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2020 UPDATE TO "A RISK ASSESSMENT OF POTENTIAL GREAT LAKES AQUATIC INVADERS"

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DEPARTMENT OF COMMERCE

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NATIONAL OCEANIC AND
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2020 UPDATE TO "A RISK ASSESSMENT OF POTENTIAL GREAT LAKES AQUATIC INVADERS"

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1.0 SUMMARY

This report includes all major changes to Risk Assessments conducted by the GLANSIS project during calendar year 2020. All new assessments were conducted following the same methods outlined in the original NOAA Technical Memorandum GLERL-169 (Fusaro et al., 2016). All re-assessments are based on new literature surveys using the original TM-169 document as a baseline and conducted using the same assessment methods. All assessments were reviewed by at least four 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 Assessment Clearinghouse (https://www.glerl.noaa.gov/glansis/riskAssessment.html). The websites are updated frequently and should be consulted for the most recent information.

Compared to the 79 species documented in the 2019 TM-169c risk assessment (Lower et al., 2020), the assessments for a total of 13 species were either added (n = 3), removed (n = 4), or revised (n = 6) in this publication.

In 2020, three new species were added to the GLANSIS Watchlist: *Lithoglyphus naticoides*; *Prymnesium parvum*; and *Salvinia minima*.

As of 2020, species assessed to have both a low risk of introduction *and* establishment will no longer be included in the GLANSIS Tech Memo series. However, these 'low risk' species assessments will still be available online in the new GLANSIS Risk Assessment Clearinghouse. Four species were removed from the Watchlist: *Atherina boyeri*; *Benthophilus stellatus*; *Cottus gobio*; and *Oncorhynchus keta*.

Six Watchlist species assessments were updated in 2020: *Albernus albernus*; *Clupeonella cultriventris; Silurus glanis; Babka gymnotrachelus; Cyprinella lutrensis;* and *Monodacna colorata*. GLANSIS is constantly being updated with new and relevant literature to resolve unknown variables and adjust risk scores accordingly. Thus, the recent changes largely reflect advances in the state of knowledge—new publications since the last update cycle—rather than information missed in the original assessment or changes in interpretation of the available data.

The risk of establishment for *Alburnus alburnus* decreased from high to moderate, while the risk of establishment for *Silurus glanis* increased from moderate to high, with justifications for these scoring changes presented in **Section 2.0**. Aside from these two species, there were no further changes to species in the high-risk categories for either introduction or establishment in this review.

The GLANSIS Watchlist now includes 78 species. A summary of overall risk for each species on the Watchlist is included in Table 1. Further details on the 2020 changes are provided in the Section 2.0 addenda and Table 2.

Table 1. Summary of overall risk for each GLANSIS Watchlist species. Asterisks indicate species with changed* or added** assessments, and strikethrough indicates species removals (in comparison to TM-169c; Lower et al., 2020).

Species	Introduction	Establishment	Environmental Impact	Socioeconomic Impact	Benefits
*Alburnus alburnus**	Moderate	Moderate	High	Low	High
Apocorophium lacustre	High	High	Moderate	Low	Low
Arundo donax	Low	Moderate	High	Moderate	Moderate
Astacus astacus	Low	Low	High	Low	High
~~*Atherina boyeri**~~	~~Moderate~~	~~Moderate~~	~~Moderate~~	~~Low~~	~~High~~
*Babka gymnotrachelus**	Moderate	High	Moderate	Low	Unknown
~~*Benthophilus stellatus**~~	~~Low~~	~~Moderate~~	~~Unknown~~	~~Low~~	~~Low~~
Brachionus leydigii	High	Moderate	Low	Low	Low
Calanipeda aquaedulis	Moderate	Moderate	High	Low	Low
Carassius carassius	Low	High	High	Low	Moderate
Channa argus	Moderate	Moderate	High	Moderate	Moderate
Chelicorophium curvispinum	Moderate	Moderate	Moderate	Low	Moderate
Cherax destructor	Low	Moderate	Moderate	Low	Moderate
Cherax quadricarinatus	High	Low	High	Low	Moderate
*Clupeonella cultriventris**	Low	Moderate	Low	Low	Moderate
Cornigerius maeoticus	Moderate	Moderate	Low	Low	Low
~~*Cottus gobio**~~	~~Moderate~~	~~Moderate~~	~~Low~~	~~Low~~	~~Low~~
Crassula helmsii	Low	Moderate	High	Moderate	Low
Cyclops kolensis	Moderate	Moderate	Moderate	Low	Low
*Cyprinella lutrensis**	High	Moderate	High	Low	Moderate
Cyprinella whipplei	Moderate	Moderate	Unknown	Low	Low
Daphnia cristata	High	Moderate	Low	Low	Moderate
Dikerogammarus haemobaphes	Moderate	High	Unknown	Low	Low
Dikerogammarus villosus	Moderate	High	High	Low	Low
Echinogammarus warpachowskyi	Moderate	Moderate	Moderate	Low	Moderate
Ectinosoma abrau	Low	Moderate	Low	Low	Low
Egeria densa	High	Moderate	High	High	Moderate
Eichhornia crassipes	High	Moderate	High	High	Moderate
Faxonius limosus	Low	Moderate	Low	Low	Low
Filinia cornuta	High	Moderate	Low	Low	Moderate
Filinia passa	High	Moderate	Low	Low	Low

Federicella sultana	High	Moderate	High	High	Low
Heterocope appendiculata	Moderate	Moderate	Unknown	Low	Low
Heterocope caspia	Moderate	Moderate	Unknown	Low	Low
Hydrilla verticillata	High	Moderate	High	High	High
Hygrophila polysperma	Moderate	Moderate	Moderate	High	Moderate
Hypania invalida	Moderate	Moderate	Low	Low	Low
Hypophthalmichthys molitrix	Moderate	Moderate	High	High	High
Hypophthalmichthys nobilis	Moderate	Moderate	High	High	High
Ictalurus furcatus	High	Moderate	Moderate	Low	High
Knipowitschia caucasica	Low	Moderate	Unknown	Low	Low
Lepomis auratus	High	Moderate	Moderate	Low	Moderate
Leuciscus idus	High	Moderate	Unknown	Low	High
Leuciscus leuciscus	Moderate	Moderate	High	High	Moderate
Leyogonimus polyoon	Moderate	Moderate	Unknown	Unknown	Low
Limnomysis benedeni	Moderate	High	Moderate	Low	Moderate
Limnoperna fortunei	Low	High	High	High	High
*Lithoglyphus naticoides***	Moderate	Moderate	High	Low	Unknown
Ludwigia grandiflora	Low	High	High	High	Low
Lysimachia punctata	High	Moderate	Unknown	Low	Low
*Monodacna colorata**	Moderate	Moderate	Unknown	Low	Low
Myriophyllum aquaticum	High	Moderate	High	Moderate	Moderate
Neogobius fluviatilis	Moderate	High	Moderate	Low	Moderate
Obesogammarus crassus	Moderate	High	High	Low	Low
Obesogammarus obesus	Low	High	High	Low	Low
~~*Oncorhynchus keta**~~	~~Low~~	~~Moderate~~	~~Moderate~~	~~Low~~	~~High~~
Osmerus eperlanus	Moderate	Moderate	High	Unknown	Moderate
Pacifastacus leniusculus	High	High	High	Moderate	High
Paraleptastacus spinicaudus triseta	Moderate	Low	Unknown	Low	Low
Paraleptastacus wilsonii	High	Moderate	Unknown	Low	Low
Paramysis (Serrapalpisis) lacustris	Moderate	Moderate	Moderate	Low	Low
Paramysis (Mesomysis) intermedia	Moderate	Moderate	Unknown	Low	Low
Paramysis (Metamysis) ullskyi)	Moderate	Moderate	Unknown	Low	Low
Perca fluviatilis	Moderate	Moderate	High	Moderate	High
Percottus glenii	Moderate	High	High	Low	Moderate
Phoxinus phoxinus	Moderate	Moderate	Moderate	Low	Low
Pistia stratiotes	High	Moderate	High	High	Moderate
Podonevadne trigona ovum	Low	Moderate	Moderate	Low	Low

Pontogammarus robustoides	Moderate	High	Moderate	Low	Moderate
Procambarus fallax f. virginalis	High	Moderate	High	Moderate	High
*Prymnesium parvum***	Moderate	Moderate	High	High	Low
Pseudrasbora parva	Low	Moderate	High	High	Low
Rhithropanopeus harrisii	Moderate	High	Unknown	Low	Low
Rutilus rutilus	Low	Moderate	High	Moderate	High
*Salvinia minima***	High	Moderate	High	High	Moderate
Sander lucioperca	Low	High	High	Unknown	High
*Silurus glanis**	Low	Moderate	High	Low	High
Sinelobus stanfordi	Moderate	Low	Unknown	Low	Low
Sparganium erectum	Moderate	Moderate	High	Moderate	Moderate
Stratiotes aloides	High	Moderate	Moderate	Moderate	Low
Tinca tinca	High	Moderate	Moderate	Low	Moderate
Typha laxmannii	High	Moderate	Moderate	Low	Moderate

2.0 ADDENDA

Three new species were added to the Watchlist in 2020, including *Lithoglyphus naticoides*, *Prymnesium parvum*, and *Salvinia minima,* as they were identified as meeting critera for inclusion in the GLANSIS database—though they are not currently found in the Great Lakes, peer-reviewed scientific literature indicates that they are likely to invade through one or more current pathways.

Four species were removed from the Watchlist, as they were assessed to have a low risk of introduction and establishment in the Great Lakes region: *Atherina boyeri*, *Benthophilus stellatus*, *Cottus gobio*, and *Oncorhynchus keta.*

Atherina boyeri was removed from the Watchlist for the following reasons: 1) high confidence that it does not have a significant risk of introduction due to increased ballast water regulations; 2) a lack of inclusion on regional regulated/prohibited species lists; 3) a poor ability to overwinter (as feeding ceases at 8°C and sustained temperatures below <4°C can be fatal); and 4) a high prevalence of predators in the Great Lakes that may be effective at preventing its establishment.

Benthophilus stellatus was removed from the Watchlist for the following reasons: 1) a high confidence that it does not have a significant risk of introduction to the Great Lakes; 2) a lack of inclusion in any regional regulated/prohibited species lists; 3) a poor ability to compete with other goby species that are already present in the Great Lakes (e.g., round goby); and 4) the fact that it is already endangered in its native range due to its poor competitive ability and unexceptional fecundity/environmental tolerance.

Cottus gobio was removed from the Watchlist due to 1) a high confidence that it does not have a significant risk of introduction to the Great Lakes due to increased ballast water regulations; 2) a lack of inclusion in any regional regulated/prohibited species lists; 3) a poor ability to compete with other goby species that are already present in the Great Lakes (e.g., round goby); and 4) a likelihood of being heavily preyed upon by species present in the Great Lakes (e.g., *Salmo trutta* and *Esox lucius*).

Oncorhynchus keta was removed from the Watchlist due to 1) high confidence that it was not at significant risk of introduction; 2) a lack of inclusion in any regional regulated/prohibited species lists; and 3) that while its likelihood of establishment is theoretically moderate, previous introductions in the first half of 1900 all failed to form self-sustaining populations.

Three additional species underwent changes to their risk assessments that were significant enough to change to their risk scores in some categories. *Albernus albernus*'s risk of establishment decreased from high to moderate based on the presence of its natural predators in the Great Lakes. The beneficial impact score of *Clupeonella cultriventris* increased from low to moderate based on its potential utility as a forage fish for Great Lakes native species. The risk of establishment for *Silurus glanis* increased from moderate to high due to a reevaluation of environmental characteristics in the Great Lakes that would be beneficial to its survival in the region, including more suitable habitat and prey availability than previous literature suggested. The common name of *Silurus glanis* as listed in GLANSIS was also changed from sheatfish to Wels catfish to reflect the far more popular use of the latter name.

Babka gymnotrachelus, Cyprinella lutrensis and *Monodacna colorata* underwent only minimal updates to their supporting literature. Since their scores remained unchanged, their updated risk assessments are not included in Section 3.0 but can be found on the GLANSIS website.

Table 2. An overview species additions/removals and changes to risk assessments for GLANSIS Watchlist species, in reference to TM-169c (Lower et al., 2020).

Species	Addenda	Author, date added
Alburnus alburnus	Establishment risk decreased from high to moderate	Bartos, 2020
Atherina boyeri	Removed from watchlist	Bartos, 2020
Babka gymnotrachelus	Minimal updates	Bartos, 2020
Benthophilus stellatus	Removed from watchlist	Bartos, 2020
Clupeonella cultriventris	Beneficial impact upgraded to moderate	Bartos, 2020
Cottus gobio	Removed from watchlist	Bartos, 2020
Cyprinella lutrensis	Minimal updates	Bartos, 2020
Lithoglyphus naticoides	New GLANSIS/NAS species	Bartos, 2020
Monodacna colorata	Minimal updates	Lower, 2020
Oncorhynchus keta	Removed from watchlist	Bartos, 2020
Prymnesium parvum	New GLANSIS/NAS species	Bartos, 2020
Salvinia minima	New to GLANSIS	Lower, 2020
Silurus glanis	Establishment risk increased from moderate to high	Bartos, 2020

3.0 RISK ASSESSMENTS

Scientific Name: *Alburnus alburnus*

Common Name: Bleak

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: 2020 update: No changes to quantitative scores or qualitative statements. Minor additions of references and supporting information.

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

- Alburnus alburnus *resides in slow-flowing streams and temperate lakes located in Europe and Asia. Its native range extends north of the Pyrenees, Caucasus, and Alps, and eastward toward the Ural and Emba rivers. It was later locally introduced to the Iberian Peninsula and is found in Spain, Portugal, Italy (Kottelat 1997), Morocco (Clavero et al., 2015), and the Ob River basin in Russia (Interesova 2016).*

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

- *N/A*

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

- *Bleak does not possess any traits that would facilitate introduction via hitchhiking or 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

- *N/A*

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 is rarely/never sold.	0 √
Unknown	U

- Alburnus alburnus *is not a popular aquarium fish or available for purchase online. Import restrictions have been placed on the transfer of Alburnus alburnus to the United Kingdom (Clarke 2006).*
- Alburnus alburnus *was locally introduced in the Northern Iberian watershed as a result of anglers purposefully releasing it as a forage fish (Vinyoles et al., 2007). It is also a popular live baitfish when targeting predatory fish such as pike and perch (Vinyoles et al., 2007).*
- Alburnus alburnus *is not available for purchase as a live baitfish in North America through online vendors. There is no evidence to suggest that* Alburnus alburnus *is easily obtained even within its native range; therefore, obtaining it in the Great Lakes region would also be very difficult and highly unlikely.*

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 is not popular or easily obtained within 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

- Alburnus alburnus *is not stocked near the Great Lakes.*

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

- *N/A*

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

- Alburnus alburnus *scales are used in the artificial pearl trade and this fish is harvested commercially in the Seine, Loire, and the Rhine rivers (Denton and Nicol 1965) and some the rivers and lakes in the Western Balkan Peninsula (Mrdak 2009; Simic et al., 2016). However, such commercial activity is limited to Europe.*

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

- *N/A*

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

- Alburnus alburnus *is a brackish water fish that lives in a salinity of 8-10 ‰ (Linden et al., 1979). Due to its stenohaline nature, its survival in ballast water given current regulations is unlikely (Wheeler 1978a).*
- *Myers (1949) categorizes Cyprinidae as strictly intolerant of salt water. There is no indication that bleak exhibits behaviors that would allow it to survive transport in a ballast tank.*
- *Niimi and Reid (2003) measured the salinity of 'No Ballast on Board' or NOBOB vessels that are exempt from mandatory ballast exchange. Out of the 26 vessels measured, 35% had at least one tank with ≤ 5 ‰ salinity. It is possible that the bleak would be able to survive transport under these conditions.*
- *Bleak can also survive in a wide range of temperatures, from 3 to 37 °C (Horoszewics 1973; Ponepal and Păunescu 2019) but may be sensitive to low oxygen concentrations (Willemsen 1980).*

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

- Alburnus alburnus *is found in the Seine, Loire, and Rhine rivers, which naturally discharge into the Atlantic Ocean (Leuven et al., 2009). The Rhine first discharges into the North Sea, which connects to the Atlantic Ocean.*
- Alburnus alburnus *occurs in the Iberian Peninsula and is found in Spain, Portugal, and Italy (Kottelat 1997, Vinyoles et al., 2007). Many ports in the Iberian Peninsula have direct connections with the Great Lakes.*

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	0	Unlikely
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)	0	x	0	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	0	Unlikely
Escape from commercial culture: Accidental introduction to Great Lakes by escape from commercial culture (e.g., aquaculture)	0	x	0	Unlikely
Trans-oceanic shipping: Ballast (BOB) or no-ballast-on-board (NOBOB) water exchange/discharge, sediment discharge, hull fouling	80	x 0.5	40	Moderate
Total Unknowns (U) 0		Confidence Level	High	

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

Potential pathway(s) of introduction: Transoceanic Shipping (ballast water)

Scoring	
Points (per vector)	**Probability for Introduction**
80-100	High
40-79	Moderate √
1-39	Low
0	Unlikely
# of Unknowns (overall)	**Confidence Level**
0	High √
1-2	Moderate
3-5	Low
>5	Very low

Section B: Potential for Establishment

ESTABLISHMENT POTENTIAL RESULTS

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

***Alburnus alburnus* has a moderate probability of establishment if introduced to the Great Lakes (Confidence level: High).**

Comments: 2020 update: The probability of establishment has been lowered from High to Moderate, primarily due to the presence of natural enemies to bleak in the Great Lakes. The following quantitative scores have changed: B3 (7 to 8), B7 (8 to 9), B8 (8 to 9), B14 (0 to -10%), and B16 (4 to 6).

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

- Alburnus alburnu*s typically lives in a temperature range of 10-20°C (Baensch and Riehl 1991), but is known to overwinter in lakes with temperature ranges to the Great Lakes.*
- *A study regarding lethal temperature for various fish species indicates that the bleaks' lethal temperature range is 37.7-40.6°C at acclimation temperatures from 25.0-27.8°C in a lake environment where temperature was gradually raised per hour (Horoszewicz 1973). At temperatures <8°C, bleak only experienced a slight increase in breathing rate and decrease in metabolism (Ponepal and Păunescu 2019).*
- Alburnus alburnus *is a brackish water fish that typically lives in salinities of 8-10 parts per thousand (Linden et al., 1979). There is no information to indicate that* A. alburnus *would be able to survive higher salinities. A study indicates that bleak does not withstand oxygen-stressed environments particularly well (Willemsen 1980).*
- Alburnus alburnus *is tolerant to pollutants such as brominated flame retardants and estrogen (Eljarrat et al., 2005; Johnson et al., 2019). According to Souchon and Tissot (2012), 14°C is the minimum temperature tolerated for reproduction.*

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

- *Due to the climatic similarities between the Great Lakes and Ponto-Caspian regions (Reid and Orlova 2002)* Alburnus alburnus *most likely endures similar overwintering conditions in its native range.*
- *Bleak spread to the Ob River basin and connected lakes, which experience temperature fluctuations throughout the year similar to the Great Lakes (Interesova 2016).*

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
	8

- Alburnus alburnus *feeds on zooplankton and insects in the epilimnion.* Alburnus alburnus *is described to have a limited diet in comparison with the roach,* Rutilus rutilus, *a generalist (Keckeis and Schiemer 1990).*

- *Vinyoles et al., (2007) cited bleaks' prey as widespread and attributes this characteristic to its successful establishment outside its native range.*
- *In reservoirs, bleak prey more on pelagic invertebrates, primarily Crustacea, while in rivers they consume more plants, benthic invertebrates and detritus (Almeida et al., 2017).*
- *Bleak have also been recorded to consume planktonic cyanobacteria (Vejřík et al., 2016) and drifting asp,* Leuciscus aspius*, eggs (Šmejkal et al., 2017; Šmejkal et al., 2018).*

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

- Alburnus alburnus *is currently threatening endemic species in the Iberian watershed due to its high reproductive rate and hybridization with other cyprinids (Vinyoles et al., 2007).*
- *Bleak's interpopulation (Maso et al., 2016; Latorre et al., 2020) and wide trophic plasticity makes it a very successful invader and likely competitor for habitat and food (Almeida et al., 2014, 2017; Latorre et al., 2018).*
- *Invasive bleak in the Iberian Peninsula have led to higher metabolic expense, reduced shelter use, and increased predation risk in the critically endangered Iberian saramugo* Anaecypris hispanica *(da SIlva et al., 2019).*

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
	8

- *It matures at 2 to 3 years old and has a high reproductive rate - spawning two to four times a season with an absolute fecundity of 7000 eggs per female (Kottelat and Freyhof 2007).*
- *The bleak's high fecundity has allowed it to become established in Cyprus where it was accidentally introduced, as well as in the Iberian watershed (Vinyoles et al., 2007).*
- Alburnus alburnus *and* Blicca bjoerkna *are multiple spawners which spawn more frequently than the single spawner* Rutilus rutilus *(Rinchard and Kestemont 1996). Compared to* R. rutilus *and* B. bjoerkna*,* A. alburnus *has a relatively moderate gonadosomatic index.*

- *Where it is introduced, bleak produces stunted populations that produce a large number of individuals that mature early at a small size (Welcomme 1988).*

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

- *Where it is introduced,* Alburnus alburnus *produces stunted populations that produce a large number of individuals that mature early at a small size (Welcomme 1988).*

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

- *The surface water temperature range of the water in the Ponto-Caspian region is similar to many of the lakes in the Great Lakes region (Reid and Orlova 2002). 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
	9

- *The Ponto-Caspian (Caspian, Azov, and Black seas) have similar climate and surface water temperature ranges as the Great Lakes (Reid and Orlova 2002; Grigorovich et al., 2003; USEPA 2008).*
- *Great Lakes underwent similar anthropogenic eutrophication as the Ponto-Caspian region (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

- *The bleak tends to live in shoals near the surface of slow-moving streams and lakes (Linden et al., 1979; Kottelat 2012). Bleak larvae inhabit the littoral zone of rivers/lakes and juveniles occur in a pelagic habitat (Kottelat 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

- *Lehtonen (1996) predicted that European fish assemblages will shift toward cyprinid dominance and that bleaks's range will expand as a result of global climate change.*
- *The bleak's establishment in the Iberian watershed (Vinyoles et al., 2007) points toward its ability to adapt to a warmer climate regime.*
- *Bleak's classification as a 'high invasiveness risk' was further elevated by potential climate change effects in Great Britain rivers under the Aquatic Species Invasiveness Screening Kit developed by Copp et al., (2016) (Dodd et al., 2019).*

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

- *The widespread nature of the bleak's prey has allowed it to successfully expand throughout its native and introduced ranges (Vinyoles et al., 2007). It is likely that the bleak would have an abundant food source in the Great Lakes.*
- *Bleak's wide trophic plasticity makes it a very successful invader (Almeida et al., 2014, 2017; Latorre et al., 2018)*

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 to indicate that bleak requires another species to survive during critical stages in its 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 to indicate that bleak would benefit from the spread of another species already in the Great Lakes.*
- *However, bleak has similar behavior and activity patterns to* Pseudorasbora parva*, another potential invader to the Great Lakes, due to major isotopic niche overlap indicating competition between the two species if resources become limited. However, they can co-exist in open systems and potentially double their trophic impact (Haubrock et al., 2019; Balzani et al., 2020).*

How likely is establishment of this species to be prevented by the herbivory, predation, or parasitism of a natural enemy that 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%

- *There have been reports of the tapeworm* Ligula intestinalis *preferentially parasitizing Alburnus alburnus in the River Thames (Harris and Wheeler 1974). Infestation may cause impairment of swimming ability (Harris and Wheeler 1974), which can increase the risk of predation. Generally, however, infestation does not lead to death of the host.* Ligula intestinalis *has not been reported to occur in the Great Lakes region.*
- *Bleak are known to be consumed by northern pike (*Esox lucius) *and largemouth bass* (Micropterus salmoides), *both of which* are *native to the Great Lakes* (*Maceda-Veiga et al., 2010; Waidbacher et al., 2018*).

- However, there is no evidence in the literature of the establishment of bleak being prevented by predators.

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

- *When a ship enters the Great Lakes, it discharges approximately 3 million liters of ballast water (Ricciardi and MacIsaac 2000).*
- *Shipping traffic from Western Europe through the St. Lawrence Seaway is a major contributor of ballast water discharge that enters the Great Lakes (USEPA 2008).*

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 bleak was introduced to the northern Iberian watershed and is now present in all major Iberian water basins and a large number of Iberian rivers (Vinyoles et al., 2007).*
- *Bleak's rapid expansion throughout the Ob River basin in Russia is attributed to human mediated and natural dispersal (Reshetnikova et al., 2017).*
- *Vinyoles et al., (2007) also noted that* Alburnus alburnus *has been introduced to Cyprus from Britain where it has established a breeding population.*

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

- *Following its introduction into the Ebro basin,* Alburnus alburnus *quickly spread throughout the entire Iberian Peninsula, where it is currently present in all major Iberian basins (Vinyoles et al., 2007).*
- *Bleak's rapid expansion throughout the Ob River basin in Russia is attributed to human mediated and natural dispersal (Reshetnikova et al., 2017).*
- *This species has a high reproductive rate and its seasonal movements from reservoirs to tributaries make it an excellent disperser (Vinyoles et al., 2007; Matano et al., 2018).*
- *Kolar and Lodge (2002) predicted that the bleak would spread quickly if introduced to the Great Lakes.*

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 existing control measures in the Great Lakes to prevent the spread of the bleak.*

Section B Scores				
Points	**Probability of Establishment**	**Total Points (pre-adjustment)**		107
>100	High	**Adjustments**		
		Critical species	A (107-0%)	107
51-99	Moderate	**Natural enemy**	B (107-10%)	96
		Control measures	C (96-0%)	96

0-50	Low	**Total Points (post-adjustment)**	**96**
		Probability of 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		

Section C: Potential for Impact

POTENTIAL IMPACT RESULTS

Environmental: High
Socio-Economic: Low
Beneficial: High

Comments: 2020 update: No changes to qualitative statements, but some quantitative scores have changed: C1 (0 to 1), C3 (U to 1), C7 (0 to 1), C9 (0 to U), and C15 (0 to 1).

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

- *Bleak are very active fish with fast metabolism which can lead to bioaccumulation of heavy metals and other toxins (Kolarević et al., 2016; Jovanović et al., 2018). 58% of bleak muscle samples from the Dunajec River, Poland contained more than the human consumption limit of lead (0.3 mg Pb kg*$^{-1}$ *dry matter) (Niemiec et al., 2018).*
- *They are host to the widespread eastern European parasites* Paracoenogonimus ovatus *(Ostrowska et al., 2019) and* Nicolla skrjabini *(Chunchukova et al., 2019) which can infect a wide variety of fish that inhabit the Great Lakes, including both invasive (e.g.* Scardinius erythrophthalmus, Gymnocephalus cernua, Salmo trutta*, and* Cyprinus carpio*) and native species (e.g.* Esox lucius*) to the Great Lakes.*
- *Bleak are also a vector for the Carp Edema Virus (Matras et al., 2019).*

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

- Alburnus alburnus *possesses a suite of life history traits that makes it a superior competitor. Its speed and specialization in surface-oriented feeding gives it a competitive advantage over fishes that only occasionally feed on the surface. Furthermore, this species' high fecundity allows it to displace other species. Bleak experiences large and sudden population increases that easily overpower and outcompete species already present. Such situations have been observed in Iberian rivers (Welcomme 1988; Pérez-Bote et al., 2004; Vinyoles et al., 2007). Other factors that may contribute to the bleak's superior competitive abilities include its ability to exploit a widespread spectrum of prey and its wide temperature tolerance (Chappaz et al., 1987; Biró and Muskó 1995; Mehner et al., 2005).*
- *In a study done by Maceda-Veiga et al., (2010) bleak was found to be the second highest non-native occurring fish in sampled catchments in Catalonia, Spain. Maceda-Veiga et al., noted that endemic fish populations have declined greatly (by a mean of 60%) in the Catalonian catchments even to the extent that the amphidromous species* A. arcasii *has suffered local extinctions. The article hypothesized that in addition to habitat alteration, introduced species such as* C. carpio *and* A. alburnus *have an impact on native fish fauna.*
- *Invasive bleak in the Iberian Peninsula have led to higher metabolic expense, reduced shelter ruse, and increased predation risk in the critically endangered Iberian saramugo* Anaecypris hispanica *(da SIlva et al., 2019).*
- *Bleak has similar behavior and activity patterns to* Pseudorasbora parva*, another potential invader to the Great Lakes, due to major isotopic niche overlap indicating competition between the two species if resources become limited, however, they can co-exist in open systems and potentially double their trophic impact (Haubrock et al., 2019; Balzani et al., 2020).*

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

- *Bleak consume drifting asp (*Leuciscus aspius*) eggs before they attach to substrate, leading to an average egg mortality of 21.2% ± 2.2% in the main tributary of the Želivka Reservoir (Šmejkal et al., 2017; Šmejkal et al., 2018).*

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

- *Bleak hybridizes easily with other cyprinids (Blachuta and Witkowski 1984; Crivelli and Dupont 1987). Squalius alburnoides resulted as a hybridization of Squalius, Bleak, and Anaecypris.*
- *In the Iberian watershed, bleak has threatened endemic species (e.g.* Squalius *and* Anaecypris *spp.) through hybridizing with other cyprinids (Sousa-Santos et al., 2018).*

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

- *Besides its impact on native fish fauna, bleak feeds on cladoceran and other small invertebrates that play an important role in these ecosystems and directly affect the water quality (Maceda-Veiga et al., 2010).*
- *Horppila and Kairesalo (1992) examined the effects of bleak on water quality by placing the fish in enclosures in the field. Algal production and chlorophyll-α levels were over two times more than enclosures without bleak.*

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

- *Field studies suggest that a bleak population can increase algal productivity and biomass (Horppila and Kairesalo 1992).*

Environmental Impact Total	**16**
Total Unknowns (U)	**0**

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

POTENTIAL SOCIO-ECONOMIC IMPACT

NOTE: In this section, a "Not significantly" response should be selected if there have been no reports of a particular impact. An "Unknown" response is appropriate if the potential for a particular impact might be inferred from a significant environmental impact but has not been explicitly reported or if there is an unresolved debate about a particular 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 bioaccumulation of heavy metals, including lead, in bleak may pose a threat to the health of humans who consume them (Niemiec et al., 2018).*

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 has not been reported to damage infrastructure in this review*

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√

- Alburnus alburnus *may affect water quality by feeding on organisms that play a direct role in water quality (Maceida-Veiga 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

- *This species has not been reported to negatively affect markets or economic sectors in this review*

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

- *This species has not been reported to inhibit recreational activities or tourism in this review*

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

- *This species has not been reported to diminish aesthetic or natural values in this review*

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

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

- *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

- Alburnus alburnus *is exploited commercially in parts of Europe, as a baitfish or forage fish (Elvira 1995; Pérez-Bote et al., 2004) and in the pearl trade (Denton and Nicol 1965). Additionally, bleak have being introduced into various reservoirs in order to improve the populations of exotic fish predators such as the Northern Pike (*Esox lucius*), the Largemouth Bass (*Micropterus salmoides*), the Zander (*Sander lucioperca*), and the Wels Catfish (*Silurus glanis*) (Maceda-Veiga et al., 2010).*
- *In the Western Balakan Peninsula, catch of bleak varies amongst lotic and lentic systems, ranging from <1% to 70% respectively (Mrdak 2009).*

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

- *A small amount of bleak is fished recreationally in the Tsimlyansk Reservoir, Russia, amounting to 141 kg in 2019 (0.5% total catch) (Kutsenko et al., 2020).*

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 significantly.*

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 significantly.*

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

- *Bleak have been frequently used to enhance the populations of exotic fish predators such as the Northern Pike (*Esox lucius*), the Largemouth Bass (*Micropterus salmoides*), the zander (*Sander lucioperca*) and the Wels Catfish (*Silurus glanis*) (Maceda-Vega et al., 2010).*

Beneficial Effect Total	**7**
Total Unknowns (U)	**0**

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

Scientific Name: *Clupeonella cultriventris*

Common Name: Black Sea Sprat

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: 2020 update: No changes to quantitative scores or qualitative statements. Minor additions of references and supporting information.

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

- C. cultriventris *currently inhabits the Ponto-Caspian region, including Iranian and Turkish waters of the Caspian Sea (Fazli et al., 2007).*

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

- *N/A*

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

- C. cultriventris *is not known to be able to adhere to surfaces or other organisms.*

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

- *N/A*

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 is rarely/never sold.	0 √
Unknown	U

- *An Internet search for* C. cultriventris *for purchase ("for sale") suggests that this species is not sold.*

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

- *N/A*

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

- C. cultriventris *has not been found anywhere in the Great Lakes region or North America.*

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

- *N/A*

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

- *C. cultriventris is not currently cultured in the Great Lakes 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

- *N/A*

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 species is euryhaline and is found in salinities up to 36‰ (Fazli et al., 2007).*
- *This species occurs in waters with temperatures of 2.6 - 26°C, but its optimal temperature range is 16-22 °C (Aseinova 2003; Stakenas 2011).*

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

- C. cultriventris *has successfully established in the Rhine River due to the opening of the Rhine-Main-Danube canal that connects to the Black Sea (Ricciardi and MacIsaac 2000).*
- C. cultriventris *spread to the Volga reservoirs to the Rybinsk Reservoir, but was unable to move further north through the Volga-Baltic canal system (Kiyashko et al., 2012).*
- C. cultriventris *is found in the Black Sea (northwestern parts), Sea of Azov, and Caspian Sea, as well as most of the affluent rivers of the area, reaching as far as 60 km inland. It is also found in Lake Palaeostomi (Bulgaria), the Bay of Feodosiya (Romania), and Lake Apolyont (Turkey) (Whitehead 1985).*
- *As such, it does not appear that* C. cultriventris *currently exists at ports in direct trade with the Great Lakes.*

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	0	Unlikely
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)	0	x	0	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	0	Unlikely
Escape from commercial culture: Accidental introduction to Great Lakes by escape from commercial culture (e.g., aquaculture)	0	x	0	Unlikely
Trans-oceanic shipping: Ballast (BOB) or no-ballast-on-board (NOBOB) water exchange/discharge, sediment discharge, hull fouling	80	x 0.1	8	Low
Total Unknowns (U) 0	Confidence Level		High	

<u>Qualitative Statements for GLANSIS Fact Sheet:</u>
Clupeonella cultriventris has a low probability of introduction to the Great Lakes (Confidence level: High).

Potential pathway(s) of introduction: Transoceanic Shipping (ballast water)

Section B: Potential for Establishment

<u>ESTABLISHMENT POTENTIAL RESULTS</u>

Clupeonella cultriventris has a moderate probability of establishment if introduced to the Great Lakes (Confidence level: High).

Comments: 2020 update: No changes to qualitative statements, but some quantitative scores have changed: B43 (3 to 6), B5 (3 to 5), B6 (3 to 7), B7 (8 to 9), B8 (8 to 9), B10 (5 to 6).

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

- C. cultriventris *is known to have broad salinity and temperature tolerance. It is considered oxyphilic (Aseinova 2003).*
- *This species is euryhaline. It can tolerate freshwaters and salinities up to 36% (Fazli et al., 2007).*
- *It is found in waters that have an annual average temperature of 12°C (Karimzadeh et al., 2010) and can tolerate water temperatures down to 3°C (Kas'yanov 2009). It occurs in waters with temperatures ranges of 2.6-26°C, and its optimal temperature is 16-22°C (Stakenas 2011). Spawning and development occurs at 10- 25°C in the pelagic zone (Kiyashko et al., 2006). It is considered eurythermal (Ricciardi and Rasmussen 1998).*

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

- C. cultriventris *is known to be an overwintering species, however oxygen requirements may limit overwintering (Aseinova 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

8

- C. cultriventris *is a euryphagous species, eating a wide variety of copepods, cladocerans, and rotifers (Aseinova 2003).*
- C. cultriventris *feeds during the day (Kiyashko et al., 2007).*
- C.cultriventris *feeds on zooplankton and its diet is relatively diverse relative to other kilka species (Aseinova 1992).*

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

- *Kolar and Lodge (2002) notes that a previous qualitative assessment suggests that* C. cultriventris *may have negative effects on the Great Lakes if introduced.*
- *Kolar and Lodge (2002) predicted that* C. cultriventris *would spread quickly and be a nuisance if introduced to the Great Lakes.*
- *It dominates the pelagic planktivorous fish assemblages in almost all reservoirs of the Volga cascade, including the Rybinsk Reservoir. The northward expansion of* C. cultriventris *is still continuing. In 2001 it dominated fish communities from Sheksna Reservoir to Beloye Lake (Slynko et al., 2002). Eutrophication, retarded flow, and formation of vast open sites suitable for these pelagic fish contributed to their dispersal and naturalization (Kiyashko et al., 2006). In addition, the nearly complete absence of competitors and low predator pressure may have been partially responsible for their spread and their dominance in the communities.*
- *Where this species is very abundant, it feeds on the same planktonic organisms as native species, and their feeding similarity indices are greater than 50%. When this species is less numerous, feeding similarity with native species is less than 40% (Kiyashko et al., 2007).*
- *It has become very abundant in the Volga River reservoirs, contributing to the decline in native populations (Mordukhaĭ-Boltovskoĭ 1979b; Ricciardi and Rasmussen 1998).*
- *Introduced in early 1960's, In 1970's, C. cultriventris became superdominant (65-99% catch) in Dneprodzerzhinsk and Kremenchug reservoirs replacing bleak (Alburnus alburnus) and common roach (Rutilus rutilus) and have maintained dominant population levels for at least 40 years (Tereschenko et al., 2015).*

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

- C. cultriventris *reaches maturity after one year (Kiyashko et al., 2006).*
- *Reproduction occurs from March to September at temperatures of 10-25°C (Kiyashko et al., 2006; Fazli et al., 2007; Karimzadeh et al., 2010) and peaked in April-May. It has a shorter reproduction period than the bigeye kilka (*Clupeonella grimmi*) (throughout the year).*
- *In the Rybinsk Reservoir, it begins spawning in early June and ends in late July, peaking in early July (Opisov and Kiyashko 2006). It reaches maturity at age one+ years at 49 mm. Males live up to 3.5 years. Females live up to 6 years. Females produce at least two batches of eggs during the spawning period. Absolute fecundity ranges from 4.2 to 66.7 thousand eggs and averages at 25.4 thousand eggs.*
- *In the Rybinsk Reservoir,* C. cultriventris *has a higher relative fecundity and egg diameter than native species (Opisov and Kiyashko 2006).*
- *The anchovy kilka,* Clupeonella engrauliformis*, has an average absolute fecundity of 12,625 ± 5533 eggs (Janbaz et al., 2012).*

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

- *Based on egg size, amount of eggs laid per fish, and early maturity it is likely that these will all give* C. cultriventris *a reproductive advantage. (Kiyashko et al., 2006; Opisov and Kiyashko 2006).*
- *Fish that produce a large number of small eggs may be more likely to establish than other fish (Kolar and Lodge 2002).*

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

- *The Ponto-Caspian (Caspian, Azov, and Black Seas) have similar climate and surface water temperature ranges as the Great Lakes (Reid and Orlova 2002; Grigorovich et al., 2003; USEPA 2008).*
- *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
	9

- *Although* C. cultriventris *is native to brackish waters of the Ponto-Caspian, it has established in freshwaters of the Rhine River (Ricciardi and MacIsaac 2000).*
- *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 (Reid and Orlova 2002; Grigorovich et al., 2003; USEPA 2008).*
- *Abiotic factors and climatic conditions of the native and introduced ranges of* C. cultriventis *are quite similar to the Great Lakes, making the region compatible (Reid and Orlova 2002; Grigorovich et al., 2003).*

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
	6

- C. cultriventris *is a pelagic fish that inhabits coastal areas shallower than 50-70 m (Fazli and Besharat 1998). It is oxyphilic, but can tolerate a wide range of temperatures (Aseinova 2003).*

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

- *Its optimal temperature range is 16 -22°C (Aseinova 2003). It may not be able to tolerate low dissolved oxygen levels (Aseinova 2003) created by ice cover, so shorter ice cover duration may benefit this species. Climate change may make the Great Lakes climate more similar to the Ponto-Caspian region (USEPA 2008).*
- *The northern dispersal of* C. cultriventris *beyond Lake Beloye in Russia is limited by temperature and food availability, therefore warmer and more productive waters from climate change may be favorable for this species' establishment and spread (Kiyashko et al., 2012).*

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

- C. cultriventris *feeds on a wide variety of copepods, cladocerans, and rotifers (Aseinova 2003). These can be found in the Great Lakes.*
- *Compared to closely related species,* C. cultriventris *has a flexible diet (Fazli et al., 2007).*

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. cultriventris*.*

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 no Great Lakes species known to facilitate the establishment of* C. cultriventris*.*

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%

- *Major predators of adult* C. cultriventris *include larger fish (Aseinova 2003), but these are unlikely to be a significant deterrent to species establishment.*
- *In the Caspian Sea,* C. cultriventris *is an important part of the diet of commercially valuable fish such as sturgeon and salmon (Karimzadeh 2011).*
- *Lake Sturgeon is threatened (in low abundance) in the Great Lakes (Hayes and Caroffino 2012).*
- *Chinook Salmon was introduced to the Great Lakes and its populations are maintained by stocking programs (MIDNR 2014).*
- *This species is also consumed by sander (*Sander lucioperca*), burbot (*Lota lota*), pike (*Esox lucius*) and adult European perch (*Perca fluviatilis*), but there is no indication that these species have prevented or limited the establishment of* C. cultriventris *(Karimzadeh 2011; Gerasimov et al., 2018).*

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

- C. cultriventris *has not yet been introduced into the Great Lakes and potential inoculum size and frequency are not known.*

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
	4

- *There are reported invasive* C. cultriventris *populations in Russia and Belarus (Slynko et al., 2002; Kiyashko et al., 2006; Khalko 2007; Semenchenko 2008,). Its distribution is continuing to spread northwards. The spread has been primarily attributed to the construction of reservoirs*

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

- C. cultriventris *dominates the pelagic planktivorous fish assemblages in almost all reservoirs of the Volga cascade, including the Rybinsk Reservoir. The northward expansion of* C. cultriventris *is still continuing. In 2001 it dominated fish communities from Sheksna Reservoir to Beloye Lake (Slynko et al., 2002). Eutrophication, retarded flow, and formation of vast open sites suitable for these pelagic fish contributed to their dispersal and naturalization (Kiyashko et al., 2006). In addition, the nearly complete absence of competitors and low predator pressure may have been partially responsible for their spread and their dominance in the communities.*
- C. cultriventris *completely colonized the Uglich and Ivan'kov Rivers within a span of 12 years and had an average expansion rate of 60km/year in the Volga river basin, spreading 2800 km in 35 years (Slyn'ko and Kiyashko 2012).*
- *The models developed by Kolar and Lodge (2002) predicted that* C. cultriventris *will spread at a fast rate and have negative impacts if introduced.*
- *It has populated the lower reaches of the Kama River in 1963-1966 (Mordukhaĭ-Boltovskoĭ 1979).*

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

- *No control methods for this species are known to be present in the Great Lakes.*

<table>
<tr><th colspan="5">Section B Scores</th></tr>
<tr><th>Points</th><th>Probability of Establishment</th><th colspan="2">Total Points (pre-adjustment)</th><th>97</th></tr>
<tr><td rowspan="2">>100</td><td rowspan="2">High</td><td colspan="2">Adjustments</td><td></td></tr>
<tr><td>Critical species</td><td>A (97- 0 %)</td><td>97</td></tr>
<tr><td rowspan="2">51-99</td><td rowspan="2">Moderate</td><td>Natural enemy</td><td>B (97-10 %)</td><td>87.3</td></tr>
<tr><td>Control measures</td><td>C (87.3-0%)</td><td>87.3</td></tr>
<tr><td>0-50</td><td>Low</td><td colspan="2">Probability of 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">1</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:
Clupeonella cultriventris has a moderate probability of establishment if introduced to the Great Lakes (Confidence level: High).

Section C: Potential for Impact

POTENTIAL IMPACT RESULTS

Environmental: Low
Socio-Economic: Low
Beneficial: Moderate

Comments: 2020 update: Beneficial impacts increased from low to moderate due to the value of *Clupeonella cultriventris* as a forage fish and a commercial food product.

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.*

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

- C. 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 62 this species in the Volga River reservoirs may have suppressed native fish populations (Mordukhai-Boltovskoi 1979b; Ricciardi and Rasmussen 1998). However, the identity of the species that have been impacted by* C. cultriventris *dominance remains unknown.*
- *In locations where* C. 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.*
- *Introduced in early 1960's, In 1970's,* C. cultriventris *became superdominant (65-99% catch) in Dneprodzerzhinsk and Kremenchug reservoirs, replacing bleak (*Alburnus alburnus*) and common roach (*Rutilus rutilus*) and have maintained dominant population levels for at least 40 years (Tereschenko et al., 2015).*

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's	**Impact**
>5	Any	**High**
2-5	Any	**Moderate**
0	0-1	**Low**√
1	0	
0	≥2	**Unknown**

1	≥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

- C. cultriventris *is a known host to the* Anisakis schupakovi *parasite, which can cause anisakis disease in humans who consume undercooked and infected fish (Abdyekova et al., 2020). However,* C. cultriventris *is not commonly consumed fresh, and therefore unlikely to be a source of infection.*

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

- *There are no reports of this species causing damage to 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

- *There are no reports of this species altering 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

- *There are no reports of this species inhibiting recreational activities.*

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

- *There are no reports of this species inhibiting recreational activities and tourism.*

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

- *There are no reports of this species diminishing aesthetic values.*

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

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

- *There are no reports of this species acting as a biological control.*

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

- *There are suggestions for its potential use in Russian commercial fisheries (Aseinova 2003).*
- *In the Caspian,* C. cultriventris *is an important source of income and protein for many people in the region (Karimzadeh et al., 2010) and is preyed on by commercially valuable fish such as sturgeon and salmon (Karimzadeh 2011). Whether this species will make a significant contribution to North American fisheries is uncertain.*
- C. cultriventris *is relatively difficult to eat fresh, as it oxidizes quickly and has many small bones and scales (Kristinsson and Liang 2006). However, it is highly valuable for prepared commercial food and animal feed (Abdollahi et al., 2017) due to its high gel strength, protein, and amino acids and can be sold as surimi, burgers, cutlets, and sausages (Devi et al., 2013; Shabanpour et al., 2015).*
- *The intestines of* C. cultriventris *contain similar concentrations to other less abundant fish of trypsin, an enzyme used in cheese ripening, meat flavoring and tenderizing, and cell culturing for diabetes therapies, making them a valuable species to harvest for its extraction (Klomklao et al., 2010; Zamani et al., 2017).*
- *Their hydrolved flesh is also a novel source of antioxidative peptides, proteins and amino acids that can be used as dietary additives to increase human health and the quality of animal feed (Liceaga-Gesualdo and Li-Chan 1999; Hosseini et al., 2018; Mahdabi et al., 2018).*
- *The flesh can also be used to generate antimicrobial and antihypertensive agents as food additives (Aqara and Nafaji 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

- *There are no suggestions of this species having 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

- *There is no information about a potential medicinal or research value of this species.*

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

- *No reports of water quality improvement by this species were found.*

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

- *Sturgeon preys on* C. cultriventris *(Karimzadeh 2011). Lake Sturgeon occurs in the Great Lakes and is listed as threatened in Michigan (Roth et al., 2013). However, increasing the amount of food available for lake sturgeon may not contribute to their conservation; they are threatened due to overfishing and declining habitat quality rather than the lack of food. In addition, the Lake Sturgeon is a benthic feeder (Hayes and Caroffino 2012), so there is a possibility that it will not feed on the pelagic* C. cultriventris*.*
- *Native fishes in the Great Lakes (i.e. pike* Esox lucius*) may use* C. cultriventris *as forage fish, but the extent to which is unknown (Gerasimov et al., 2018).*

Beneficial Effect Total	**2**
Total Unknowns (U)	**0**

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

Scientific Name: *Lithoglyphus naticoides*

Common Name: Gravel snail

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: Introduction to the Great Lakes is most likely from shipping ballast water (Grigorovich et al., 2003; Bailey et al., 2011).

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

- *No reports of L. naticoides have been made in North America.*

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

- *N/A.*

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

- *N/A.*

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 is rarely/never sold.	0 √
Unknown	U

- *Not reported.*

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

- *N/A.*

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 <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

- *N/A.*

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.*

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

- *N/A.*

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

- L. naticoides *is euryhaline (Gittenberger et al., 1998).*
- *It has been predicted to be able to survive introduction to the Great Lakes via ballast water, and Montreal, Quebec and Quebec City, Quebec are identified as ports with a high risk of introduction (Bailey et al., 2011).*

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

- *Occurs in the North, Black, Baltic, and Azov Sea basins (Grigorovich et al., 2003), which are connected to Great Lakes ports via international shipping routes (Bailey et al., 2011).*

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	0	Unlikely

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)	0	x	0	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	0	Unlikely
Escape from commercial culture: Accidental introduction to Great Lakes by escape from commercial culture (e.g., aquaculture)	0	x	0	Unlikely
Trans-oceanic shipping: Ballast (BOB) or no-ballast-on-board (NOBOB) water exchange/discharge, sediment discharge, hull fouling	100	x 0.5	50	Moderate
Total Unknowns (U)	0	Confidence Level	High	

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

Potential pathway(s) of introduction: Shipping ballast water.

Scoring	
Points (per vector)	**Probability for Introduction**
80-100	High
40-79	Moderate√
1-39	Low
0	Unlikely
# of Unknowns (overall)	**Confidence Level**
0	High√
1-2	Moderate
3-5	Low

Section B: Potential for Establishment

ESTABLISHMENT POTENTIAL RESULTS

***Lithoglyphus naticoides* 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
	6

- *Euryhaline (Gittenberger et al., 1998).*
- *Unknown lower temperature limit, but reported in 13.5 to 27 C waters (Kurina 2017).*
- *Dispersal is limited by low dissolved oxygen concentrations (Sharpova 2007; Yakovlev et al., 2010).*
- *Survives in eutrophic waters (Bij de Vaate et al., 2002).*

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

- *Native to Ponto-Caspian region, which has proved a large donor source of invasive species to the Great Lakes with high environmental similarity (species able to overwinter) (Ricciardi and MacIsaac 2000).*

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

- L. naticoides *is a facultative bottom feeder, consuming suspended organic matter including diatoms and algae and plant remains (Bij de Vaate et al., 2002; Olenin and Daunys 2004; Mouthon 2005).*
- *Nonspecific diet (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

- *No direct reports of competition, but can form dense mats with very high numbers of individuals per area that excludes competing mollusc species (Biserova 1990; Mastitsky and Samoilenko 2006).*

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

- *Produces only one cohort a year, but quantity is unknown (Yakovlev 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
	0

- *Produces only one cohort a year, but quantity is unknown (Yakovlev et al., 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
	9

- *The Ponto-Capsian regions and the Great Lakes are very similar in climatic conditions and the former is an established donor region (Casties et al., 2016).*

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
	7

- *The Ponto-Capsian regions and the Great Lakes are very similar in abiotic conditions and the former is an established donor region (Casties et al., 2016).*
- L. naticoides *is also euryhaline, thrives in eutrophic waters, and appears to inhabit a wide range of temperatures (Gittenberger et al., 1998; Bij de Vaate et al., 2002; Kurina 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
	6

- *Most abundant in shallow, slow-moving water <20 meters with silty sand or dead mollusc substrate (Matitsky and Samoilenko 2006; Yakovlev et al., 2010).*

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
	5

- *Northward expansion of* L. naticoides *in Europe and Russia is facilitated by warmer fall and winter temperatures (Yakovlev et al., 2010).*
- *Euryhaline (Gittenberger et al., 1998).*

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

7

- L. naticoides *is a facultative bottom feeder, consuming suspended organic matter including diatoms and algae and plant remains (Bij de Vaate et al., 2002; Mouthon 2004; Olenin and Daunys 2004).*
- *Nonspecific diet (Bij de Vaate et al., 2002).*

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 critical species required.*

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

- *Not reported.*

How likely is establishment of this species to be prevented by the herbivory, predation, or parasitism of a natural enemy that 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

- *This species is consumed by the fish* Benthophilus stellatus *(Starry Goby), but it does not significantly impact populations and is also not present in the Great Lakes (Frolova and Galanin 2007).*

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
	3

- *Local dispersal via waterways is slow (much slower than other invasive molluscs) and ballast water introductions are likely to be small (Grigorovich et al., 2003; Bodis et al., 2012).*

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

- *Beginning in the 1800s,* L. naticoides *has spread across Europe via canals and shipping and is found in the Baltic Sea (Piechocki 1979; Bodis et al., 2012), the Rhine and Danube river basins, and the following countries: Netherlands, Germany, Belarus, Finland, Hungary, Lithuania, France, Ukraine, Turkey, and Russia (Gittenberger et al., 1998; Butkus et al., 2014; Bodis et al., 2015; Yakovleva et al., 2016; Perova et al., 2019).*

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

- *It has taken* L. naticoides *nearly 100 years to spread to the eastern half of France, while* Dreissena polymorpha *and* Corbicula fluminea *spread to the whole country in less than 30 years (Mouthon 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
	-0%

- *No existing control methods.*

<table>
<tr><th colspan="5">Section B Scores</th></tr>
<tr><th>Points</th><th>Probability of Establishment</th><th colspan="2">Total Points (pre-adjustment)</th><th>73</th></tr>
<tr><td rowspan="2">>100</td><td rowspan="2">High</td><th colspan="2">Adjustments</th><td></td></tr>
<tr><th>Critical species</th><th>A (73- 0 %)</th><th>73</th></tr>
<tr><td rowspan="2">51-99</td><td rowspan="2">Moderate</td><th>Natural enemy</th><th>B (73- 0 %)</th><th>73</th></tr>
<tr><th>Control measures</th><th>C (73- 0 %)</th><th>73</th></tr>
<tr><td>0-50</td><td>Low</td><th colspan="2">Probability of Establishment</th><td>Moderate</td></tr>
<tr><th># of questions answered as “unable to determine”</th><th>Confidence Level</th><td colspan="3"></td></tr>
<tr><td>0-1</td><td>High</td><th colspan="2" rowspan="2">Total # of questions unknown</th><td rowspan="2">1</td></tr>
<tr><td>2-5</td><td>Moderate</td></tr>
<tr><td>6-9</td><td>Low</td><th colspan="2" rowspan="2">Confidence Level</th><td rowspan="2">High</td></tr>
<tr><td>>9</td><td>Very low</td></tr>
</table>

Section C: Potential for Impact

POTENTIAL IMPACT RESULTS

Environmental: Moderate
Socio-Economic: Low
Beneficial: Unknown

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

- L. naticoides *serves as the first intermediate host and dispersal mechanism for several parasitic trematode species (e.g.* Apophallus *spp.,* Nicolla skrjabini, Echinochasmus *spp.,* Sanguinicola *sp. and* Palaeorchis incognitus*) (Zhokhov and Pugacheva 2001; Matisky 2007; Stanevičiūtė et al., 2008; Tyutin and Slynko 2010; Molnár et al., 2016; Petkevičiūtė et al., 2020). Trematode infections are correlated with high abundance of* L. naticoides *(Yakovlev et al., 2010). Several trematode species, including* Apophallus müehlingi *and* A. donicum *in heavily infected hosts, can cause a black-spot disease in young fish, resulting in an 80% mortality rate in some cyprinids (Biserova 1990; 2005; Matisky 2007).*
- *Birds and mammals, including humans, that consume raw fish exhibiting symptoms of black-spot disease may also experience pathogenic effects (Niemi andMacy1974; Biserova 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

- *Under favorable conditions,* L. naticoides *can form dense populations on substrate, reaching a maximum of 8800 individuals per m2 (Biserova 1990; Mastitsky and Samoilenko 2006). However, mean yearly proportions of* L. naticoides *did not exceed 8% of total biomass of macrozoobenthos in Lake Lukomskoe, Belarus (Matisky and Samoilenko 2006). However, a few populations of* L. naticoides *in the lower Nemunas River, Lithuania were considered "high-impact" and were associated with lower native species diversity and abundance (Arbačiauskas et al., 2011b).*

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

- *Not 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

- *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)	**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

- *Birds and mammals, including humans that consume raw fish exhibiting symptoms of black-spot disease may also experience pathogenic effects (Niemi andMacy1974; Biserova 2005).*

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 significantly, in fact some populations in Poland are decreasing due to anthropogenic water pollution (Zajac 2005).*

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 significantly.*

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 significantly.*

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 significantly.*

Socio-Economic Impact Total	**1**
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√

- *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

- *Not significantly.*

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 significantly.*

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√

- *Unknown.*

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√

- *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√

- *Unknown.*

Beneficial Effect Total	**0**
Total Unknowns (U)	**4**

Scientific Name: *Prymnesium parvum*

Common Name: Golden algae

Section A: Potential for Introduction

INTRODUCTION POTENTIAL RESULTS

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

Comments: Local dispersal is likely driven by recreational boat transport or birds (Renner 2009).

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

- *Dispersal can occur via wind and water (Kristiansen 1996; Hallegraeff and Gollasch 2006; Renner 2009).*

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

- *The closest report of a* P. parvum *bloom was in Dunkard Creek, Pennsylvania in 2009 (Renner 2009).*

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

- *Local dispersal is attributed to transportation by birds, wind, and anthropogenic movement (drilling equipment, water tankers, and recreational boats) (Kristiansen 1996; Renner 2009).*
- P. parvum *has spread to 23 U.S. states in 35 years (Roelke et al., 2016).*
- *Transoceanic, long distance invasions are hypothesized to be facilitated by air and ocean currents and by ballast water and global trade of aquaculture (Hallegraeff and Gollasch 2006).*

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

- *The closest report of a* P. parvum *bloom was in Dunkard Creek, Pennsylvania in 2009 (Renner 2009).*

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 is rarely/never sold.	0 √
Unknown	U

- *Not reported.*

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

- *N/A.*

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 <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

- *N/A.*

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.*

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

- *N/A.*

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

- P. parvum *has a resting cyst form that may serve as a way to reseed populations following unfavorable conditions (Garcés et al., 2001; Graneli et al., 2012).*
- *It can survive temperatures from 5°C to 35°C, salinity from ~0.5 psu to 45 psu, and a wide range of pHs (Brand 1984; Larsen et al., 1993; Larsen and Bryant 1998; Baker et al., 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

- P. parvum *exists on every continent except Antarctica and is found in coastal waters of Germany, Norway, United Kingdom, and Australia (Roelke et al., 2016).*

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	100	x 0.25	25	Low
Hitchhiking/Fouling: Transport via recreational gear, boats, trailers, mobile fauna, stocked/planted organisms, packing materials, host organisms, etc.	100	x 0.1	10	Low
Release: Unauthorized intentional release of organisms in trade (e.g., aquaria, water gardens, live food)	0	x	0	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	0	Unlikely
Escape from commercial culture: Accidental introduction to Great Lakes by escape from commercial culture (e.g., aquaculture)	0	x	0	Unlikely
Trans-oceanic shipping: Ballast (BOB) or no-ballast-on-board (NOBOB) water exchange/discharge, sediment discharge, hull fouling	100	x 0.5	50	Moderate
Total Unknowns (U)	0	Confidence Level	High	

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

Potential pathway(s) of introduction: Dispersed by wind, hitchhiker on waterfowl, shipping ballast water.

Section B: Potential for Establishment

ESTABLISHMENT POTENTIAL RESULTS

Prymnesium parvum **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
	6

- *It can survive temperatures from 5°C to 35°C, salinity from ~0.5 psu to 45 psu, and a wide range of pHs (Brand 1984; Larsen et al., 1993; Larsen and Bryant 1998; Baker et al., 2007)*
- *It prefers eutrophic waters, but can acquire nutrients via heterotrophy if necessary (Fistarol et al.,, 2003; Tillmann, 2003; Grane´li and Johansson, 2003a)*

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

- *See above on temperature.*
- P. parvum *has a resting cyst form that may serve as a way to reseed populations following unfavorable conditions (Garcés et al., 2001; Graneli 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
	9

- *During a* P. parvum *bloom when toxin concentrations are high enough to lyse the cells of zooplankton and other phytoplankton,* P. parvum *can consume them by phagotrophy and absorb the recently released dissolved organic material by saprophy, effectively resisting potential inorganic nutrient limitation from their rapid growth (Graneli et al., 2012; Roelke et al., 2016).*

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
	7

- *Blooms of* P. parvum *are capable of producing concentrations of chemicals that can suppress the growth or kill competing phytoplankton and predatory zooplankton (e.g.* Harpacticus *sp. and* Daphnia magna*) (Fistarol et al., 2003, 2005; Grane´li and Johansson, 2003; Roelke et al., 2007; Errera et al., 2008; Brooks et al., 2010).*
- *However, without the allelopathic effects of its toxins,* P. parvum *has minimal competitive ability (Graneli et al., 2012).*

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

- *Its maximum growth is at least 1.15 cell division per day via mitosis, increasing as environmental conditions become more favorable (e.g. moderate salinity and temperatures) (Larsen and Byrant 1998).*
- *Other haptophytes growth rates range from 0.93 to 2.23 division per day (Seoane 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

3

- P. parvum *may use its resting cyst form to inhabit new environments and bloom when conditions are appropriate (Garcés et al., 2001; Graneli et al., 2012).*

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

- P. parvum *is ubiquitous worldwide in temperate zones and has bloomed as far north as Wyoming in the U.S. (Roelke et al., 2016).*

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
	1

- P. parvum *is ubiquitous worldwide in temperate zones, and nutrients, temperature, and pH of the Great Lakes are suitable for survival. However, the salinity in most of the Great Lakes is too low (<0.5 psu) for toxic bloom formation in most of the waters. Although, some shallow bays, estuaries, coasts, and mouths of tributaries may achieve sufficient salinities (>0.5 psu) to support a bloom, especially with increased salt runoff from winter road application (e.g. Old Woman Creek Estuary, (Herdendorf et al., 2006; Jackson et al., 2008; Dugan et al., 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
	1

- *See above on salinity.*

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

- *Altered precipitation and longer hydraulic residence times in estuaries and bays will favor the slower growth of* P. parvum *(Kimmel and Groeger 1984; Roelke et al., 2016).*
- *Increased salinity will also favor* P. parvum *growth and bloom formation (Roelke et al., 2012).*

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

- P. parvum *consumes light, phytoplankton, and zooplankton, all of which are abundant in the Great Lakes (Roelke 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

- *No critical species required.*

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

- *Not reported.*

How likely is establishment of this species to be prevented by the herbivory, predation, or parasitism of a natural enemy that 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

- *A few grazers, including some ciliates, rotifers, and dinoflagellates, do consume* P. parvum *when it is not in bloom as they are also susceptible to its toxins. Bloom suppression by grazing is unlikely (Tillman 2003; Rosetta and McManus 2003; Schwierzke 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
	5

- *Because* P. parvum *has a resting cyst stage, it can be spread and bloom rapidly when environmental conditions are appropriate (especially in Texas) (Southard et al., 2010).*

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

- *Native range is unknown, but* P. parvum *is ubiquitous worldwide in temperate zones and has invaded dozens of countries (Roelke et al., 2016).*

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

- P. parvum *has invaded 23 U.S. states within 35 years, and in dozens of counties in Texas (Roelke et. al. 2016).*

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%

- *Control methods exist (flocculation, algaecides, flooding) but are highly destructive to the entire ecosystem and unlikely to be used. Furthermore, blooms and fish kills can start and end within a few days, making timely management and control difficult (Renner 2009; Southard et al., 2010; Rodgers et al., 2010).*

Section B Scores				
Points	**Probability of Establishment**	**Total Points (pre-adjustment)**		**89**
>100	High	**Adjustments**		
		Critical species	**A (89- 0 %)**	**89**
51-99	Moderate	**Natural enemy**	**B (89- 0 %)**	**89**
		Control measures	**C (89- 0 %)**	**89**
0-50	Low	**Probability of 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

POTENTIAL IMPACT RESULTS

Environmental: High
Socio-Economic: High
Beneficial: 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

- *Blooms of* P. parvum *are capable of producing concentrations of chemicals that can suppress the growth or kill competing phytoplankton and predatory zooplankton (e.g.* Harpacticus *sp. and* Daphnia magna*) (Fistarol et al., 2003, 2005; Grane´li and Johansson 2003; Roelke et al., 2007; Errera et al., 2008; Brooks et al., 2010). However, toxins are unlikely to be produced in freshwater systems (<0.5 psu) and* P. parvum *would have little to no environmental impact.*
- P. parvum *also produces a wide range of ichthyotoxic compounds, including prynmnesiens (Igarashi et al., 1996, 1999), fatty acids (Henrikson et al., 2010), and fatty acid amides (Bertin et al., 2012a, b), which damage gill membranes in fish, tadpoles, bivalves, and crayfish (Ultizer and Shilo 1966; Ulitzer 1973; Graneli et al., 2012; Svendsen et al., 2018) and have hemolytic and anticoagulant effects (Skingel et al., 2010).*
- *Presence of* P. parvum *compounds the mortality effects of viral hemorrhagic septicemia virus by 50% in* Oncorhynchus mykiss *(rainbow trout) when compared to the virus alone (Andersen et al., 2016).*

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

- P. parvum *is highly competitive, but only with the aid of its allelopathic chemicals (Graneli et al., 2012). Toxins are unlikely to be produced in freshwater systems (<0.5 psu) and* P. parvum *would have little to no competitive ability.*

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

- *Sustained declines of the relative size and/or abundance of nine fish species in the Upper Colorado River were attributed to toxic* P. parvum *blooms in 2001 (VanLandeghem et al., 2013).*
- *Dunkard Creek in Pennsylvania experienced a major fish kill, with* P. parvum *wiping out 18 fish and 14 freshwater mussel species (Renner 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√

- *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	**18**
Total Unknowns (U)	**0**

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

- *Not significantly.*

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 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

- *Fish kills from* P. parvum *toxicity is a major source of economic impact. As of 2010,* P. parvum *was responsible for the death of over 34 million fish in 33 waterbodies in Texas with an estimated value of US$13 million. Numerous Texas sport fisheries have also been severely affected, and economic losses in three counties surrounding an infested lake over two years were estimated at US$3.9 million (Southard et al., 2010). However, economic losses are currently limited to brackish waterbodies.*
- *Management and control are also very costly, especially in large water bodies (Roelke et al., 2016).*
- *Impacts in the Great Lakes region may be limited to gradual increases or sudden spikes in salinity due to road salt runoff or a release of pollution.*

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

- *Infested lakes are unsightly and can reduce recreation, tourism, and fishing (Glass 2003). Though blooms are unlikely in freshwater and current impacts are limited to brackish water.*

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

- *Like most harmful algae blooms,* P. parvum *infested lakes are unsightly and considered a nuisance (due to yellow tinted water and abundant surface foam) (Glass 2003).*

Socio-Economic Impact Total	**18**
Total Unknowns (U)	**0**

Scoring		
Score	# U's	**Impact**
>5	Any	**High**√
2-5	Any	**Moderate**
0	0-1	**Low**

1	0	
0	≥2	**Unknown**
1	≥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

- *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

- *Not significantly.*

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 significantly.*

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

- P. parvum *cells have a high lipid content and may be useful in the production of biofuel (Ng et al., 2015; Trivedi et al., 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

- *Not significantly.*

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 significantly.*

Beneficial Effect Total	**1**
Total Unknowns (U)	**0**

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

Scientific Name: *Salvinia minima*

Common Name: Water spangles

Section A: Potential for Introduction

INTRODUCTION POTENTIAL RESULTS

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

Comments: Waif populations have been reported sporadically in Great Lakes tributaries, though none have persisted.

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

- *Nearest persisting population is in the southeastern US.*

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

- *Nearest persisting population is in the southeastern 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

- *The continuous branching and fragmentation of rhizomes turns out large volumes of vegetative daughter plants throughout the growing season. Copious hairy coverings minimize the desiccation of plants spotted on boats, trailers, alligators, turtles and even dogs leaving the water. Lateral buds deeply embedded in the rhizome, may lie dormant during periods of reduced moisture and cold temperature. Small rhizome fragments, commonly sheltered in associating vegetation, provide material for reintroduction on the return of favorable growing conditions (USGS).*

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

- *Escaped populations of this species are primarily known from the southeastern 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 is rarely/never sold.	0
Unknown	U

- *Very commonly sold online, e.g. eBay and Amazon. Commonly grown by aquarium and pond owners (ISSG).*
- Salvinia minima *is still widely available in the water garden trade, either as a sale item or as a contaminant. Although it continues to infest new regions, it is not included on the Federal Noxious Weed List and is prohibited only in the states of Texas and Louisiana (USGS).*
- *Commonly associated with commercially sold species (received 25% of the time) (Make and Galatowitsch 2004).*

- *Synonym* S. rotundifolia *cultured and sold in the Great Lakes basin (OH).*

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

- *Readily available online and in the water garden and aquarium trade.*

<u>POTENTIAL INTRODUCTION VIA STOCKING/PLANTING OR ESCAPE FROM RECREATIONAL CULTURE</u>

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

- *Commonly grown by aquarium and pond owners (ISSG).*
- Salvinia minima *is still widely available in the water garden trade, either as a sale item or as a contaminant. Although it continues to infest new regions, it is not included on the Federal Noxious Weed List and is prohibited only in the states of Texas and Louisiana (USGS).*
- *Synonym* S. rotundifolia *cultured and sold in Great Lakes basin (OH).*

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

- *This species is readily available across the US, including 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

- *Cultured and sold in Great Lakes basin (OH).*

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

- *Unregulated and readily available throughout the Great Lakes basin.*

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

- *While this species is generally resilient, it is not capable of surviving salinities over 7 ppt.*

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

- *Yes, but has not been observed in ballast.*

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**	Unlikely
Hitchhiking/fouling: Transport via recreational gear, boats, trailers, mobile fauna, stocked/planted organisms, packing materials, host organisms, etc.	**100**	x 0.1	**10**	Low
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 1	**100**	High
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	

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

Salvinia minima has a high probability of introduction to the Great Lakes (Confidence level: high).

Potential pathway(s) of introduction: Stocking/planting/escape from recreational culture, escape from commercial culture, unauthorized intentional release.

Section B: Potential for Establishment

ESTABLISHMENT POTENTIAL RESULTS

***Salvinia minima* has a moderate probability of establishment if introduced to the Great Lakes (Confidence level: High).**

Comments: While this species is highly adaptable to a variety of environmental variables and conditions, persistent low temperatures and ice cover in the Great Lakes region would provide significant barriers to 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
	5

- *Tolerates salinity up to about 4-7ppt (USGS).*
- *Prefers warm temperatures of subtropics and tropics (optimal temperatures is 18-38°C). Does well in areas with high nutrients (WI DNR Lit Review; GISD).*
- S. minima *can grow in a wide variety of aquatic habitats, but does best in those with a high organic content (UFL-IFAS, 2002). It is also most frequently found in still and slow-moving water. Phytoremediation investigations suggest that* S. minima *be grown at a pH of 5.0 or 6.0 and with a maximum initial ammonium-nitrogen concentration of 70 mg/L (Olguin et al., 2007) (in Mikulyuk and Nault 2009).*

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

- *Waif populations: A specimen collected in 1994 from Aggie Pond, on the New Mexico State University campus represents a non-persisting occurrence, as do undocumented records from southern New York, coastal Massachusetts, Ohio, Maryland and Oklahoma. Otherwise, not known north of southeastern US (USGS).*
- S. minima *is negatively impacted by flooding and freezing (Dickinson and Miller 1998), and cannot survive extended hard freezes.*
- *This species dies back at temperatures below 15°C and is extremely unlikely to survive winter in the Great Lakes (WI DNR Lit Review; GISD).*

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

- *This species 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
	5

- *During earlier stages of colonization,* Salvinia minima *demonstrates exponential growth rates (Gaudet, 1973), which may be just as high as those of* Salvinia molesta *(USGS).*
- *In Texas and Louisiana,* S. minima t*ypically occurs in dense, expansive populations and is known as a very troublesome weed. At Lacassine Bayou, southwestern Louisiana, plants completely blanket a waterway measuring 19.3 km long and 110 m wide (Jacono et al 2001). Mats in Louisiana have been measured as thick as 20-25 cm (Montz 1989).*
- *Clatworthy and Harper (1962) studied the competition among three species of duckweed,* Spirodela polyrrhiza, Lemna gibba, Lemna minor *and the single temperate species of Salvinia,* S. natans*. In mixed cultures, they found that* Lemna gibba *and* Salvinia natans *displaced* Spirodela polyrhiza *and* Lemna minor. *The presence of aerenchyma in* Lemna gibba *and the strong connecting rhizome between the fronds in*

Salvinia, as well as the stiff hairs of Salvinia, enabled these two species to ride over and displace the thinner, flat fronds of the others (reviewed in Landolt 1986).

- *An eight-year study at Jean Lafitte National Historic Park, Louisiana, found complete displacement of native* Lemna *species by* Salvinia minima*. (T. Doyle, LA, pers. comm.) (USGS).*
- *An investigation of competition among* Salvinia minima*,* Spirodela [Landoltia] punctata *(G.F.W. Mey.) C.H. Thompson and* Azolla caroliniana *Willdenow in north Florida found* Salvinia minima *dominating during the summer months (Dickinson and Miller 1998). Later in the season*, S. minima *was impacted by flooding and freezing and* Spirodela punctata *became the most abundant species (Dickinson and Miller 1998).*
- *In Texas, Hatch (1995) observed* S. minima *shading out some submersed plant species (Jacono et al., 2001).*
- *However, cold fall and winter temperatures would likely limit the competitive ability of this species.*

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

- *The continuous branching and fragmentation of rhizomes turns out large volumes of vegetative daughter plants throughout the growing season (USGS)*
- Salvinia minima *is believed to be a sterile species. It is not known to produce fertile spores and is postulated to be of hybrid origin (Schneller 1980 in USGS).*

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

- *Horizontal, branching rhizomes float just below the water surface and produce, at each node, two floating to emergent leaves, and a third, submersed leaf. The continuous branching and fragmentation of rhizomes turns out large volumes of vegetative daughter plants throughout the growing season (USGS).*

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
	2

- *Southern US has a Cfa climate, which would have somewhat similar seasonality, but much warmer temperatures.*
- *The extended cold season and freezing conditions in the Great Lakes region would not be conducive to this species' survival.*

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
	2

- *Prefers warm temperatures of subtropics and tropics (optimal temperature is 18-38°C). Does well in areas with high nutrients (WI DNR Lit Review; GISD).*
- *Great Lakes waters with sufficient temperatures year-round (18°C) would be rare.*
- *S. minima can grow in a wide variety of aquatic habitats, but does best in those with a high organic content (UFL-IFAS, 2002). It is also most frequently found in still and slow-moving water. Phytoremediation investigations suggest that S. minima be grown at a pH of 5.0 or 6.0 and with a maximum initial ammonium-nitrogen concentration of 70 mg/L (Olguin et al., 2007) (in Mikulyuk and Nault 2009).*

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
	1

- *This species prefers shallow backwaters of bayous, lakes and ponds, oxbows, ditches, slow-flowing streams, cypress swamps and marshes (USGS).*
- *However, waters with sufficient temperatures year-round (18°C) would be rare.*

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

- *Tolerates salinity up to about 4-7ppt (USGS).*
- *Would benefit significantly from warmer temperatures and reduced ice cover.*

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 an autotroph.*

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 additional species are required for* S. minima*'s survival.*

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 to the Great Lakes that facilitates the development of this species has not been established in the Great Lakes*

How likely is establishment of this species to be prevented by the herbivory, predation, or parasitism of a natural enemy that 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%

- *A number of natural enemies, including the salvinia stem-borer moth (*Samea multiplicalis*) and the salvinia weevil (*Cyrtobagous salviniae*) have been used to control S. minima in its introduced ranges in the southern United States, but these species are not common 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
	3

- *Very commonly sold online, and is available for sale in the basin: frequent, small inocula are most likely from aquarium or water garden 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
	3

- *Native to Central and South America; common and wide-ranging from southern Mexico to northern Argentina and Brazil (Mickel and Beitel 1988, Stolze 1983 in USGS).*
- *Recent works consider S. minima native to North America (Nauman 1993, Wunderlin 1998). However, Fernald (1950) considered the species to be introduced to the United States. Salvinia minima is regarded as introduced to Bermuda (Weatherby 1937), Puerto Rico (Proctor 1989) and Spain (Lawalree 1964) (Jacono et al., 2001).*
- *Waif populations: A specimen collected in 1994 from Aggie Pond, on the New Mexico State University campus [Roalson 764 (NMCR)] represents a non-persisting occurrence, as do undocumented records from southern New York, coastal Massachusetts, Maryland and Oklahoma (USGS).*

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
	4

- *In the southeastern US, this species went from being reported in two drainage basins in 1932 to 68 in 2001 (Jacono et al., 2001).*

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

- *No control methods have been set to prevent the establishment and/or spread of this species.*

<table>
<tr><th colspan="5">Establishment Potential Scorecard</th></tr>
<tr><td>Points</td><td>Probability for Establishment</td><td colspan="2">A. Total Points (pre-adjustment)</td><td>58</td></tr>
<tr><td rowspan="2">>100</td><td rowspan="2">High</td><td colspan="2">Adjustments</td><td></td></tr>
<tr><td>B. Critical species</td><td>A*(58-0%)</td><td>58</td></tr>
<tr><td rowspan="2">51-99</td><td rowspan="2">Moderate</td><td>C. Natural enemy</td><td>B*(58-10%)</td><td>52.2</td></tr>
<tr><td>Control measures</td><td>C*(1-0%)</td><td>52.2</td></tr>
<tr><td>0-50</td><td>Low</td><td colspan="2">Potential 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>

Section C: Potential for Impact

IMPACT POTENTIAL RESULTS

Environmental: High
Socio-Economic: High
Beneficial: Moderate

Comments: Although this species is not included in the giant Salvinia complex (*S. auriculata, biloba, herzogii and molesta*), the Salvinia genus in general is widely known to be a problematic invader.

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 not documented to pose a direct health hazard or threat 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

- *During earlier stages of colonization,* Salvinia minima *demonstrates exponential growth rates (Gaudet, 1973).*
- *In Texas and Louisiana, S. minima typically occurs in dense, expansive populations and is known as a very troublesome weed. At Lacassine Bayou, southwestern Louisiana, plants completely blanket a waterway measuring 19.3 km long and 110 m wide (Jacono et al 2001). Mats in Louisiana have been measured as thick as 20-25 cm (Montz 1989 in USGS).*
- *Clatworthy and Harper (1962) studied the competition among three species of duckweed,* Spirodela polyrrhiza, Lemna gibba, Lemna minor *and the single temperate species of Salvinia,* S. natans*. In mixed cultures, they found that* Lemna gibba *and* Salvinia natans *were able to actually thrust aside* Spirodela polyrhiza *and* Lemna minor*. On the other hand,* Lemna minor *and* Spirodela polyrrhiza *coexisted without*

dominating each other. The authors correlated success in competition not with growth rate in pure culture, but rather with morphological characteristics. The presence of aerenchyma in Lemna gibba *and the strong connecting rhizome between the fronds in Salvinia, as well as the stiff hairs of Salvinia, enabled these two species to override and displace the thinner, flat fronds of the others (reviewed in Landolt 1986). It should be noted that* Salvinia natans *is smaller and more delicate than* S. minima*.*

- *An eight-year study at Jean Lafitte National Historic Park, Louisiana, found complete displacement of native Lemna species by* Salvinia minima*. (T. Doyle, LA, pers. comm.) (USGS).*
- *An investigation of competition among* Salvinia minima, Spirodela [Landoltia] punctata (G.F.W. Mey.) C.H. Thompson *and* Azolla caroliniana Willdenow *in north Florida found* Salvinia minima *dominating during the summer months (Dickinson and Miller 1998). Later in the season,* S. minima *was impacted by flooding and freezing and* Spirodela punctata *became the most abundant species (Dickinson and Miller 1998).*
- *In Texas, Hatch (1995) observed* S. minima *shading out some submersed plant species (Jacono et al., 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

- *This species is not reported to alter predator-prey dynamics.*

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

- *This species is not reported to alter native populations genetically.*

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

- *Dense infestations block out sunlight and decrease oxygen concentration to the detriment of fish and other aquatic species. When plant masses die, decomposition lowers dissolved oxygen still further (ISSG).*

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

- *A study at Jean Lafitte National Historic Park, Louisiana, found complete displacement of native Lemna species by* Salvinia minima*. (T. Doyle, LA, pers. comm.) (USGS). The Lemnaceae (duckweeds) contain high protein content and are important food sources for waterfowl.*
- *This species is known to outcompete other floating plants and shade out submerged vegetation, thereby changing macrophyte composition.*

Environmental Impact Total	**12**
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

- *This species is not reported to have negative effects 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

- S. minima *can clog irrigation systems, interfere with power production, and clog water intakes (Aquatic Plant Information System, 2002; Jacono, 2003; Madeira et al., 2003).*

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 to negatively affect 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

- S. minima *can negatively affect fisheries (Aquatic Plant Information System, 2002; Jacono, 2003; Madeira et al., 2003; and McKinney and Durocher, Undated in ISSG).*

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

- Salvinia minima *produces excessive surface growth, which can impede waterways and restrict boating (ISSG).*

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

- *This species is not reported to negatively impact aesthetic value.*

Socio-Economic Impact Total	**8**
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 to be a biological control.*

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

- *Sold as a common, inexpensive aquarium plant.*

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

- *Commonly used in home aquariums in planted tanks.*

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

- *No significant research value reported in the literature.*

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 to reduce toxin or pollutant load.*

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 other positive impacts.*

Beneficial Effect Total	2
Total Unknowns (U)	0

Scientific Name: *Silurus glanis*

Common Name: Wels Catfish

Section A: Potential for Introduction

INTRODUCTION POTENTIAL RESULTS

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

Comments: 2020 update: no changes to quantitative or qualitative scores. Minor new information added.

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

- *Not cultured or transported in the region.*

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

- *n/a*

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 likely to hitchhike.*

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

- *n/a*

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 is rarely/never sold.	0
Unknown	U√

- *The import and sale of* S. glanis *to the United States was banned under the Lacey Act in 2016. Several hobbyist forums included posts by individuals seeking this fish since 2016, and one indicated they had a specimen for sale in California, United States. However, these claims cannot be verified, so this vector remains unknown. Nonetheless, due to the previous legality of their trade and extensive life span, an unknown number of specimens may still exist in 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√

- *Unknown.*

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

- *Is not stocked in the great Lakes.*

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

- *n/a*

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 or transported 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

- *n/a*

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

- *Would not survive in a ballast tank.*

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

- *n/a*

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	0	Unlikely
Hitchhiking/Fouling: Transport via recreational gear, boats, trailers, mobile fauna,	0	x	0	Unlikely

stocked/planted organisms, packing materials, host organisms, etc.				
Release: Unauthorized intentional release of organisms in trade (e.g., aquaria, water gardens, live food)	U	x	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	Unlikely
Escape from commercial culture: Accidental introduction to Great Lakes by escape from commercial culture (e.g., aquaculture)	0	x	0	Unlikely
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:
Silurus glanis has an unknown/low probability of introduction to the Great Lakes (Confidence level: Moderate).

Potential pathway(s) of introduction: Unauthorized intentional release

Scoring	
Points (per vector)	**Probability for Introduction**
80-100	High
40-79	Moderate
1-39	Low
0	Unlikely√
# of Unknowns (overall)	**Confidence Level**
0	High
1-2	Moderate√
3-5	Low
>5	Very low

Section B: Potential for Establishment

ESTABLISHMENT POTENTIAL RESULTS

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

Comments: 2020 update: some increases to quantitative scores, including B1 (8 to 9), B7 (6 to 8), B8 (6 to 8), B9 (6 to 7), B11 (8 to 9), and B18 (0 to U). Upgraded from moderate to high 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
	9

- S. glanis *occupies water temperatures from 0 to at least 30°C (thermal optimum between 25-27°C),though success may be limited in lower water temperatures (David 2006; Britton et al., 2007).*
- *This species spawns at 18-22°C (Copp et al., 2009)* S. glanis *tolerates salinity up to 15 ppm (Copp et al., 2009).*
- *This species can inhabit eutrophic and turbid waters (Castaldelli et al., 2013).*
- *High levels of hemoglobin also make* S. glanis *relatively tolerant of pollution (Lelek 1987) and prolonged periods of hypoxia (Massabuau and Forgue 1995).* S. glanis *regularly tolerates dissolved oxygen levels of 3.0 to 3.5 mg/L (Copp et al., 2009)*

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

- S. glanis *inhabits waters 0-5°C (Britton et al., 2007).*
- *This species is able to withstand prolonged periods of hypoxia (Massabuau and Forgue 1995), due to high levels of hemoglobin (Copp et al., 2009).*
- S. glanis *has well-developed non-visual sensors that make it well adapted to waters with low visibility (Copp et al., 2009), giving it a high degree of plasticity in light regime (Placinta et al., 2020).*
- *During winter, it hibernates in rivers in deep holes, dens and crevices in the bed; in lakes, it lies in the lower third of the water column or on soft mud (Lelek et al., 1964; Lelek 1987; Copp et al., 2009).*

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

- *In a study performed by Carol (2009)* S. glanis *diet depended on site and catfish size. Catfish measuring less than 30 cm consumed mostly invertebrates, thereafter shifting to red swamp crayfish (*Procambarus clarkia*) (old introductions) or fish (recent introductions). A number of fish species were present in stomachs but common carp (*Cyprinus carpio*) and birds were only present in very large fish (> 120 cm.*
- *It is well documented that* S. glanis *take advantage of its diet plasticity and ability to prey upon the most abundant available species of a suitable size within its habitat (Carol 2009, Syväranta et al., 2010; Martino et al., 2011; Castaldelli et al., 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
	7

- *There is limited data, but* S. glanis *is considered abundant where introduced on the Iberian peninsula (Carol et al., 2007).*

- *In the Po River basin in 1991,* S. glanis *accounted for 6.1% of the total biomass. With optimal foraging conditions, abundant prey, and few competitors, it reached 77%, 71%, and 62% of the overall biomass in 1997, 2003, and 2009, respectively (Castaldelli et al., 2013).*
- *This species has remained rare in the River Thames (Copp 2007).*
- *In French rivers, an invasion of* S. glanis *impacted some fish communities through predation and competition, but not on a generalised basis as some rivers were productive enough to support both invasive species and natives (Guillerault et al., 2015).*
- *May adapt foraging behaviors in new habitats and introduced populations have started breaching onto shores to capture birds on land (Syväranta 2010; Cucherousset et al., 2012).*

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

- *The absolute fecundity of female* S. glanis *ranges from 14 600 to 354 000 eggs (Copp et al., 2009).*
- *Relative fecundity (eggs per kg body weight) of siluroid species is as follows (Legendre et al., 1996):*
    - Silurus glanis*: 10,000-25,000*
    - Guleichthys feliceps*: 50,000*
    - lctalurus punctutus*: 8,000*
    - Chtysichthys nigrodigitaius*: 15,000-18,000*
    - Hoplosternum littorale*: 45,000-75,000*
    - Clarias gariepinus*: 60,000-150,000*
    - Clarias macrocephalus*: 20,000-50,000*
    - Heterobranchus longifilis*: 30,000-120,000*
    - Pseudoplatystoma coruscans*: 120,000-130,000*

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

- S. glanis *is a nest guarder (Copp et al., 2009).*

- *Adults are known to live upwards of 80 years (Freyhoff and Kottelat 2007).*

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

- S. glanis's *native distribution extends from Germany eastwards through to Poland, up to Southern Sweden and down to Southern Turkey and north Iran stretching through the Baltic States to Russia (Greenhalgh 1999) and to the Aral Sea of Kazakhstan and Uzbekistan (Phillips and Rix 1988; Copp et al., 2009).*
- *This range of climates include many of the conditions found in 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
	8

- *High levels of hemoglobin also make* S. glani*s relatively tolerant of pollution (Lelek 1987).*
- *This species has well-developed non-visual sensors that make it well adapted to waters with low visibility (Copp et al., 2009).*
- S. glanis *survives water temperatures 0-27°C, though success may be limited in lower water temperatures (David 2006; Britton et al., 2007). This species can inhabit eutrophic and turbid waters (Castaldelli et al., 2013).*
- S. glanis *is also able to withstand prolonged periods of hypoxia (Massabuau and Forgue 1995).*
- S. glanis *can withstand low levels of salinity (<15 ppm) (Copp et al., 2009).*

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

- S. glanis *inhabits the lower reaches of large rivers and muddy lakes (Alp et al., 2011)*
- *Individuals are usually strongly associated with areas with a high density of woody debris, boulders, low flow and tree roots (Abdullayev et al., 1978). The species, therefore, appears to prefer large water bodies with cryptic habitat (Britton et al., 2007).*
- S. glanis *has thrived in degraded habitats (Italy), i.e., canals that were eutrophic and turbid, without morphological complexity, and with sparse vegetation (Castaldelli et al., 2013).*
- *The species is normally encountered throughout their range in large rivers, lakes and coastal areas of low salinity (<15 ppm). Primarily a fish of rich, weedy lakes and slow, deep lowland rivers, in its native range, the species is known to shift during their first year of life into mid channel habitats (Wolter and Vilcinskas 1996; Wolter and Freyhof 2004), which are important for reproduction and habitat partitioning between different age groups (Wolter and Bischoff 2001). However, the preferred habitat of* S. glanis *is still waters (Wheeler 1969; Greenhalgh 1999). During winter, it hibernates in rivers in deep holes, dens and crevices in the bed; in lakes, it lies in the lower third of the water column or on soft mud (Lelek et al., 1964; Lelek 1987; Copp et al., 2009).*
- *They also prefer artificially heated habitats such as those near nuclear power plants (Capra et al., 2018).*

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

- S. glanis *maximum growth occurs at 25-27°C, so warming waters would benefit this species (David 2006).*
- *It can withstand low salinity, so it may be able to outcompete native species limited to freshwater if salinization increases (Copp et al., 2009).*
- *Relocation and home range size increased with higher water temperatures (Danek et al., 2016).*

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 consumes whatever is most abundant, from crustaceans to fish (Castaldelli et al., 2013).*
- *Trophic position increases with size, with the largest individuals acting as apex predators (Rees 2020).*
- *The broad diet of* S. glanis *extends to species considered invasive to the Great Lakes, including sea lamprey (*Petromyzon marinus*) (Boulêtreau et al., 2020), rudd (*Scardinius erythrophthalmus*), tubenose (*Proterorhinus semilunaris*), round (*Neogobius melanostomus*) and monkey goby (*Neogobius fluviatilis*), and zebra mussels (*Dreissena polymorpha*) (Didenko et al., 2016; Mikl et al., 2017).*

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, there is no critical species required by the species being assessed.*

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	3

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)	
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 species non-indigenous to the Great Lakes that facilitates the development of* S. glanis *has not been established in the Great Lakes.*

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

- *The fast growth and large size of* S. glanis *makes them unlikely prey for other piscivores (Copp et al., 2009).*

<u>PROPAGULE PRESSURE</u>

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

- S. glanis *are banned from entering the US and from trade between states under the Lacey Act.*

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

- S. glanis *is native to eastern Europe and western Asia. This species has been introduced to many European countries, including France, Italy, the Netherlands, Spain and the United Kingdom due to its popularity among anglers Bănărescu 1989; Krieg et al., 2000; Britton et al., 2007; Carol et al., 2007; Carol 2009; Copp et al., 2009; Alp et al., 2011).*
- *This includes intentional, unauthorized introduction (Pérez-Bote 2009). This species is farmed in Austria, Bulgaria, Croatia, Czech Republic, France, Hungary, Greece, Macedonia, Poland, and Romania (Linhart 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
	6

- S. glanis *has spread via natural dispersal or stocking over 700 km in the River Tagus, Spain between their first introduction in 1998 and 2015 (Gago et al., 2016).*
- *Since 1974,* S. glanis *has spread into 6 of 7 of the watersheds in the Ebro basin, Spain, likely accelerated by angling activities and governmental water transfers (Parrando et al., 2018).*

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
	U

- *Hook-lines and angling were an effective method of reducing* S. glanis *populations to harmless levels in two lakes in the Czech Republic, but this method has not been tested in any other waters (Vejřík et al., 2019)*

Section B Scores				
Points	**Probability of Establishment**	**Total Points (pre-adjustment)**		**100**
>100	High	**Adjustments**		
		Critical species	**A (100-0 %)**	**100**
51-99	Moderate	**Natural enemy**	**B (100-0%)**	**100**
		Control measures	**C (100-0 %)**	**100**
0-50	Low	**Probability of Establishment**		High
# 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:

Silurus glanis has a high probability of establishment if introduced to the Great Lakes (Confidence level: High).

Section C: Potential for Impact

POTENTIAL IMPACT RESULTS

Environmental: High
Socio-Economic: Low
Beneficial: High

Comments: 2020 updates: some increases to quantitative scores, but no changes to qualitative scores. Changed quantitative scores include C1 (U to 6), C2 (0 to 1), C7 (0 to 1), C16 (0 to 1), and C18 (0 to U).

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

- S. glanis *has several associated parasites (Copp et al., 2009):*
  - *Myxobolidae can have a significant pathological impact on wild and cultured fishes, and such episodes are often preceded by environmental stressors such as oxygen depletion of the water (Lom and Dykova 1992).*
  - *Acanthocephalans (e.g.* L. plagicephalus*) can cause extensive damage such as lesions to the intestinal tract of fish where they attach leading secondarily to infections by bacteria (Dezfuli et al., 1990).*
  - *High intensities of parasitic crustaceans such as* Ergasilus sieboldi *can inflict severe damage to the gills (Dezfuli et al., 2003) resulting in large-scale mortalities of fish (Kabata 1979).*
  - S. glanis *is subject to* Aeromonas veronii *infection, which is known to cause economic losses in aquaculture (Xiucai et al., 2019).*
  - *The parasitic nematode* Anisaki schupakovbia *infects* S. glanis*, which when consumed by humans can cause anisakiasis (Abdybekova et al., 2020).*
  - *Other known parasites include* Triaenophorus crassus, Raphidascaroides *sp.,* Lernaea cyprinacea *(Khara et al., 2016),* Lamproglena pulchella *(Molnar et al., 2018),* Sphaerospora siluri *(Patra et al., 2018), T*haparocleidus vistulensi *(Rees 2020), and mycoplasmas (Selyei et al., 2020).*
- *Further introductions of* S. glanis *may extend the distribution of specialist species such as* Trichodina siluri, M. miyarii, L. plagicephalus *and* Pseudotracheliastes stellifer*, the latter of which may have pathogenic potential as its congener,* P. stellatus*, is known to be pathogenic to sturgeons (Bauer et al., 2002, Copp et al., 2009).*

- S. glanis *can carry the European sheatfish virus (ESV), a strain of ranavirus, which has been reported to also infect and be lethal to zebrafish (*Danio rerio*), pike (*Esox lucius*), and pike-perch (*Sander lucioperca*) (Jensen et al., 2009, 2011; Martin et al., 2015).*
- *Accumulation of heavy metals and chemicals such as PCBs and PAHs in* S. glanis *has been recorded above acceptable levels for human consumption and may be damaging to ecosystem health (Ivanovic et al., 2016; Milanov et al., 2016; Pastorino et al., 2016; Squadrone et al., 2016).*

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

- *If established as an apex predator in an ecosystem,* S. glanis *can heavily impact other species through predation and food web alterations (Vejrik et al., 2017). However, in French rivers, an invasion of* S. glanis *only impacted some fish communities, as some rivers were productive enough to support both invasive species and natives (Guillerault et al., 2015)*

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

- *The differences in condition and growth rates between recent and older introduction of* S. glanis *may be related to diet. In early stage invasion sites,* S. glanis *mainly consumed fish because of a high abundance of small cyprinid species, such as Roach and Bleak (Carol et al., 2007). In contrast, crayfish was the main prey of* S. glanis *in advanced stage invasion sites and the ontogenetic shift to piscivory was delayed until the catfish grew larger. Accordingly, these advanced stage invasion reservoirs had size structures dominated by larger sizes of Common Carp. Although further data are needed to see how frequent these patterns are, our results strongly suggest that at the early stages of invasion, catfish grow faster and are in better condition because they prey more on fish. As invasion proceeds, however, the catfish reduce fish numbers, particularly of smaller fish, indirectly favoring crayfish and eventually resulting in their own reduced growth rates (Carol 2009).*
- *In addition to fish prey, another likely ecological impact of catfish is on some groups of waterbirds, especially in the Anatidae family. Few birds have been observed in the catfish stomach contents (Czarnecki et al., 2003, Omarov and Popova 1984). Carol (2009) found that waterbird abundance varied significantly with the invasion sequence (advance stage correlated with lower bird abundance) and this was not due to correlation or confounding with abiotic factors (e.g. reservoir size, altitude or trophic state) (Carol 2009). The significantly lower abundance of waterbirds in reservoirs with catfish could be due to either a direct*

ecological impact (predation) by S. glanis *and/or to avoidance behavior by waterbirds to reduce predation risk (Carol 2009).*

- *Data from Castaldelli et al., (2013) showed a clear temporal gradient in fish community structure. After the establishment of the exotic predator* S. glanis*, some native species significantly declined in abundance and biomass (i.e.* Alburnus arborell*a and* Scardinius erythrophthalmus*) or disappeared (i.e.* Rutilus aula *and* Tinca tinca*). It is well documented that* S. glanis *takes advantage of its diet plasticity and ability to prey upon the most abundant available species of a suitable size within its habitat (Carol 2009; Martino et al., 2011; Syväranta et al., 2010). This may have contributed to the sequence of the decline in species. Among the most abundant native species in 1991, Tench and Italian Red-eye Roach were the first to disappear, with none captured in 2003. These are small fish with a marked benthic lifestyle. The population of Italian Bleak and Rudd, which differ from the above mentioned species in having fewer marked benthic traits, decreased more slowly, and they were still present in 2009, although greatly reduced (Castaldelli et al., 2013).*
- *If established as an apex predator in an ecosystem,* S. glanis *can heavily impact other species through predation and food web alterations (Vejrik et al., 2017).* S. glanis *has even been reported to consume Atlantic salmon (*Salmo salar*) in France (Boulêtreau et al., 2018).*

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

- *This species was not found to affect any native populations genetically in this review.*

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 was not found to negatively affect water quality in this review.*

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

- *This species was not found to alter physical components of the ecosystem in this review.*

Environmental Impact Total	**13**
Total Unknowns (U)	**0**

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

POTENTIAL SOCIO-ECONOMIC IMPACT

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

- *Accumulation of heavy metals and chemicals such as PCBs and PAHs in* S. glanis *has been recorded above acceptable levels for human consumption and may be damaging to ecosystem health (Ivanovic et al., 2016; Milanov et al., 2016; Pastorino et al., 2016; Squadrone et al., 2016).*
- *The parasitic nematode* Anisaki schupakovbia *infects* S. glanis*, which when consumed by humans can cause anisakiasis (Abdybekova et al., 2020).*

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 was not found to damage infrastructure in this review.*

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 was not found to negatively affect water quality in this review.*

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

- *This species was not found to negatively affect markets or economic sectors in this review.*

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

- *This species was not found to inhibit recreation or tourism in this review.*

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

- *This species was not found to negatively affect the aesthetic or natural value of the environment in this review.*

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

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

- *The broad diet of* S. glanis *extends to species considered invasive to the Great Lakes, including sea lamprey (*Petromyzon marinus*) (Boulêtreau et al., 2020), rudd (*Scardinius erythrophthalmus*), tubenose (*Proterorhinus semilunaris*), round (*Neogobius melanostomus*) and monkey goby (*Neogobius fluviatilis*), and zebra mussels (*Dreissena polymorpha*) (Didenko et al., 2016; Mikl et al., 2017).*
- *They also consume European perch (*Perca fluviatilis*) eggs, which were originally thought to be unpalatable to fish (Vejřık et al., 2017).*
- S. glanis *has been introduced to regulate cyprinid fish numbers in the Netherlands, where it escaped and dispersed to other waters (Copp et al., 2009).*

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

- S. glanis *has an economic importance in commercial and recreational fisheries as well as in aquaculture. Its aquaculture production has increased from 600 tonnes in 1993 to 2,000 tonnes in 2002 in ten European countries (Linhart et al., 2002; Copp et al., 2009).*
- *Fast and efficient growth, ease of breeding and rearing, and recent genome manipulation makes* S. glanis *ideal for commercial aquaculture (Copp et al., 2009; Cucherousset et al., 2018).*
- *This species is considered a delicacy in some countries (e.g. Hungary, Poland, Slovakia, Lithuania), where it is exploited for its flesh (tender white meat), skin (for leather and glue production) and eggs (for caviar) (Copp et al., 2009).*
- *The flesh of* S. glanis *is highly nutritional in regard to fatty acid composition (Salie et al., 2017; Linhartova et al., 2018) and protein quality (Pyz-Łukasik and Paszkiewicz 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 popularity of* S. glanis *relates to the large sizes they can reach; they are perceived as an attractive big game species by many United Kingdom and Italian anglers (Hickley and Chare 2004; Copp et al., 2016; Rees et al., 2017).*
- *Overall, the fishing effort and harvest of* S. glanis *has increased with angling and air temperature in Central Europe between 1986-2017 (Lyach and Remr 2019).*
- *They are a sought-after pet species, and online forums in the US contain posts selling and buying* S. glanis*.*

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

- S. glanis *has value as a research and medicinal subject. It's environmental resilience and longevity make it useful for modeling the effects of parasites (Defzuli et al., 2017) and contamination of hexachlorobenzene and hexachlorobutadiene (Dssis et al., 2017).*
- *Further*, S. glanis *is an important model for investigating evolutionary dynamics of fish chromosomes (Ditcharoen et al., 2019).*

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

- *This species was not found to inhibit recreation or tourism in this review.*

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√

- *When acting as an apex predator,* S. glanis *can play a key role in ecosystem stability due to their multiple predator effects (Vejřík et al., 2017). However, it is unknown whether* S. glanis *will have this effect in the Great Lakes.*

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

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

Scoring			**Qualitative Statement**
Score	# U's	**Impact**	
>5	Any	**High**	___ has the potential for high ___ impact if introduced to the Great Lakes.
2-5	Any	**Moderate**	___ has the potential for moderate ___ impact if introduced to the Great Lakes.
0	0-1	**Low**	There is little or no evidence to support that ___ has the potential for significant ___ impacts if introduced to the Great Lakes.
1	0		
0	≥2	**Unknown**	Current research on the potential for ___ impacts to result from ___ if introduced to the Great Lakes is inadequate to support proper assessment.
1	≥1		

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