmissibility, mild effects on populations and ecosystems)	1
Not significantly	0√
Unknown	U

- *Not reported to pose a threat to the health of native species.*

Does it out-compete native species for available resources (e.g., habitat, food, nutrients, light)?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species or caused critical reduction, extinction, behavioral changes including modified spawning behavior) on one or more native populations	6
Yes, and it has caused some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population	1√

Not significantly	0
Unknown	U

- *Creates monospecific stands that are dense and tall (Gurnell, 2013).*

Does it alter predator-prey relationships?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species, caused significant reduction or extinction of one or more native populations, creation of a dead end or any other significant alteration in the food web)	6
Yes, and it has resulted in some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population AND/OR Yes, and it has resulted in some alteration of the food web structure or processes, the effects of which have not been widespread or severe	1
Not significantly	0√
Unknown	U

- *No reports of food web effects.*

Has it affected any native populations genetically (e.g., through hybridization, selective pressure, introgression)?

Yes, and it has caused a loss or alteration of genes that may be irreversible or has led to the decline of one or more native species (or added pressure to threatened/endangered species)	6
Yes, some genetic effects have been observed, but consequences have been limited to the individual level	1
Not significantly	0
Unknown	U√

- *Not reported to hybridize with any native species.*

Does it negatively affect water quality (e.g., increased turbidity or clarity, altered nutrient, oxygen, or other chemical levels/cycles)?

Yes, and it has had a widespread, long-term, or severe negative effect on water quality AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected water quality to some extent, but the alterations and resulting adverse effects have been limited or inconsistent (as compared with above statement)	1 √
Not significantly	0
Unknown	U

- *Fine sediment retention can contribute to increased clarity (Bal et al, 2017).*

Does it alter physical components of the ecosystem in some way (e.g., facilitated erosion/siltation, altered hydrology, altered macrophyte/phytoplankton communities, physical or chemical changes to substrate)?

Yes, and it has had a widespread, long term, or severe negative effect on the physical ecosystem AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6√

Yes, it has affected the physical ecosystem to some extent, but the alterations and resulting adverse effects have been mild	1
Not significantly	0
Unknown	U

- *Retains fine sediment that can change the shape of river reaches, affect discharge, and lead to flooding (Bal et al, 2017; Gurnell et al 2013; O'hare et al 2011).*

Environmental Impact Total	**8**
Total Unknowns (U)	**1**

POTENTIAL SOCIO-ECONOMIC IMPACT

Does the species pose some hazard or threat to human health (e.g., it magnifies toxin levels, is poisonous, a virus, bacteria, parasite, or a vector of one)?

Yes, significant effects on human health have already been observed	6
Yes, but negative consequences have not been widespread, long lasting, or severe	1
Not significantly	0 √
Unknown	U

- *No reports.*

Does it cause damage to infrastructure (e.g., water intakes, pipes, or any other industrial or recreational infrastructure)?

Yes, it is known to cause significant damage	6
Yes, but the costs have been small and are largely reparable or preventable	1
Not significantly	0 √
Unknown	U

- *Not reported.*

Does it negatively affect water quality (i.e. in terms of being less suitable for human use)?

Yes, it has significantly affected water quality, and is costly or difficult to reverse	6
Yes, but the effects are negligible and/or easily reversed	1 √
Not significantly	0
Unknown	U

- *Sediment retention has been reported to cause localized flooding (Aseada et al., 2010)*

Does it negatively affect any markets or economic sectors (e.g., commercial fisheries, aquaculture, agriculture)?

Yes, it has caused significant damage to one or more markets or economic sectors	6
Some damage to markets or sectors has been observed, but negative consequences have been small	1
Not significantly	0 √
Unknown	U

- *Not reported to significantly affect any economic sectors.*

Does it inhibit recreational activities and/or associated tourism (e.g., through frequent water closures, equipment damage, decline of recreational species)?

Yes, it has caused widespread, frequent, or otherwise expensive inhibition of recreation and tourism	6
Yes, but negative consequences have been small	1
Not significantly	0√
Unknown	U

- *Not reported.*

Does it diminish the perceived aesthetic or natural value of the areas it inhabits?

Yes, the species has received significant attention from the media/public, significantly diminished the natural or cultural character of the area, or significantly reduced the area's value for future generations	6
Yes, but negative consequences have been small	1 √
Not significantly	0
Unknown	U

- *Monospecific stands may decrease perceived aesthetic of wetlands and shorelines.*

Socio-Economic Impact Total	**2**
Total Unknowns (U)	**0**

<u>POTENTIAL BENEFICIAL EFFECT</u>

Does it act as a biological control agent for aquatic weeds or other harmful nonindigenous organisms?

Yes, it has succeeded significantly as a control agent	6
Yes, it has had some success as a control agent, but may be inconsistent or lack a desired level of effectiveness	1
Not significantly	0√
Unknown	U

- *Not reported to act as a control agent for nuisance species.*

Is it commercially valuable (e.g., for fisheries, aquaculture, agriculture, bait, ornamental trade)?

Yes, it is economically important to at least one of these industries	6
Yes, but its economic contribution is small	1√
Not significantly	0
Unknown	U

- *Klamath Indians have eaten* S. erectum *tubers (Favorite, 2002).*
- *Popular ornamental plant (Kay and Hoyle, 2001).*

Is it recreationally valuable (e.g., for sport or leisurely fishing, as a pet, or for any other personal activity)?

Yes, it is commonly employed recreationally and has some perceived value for local communities and/or tourism	6
It is sometimes employed recreationally, but adds little value to local communities or tourism	1

Not significantly	0√
Unknown	U

- *No reports of recreational value.*

Does the species have some medicinal or research value (i.e. outside of research geared towards its control)?

Yes, it has significant medicinal or research value	6
It has some medicinal or research value, but is not of high priority OR It is potentially important to medicine or research and is currently being or scheduled to be studied	1√
Not significantly	0
Unknown	U

- *Taken as a supplement, traditionally used to treat chills.*

Does the species remove toxins or pollutants from the water or otherwise increase water quality?

Yes, it reduces water treatment costs or has a significant positive impact for the health of humans and/or native species	6
Yes, but positive impact for humans or native species is considered negligible	1√
Not significantly	0
Unknown	U

- *Fine sediment retention may contribute to bank stability; however, it can also affect the discharge of a river and lead to flooding (Asaeda et al., 2010)*

Does the species have a positive ecological impact outside of biological control (e.g., increases the growth or reproduction rates of other species, fills an important gap in the food web, supports the survival of a species that is threatened, endangered species, or commercially valuable)?

Yes, it significantly contributes to the ecosystem in one or more of these ways	6
Yes, it provides some positive contribution to the ecosystem, but is not vital	1
Not significantly	0 √
Unknown	U

- *Not reported to have any other positive ecological impact.*

Beneficial Effect Total	**3**
Total Unknowns (U)	**0**

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