NOAA Technical Memorandum GLERL-169c
DOI: 10.25923/w9vp-bk86

2019 UPDATE TO "A RISK ASSESSMENT OF POTENTIAL GREAT LAKES AQUATIC INVADERS"

El Lower[1], Nicholas Boucher[2], Alisha Davidson[3], Ashley Elgin[4], Rochelle Sturtevant[1]

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

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

Wednesday, July 08, 2020

UNITED STATES
DEPARTMENT OF COMMERCE

Wilbur L. Ross, Jr.
Secretary

NATIONAL OCEANIC AND
ATMOSPHERIC ADMINISTRATION

Dr. Neil Jacobs,
Acting Administrator

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2019 UPDATE TO "A RISK ASSESSMENT OF POTENTIAL GREAT LAKES AQUATIC INVADERS"

El Lower, Nicholas Boucher, Peter Alsip, Alisha Davidson, Rochelle Sturtevant

1.0 SUMMARY

This report includes all major changes to Risk Assessments of watchlist species conducted by the GLANSIS project during calendar year 2019. 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 as a baseline and conducted using the same methods. All assessments were reviewed by co-authors on the GLANSIS team, and each new or substantively updated assessment was checked 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. The websites are updated more frequently and should be considered the most recent information.

Out of 71 species documented in the most recently updated NOAA Technical Memorandum GLERL-169b, (Lower et al., 2019), four assessments were updated in this publication, and eight new species were added. GLANSIS is constantly being updated with new and relevant literature to resolve unknown variables and adjust risk scores accordingly. Thus, 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.

In 2019, eight new species were added to the GLANSIS Watchlist: *Astacus astacus, Cherax quadricarinatus, Faxonius limosus, Ludwigia grandiflora, Lysimachia punctata, Pacifasticus leniusculus, Tinca tinca,* and *Typha laxmannii*. Four additional watchlist species assessments were updated this year, including *Filinia cornuta, Filinia passa, Federicella sultana*, and *Rutilus rutilus*. *Ctenopharyngodon idella* was removed from the watchlist, as the population in western Lake Erie is reproducing and thus meets the criteria for inclusion in the nonindigenous list (see NOAA Technical Memorandum GLERL-161c (Lower et al., 2020) for discussion). The GLANSIS Watchlist now includes 79 species. A summary of overall risk for each species on the watchlist is included in Table 1 below, with asterisks indicating new or updated assessments.

Table 1. Summary of overall risk for each species (asterisks indicate updated* or added** assessments, strike-through indicates species that have been removed).

Species	Introduction	Establishment	Environmental Impact	Socioeconomic Impact	Benefits
Alburnus alburnus	Moderate	High	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	Low
Cornigerius maeoticus	Moderate	Moderate	Low	Low	Low
Cottus gobio	Moderate	Moderate	Low	Low	Low
Crassula helmsii	Low	Moderate	High	Moderate	Low
~~*Ctenopharyngodon idella*~~	~~High~~	~~Moderate~~	~~High~~	~~Low~~	~~High~~
Cyclops kolensis	Moderate	Moderate	Moderate	Low	Low
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
*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
Pseudrasbora parva	Low	Moderate	High	High	Low
Rhithropanopeus harrisii	Moderate	High	Unknown	Low	Low
*Rutilus rutilus**	Low	Moderate	High	Moderate	High
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

Of the species reassessed or new for this document, *Pacifastacus lenisculus* scored high for both introduction and establishment, joining *Apocorophium lacustre* in our highest risk category. *P. lenisculus* scored high for potential environmental impact and moderate for potential socioeconomic impact, displacing *A. lacustre* as the species posing the greatest potential risk for becoming invasive in the Great Lakes.

Three newly assessed species – *Lysimachia punctata, Tinca tinca*, and *Typha laxmanii* – scored high risk for introduction and moderate risk for establishment, joining our second-tier risk category. *Tinca tinca* and *Typha laxmani* scored as moderate risk for environmental impact, while available information was insufficient to determine the potential risk to the environment posed by *L. punctata*. *Lysimachia punctata* should thus be considered an important subject for additional risk assessment research.

2.0 SCORING SUMMARY

Introduction

The potential for introduction assessment took into account a "proximity" proxy for each pathway using a suite of 12 paired questions (two per vector). The first question in a pair considered potential pathways for introduction, assigning a score from 0 to 100—usually 100 for being in a particular pathway and 0 for not—while the second question evaluated the likelihood of a species to enter the Great Lakes through that pathway, using a multiplicative factor from 0 to 1. If a question could not be answered based on available data, an "unknown" option was available, which were treated as zeroes when used as a score multiplyer. Overall probability for introduction per vector (High, Moderate, Low) was thus determined by the adjusted point score for the species in that vector on a scale of 0 to 100. Overall risk of introduction was determined as a sum across all vectors, e.g. a species that scores 75 (moderate) on each of two vectors has a total score of 125 and was considered to have a high overall probability of introduction. Although summation in this fashion led to a possible maximum score of 600, this was only possible if a species were to be present and in high proximity in all six vectors simultaneously. Scores exceeding 100 were quite rare.

Establishment

The establishment assessment was developed based on a literature review of variables that aid or detract from an invader's establishment success and spread potential, as relevant to the Great Lakes. Contributing variables were broadly grouped into a total of 18 questions within four categories. The assessment did not weight all 4 categories equally. Overall species' establishment potential was determined by its total point score. Answers to three of the 18 questions could lead to an overall percentage reduction in a species' score. Such adjustments were warranted when a variable would counter or prevent the species' establishment; these included lack of a critical species (e.g., host), presence of a natural enemy, and implementation of control measures. Species could score a high establishment potential if at least three-quarters of the questions (14/18) were scored as 9s or a moderate establishment potential if more than half of the questions (9/18) were scored as 6s (or were evenly split with equivalent numbers of 3s and 9s); otherwise, the species was ranked as having a low establishment potential.

Impact

The potential for impact assessment was modeled after the tool used to assess the realized consequences

of nonindigenous species already established in the Great Lakes (Sturtevant et al., 2014). It examines potential adverse environmental and socioeconomic impacts (including human health), as well as potential beneficial effects. Scores for each criteria (0, 1, or 6) were summed for each of 3 impact categories (36 point maximum each) and converted to an overall impact ranking that accounts for level of uncertainty in the assessment. Because the effect of unanswered questions may only result in a lower score, those sub-assessments scoring moderate to high with significant unknowns should be considered 'at least' moderate or 'at least' high.

3.0 ADDENDA

Eight new species were added to the Watchlist in 2019: *Astacus astacus, Cherax quadricarinatus, Faxonius limosus, Ludwigia grandiflora, Lysimachia punctata, Pacifasticus leniusculus, Tinca tinca,* and *Typha laxmannii*. Two additional species assessments underwent significant changes to their risk assessment sections. *Filinia cornuta*'s benefit score was changed from low to moderate, and *Rutilus rutilus* had its likelihood of introduction changed from high to low, confidence level of establishment changed from moderate to high, and benefits changed from moderate to high.

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

Species	Addenda	Author, date added
Astacus astacus	New assessment	Boucher, 2019
Cherax quadricarinatus	New assessment	Boucher, 2019
Faxonius limosus	New assessment	Boucher, 2019
Ludwigia grandiflora	New assessment	Boucher and Davidson, 2019
Lysimachia punctata	New assessment	Lower, 2019
Pacifasticus leniusculus	New assessment	Boucher, 2019
Tinca tinca	New assessment	Boucher and Davidson, 2019
Typha laxmannii	New assessment	Lower and Davidson, 2019
Filinia cornuta	Benefits changed from low to moderate	Boucher, 2019
Filinia passa	Reassessed, no changes to scores.	Boucher, 2019
Federicella sultana	Reassessed, no changes to scores.	Boucher, 2019
Rutilus rutilus	Likelihood of introduction changed from high to low, confidence level of establishment changed from moderate to high, and benefits changed from moderate to high	Boucher, 2019

Species profiles have been developed for each of the new species (available through GLANSIS http://www.glerl.noaa.gov/glansis), which provide information on identification, life history, ecology, invasion history, risk assessment, potential impacts, and management options as well as a summary of the individual risk assessment. It is our intent that this information resource should assist managers in targeting prevention programs, early detection and rapid response.

4.0 RISK ASSESSMENTS

Scientific Name: *Astacus astacus*

Common Name: Noble crayfish

Section A: Potential for Introduction

INTRODUCTION POTENTIAL RESULTS

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

POTENTIAL INTRODUCTION VIA DISPERSAL

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

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

- *Widely distributed in Europe, extending from France in the southeast to Russia in the east, and from Italy, Albania and Greece in the south to Scandinavia in the north (CABI, 2014)*
- *Not reported in US (USFWS, 2014)*

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

- *Native and introduced range is currently Europe and Eurasia.*

POTENTIAL INTRODUCTION VIA HITCHHIKING/FOULING

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

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

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

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

POTENTIAL INTRODUCTION VIA UNAUTHORIZED INTENTIONAL RELEASE

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

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

- *Considered a delicacy in Europe (USFWS, 2014). No US retailers found.*

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

- *Only reported culture is in Europe.*

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

- *Stocked/cultured in Europe as food source.*

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

- *Only reported culture is in Europe.*

POTENTIAL INTRODUCTION VIA ESCAPE FROM COMMERCIAL CULTURE

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

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

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

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

POTENTIAL INTRODUCTION VIA SHIPPING

Is this species 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

- *Astacus astacus is restricted to fresh water, living only in unpolluted streams, rivers and lakes (EOL).*
- *This species has high dissolved oxygen requirements.*

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

Yes, and this species has been observed in ballast of or fouling ships entering the Great Lakes.	Score x 1
Yes, and this species has been observed in ports that have direct trade connections with the Great Lakes (e.g., Baltic Sea).	Score x 0. 5
Yes, but this species has neither been observed in ballast/fouling ships entering the Great Lakes nor in ports in direct trade with the Great Lakes.	Score x 0.1 √
No, this species does not occur in waters from which shipping traffic to the Great Lakes originates.	Score x 0
Unknown	U

Potential Vector Scorecard				
Vector	**Raw Points Scored**	**Proximity Multiplier**	**Total Points Scored**	**Probability of Introduction**
Dispersal: Natural dispersal through waterbody connections or wind	**0**	x 0.25	**0**	Low
Hitchhiking/Fouling: Transport via recreational gear, boats, trailers, mobile fauna, stocked/planted organisms, packing materials, host organisms, etc.	**0**	x 0.1	**0**	Low
Release: Unauthorized intentional release of organisms in trade (e.g., aquaria, water gardens, live food)	**100**	x 0.1	**10**	Low

Stocking/Planting/Escape from recreational culture: Intentional authorized or unauthorized introduction to natural waters in the Great Lakes OR Accidental introduction to Great Lakes by escape from recreational culture (e.g., water gardens)	**100**	x 0	**0.25**	Low
Escape from commercial culture: Accidental introduction to Great Lakes by escape from commercial culture (e.g., aquaculture)	**0**	x 0.1	**0**	Low
Trans-oceanic shipping: Ballast (BOB) or no-ballast-on-board (NOBOB) water exchange/discharge, sediment discharge, hull fouling	**0**	X 0.1	**0**	Low
Total Unknowns (U) **0**	**Confidence Level**		High	

Qualitative Statements for GLANSIS Fact Sheet:
Astacus astacus has a low probability of introduction to the Great Lakes (Confidence level: high)

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

Section B: Potential for Establishment

ESTABLISHMENT POTENTIAL RESULTS

Astacus astacus has a low 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

- *Capable of tolerating lower calcium levels, as low as 2-3 mgl^{-1} Ca, where other species of crayfish may be excluded. The optimum temperature for best growth is between 16 and 24°C, although up to 28°C can generally be tolerated. In addition, oxygen content below 3-4 mgl^{-1} is deemed unsuitable for this species.*

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

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

- *Can tolerate winter temperatures based on its native range, however lower limit of its oxygen tolerance is 3-4mg/l.*

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

- *No reports on diet flexibility, but Encyclopedia of Life notes they feed "...on worms, aquatic insects, molluscs and plants" which are common and available in Great Lakes.*

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

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

- *Somewhat broad physiological tolerances and diet, however no reports of invasive populations.*

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
	0

- *Fecundity limited by females who can have long periods of infertility between breeding years.*

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

- *At maturation, males normally mate every year, while female reproductive activity is usually restricted to a single year between periods of sexual inactivity. Thus, numbers of sexually active females may vary greatly depending on locality and year (Souty-Grosset et al., 2006).*

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

- *Climate match with the United States is high, particularly the Great Lakes region (Australian Bureau of Rural Sciences, 2008).*

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

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

- *Abiotic factors seem to be similar to those in the Great Lakes.*

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

- *This species is found in rivers, lakes, ponds, and reservoirs, in both lowlands and hills, where shelter availability is high (Souty-Grosset et al., 2006). This includes stones, logs, roots and aquatic and marginal vegetation. This species prefers soft bottoms with some sand and is not usually found in water bodies with a muddy substrate. In addition, it prefers soft banks where it constructs simple burrows (Edsman 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
	0

- *Climate match analysis had Great Lakes as highest match: climate change would probably make the region a worse match.*

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

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

- *Feeds on worms, aquatic insects, molluscs and plants (Encyclopedia of Life), however it there are no reports on their dietary flexibility.*

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

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

- *No, this species does not require the presence of any other species to grow, reproduce, or spread.*

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

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

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

- *No species has been found that facilitates spread.*

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
	-80%

- *Vulnerable to preyfish plague which is carried by crayfish native to the United States, including* Procambarus clarkii*, which is already present in the Great Lakes region.*
- *Populations in its native range are threatened by competition with introduced crayfish from North America.*

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

- *Not reported.*

HISTORY OF INVASION AND SPREAD

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

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

- *Not reported.*

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

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

- *Not reported.*

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

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

No control methods have been set to prevent the establishment and/or spread of this species	0 √
Unknown	U
	0

- *No specific control methods in Great Lakes states.*

Establishment Potential Scorecard				
Points	**Probability for Establishment**	Total Points (pre-adjustment)		51
>100	High	Adjustments		
		Critical species	A (60 - 0%)	B: 51
51-99	Moderate	Natural enemy	B (51 – 40.8%)	C: 10.2
		Control measures	C (10 - 0)	**10.2**
0-50	Low	Probability for Establishment		Low
# of questions answered as "unable to determine"	**Confidence Level**			
0-1	High	Total # of questions unknown		2
2-5	Moderate			
6-9	Low	Confidence Level		Moderate
>9	Very low			

Qualitative Statements for GLANSIS Fact Sheet:
Astacus astacus has a low probability of establishment in the Great Lakes (confidence level: moderate.)

Section C: Potential for Impact

IMPACT POTENTIAL RESULTS

Environmental: High
Socio-Economic: Low
Beneficial: High

Comments: Commonly eaten in Europe. Known carrier of IPNV, which has infected rainbow trout in lab experiments.

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

- *An important pathogen of fish, infectious pancreatic necrosis virus (IPNV) has been associated with mortalities in salmonid fish. Halder and Ahne (1988) exposed A. astacus to IPNV through various routes. They were able to transmit the virus back to naïve rainbow trout fry and eggs. IPNV could be detected in haemocytes of the antennal gland, gills and hepatopancreas of exposed crayfish although no pathological changes were noted in infected crayfish. The virus persisted in crayfish for up to a year after exposure, suggesting replication is possible and raising concerns over the role of crayfish in transmission of the virus to fish (CABI, 2014).*

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 √

- *FWS RA rates history of invasiveness as "Uncertain".*

Does it alter predator-prey relationships?

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

- *Not reported.*

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

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

- *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	**6**
Total Unknowns (U)	**3**

POTENTIAL SOCIO-ECONOMIC IMPACT

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

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

- *Not reported.*

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

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

- *Not reported.*

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

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

- *Not reported.*

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

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

- *Known carrier of IPNV, which has affected rainbow trout in the lab: no reports on this in the wild.*

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

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

- *Not reported.*

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

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

- *Not reported.*

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

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

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

- *Valued as a food source and for zoological study.*

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 √

- *Could potentially be a recreational fishery given that they are commonly caught and eaten in Europe, but has not been explicitly reported.*

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

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

- *USFWS RA notes that it is important for zoological study, does not seem to be high-priority research.*

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

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

- *Not reported.*

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

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

- *Not reported.*

Beneficial Effect Total	**7**
Total Unknowns (U)	**1**

Scientific Name: *Cherax quadricarinatus*

Common Name: Australian redclaw crayfish

Section A: Potential for Introduction

INTRODUCTION POTENTIAL RESULTS

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

POTENTIAL INTRODUCTION VIA DISPERSAL

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

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

- *Established in Puerto Rico and Mexico, but not continental US (FWS, NAS).*

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

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

POTENTIAL INTRODUCTION VIA HITCHHIKING/FOULING

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

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

- *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

- *As of 2018, specimens have only been found in captivity in the continental US. Established populations in Puerto Rico (NAS).*

POTENTIAL INTRODUCTION VIA UNAUTHORIZED INTENTIONAL RELEASE

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

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

- *Live Aquaponics ships 15 to Michigan for $150 (https://www.liveaquaponics.com/, 8/24/2018).*
- *Available on Ebay and Amazon.*

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

- *Unclear popularity in Great Lakes Region. However, it is easily obtained through Amazon, Ebay, and specialty retailers.*

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√

- *Available for sale from online retailers, no reports of stocking it in water gardens, etc.*

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√

- *Unknown.*

POTENTIAL INTRODUCTION VIA ESCAPE FROM COMMERCIAL CULTURE

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

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

- *No reports -- cultured in Puerto Rico but not in the continental US.*

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

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

POTENTIAL INTRODUCTION VIA SHIPPING

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

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

- *An LC50 of approximately 11 g/L was determined for juvenile survival in seawater through 15 d. Sodium chloride salinity levels as low as 1 g/L killed all crayfish within 15 days (Austin et al., 2009).*

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

Yes, and this species has been observed in ballast of or fouling ships entering the Great Lakes.	Score x 1
Yes, and this species has been observed in ports that have direct trade connections with the Great Lakes (e.g., Baltic Sea).	Score x 0. 5
Yes, but this species has neither been observed in ballast/fouling ships entering the Great Lakes nor in ports in direct trade with the Great Lakes.	Score x 0.1 √
No, this species does not occur in waters from which shipping traffic to the Great Lakes originates.	Score x 0
Unknown	U

Potential Vector Scorecard				
Vector	**Raw Points Scored**	**Proximity Multiplier**	**Total Points Scored**	**Probability of Introduction**
Dispersal: Natural dispersal through waterbody connections or wind	**0**	x 0.25	**0**	Low
Hitchhiking/Fouling: Transport via recreational gear, boats, trailers, mobile fauna, stocked/planted organisms, packing materials, host organisms, etc.	**0**	x 0.1	**0**	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)		**U**	x U	**U**	Unknown
Escape from commercial culture: Accidental introduction to Great Lakes by escape from commercial culture (e.g., aquaculture)		**0**	x 0.1	**0**	Low
Trans-oceanic shipping: Ballast (BOB) or no-ballast-on-board (NOBOB) water exchange/discharge, sediment discharge, hull fouling		**0**	x 0.1	**0**	Low
Total Unknowns (U)	**1**	**Confidence Level**		Moderate	

Qualitative Statements for GLANSIS Fact Sheet:
Cherax quadricarinatus has a high probability of introduction to the Great Lakes (Confidence level: moderate).

Potential pathway(s) of introduction: unauthorized intentional release.

Section B: Potential for Establishment

ESTABLISHMENT POTENTIAL RESULTS

Cherax quadricarinatus has a low probability of establishment if introduced to the Great Lakes (Confidence level: high).

Comments: *Cannot survive below 14 degrees Celsius. Many of the questions were re-interpreted to consider this temperature requirement.*

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

- *Tolerant of high temperatures and low dissolved oxygen (Masser and Rouse 1997).*

- *Cannot tolerate low temperatures: 100 % mortality when cultured outdoors mid-december in Alabama (Patillo, 2010).*

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

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

- *Prefers tropical/subtropical environments (Wingfield 2002).*
- *Immobilized below 14 C (Patillo, 2010).*

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

- *Requires a low-protein diet (FAO, 2018). Predates on native shrimp in Puerto Rico (Williams et al., 2001).*
- *Omnivores that feed on other organisms as well as plants and detritus (Department of Fisheries, 2005)*
- *Diet consists of macrophytes, detritus, and macroinvertebrates (Marufu 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

	0

- *CLIMATCH is poor for the Great Lakes region, and there are no reports of them becoming invasive outside of tropical/subtropical regions.*
- *C. quadricarinatus is a reasonably non-aggressive, non-territorial freshwater crayfish species that does not compete well with other species occupying similar niches. (Jones, 2005).*

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

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

- *Cherax quadricarinatus become sexual maturity within one year. Females produce up to 1000 eggs at temperatures of 59°F and above and can produce 3-5 broods during a breeding season (Masser and Rouse 1997). K selected species.*

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

- *Highly fecund, however no predictions of invasive potential in the Great Lakes.*

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
	0

- *CLIMATCH scoring for Great Lakes Region is between 0 (lowest match) and 2 (Australian Bureau of Rural Sciences 2010)*

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

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

- *Water temperature is significantly colder than what C. quadricarinatus can survive in many parts of the Great Lakes, but other abiotic factors may be fairly compatible.*
- *Prefers freshwater, particularly slower moving streams and rivers as well as lakes and ponds (Austin 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
	0

- *This species is tolerant of a wide variety of habitats (Austin et al., 2009). However, they require temperatures above 14 C (Patillo, 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
	6

- *Prefers warmer temperatures, so climatic warming would benefit them. However, significant warming would have to occur before the lakes were a habitable temperature year round.*
- *Prefers slower moving water, so it likely would <u>not</u> benefit from altered streamflow patterns.*

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

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

- *Diet consists of macrophytes, detritus, and macroinvertebrates (Marufu 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

- *No, this species does not require the presence of any other species to grow, reproduce, or spread.*

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

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

- *They are not reported to be aided by any other species*

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

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

- *Eels and other predatory fish prey on crayfish, but are unlikely to be able to control a rapidly reproducing population (Aquiloni et al., 2010).*

PROPAGULE PRESSURE

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

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

- *Occasional aquarium releases by pet owners are the likely vector, and would not occur with great frequency or in high numbers (Souty-Grosset et al., 2006).*

HISTORY OF INVASION AND SPREAD

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

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

- *Feral populations in South Africa, Mexico, Jamaica and Puerto Rico (Ahyong and Yeo, 2007).*
- *"It would appear, that it is easily predated and/or competitively excluded to the extent that it is not able to colonise these areas. From that perspective, it can be considered a non-invasive species." (Jones, 2005).*

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

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

- *No reports of spread outside of aquaculture escapes.*
- *USFWS (2012) notes that "Despite the opportunity for it to establish itself in the rivers and streams adjacent to the reservoirs or farms, there are no reports of it having done so." However, there are reports of feral populations.*

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 species specific regulations or control methods and they are readily available through online retailers*

Section B Scores				
Points	**Probability for Establishment**	Total Points (pre-adjustment)		**A: 48**
>100	High	Adjustments		
		Critical species	A (48 - 0)	**B: 48**
51-99	Moderate	Natural enemy	B (48 - 0)	**C: 48**
		Control measures	C (48 - 0)	**48**
0-50	Low	Probability for Establishment		Low
# 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

IMPACT POTENTIAL RESULTS

Environmental: High
Socio-Economic: Low
Beneficial: Moderate

POTENTIAL ENVIRONMENTAL IMPACT

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

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

- *Yes, it is a known vector of Crayfish Plague (FWS, 2012).*

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

- *Threat to native PR freshwater shrimp (NAS, 2018).*
- C. quadricarinatus *is a reasonably non-aggressive, non-territorial freshwater crayfish species that does not compete well with other species occupying similar niches. Although there is no definitive research to support this notion, circumstantial evidence from areas to which* C. quadricarinatus *has been translocated, is compelling.* C. quadricarinatus *has been widely translocated outside its natural range in northeastern Australia. It has developed abundant, self-sustaining populations in many large, man-made reservoirs and has been stocked to aquaculture developments within many catchments in which it is not native. Despite the opportunity for it to establish itself in the rivers and streams adjacent to the reservoirs or farms, there are no reports of it having done so. It would appear, that it is easily predated and/or competitively excluded to the extent that it is not able to colonise these areas (USFWS, 2012).*

Does it alter predator-prey relationships?

Yes, and it has resulted in significant adverse effects (e.g., impacted threatened/endangered species, caused significant reduction or extinction of one or more native populations, creation of a dead end or any other significant alteration in the food web)	6

Yes, and it has resulted in some noticeable stress to (e.g., decrease in growth, survival, fecundity) or decline of at least one native population AND/OR Yes, and it has resulted in some alteration of the food web structure or processes, the effects of which have not been widespread or severe	1 √
Not significantly	0
Unknown	U

- *May affect native populations through predation, competition, or habitat modification (Ahyong and Yeo 2007)*
- *Caused significant short-term decrease in size, but not survival of native species (Patillo, 2010).*

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

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

- *No reports of hybridization.*

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

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

- *No reports.*

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

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

Environmental Impact Total	**7**

Total Unknowns (U)	**2**

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

- *No reports of hazards to 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

- *No reports of damaging infrastructure.*

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

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

- *No reports on effects of water quality.*

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

Yes, it has caused significant damage to one or more markets or economic sectors	6

Some damage to markets or sectors has been observed, but negative consequences have been small	1
Not significantly	0 √
Unknown	U

- *No reports. No crayfish fishery in GL, so outcompeting native crayfish probably wouldn't have any economic effect unless they caused damage to another fishery.*

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

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

- *No reports.*

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

- *Does not control aquatic weeds to a significant extent.*

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

- *FAO lists it as a significant species for aquaculture. Cultured in Australia and Puerto Rico, however "total production is small".*

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 a common recreational fishery. Fishing is prohibited in its native range (Austin et al., 2009).*
- *Commonly used as bait for fishing.*

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

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

- *Not used for any research applications.*

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

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

- *No reports.*

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

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

- *No reports.*

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**

Scientific Name: *Faxonius limosus*

Common Name: Spiny-cheek crayfish

Section A: Potential for Introduction

INTRODUCTION POTENTIAL RESULTS

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

POTENTIAL INTRODUCTION VIA DISPERSAL

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

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

- *Occurring in the Atlantic watershed in Connecticut, District of Columbia, Delaware, Massachusetts, Maryland, Maine, New Brunswick, New Hampshire, New Jersey, New York, Pennsylvania, Québec, Rhode Island, Virginia, Vermont and West Virginia (Fetzner 2008, Hobbs 1974, Jezerinac et al., 1995; Souty-Grosset et al., 2006).*

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

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

POTENTIAL INTRODUCTION VIA HITCHHIKING/FOULING

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

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

- *No reports.*

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

- *No populations outside their native range in the US (FWS, 2015).*

POTENTIAL INTRODUCTION VIA UNAUTHORIZED INTENTIONAL RELEASE

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

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

- *Listed as a popular aquarium pet by FWS, but we were unable to find any retailers selling them specifically.*
- *Bait release is listed as cause for their introduction to the United Kingdom.*

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

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

POTENTIAL INTRODUCTION VIA STOCKING/PLANTING OR ESCAPE FROM RECREATIONAL CULTURE

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

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

- *No reports, unable to find them for sale.*

What is the nature and proximity of this activity to the Great Lakes basin? Not Applicable

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

POTENTIAL INTRODUCTION VIA ESCAPE FROM COMMERCIAL CULTURE

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

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

- *No reports, not a popular species for commercial culture because they are relatively small*

What is the nature and proximity of this activity to the Great Lakes basin? Not Applicable

This activity is unregulated or minimally regulated and is occurring directly in the Great Lakes.	Score x 1
This activity is unregulated or minimally regulated and is occurring in Great Lakes tributaries or connecting waters, or within 20 km of the Great Lakes basin.	Score x 0.75
This activity is strictly regulated but occurs directly in the Great Lakes, and/or this activity involves transport of live organisms on/across the Great Lakes.	Score x 0.5
This activity is strictly regulated but occurs in Great Lakes tributaries, connecting waters, or within 20 km of the Great Lakes basin, and/or this activity involves transport of live organisms within 20 km of the Great Lakes basin.	Score x 0.25

This activity occurs >20 km from the Great Lakes basin and typically does not involve transport of live organisms closer to the basin.	Score x 0.1
Unknown	U

POTENTIAL INTRODUCTION VIA SHIPPING

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

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

- *Not reported.*

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

Yes, and this species has been observed in ballast of or fouling ships entering the Great Lakes.	Score x 1
Yes, and this species has been observed in ports that have direct trade connections with the Great Lakes (e.g., Baltic Sea).	Score x 0. 5
Yes, but this species has neither been observed in ballast/fouling ships entering the Great Lakes nor in ports in direct trade with the Great Lakes.	Score x 0.1
No, this species does not occur in waters from which shipping traffic to the Great Lakes originates.	Score x 0√
Unknown	U

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.	**0**	x 0.1	**0**	Low
Release: Unauthorized intentional release of organisms in trade (e.g., aquaria, water gardens, live food)	**U**	x 0.1	**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	**0**	Low
Escape from commercial culture: Accidental introduction to Great Lakes by escape from commercial culture (e.g., aquaculture)	**0**	x 0	**0**	Low
Trans-oceanic shipping: Ballast (BOB) or no-ballast-on-board (NOBOB) water exchange/discharge, sediment discharge, hull fouling	**0**	x 0	**0**	Low
Total Unknowns (U) **1**	**Confidence Level**		Moderate	

Qualitative Statements for GLANSIS Fact Sheet:

Faxonius limosus has a low probability of introduction to the Great Lakes (confidence level: moderate).

Potential pathway(s) of introduction: unauthorized intentional release.

Section B: Potential for Establishment

ESTABLISHMENT POTENTIAL RESULTS

O. limosus ***has a moderate probability of establishment if introduced to the Great Lakes (confidence level: high).***

Comments: Capable of parthenogenesis.

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

- *Adults are tolerant of low temperatures, dry conditions and water pollution (Aldridge, 2011)*

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

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

- *Native to Canada.*

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

- *Aldridge (2011) refers to it as an omnivore, unclear diet flexibility overall.*

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
	0

- *Not present outside of its native range in the US (FWS, 2014).*

- *Introduced populations in Europe, but may have been aided by declines in native crayfish as well as the fact that it carries crayfish plague (Holdich and Black, 2007).*
- *Lucic (2012) found superior competitive abilities in its introduced populations: "The present study demonstrated that invasive crayfish had better condition indices when compared to native species, as the energy content of hepatopancreas, abdominal muscle and gonads was almost always higher in invasive than in native 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
	6

- *This species mates in the spring and females lay up to 372 eggs (average 138) in April/May. They carry their eggs for 1-3 weeks, before hatching in May or June. A second mating period is sometimes observed in autumn, which allows sperm to be stored to produce young in early spring. The young mature in their second summer." (Aldridge, 2011).*
- *Capable of parthogenesis (Buřič et al., 2011).*

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

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

- *High fecundity, rapid maturation and reproduction give spiny-cheek crayfish high invasive potential. (Aldridge, 2011).*
- Faxonius limosus *are capable of facultative parthenogenesis. (Buřič et al., 2011)*

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

- *CLIMATCH analysis rates Great Lakes region as high.*

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

- *Native to Canada and the northeastern US.*

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

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

- *...inhabits clear streams that are 10- 100 m wide, with silt, cobble, gravel and sand substrates (Jezerinac et al., 1995, Aiken 1965). This species has also been found in lakes (Aiken 1965). Individuals are often found in shallow depressions in pools and have rarely been captured where silt is absent from the substrate (Jezerinac et al., 1995).*

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
	0

- *Given that Great Lakes Region has a high climate match and it is native to regions in equal or higher latitude to the Great Lakes, it is unlikely that it would benefit from the effects of climate change.*

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

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

- *Broad dietary range.*

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

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

Yes, but the critical species (or one that may provide a similar function) is not present in the Great Lakes and is not likely to be introduced	-80% total points (at end)
Unknown	U
	9

- *No, this species does not require the presence of any other species to grow, reproduce, or spread.*

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

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

- *None reported.*

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%

- *Large fish, such as carp, may eat the spiny-cheek crayfish. Coots have been observed attacking crayfish and it is likely that herons, cormorants and wildfowl may also predate them (Aldridge, 2011). These species are present in the native range of O. limosus, but they do not seem to limit its population.*

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

- *Commonly used as bait and fish food (FWS, 2015): we were unable to find it for sale in the Great Lakes or online.*

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

- *Invasive populations in Europe, but has not expanded outside of its native range in the U.S.*

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

- *Has not spread outside of its native range in North America, history of invasion in Europe. Successfully invaded England across the English Channel because of accidental or unauthorized release and bait transfer.*
- *European populations spread rapidly downstream in the Romanian stretch of the Danube.*

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 specific control methods in Great Lakes Region.*

Establishment Potential Scorecard				
Points	**Probability for Establishment**	Total Points (pre-adjustment)		A: 93
>100	High	Adjustments		
		Critical species	A (99- 0%)	B: 84
51-99	Moderate	Natural enemy	B (99-10%)	C: 89.1
		Control measures	C (89.1-20%)	**89.1**
0-50	Low	Probability for Establishment		Moderate
# of questions answered as "unable to determine"	**Confidence Level**			
0-1	High	Total # of questions unknown		1
2-5	Moderate			
6-9	Low	Confidence Level		High
>9	Very low			

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

Section C: Potential for Impact

IMPACT POTENTIAL RESULTS

Environmental: High
Socio-Economic: Low
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

- *Contributed to spread of crayfish plague in Europe (Pârvulescu et al., 2012).*

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

- *Spiny-cheek crayfish successfully repelled YOY burbot from their preferred daytime shelters into alternative, previously unselected shelters. Crayfish also affected the nocturnal behaviour of YOY burbot by eliciting avoidance behaviour and caused an increase in the plasma cortisol levels (Hirsch and Fischer, 2008).*

Does it alter predator-prey relationships?

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

Unknown	U√

- *No reports.*

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

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

- *No reports of hybridization.*

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

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

- *No reports.*

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

- *Burrowing may cause riverbank erosion, which could increase turbidity (Aldridge, 2011). No reports of effects on native species or long-term effects.*

Environmental Impact Total	**12**
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 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

- *No reports.*

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

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

- *Burrowing by crayfish may destabilise river banks causing damage to buildings or endangering livestock grazing nearby (Aldridge, 2011)*

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

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

- *No reports on effects of water quality.*
- *Burrowing increases turbidity.*

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

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

- *No reports.*

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

- *No reports.*

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

- *Bank burrowing habit could cause erosion, which would diminish perceived aesthetic.*

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

- *No reports.*

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

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

- *Not cultured, but popular source of bait and fish food.*

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

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

- *No recreational purpose other than use as bait, alternatives relatively available in Great Lakes.*

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

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

- *Not used for any research applications.*

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

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

- *No reports.*

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

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

- *No reports*

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: *Ludwigia grandiflora*

Common Name: Water primrose

Section A: Potential for Introduction

INTRODUCTION POTENTIAL RESULTS

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

POTENTIAL INTRODUCTION VIA DISPERSAL

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

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

- *Closest populations are in eastern PA and SE NY (eddmaps)*

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

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

POTENTIAL INTRODUCTION VIA HITCHHIKING/FOULING

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

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

- *Spreads via vegetative fragmentation.*

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

- *Populations in southeast NY and eastern PA.*

POTENTIAL INTRODUCTION VIA UNAUTHORIZED INTENTIONAL RELEASE

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

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

- *Not listed for sale through Great Lakes retailers, however it is commonly used in hobby gardens and may be sold under a different name or misidentified (Dandelot et al., 2005).*

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

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

- *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

- *Commonly used in recreational culture. Use as an ornamental has accelerated its spread throughout Europe (Dandelot et al., 2005).*

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

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

- *No reports of sale in Great Lakes; however they are very difficult to identify morphologically (Dandelot et al., 2005) so they may be misidentified.*

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

- *No reports of commercial culture.*

What is the nature and proximity of this activity to the Great Lakes basin? Not applicable

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

Unknown	U

POTENTIAL INTRODUCTION VIA SHIPPING

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

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

- *Not reported.*

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

Yes, and this species has been observed in ballast of or fouling ships entering the Great Lakes.	Score x 1
Yes, and this species has been observed in ports that have direct trade connections with the Great Lakes (e.g., Baltic Sea).	Score x 0. 5
Yes, but this species has neither been observed in ballast/fouling ships entering the Great Lakes nor in ports in direct trade with the Great Lakes.	Score x 0.1
No, this species does not occur in waters from which shipping traffic to the Great Lakes originates.	Score x 0
Unknown	U√

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	0	Low
Hitchhiking/Fouling: Transport via recreational gear, boats, trailers, mobile fauna,	100	x 0.1	10	Low

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	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)		100	x U	0	Low
Escape from commercial culture: Accidental introduction to Great Lakes by escape from commercial culture (e.g., aquaculture)		0	x	0	Low
Trans-oceanic shipping: Ballast (BOB) or no-ballast-on-board (NOBOB) water exchange/discharge, sediment discharge, hull fouling		0	x	0	Low
Total Unknowns (U)	1	**Confidence Level**		High	

Qualitative Statements for GLANSIS Fact Sheet:

Ludwigia grandiflora has a low probability of introduction to the Great Lakes (Confidence level: high)

Potential pathway(s) of introduction: unauthorized intentional release.

Section B: Potential for Establishment

ESTABLISHMENT POTENTIAL RESULTS

Ludwigia grandiflora ***has a high 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

- *High levels of polymorphism and phenotypic plasticity have been reported for this species in France, which allows the species to grow in a wide range of environments (Ruaux et al., 2009).*
- *Can survive and flower under the worst conditions (pollution, salinity, drought, etc.) (Dandelot et al., 2008).*
- *Can withstand freezing to warm tropical temperatures.*

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

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

- *Low temperatures (4-8°C), comparable to winter conditions on the middle Loire River, had no impact on viability rates. Only freezing of seeds that were stored under water reduced seed viability in both species (by more than 50% in* L. grandiflora*). The study thus suggests that sexual reproduction could become an additional mechanism for winter survival and spread of Ludwigia, especially over long distances (Ruaux 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
	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
	6

- L. grandiflora *seemed to have little impact on native species, which may coexist with* L. grandiflora *during the early stages of* L. grandiflora *establishment in the introduction area (Thouvenot et al., 2013).*
- *Its allelopathic properties mean it is an ecosystem engineer, and by making habitats unsuitable for native flora, it increases its competitive potential (Dandelot et al., 2008).*
- *In several ponds in the Landes region (South-West France), decreases in* Potamogeton natans, Myriophyllum spicatum, Iris pseudacorus *and* Ludwigia palustris *have been observed as a consequence of competition with* Ludwigia grandiflora *and* Lagarosiphon major *(Dutartre, 2002 in EPPP Fact Sheet).*
- *In Belgian ponds, the cover of* L. grandiflora *has caused a reduction in native species richness. A decrease of 70% has been measured from uninvaded plots to heavily invaded plots. The submerged vegetation was the most vulnerable to the invasion. Significant differences in native species abundance following invasion were found for the submerged* Ceratophyllum demersum *and for the emergent* Alisma plantago-aquatica *and* Lycopus europaeus *(Stiers et al., 2011).*

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

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

- *Fruit contains 40-50 seeds (CABI). Can produce 10,000 seeds/square meter (Ruauc et al., 2009).*
- *Primarily spreads through vegetative growth (Dandelot et al., 2005).*
- *Vegetative growth can produce up to 2kg/ m^2 dry matter (Dandelot et al., 2005).*

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

Likely (The reproductive strategy or habits of this species are known to aid establishment in new environments, AND available literature predicts establishment in the Great Lakes based on these attributes)	9
Somewhat likely (The reproductive strategy or habits of this species are known to aid establishment in new environments, but there is no literature available regarding establishment in the Great Lakes based on these attributes)	6√

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

- *High fecundity, vegetative fragmentation allows it to establish in new environments.*

ENVIRONMENTAL COMPATIBILITY

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

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

- *Known in eastern PA and NY, as well as continental Europe. These regions have similar climates, albeit less severe winters.*
- *Low temperatures (4-8°C), comparable to winter conditions on the middle Loire River, had no impact on viability rates. Only freezing of seeds that were stored under water reduced seed viability in both species (by about 40% in L. peploides and more than 50% in* L. grandiflora*). The study thus suggests that sexual reproduction could become an additional mechanism for winter survival and spread of Ludwigia, especially over long distances (Ruaux et al., 2009).*

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

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

- *High levels of polymorphism and phenotypic plasticity have been reported for this species in France, which allows the species to grow in a wide range of environments (Ruaux et al., 2009).*
- *Can survive and flower under the worst conditions (pollution, salinity, drought, etc.) (Dandelot et al., 2008).*
- *Can withstand freezing to warm tropical temperatures.*

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

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

- L. grandiflora *inhabits marshes, swamps, ponds, lakes, ditches, channels and slow-running rivers, as well as wet meadows (Lambert et al., 2010).* L. grandiflora *is tolerant to a wide range of fluctuations in habitat characteristics (e.g., water level; Hussner, 2010) and soil moisture (Ruaux, 2008) and possesses a rapid growth rate and an efficient vegetative reproduction capacity (Okada et al., 2009).* Ludwigia spp. *prefers high nutrient substrates (Hussner, 2010) and becomes dominant in nutrient-rich conditions (Rejmankova, 1992). It prefers full sunlight but can tolerate shade (biomass production is reduced under shade); it is limited by flow velocity (Dandelot, 2004) and by salinity (Thouvenot et al., 2012) (in Thouvenot et al., 2013).*
- *In the interior portions of its range in the USA, the plant is found in three kinds of habitats: 1) emergent marshes and swamps in permanently pooled bottomland depressions that experience periodic flooding; 2) along shorelines and extending out into shallow bays; and 3) on sandy banks and gravel bars of shallow streams (Chester and Holt, 1990 in CABI).*

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

- L. grandiflora *is quite tolerant of fluctuations in water level and flooding (CABI).*
- *Increasing temperatures will favour stock development and spreading (Hussner 2009).*
- *Tolerant to higher salinity, pollution, and drought (Dandelot et al., 2008).*

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

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

- *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 critical species.*

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

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

- *No natural enemy is predicted to prevent its establishment.*
- *Red Swamp crayfish consume large quantities of* L. grandiflora*, however there are only a few RSC populations in the Great Lakes.*

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

- *Could be spread from existing populations by hitchhiking on recreational boats or other gear.*

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

- *Native to South America. Extensive populations in Europe, particularly throughout France (EPPO, 2011)*

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

- L. grandiflora *was introduced from the Americas to Montpellier in France in the 1830s, and has become one of the most widespread and detrimental aquatic invasive plants in that country (Ruaux et al., 2009).*
- *After an initial observation of only a few individuals in 2004, a dense growth of* L. grandiflora *has been observed from 2009 onwards, in Germany (Nehring and Kolthoff 2011).*

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 regulations.*
- *PA considering adding to Noxious Weed List (personal communication).*

Establishment Potential Scorecard				
Points	**Probability for Establishment**	Total Points (pre-adjustment)		102
>100	High	Adjustments		
		Critical species	A (1- 0%)	B: 102
51-99	Moderate	Natural enemy	B (1-0%)	C: 102
		Control measures	C (1-0%)	
0-50	Low	Probability for Establishment		High
# 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			

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

Section C: Potential for Impact

IMPACT POTENTIAL RESULTS

Environmental: High
Socio-Economic: High
Beneficial: 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

- *The water of each* Ludwigia *tank induced: (1) a decrease in germination for watercress in August (control: 68.6%,* L. peploides*: 48.6%,* L. grandiflora*: 61.1%); (2) an increase in mortality in May only for watercress (control: 3.4%,* L. peploides*: 13.5%,* L. grandiflora*: 12%) and in August for both target species (up to 22.3% vs. 3% for lettuce and 27% vs. 12.5% for watercress); (3) a disturbance of seedling elongation for lettuce in all seasons; and (4) a seedling chlorosis of both target species, particularly in May and August. This study showed that* L. peploides *and* L. grandiflora *possess an allelopathic activity that influences the water quality throughout the year (Dandelot et al., 2008).*

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

- L. grandiflora *seemed to have little impact on native species, which may coexist with* L. grandiflora *during the early stages of* L. grandiflora *establishment in the introduction area (Thouvenot et al., 2013).*
- *Its allelopathic properties mean it is an ecosystem engineer, and by making habitats unsuitable for native flora, it increases its competitive potential (Dandelot et al., 2008).*
- *In several ponds in the Landes region (southwest France), decreases in* Potamogeton natans*,* Myriophyllum spicatum*,* Iris pseudacorus *and* Ludwigia palustris *have been observed as a consequence of competition with* Ludwigia grandiflora *and* Lagarosiphon major *(Dutartre, 2002 in EPPP Fact Sheet).*
- *In Belgian ponds, the cover of* L. grandiflora *has caused a reduction in native species richness. A decrease of 70% has been measured from uninvaded plots to heavily invaded plots. The submerged vegetation was the most vulnerable to the invasion. Significant differences in native species abundance following invasion were found for the submerged* Ceratophyllum demersum *and for the emergent* Alisma plantago-aquatica *and* Lycopus europaeus *(Stiers et al., 2011).*

Does it alter predator-prey relationships?

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

- *Not reported to alter predator-prey relationships.*

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

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

- *Not reported to have genetically impacted any populations.*

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

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

- *Can lead to dissolved oxygen crashes and the accumulation of sulphide and phosphate in the water. These not insubstantial and year-round effects on water quality can cause 'dystrophic crises' and intoxicated ecosystems (Dandelot et al., 2005a in Dandelot 2008).*
- *In addition to shading, decaying mats of* Ludwigia *cause deoxygenation of the water with potential damage to fish stocks and to other fauna (Lambert et al., 2010; Stiers et al., 2009).*
- *The major effects of these invasions are: reduction of the flow and hyper-sedimentation leading to silting up, in particular in ponds, the drastic decline of the local biodiversity (dense monotypic stands) and in summer water hypoxia and major alterations in bacterial communities (Dandelot et al., 2008)*

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

- *The plant can also cause hyper-sedimentation and silting (Dandelot et al., 2008).*
- *Uninvaded ponds supported a more distinct invertebrate community, including species (e.g. Ephemeroptera) that are rare or missing from invaded* L. grandiflora *ponds. Uninvaded ponds had 17 different families, while* L. grandiflora *ponds had nine families (Stiers et al., 2011).*
- *Introduction has resulted in a floristic standardization and a strong local reduction of fauna (macroinvertebrates and fishes: Grillas et al., 1992; Dutartre et al., 1997 in Dandelot et al., 2005).*

Environmental Impact Total	**24**
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

- *Dense matting also prevents effective mosquito control (Okada et al., 2009).*

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 repairable or preventable	1√
Not significantly	0
Unknown	U

- *Interferes with flood control and drainage systems, clogs waterways and impacts navigation and recreation (IPAMS, 2009 in CABI).*
- *In California, USA dense stands of* L. grandiflora *reduce flood water retention (Okada et al., 2009).*

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

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

- *Not reported.*

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

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

- *Interferes with flood control and drainage systems, clogs waterways and impacts navigation and recreation (IPAMS, 2009 in CABI).*
- *By outcompeting wetland grasses,* L. grandiflora *can reduce grazing space for livestock in wet meadows when it displaces grasses (Dutartre, 2004a in EPPO Fact Sheet).*

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 plant can cause substantial nuisance to recreational users by impeding navigation and interfering with hunting, fishing and other recreational activities (IPAMS, 2009 in CABI).*

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

- *Can decrease aesthetic value of water bodies (CABI).*

Socio-Economic Impact Total	**10**
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

- Not reported to control any nuisance species

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

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

- *Sometimes employed as an ornamental 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

- *No reports of recreational value.*

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

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

- *Not employed for research.*

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 benefits to water quality.*

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

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

- *No other positive impact.*

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

Scientific Name: *Lysimachia punctata*

Common Name: Large yellow loosestrife

Section A: Potential for Introduction

INTRODUCTION POTENTIAL RESULTS

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

POTENTIAL INTRODUCTION VIA DISPERSAL

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

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

- *This species, as a plant, is not motile.*

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

- *Has been found within counties bordering the Great Lakes, but is not mobile.*

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 significantly.*

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

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

POTENTIAL INTRODUCTION VIA UNAUTHORIZED INTENTIONAL RELEASE

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

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

- *Sold as a garden ornamental by many botanical retailers.*

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

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

- *This species is readily available in retail settings and no restrictions on its sale currently exist.*

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

- *This species is planted as an ornamental somewhat commonly in moist gardens or along creeks.*

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

- *Reported at several wet garden sites within 20 km of the Great Lakes basin, but none below the ordinary high water mark.*

POTENTIAL INTRODUCTION VIA ESCAPE FROM COMMERCIAL CULTURE

A9) 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√

- *This species is a common ornamental and no restrictions are reported on its culture or transport 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√

- *No reports of this species being specifically cultivated near the Great Lakes exist, though this species is not regulated.*

POTENTIAL INTRODUCTION VIA SHIPPING

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

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

- *Not reported.*

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

Yes, and this species has been observed in ballast of or fouling ships entering the Great Lakes.	Score x 1
Yes, and this species has been observed in ports that have direct trade connections with the Great Lakes (e.g., Baltic Sea).	Score x 0. 5
Yes, but this species has neither been observed in ballast/fouling ships entering the Great Lakes nor in ports in direct trade with the Great Lakes.	Score x 0.1
No, this species does not occur in waters from which shipping traffic to the Great Lakes originates.	Score x 0
Unknown	U√

- *Unknown.*

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 .75	0	Low
Hitchhiking/Fouling: Transport via recreational gear, boats, trailers, mobile fauna,	0	x .5	0	Low

stocked/planted organisms, packing materials, host organisms, etc.					
Release: Unauthorized intentional release of organisms in trade (e.g., aquaria, water gardens, live food)		100	x 1	100	High
Stocking/Planting/Escape from recreational culture: Intentional authorized or unauthorized introduction to natural waters in the Great Lakes *OR* Accidental introduction to Great Lakes by escape from recreational culture (e.g., water gardens)		100	x .75	75	High
Escape from commercial culture: Accidental introduction to Great Lakes by escape from commercial culture (e.g., aquaculture)		U	x U	U	Unknown
Trans-oceanic shipping: Ballast (BOB) or no-ballast-on-board (NOBOB) water exchange/discharge, sediment discharge, hull fouling		0	x U	0	Low
Total Unknowns (U)	3	**Confidence Level**		Low	

Qualitative Statements for GLANSIS Fact Sheet:

Lysimachia punctata has a high probability of introduction to the Great Lakes (Confidence level: low).

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

Section B: Potential for Establishment

ESTABLISHMENT POTENTIAL RESULTS

Lysimachia punctata ***has a moderate probability of establishment if introduced to the Great Lakes (Confidence level: Low).***

Comments: Little research has been done on this species, especially compared to its invasive relatives such as *Lysimachia vulgaris*. However, it appears to be less aggressive than these related species across the board.

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

- Lysimachia punctata *tolerates medium to wet soil conditions and part shade to full sun (Missouri Botanical Garden, 2019). Additionally, it can survive in a range of soil types and pHs (Perennials.com, 2019), though other variables have not been reported.*

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

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

- *This species is a wetland plant hardy in USDA zones 4-8, indicating an ability to survive overwintering in the Great Lakes region (Missouri Botanical Garden, 2019).*

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
	6

- *This species has been reported to crowd out other plants by forming dense stands, but there are few specific cases of direct competition and no predictions have been made on its behavior in the Great Lakes.*

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

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

- *Specific fecundity is unreported, but this species self-seeds under favorable conditions.*

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

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

- *This species self-seeds and also spreads rhizomatically.*

ENVIRONMENTAL COMPATIBILITY

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

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

- *This species is distributed widely across Eurasia, which shares similar climatic conditions with the Great Lakes region.*

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

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

- *Specific variables have not been reported.*

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

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

- *This species is adaptable and tolerant of variable conditions similar to those found in the Great Lakes region.*

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

Likely (Most of the effects described above make the Great Lakes a better environment for establishment and spread of this species, OR this species could easily adapt to these changes due to its wide environmental tolerances)	9

Somewhat likely (Several of the effects described above could make the Great Lakes a better environment for establishment and spread of this species)	6
Somewhat unlikely (Few of the effects described above would make the Great Lakes a better environment for establishment and spread of this species)	3
Unlikely (Most of the effects described above would have no effect on establishment and spread of this species or would make the environment of the Great Lakes unsuitable)	0
Unknown	U√
	U

- *Unknown.*

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 with broad sun and soil tolerances.*

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 is 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

- *A facilitator 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 this is already present in the Great Lakes and may preferentially target this species?

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

- *No studies on natural predators have been reported.*

PROPAGULE PRESSURE

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

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

- *Individual stands may be planted by gardeners, and numbers and frequency are likely low but remain unknown.*

HISTORY OF INVASION AND SPREAD

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

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

- *Few invasive populations have been reported due to its lack of classification as an invader, though they are likely to exist.*

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

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

- *While this species is recognized as being locally aggressive, there is little literature on its rate of spread.*

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

- *This species is likely to be able to be controlled by mechanical removal or herbicide applications, but no regulations and very little literature on its control currently exist.*

Establishment Potential Scorecard				
Points	**Probability for Establishment**	Total Points (pre-adjustment)		63
>100	High	Adjustments		
		Critical species	A (1- 0%)	
51-99	Moderate	Natural enemy	B (1-0%)	
		Control measures	C (1-0%)	**63**
0-50	Low	Probability for Establishment		Moderate
# of questions answered as "unable to determine"	**Confidence Level**			
0-1	High	Total # of questions unknown		7
2-5	Moderate			
6-9	Low	Confidence Level		Low
>9	Very low			

Qualitative Statements for GLANSIS Fact Sheet:

Lysimachia punctata has a moderate probability of establishment if introduced to the Great Lakes (confidence level: low).

Section C: Potential for Impact

IMPACT POTENTIAL RESULTS

Environmental: Unknown

Socio-Economic: Low
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

- *Not significantly.*

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

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

- *This species spreads rhizomatically and forms dense stands that can crowd out other species, but is not as aggressive as other loosestrifes (Missouri Botanical Garden, 2019).*

Does it alter predator-prey relationships?

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

- *Not 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 significantly.*

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

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

- *Not reported.*

Environmental Impact Total	**1**
Total Unknowns (U)	**2**

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

- *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 significantly.*

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

- *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 reported.*

Socio-Economic Impact Total	**0**
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 reported.*

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

Yes, it is economically important to at least one of these industries	6

Yes, but its economic contribution is small	1√
Not significantly	0
Unknown	U

- *This species is commonly sold as a garden ornamental for its showy yellow flowers (Missouri Botanical Garden, 2019).*

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

- *The leaves and flowers are sometimes boiled and consumed as tea to help with abdominal pain (Kargıoğlu et al., 2008).*

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√

- *Utilized by pollinators and attractive to butterflies, but the extent to which this is beneficial is unknown.*

Beneficial Effect Total	**2**
Total Unknowns (U)	**1**

Scientific Name: *Pacifasticus leniusculus*

Common Name: Signal crayfish

Section A: Potential for Introduction

INTRODUCTION POTENTIAL RESULTS

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

POTENTIAL INTRODUCTION VIA DISPERSAL

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

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

- *Occurs from British Columbia in the north, central California in the south, and Utah in the east (GISD, 2005).*
- *California - Introduced, Idaho, Nevada - Introduced, Oregon, Utah - Introduced, Washington (Schuster et al., 2005).*

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

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

POTENTIAL INTRODUCTION VIA HITCHHIKING/FOULING

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

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

- *No reports.*

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

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

- *As of 2018, they have not moved east of the Rocky Mountains. NAS nonindigenous occurrences: Alaska, California, Nevada, Oregon.*

POTENTIAL INTRODUCTION VIA UNAUTHORIZED INTENTIONAL RELEASE

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

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

- *Available through a number of online retailers including Amazon.*

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

- *Popular bait species, no specific restrictions on sales in the Great Lakes region.*
- *Listed as a common aquarium species by Encyclopedia of Life (Hogan, 2008).*

POTENTIAL INTRODUCTION VIA STOCKING/PLANTING OR ESCAPE FROM RECREATIONAL CULTURE

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

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

- *No reports of recreational culture in GL. Popular bait species. Unauthorized stocking in small bodies of water for use as bait may occur.*

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√

- *Unknown.*

POTENTIAL INTRODUCTION VIA ESCAPE FROM COMMERCIAL CULTURE

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

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

- *Popular recreational culture species, but no reports of commercial culture in the Great Lakes*

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

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

Unknown	U

- *Cultured outside Great Lakes Region (USFWS, 2015).*

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

- *Does not burrow in native range, burrows in introduced range.*
- *"Well-adapted for surviving salinities of at least 21ppt in the long term and of being transferred directly back into freshwater" (IUCN).*
- *"Highly adaptable and can be found in a wide variety of habitats including...saline waters in river deltas" (Hogan, 2008).*
- *100% mortality after 21 hours held in water with DO levels of 0.00-0.05 mg/l.*

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

Yes, and this species has been observed in ballast of or fouling ships entering the Great Lakes.	Score x 1
Yes, and this species has been observed in ports that have direct trade connections with the Great Lakes (e.g., Baltic Sea).	Score x 0. 5
Yes, but this species has neither been observed in ballast/fouling ships entering the Great Lakes nor in ports in direct trade with the Great Lakes.	Score x 0.1
No, this species does not occur in waters from which shipping traffic to the Great Lakes originates.	Score x 0√
Unknown	U

Potential Vector Ranking and Points				
Vector	**Raw Points Scored**	**Proximity Multiplier**	**Total Points Scored**	**Probability of Introduction**

Dispersal: Natural dispersal through waterbody connections or wind		**0**	x U	**0**	Low
Hitchhiking/Fouling: Transport via recreational gear, boats, trailers, mobile fauna, stocked/planted organisms, packing materials, host organisms, etc.		**0**	x 0.1	**0**	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)		**U**	x U	**U**	Unknown
Escape from commercial culture: Accidental introduction to Great Lakes by escape from commercial culture (e.g., aquaculture)		**0**	x 0.1	**0**	Low
Trans-oceanic shipping: Ballast (BOB) or no-ballast-on-board (NOBOB) water exchange/discharge, sediment discharge, hull fouling		**0**	x 0	**0**	Low
Total Unknowns (U)	**1**	**Confidence Level**		Moderate	

Qualitative Statements for GLANSIS Fact Sheet:

Pacifastacus leniusculus has a high probability of introduction to the Great Lakes (Confidence level: moderate).

Potential pathway(s) of introduction: unauthorized intentional release.

Section B: Potential for Establishment

ESTABLISHMENT POTENTIAL RESULTS

***Pacifastacus leniusculus has* a high 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

- *Broad temperature and salinity range (Fofonoff et al., 2003)*
- *Does not occur in waters with pH lower than 6 (GISD, 2005)*
- *100% mortality after 21 hours of exposure to anoxic water (0.0-0.05 mg/l) ; in Britain P. leniusculus can inhabit eutrophic waters with low DO (1.2 mg/l) (Harlıoğlu, 1996)*

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

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

6

- *Native and introduced ranges have long cold winters.*
- *Lowest reported DO they can survive is 1.2 mg/l; however, crayfish may emerge and breathe air in anoxic conditions (Harlıoğlu, 1996).*

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

- *...an opportunistic polytrophic feeder,* P. leniusculus *will eat anything that is available, including other crayfish. The diet was found to shift from aquatic insects in juveniles, to more plant material in adults in some American populations (Lewis, 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
	9

- *Extensive history of invasive populations including effects on European crayfish following introduction.*

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

- *Egg numbers usually range from 200 to 400, although some individuals of 66mm CL have been reported as having over 500 eggs. (GISD, 2005).*
- *R-selected species (Schuster 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
	6

- *The breeding cycle is typical of a cool temperate zone species, although* P. leniusculus *grows faster and reaches a greater size than its counterparts (GISD, 2005).*

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

- *CLIMATCH analysis rates Great Lakes region between 7 and 8 on a scale out of 10.*

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

- *Their native range includes high alpine lakes which are oligotrophic (Lowery and Holdich, 1988) including Lake Tahoe which has similar nutrient concentrations to the Great Lakes (excluding Lake Erie) following the* Dreissenna spp. *invasions.*
- *A 2001-2010 USGS study classified 75% of inland Lakes in Michigan as oligotrophic or mesotrophic (Fuller and Taricska, 2012).*
- *Majority of water bodies in Wisconsin report to congress were listed as mesotrophic or oligotrophic (Wisconsin DNR, 2016).*
- *Signal Crayfish prefer waters with pH higher than 6 (GISD, 2005).*
- *Majority of inland lakes studied in Michigan had pH of 6.5 or higher (Fuller and Taricska, 2012)*
- *Has also been found to occupy eutrophic waters in Britain (Harlıoğlu, 1996), so they could likely survive in the region's more productive waters such as Lake Erie.*
- *Inhabits water as deep as 60 meters (Moshiri et al., 1970) indicating they could survive in similar temperatures and light levels to those available in the Great Lakes and surrounding waters.*

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

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

Unknown	U
	9

- Pacifastacus leniusculus *occupies a wide range of habitats from small streams to large rivers (e.g. Columbia River) and natural lakes, including sub-alpine lakes, such as Lakes Tahoe and Donner (GISD, 2005).*

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

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

- *Great Lakes region is similar to native and introduced zone. It is tolerant of these changes (e.g. increased salinization), but they would only make GL more suitable by reducing fitness of species it might compete with that are less tolerant.*

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

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

- *Broad and flexible polytrophic diet (FWS, 2015).*

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

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

- *No, this species does not require the presence of any other species to grow, reproduce, or spread.*

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

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

- *No reports of a species that facilitates its development.*

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

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

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

- *No natural predators reported in region. Preyed upon by* Perca fluviatilis *and* Anguilla anguilla *in Europe (Blake, 1993). This indicates that* P. leniusculus *do not have a natural defense that protects them from predation outside of their native range. They are likely to be preyed upon by Great Lakes fishes; however, there is no indication that fish predation would prevent establishment of the signal crayfish.*

PROPAGULE PRESSURE

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

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

- *Not commercially cultured or shipped in the region, no reports of stocking in natural waters. Only existing inocula are most likely aquarium releases or escapes*

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

- *Introduced throughout Europe.*

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

- *Has spread upstream as much as 1km/ year, and even faster downstream in Finland and England (Johnsen and Taugbøl, 2010)*
- *Can bypass physical barriers (e.g. dams) by walking on dry land (Johnsen and Taugbøl, 2010)*

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 specific control methods in Great Lakes states.*

Establishment Potential Scorecard				
Points	**Probability for Establishment**	Total Points (pre-adjustment)		106
>100	High	Adjustments		
		Critical species	A (1- 0%)	106
51-99	Moderate	Natural enemy	B (1-0%)	106
		Control measures	C (1-0%)	**106**
0-50	Low	Probability for Establishment		High
# of questions answered as "unable to determine"	**Confidence Level**			
0-1	High			0

2-5	Moderate	Total # of questions unknown	
6-9	Low	Confidence Level	High
>9	Very low		

Section C: Potential for Impact

IMPACT POTENTIAL RESULTS

Environmental: High
Socio-Economic: Moderate
Beneficial: High

Comments: Carrier of crayfish plague, responsible for declining populations of *A. astacus* in Europe.

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

- *Carrier of crayfish plague (Holdich et al., 2009), reduced European populations (esp* Astacus astacus*) through introduction of plague + direct competition.*

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. leniusculus *displays opportunistic polytrophic feeding habits... It can have a considerable impact on populations of macro-invertebrates, benthic fish, and aquatic plants (Guan & Wiles 1997; Nyström 1999; Lewis 2002)... Griffiths et al. (2004) found that the presence of* P. leniusculus *significantly reduced the number of Atlantic salmon using shelters in artificial test arenas. Sooty crayfish ... has become extinct partly due to interspecific competition with* P. leniusculus*, which was introduced into its range.* P. leniusculus *has also been implicated in causing a reduction in the range of the already narrowly endemic shasta crayfish ... (Taylor 2002)" (GISD, 2005).*

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

- *Their highly polytrophic diet suggests that if they reach high abundance, they have the potential to affect a broad range of flora and fauna (Crawford et al., 2006).*
- *Crawford et al. (2006) found a strong correlation between crayfish density and species richness.*
- *Removing signal crayfish has been shown to improve macroinvertebrate taxon richness as well as abundance (Moorhouse et al., 2014).*

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

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

- *No reports of hybridization.*

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

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

- *No reports, but GISD (2005) notes that it can be used to "clear weeds from ponds in fish farms," could potentially alter nutrient cycle by reducing macrophytes in the GL.*

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

- *"Their burrows can reach high densities, i.e.14 m -1, and they can have a serious impact on bank morphology, causing them to collapse. It was considered to be a non-burrowing species, but in Europe in constructs burrows under rocks or in river and lake banks (Guan, 1994; Sibley, 2000)." (GISD, 2005)*

Environmental Impact Total	**19**
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 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

- *No known impacts on human health*

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

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

- *No reports.*

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

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

- *No reports on effects of 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

- *2+ year old P. leniusculus have been found to predate on unburied Atlantic salmon eggs (Findlay et al., 2014).*
- *Outcompetes Atlantic salmon for shelter making them vulnerable to predation (Griffiths et al. 2004).*

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

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

- *Burrows reduce bank stability and cause erosion (GISD, 2005).*

Socio-Economic Impact 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	

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

- *Used as a control agent of weeds in aquaculture ponds (GISD, 2005). However, existing control agents in GL don't require introduction of potentially invasive species*

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

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

- *Captured and cultured for human consumption as well as for use as bait (GISD, 2005)*

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

- *Could be recreationally caught for consumption.*

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	1

It is potentially important to medicine or research and is currently being or scheduled to be studied	
Not significantly	0 √
Unknown	U

- *Not used for any research applications.*

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

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

- *No reports that they improve water quality.*

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

- *Signal crayfish would not fill a role in the food web that is not already covered by existing crayfish species in the Great Lakes region.*

Beneficial Effect Total	**8**
Total Unknowns (U)	**0**

Scientific Name: *Tinca tinca*

Common Name: Tench

Section A: Potential for Introduction

INTRODUCTION POTENTIAL RESULTS

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

POTENTIAL INTRODUCTION VIA DISPERSAL

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

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

- *Established in St. Lawrence River.*
- *Collected in Bay of Quinte October 2018.*

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

- *Established population in the Humber River, ~50 km from Lake Ontario.*
- *Established in St. Lawrence River, but separated by a dam from Lake Ontario.*
- *Individual collected in the Bay of Quinte in 2018.*

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

- *Established in the St. Lawrence River.*

POTENTIAL INTRODUCTION VIA UNAUTHORIZED INTENTIONAL RELEASE

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

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

- *Often mistaken for native baitfish species and used as bait.*

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

- *Not specifically sought out as bait species, but may be mixed in with other more popular species.*

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

- *Stocked in the US throughout the 18th century (USFWS ERSS, 2014). Illegally stocked in Quebec during the 1980s; however, there are no reports of it being stocked since (Marcogliese et al., 2009).*

What is the nature and proximity of this activity to the Great Lakes basin? Not Applicable

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

POTENTIAL INTRODUCTION VIA ESCAPE FROM COMMERCIAL CULTURE

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

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

- *Illegally cultured in the 1980s in Quebec; no longer cultured due to lack of demand (Marcogliese et al., 2009)*

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

This activity is unregulated or minimally regulated and is occurring directly in the Great Lakes.	Score x 1
This activity is unregulated or minimally regulated and is occurring in Great Lakes tributaries or connecting waters, or within 20 km of the Great Lakes basin.	Score x 0.75
This activity is strictly regulated but occurs directly in the Great Lakes, and/or this activity involves transport of live organisms on/across the Great Lakes.	Score x 0.5

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

POTENTIAL INTRODUCTION VIA SHIPPING

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

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

- *Tolerant to extreme temperatures, salinity, and low oxygen. Has been found to bury itself in sediment to avoid freezing or drying of ponds (Avlijaš et al., 2017).*

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

Yes, and this species has been observed in ballast of or fouling ships entering the Great Lakes.	Score x 1
Yes, and this species has been observed in ports that have direct trade connections with the Great Lakes (e.g., Baltic Sea).	Score x 0. 5
Yes, but this species has neither been observed in ballast/fouling ships entering the Great Lakes nor in ports in direct trade with the Great Lakes.	Score x 0.1
No, this species does not occur in waters from which shipping traffic to the Great Lakes originates.	Score x 0√
Unknown	U

Potential Vector 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 0.5	**50**	Moderate
Hitchhiking/Fouling: Transport via recreational gear, boats, trailers, mobile fauna, stocked/planted organisms, packing materials, host organisms, etc.		**0**	x 0.5	**0**	Low
Release: Unauthorized intentional release of organisms in trade (e.g., aquaria, water gardens, live food)		**100**	x 0.1	**10**	Low
Stocking/Planting/Escape from recreational culture: Intentional authorized or unauthorized introduction to natural waters in the Great Lakes OR Accidental introduction to Great Lakes by escape from recreational culture (e.g., water gardens)		**0**	x 0	**0**	Low
Escape from commercial culture: Accidental introduction to Great Lakes by escape from commercial culture (e.g., aquaculture)		**0**	x 0.1	**0**	Low
Trans-oceanic shipping: Ballast (BOB) or no-ballast-on-board (NOBOB) water exchange/discharge, sediment discharge, hull fouling		**80**	x0	**0**	Low
Total Unknowns (U)	**0**	**Confidence Level**		High	

Qualitative Statements for GLANSIS Fact Sheet:

Tinca tinca has a moderate probability of introduction to the Great Lakes (Confidence level: high).

Potential pathway(s) of introduction: dispersal.

Section B: Potential for Establishment

ESTABLISHMENT POTENTIAL RESULTS

***Tinca tinca* 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

- *Tolerant to a wide range of environmental conditions (Sabapathy 2014).*
- *Tolerant of low DO, low pH. Can survive a broad range of temperatures (0-38 C) (Avlijaš et al., 2017).*
- *Prefers still or slow moving water (<0.5 m/s) (Avlijaš et al., 2017).*

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

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

- *Established in Colorado at elevations exceeding 2,850 meters, an area with long cold winters (Zuckerman and Behnke, 1986).*
- *Established and continuing to spread throughout St. Lawrence River (Avlijaš et al., 2017).*

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

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

- *Their diet consists mainly of aquatic insect larvae and molluscs (Nico et al., 2014)*
- *It feeds largely on zooplankton (particularly large-bodied cladocerans) in the first few years of its life, whereas insects and molluscs dominate its diet in later years (Avlijaš et al., 2017).*

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

Likely (This species is known to have superior competitive abilities and has a history of outcompeting other species, AND/OR available literature predicts it might outcompete native species in the Great Lakes)	9 √
Somewhat likely (This species is known to have superior competitive abilities, but there are few reported cases of this species outcompeting another and no predictions regarding species in the Great Lakes)	6
Somewhat unlikely (This species has average competitive abilities, and there are no reported cases of this species outcompeting another and no predictions regarding species in the Great Lakes)	3

Unlikely (This species is known as a poor competitor that thrives only in environments with low biodiversity, AND/OR available literature predicts it might be outcompeted by a species in the Great Lakes)	0
Unknown	U
	9

- *Avlijaš (2017) predicts it may outcompete Red Horse, which depends mainly on molluscs for its diet.*
- *There is no evidence that they affect other fish directly, however, a number of studies have implicated them in water quality decline (GISD, 2004)*
- *In Australia it is thought that tench may directly compete with trout and native fish for food resources (GISD, 2004)*

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

- *Reported as highly fecund by Avlijaš et al., (2017).*
- *Alas and Solak (2004) estimated that females lay approximately 40,000 eggs per spawning season.*

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

- *Alas and Solak (2004) claim its reproductive ability allowed it to adapt to conditions in a Turkish lake.*

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

- *Established in the St. Lawrence River, Richelieu watershed, and Humber River, Ontario (Avlijaš et al., 2017).*
- *CLIMATCH analysis rates the Great Lakes Region between 8 and 10 on a scale of 1:10 (Australian Bureau of Rural Sciences, 2008).*

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

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

- *DeVaney et al., (2009) performed ecological niche modeling to examine the invasion potential for tench and three other invasive cyprinids (common carp* Cyprinus carpio*, grass carp* Ctenopharyngodon idella*, and black carp* Mylopharyngodon piceus*). All of the current established populations of tench were in areas of predicted high suitability for this species. Interestingly, many areas where tench failed to become established or is currently extirpated (e.g., Great Lakes region) also had a moderate to high predicted suitability. DeVaney et al., (2009) attributed this potentially to negative interactions with sunfishes or unmeasured environmental factors.*
- *Classified as extremely tolerant fishes capable of living in waters with water quality that excludes most other fishes (Marchetti et al., 2004).*

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

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

Unknown	U
	9

- *Prefer calm shallow, densely vegetated lakes and ponds; however, they have a broad environmental tolerance (Kennedy and Fitzmaurice, 1970).*
- *Prefer muddy substrate (Rendon et al., 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

- *Positive correlation between water temperature and fecundity (Alas and Solak, 2004).*
- *Tolerant of high water temperatures.*

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

- *Relatively broad diet consisting of molluscs, insect larvae, and cladocerans (Nico et al., 2014), all of which are readily available in the Great Lakes region.*
- *The tench is a nonselective generalist predator of macroinvertebrates, including zooplankton, insects, amphipods, crayfishes, gastropods, and small bivalves (Avlijaš 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

- *This species does not require the presence of any other species to grow, reproduce, or spread.*

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

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

- *Not reported to be facilitated by any other species*

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

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

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

- *Introduced widely in the Great Lakes but, despite a high predicted environmental match, failed to establish. The reasons for the broad failure of tench introductions are currently not known, although some observational evidence suggests that biotic interactions with sunfishes (*Centrarchidae*), which are not native to Europe, may be responsible (Baughman 1947 in DeVaney et al., 2009). However, the mechanism of this interaction is not known.*
- *Zuckerman and Behnke (1986) noticed that the decline of tench in Colorado coincided with the spread and establishment of the common carp.*

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

- *Primary source of inocula would probably be from individuals dispersing through connected waterways from the St. Lawrence into Lake Ontario.*

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

- *Established on every continent except for Antarctica; however, it is no longer present in many areas where it was once stocked (Avlijaš et al., 2017)*

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
	3

- *Due to spread by humans for fishing and consumption, tench is now present on every continent except for Antarctica (Avlijaš et al., 2017)*
- *Was stocked extensively throughout the 18th and 19th centuries, but is no longer present in many of these areas (Avlijaš et al., 2017; Sabapathy, 2014)*
- *Presence of centrarchids may prevent establishment of tench (Sabapathy, 2014)*

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 species-specific control methods.*

Establishment Potential Scorecard				
Points	**Probability for Establishment**	Total Points (pre-adjustment)		105
>100	High	Adjustments		
		Critical species	A (105- 0%)	105

51-99	Moderate	Natural enemy	B (105-10%)	94.5
		Control measures	C (94.5-0%)	**94.5**
0-50	Low	Probability for Establishment		Moderate
# of questions answered as "unable to determine"	**Confidence Level**			
0-1	High	Total # of questions unknown		0
2-5	Moderate			
6-9	Low	Confidence Level		High
>9	Very low			

Qualitative Statements for GLANSIS Fact Sheet:

Tinca tinca has a moderate probability of establishment if introduced to the Great Lakes (Confidence level: high).

Section C: Potential for Impact

IMPACT POTENTIAL RESULTS

Environmental: Moderate
Socio-Economic: Low
Beneficial: Moderate

POTENTIAL ENVIRONMENTAL IMPACT

Does the species pose some hazard or threat to the health of native species (e.g., it magnifies toxin levels; is poisonous; 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

- *Of 10 fish sampled from an established population in the Richelieu River, 9 were infected with parasites. One parasite,* V. campylancristota, *was thought to pose a threat to copper redhorse (Marcogliese et al., 2009)*

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

- *Predicted to outcompete redhorse for molluscs if it becomes established in the Great Lakes (Avlijaš et al., 2017).*

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

- *Tench reduced the numbers of gastropods but not of other macroinvertebrates, and in turn increased the biomass of periphyton growing on artificial substrata within the enclosures. The higher lily density reduced oxygen concentrations and pH values and increased total phosphorus and soluble reactive phosphorus concentrations but otherwise had little effect on water chemistry (Bekliogu and Moss 1998).*
- *Reduces growth of submerged macrophytes, owing to sediment disturbance and trophic cascades that promote epiphyticalgae (Avlijaš et al., 2017).*

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

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

- *No reports of hybridization.*

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

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

- *Stirs up bottom sediments increasing turbidity, but not to the extent that common carp do (Nico et al., 2014).*

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

- *Reduces growth of submerged macrophytes, owing to sediment disturbance and trophic cascades that promote epiphyticalgae (Avlijaš et al., 2017).*

Environmental Impact Total	**5**
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

- *No reports.*

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

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

- *No reports of significant 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

- *Not reported to impact water quality in terms of human use.*

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

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

- *Not reported to harm economic sectors.*

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

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

- *Not reported.*

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

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

- *Not reported to diminish aesthetic significantly.*

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

- *Not reported to control any nuisance species.*

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

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

- *Cultured in Canada as recently as the 1980s, however, demand was low and it is no longer cultured (Marcogliese et al., 2009).*
- *Mandrak (personal observation) recorded tench for sale in Toronto fish market, possible caught and sold with other rough fish (Avlijaš et al., 2017).*

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

- *Sometimes fished for as a sport fish, however there are similar species available for recreational fishing already in the Great Lakes.*

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

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

- *Not used for any research applications.*

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

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

- *Not reported.*

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

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

- *Not reported.*

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

Scientific Name: *Typha laxmannii*

Common Name: Graceful cattail

Section A: Potential for Introduction

INTRODUCTION POTENTIAL RESULTS

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

POTENTIAL INTRODUCTION VIA DISPERSAL

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

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

- *Not known in the U.S.*

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

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

POTENTIAL INTRODUCTION VIA HITCHHIKING/FOULING

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

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

- *Not known in the U.S.*

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

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

POTENTIAL INTRODUCTION VIA UNAUTHORIZED INTENTIONAL RELEASE

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

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

- *Available from several online stores, including Amazon.*

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

- *Easily obtained (only regulated in IL and WI).*

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 √

- *While it is for sale, it is not sold anywhere 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 √

- *Unknown.*

POTENTIAL INTRODUCTION VIA ESCAPE FROM COMMERCIAL CULTURE

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

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

- *Not reported.*

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

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

POTENTIAL INTRODUCTION VIA SHIPPING

Is this species likely to be taken up in ballast, and capable of surviving adverse environments (i.e. extreme temperatures, absence of light, low oxygen levels) and partial-to-complete ballast water

exchange/flushing (e.g., is euryhaline, buries in sediment, produces resistant resting stages, has other attributes or behaviors facilitating survival under these conditions)?

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

- *Freshwater species.*

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

- *Not reported.*

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 0.75	**0**	Low
Hitchhiking/fouling: Transport via recreational gear, boats, trailers, mobile fauna, stocked/planted organisms, packing materials, host organisms, etc.	**0**	X 0.5	**0**	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	**U**	x U	**U**	Unknown

Great Lakes OR Accidental introduction to Great Lakes by escape from recreational culture (e.g., water gardens)					
Escape from commercial culture: Accidental introduction to Great Lakes by escape from commercial culture (e.g., aquaculture)		**0**	x	**0**	Low
Trans-oceanic shipping: Ballast (BOB) or no-ballast-on-board (NOBOB) water exchange/discharge, sediment discharge, hull fouling		**0**	x 0.1	**0**	Low
Total Unknowns (U)	**1**	**Confidence Level**		Moderate	

Qualitative Statements for GLANSIS Fact Sheet:

Typha laxmanii has a high probability of introduction to the Great Lakes (Confidence level: moderate).

Potential pathway(s) of introduction: unauthorized intentional release.

Section B: Potential for Establishment

ESTABLISHMENT POTENTIAL RESULTS

Typha laxmannii has a moderate probability of establishment if introduced to the Great Lakes (Confidence level: high).

Comments: *Very little available information on this species.*

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

- *Can grow at sites after coal production that are not very permeable, slightly acidic with high C, K, Mg, Mn and Na; low Ca and P (Woch et al., 2013).*

- *Temperature tolerances not described, but range includes Ukraine to France.*
- *Freshwater species.*

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

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

- *Köppen-Geiger climate classification of the Great Lakes region are Dfa, Dfb and Dfc; this species occurs in Romania and Ukraine, which are Dfb.*

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
	6

- *Unless restrained by some means, such as a large container, the plant will soon completely take over a site and will grow into the pond, gradually filling it in. This species will often form an almost complete monoculture in boggy soil (Plants for a Future Database, 2010).*

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

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

- *Spreads via rhizomes, as well as seeds.*

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

- *Spreads via rhizomes, as well as seeds.*

ENVIRONMENTAL COMPATIBILITY

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

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

- *Köppen-Geiger climate classification of the Great Lakes region are Dfa, Dfb and Dfc; this species occurs in Romania and Ukraine, which are Dfb.*

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

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

- *As this species can establish in soil previously exposed to coal production, it is likely somewhat tolerant of adverse conditions.*
- *Also tends to grow in anthropogenically disturbed sites (Baryla et al., 2005).*

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

- *Freshwater marshes, wet meadows, fens, roadsides, ditches, shallow ponds, stream, and lake shores are all very common in the Great Lakes region.*

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

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

- *Has established in areas somewhat warmer than the Great Lakes (e.g., France) so would likely not be harmed by climate change. Would not benefit from salinization, however.*

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, and appropriate soil conditions are easily found in the Great Lakes to meet this species' other nutrient-based requirements.*

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 is 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	9

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)	
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 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

- *Not reported.*

PROPAGULE PRESSURE

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

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

- *Unauthorized unintentional release and escape from recreational culture two potential pathways. These would be small/infrequent, however.*

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

- *In Europe,* T. laxmannii *occurs naturally in Bulgaria, Romania, and the Ukraine, as well as the southwestern part of Russia. Asian range is largely unknown (Baryla et al., 2005).*

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

- *Population has increased significantly in Poland (Baryla et al., 2005).*

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

- *This species is prohibited in a few Great Lakes states, but no specific control methods have been established.*

Establishment Potential Scorecard				
Points	**Probability for Establishment**	Total Points (pre-adjustment)		81
>100	High	Adjustments		
		Critical species	A (1- 0%)	81
51-99	Moderate	Natural enemy	B (1-10%)	81
		Control measures	C (1-20%)	**81**
0-50	Low	Probability for Establishment		Moderate
# of questions answered as "unable to determine"	**Confidence Level**			
0-1	High	Total # of questions unknown		0
2-5	Moderate			
6-9	Low	Confidence Level		High
>9	Very low			

Qualitative Statements for GLANSIS Fact Sheet:

Typha laxmannii has a moderate probability of establishment if introduced to the Great Lakes (Confidence level: high).

Section C: Potential for Impact

IMPACT POTENTIAL RESULTS

Environmental: Moderate
Socio-Economic: Low
Beneficial: Moderate

POTENTIAL ENVIRONMENTAL IMPACT

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

Yes, and it has impacted threatened/endangered species, resulted in the reduction or extinction of one or more native populations, affects multiple species, or is a reportable disease	6
Yes, but negative consequences have been small (e.g., limited number of infected individuals, limited pathogen transmissibility, mild effects on populations and ecosystems)	1

Not significantly	0√
Unknown	U

- *Not significantly.*

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

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

- *Documented to outcompete native plant communities in Eurasia (Baryla et al., 2005).*

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 √

- *Unknown.*

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

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

- *Can hybridize with* T. latifolia *to produce a hybrid known as* Typha x smirnovii *(Mavrodiev, 2000).*

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	6

Yes, and it has resulted in significant negative consequences for at least one native species	
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

- *Reductions in water quality have been reported for other species, though none have been reported specifically for* T. laxmanii.

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

- *Undocumented for this species specifically, but cattails in general may alter hydrology due to the structure of their dense stands.*

Environmental Impact Total	**4**
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 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

- *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 significantly.*

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

- *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	**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

- *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

- *Used as a decorative species in water gardens due to its smaller size compared to other cattail species (Dave's Garden, 2011).*

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

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

- *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

- *This species is edible, utilized for thatching, paper-making, insulation, and fireworks (Plants for a Future Database, 2010).*

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 for this species.*

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

- *Reduces bank erosion like other cattail species, but risk of release and expansion outweigh benefits (Plants For A Future Database, 2010).*

Beneficial Effect Total	**3**
Total Unknowns (U)	**1**

Scientific Name: *Filinia cornuta*

Common Name: Wheel animal

Notes: Potential benefits changed from low (a score of 1) to moderate (a score of 2) based on new studies showing that this species is used as a food source by native fish. Other sections of the assessment remain unchanged (See Fusaro et al., 2016).

Section C: Potential for Impact

IMPACT POTENTIAL RESULTS

Environmental: Low
Socio-Economic: Low
Beneficial: Moderate

POTENTIAL BENEFICIAL EFFECT

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

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

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

- *Not reported.*

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

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

- *Not reported.*

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

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

Unknown	U

- *Not reported.*

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

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

- *Not reported.*

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

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

- *Colloids (suspended solids) and wastewater provide common food sources for this species, and it may enhance water quality (Sladecek 1983).*

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

- *This species is important as a food source for fishes (Geng et al., 2005), including for fish larvae (e.g., carp larvae) (Swift 1992, Valdenberg et al., 2006).*

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

Scientific Name: *Rutilus rutilus*

Common Name: Roach

Notes: Likelihood of introduction changed from high to low since this species is now listed in the Lacey Act as of 2016, and its transportation and sale is forbidden. Confidence level of establishment changed from moderate to high based on new literature, and benefits changed from moderate to high based on literature showing its popularity among recreational anglers. Other sections of this assessment remain unchanged (See Fusaro et. al, 2016).

Section A: Potential for Introduction

INTRODUCTION POTENTIAL RESULTS

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

POTENTIAL INTRODUCTION VIA DISPERSAL

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

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

- *There are no known introductions of* Rutilus rutilus *in the United States (USFWS 2012).*
- *The species is found in the United Kingdom and Northern Europe (Froese and Pauly 2015).*

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

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

POTENTIAL INTRODUCTION VIA HITCHHIKING/FOULING

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

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

- *There is no reported transport of* R. rutilus *in North America (USFWS 2012).*

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

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

POTENTIAL INTRODUCTION VIA UNAUTHORIZED INTENTIONAL RELEASE

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

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

- *As of 2016, this species was added to the Lacey Act and cannot be imported or sold across state lines anywhere in the US.*

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

- *Roach is not found in the Great Lakes nor can it be obtained live in North America, and is prohibited by the Lacey Act.*

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

- *Roach is not found in the Great Lakes nor can it be obtained live in North America, and is prohibited by the Lacey Act.*
- *Roach has a low commercial value and is used just for recreational fishing (Froese and Pauly 2015).*

What is the nature and proximity of this activity to the Great Lakes basin? Not Applicable

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

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

- *Ireland is the closest region where roach have been reported (Ferguson 2008).*
- *It has low commercial value and is used just for recreational fishing (Froese and Pauly 2015)*

What is the nature and proximity of this activity to the Great Lakes basin? Not Applicable

This activity is unregulated or minimally regulated and is occurring directly in the Great Lakes.	Score x 1

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

POTENTIAL INTRODUCTION VIA SHIPPING

A11) 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

- Rutilus rutilus *has not been reported to be found in ballast water, but it has high survival in a variety of environments (USFWS 2012).*

A12) Does this species occur in waters from which shipping traffic to the Great Lakes originates?

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

- *The species is prevalent in the Baltic and Black seas near coastal area (Härmä et al., 2008).*
- *In the Northern Baltic Sea, roach was abundant in gill net catches (Lappalainen et al., 2001).*

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 0.25	0	Low
Hitchhiking/Fouling: Transport via recreational gear, boats, trailers, mobile fauna, stocked/planted organisms, packing materials, host organisms, etc.		0	x 0.1	0	Low
Release: Unauthorized intentional release of organisms in trade (e.g., aquaria, water gardens, live food)		0	x 0.1	0	Low
Stocking/Planting/Escape from recreational culture: Intentional authorized or unauthorized introduction to natural waters in the Great Lakes *OR* Accidental introduction to Great Lakes by escape from recreational culture (e.g., water gardens)		0	x NA	0	Low
Escape from commercial culture: Accidental introduction to Great Lakes by escape from commercial culture (e.g., aquaculture)		0	x NA	0	Low
Trans-oceanic shipping: Ballast (BOB) or no-ballast-on-board (NOBOB) water exchange/discharge, sediment discharge, hull fouling		60	x 0.5	30	Low
Total Unknowns (U)	0	**Confidence Level**		High	

Qualitative Statements for GLANSIS Fact Sheet:

Rutilus rutilus has a low probability of introduction to the Great Lakes (Confidence level: high).

Potential pathway(s) of introduction: unauthorized intentional release.

Section B: Potential for Establishment

ESTABLISHMENT POTENTIAL RESULTS

Rutilus rutilus ***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

- *Adult roaches like to live in brackish waters with salinities of 10ppt to 15ppt, while reproduction occurs in ranges of <3.5ppt (Bănărescu and Coad 1991, Härmä et al., 2008).*
- *Upper salinity ranges for reproduction have been experimentally determined to be between 7.5ppt to 10ppt (Härmä et al., 2008).*
- *However, other reports of this species state that it lives in both fresh and brackish water, and breeds among dense submerged vegetation in backwaters or lakes, flooded meadows or in shallow, fast-flowing river habitats on plant or gravel bottom (Froese and Pauly 2015).*
- Rutilus rutilus *is found in a variety of waters such as the Baltic, Caspian, and Aral Sea with a temperature tolerance of <12-28°C and an optimum growth temperature of 20-27°C (Linlokken et al., 2010).*
- *Lower temperature ranges have not been researched experimentally. Feeding and growth of* R. rutilusis *reduced at temperatures <12°C (Linlokken et al., 2010).*
- *Early life stages of* R. rutilus *are sensitive to salinity (Härmä et al., 2008).*
- *It occurs in waters that have temperatures of 4°C (Geraudie et al., 2010) and have been shown to tolerate temperatures up to 30°C (Cocking 1958). At high temperatures of 30°C, it cannot tolerate oxygen levels under 1 mg/L.*

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

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

Unlikely	0
Unknown	U

6

- *Studies were not done in lower temperatures to see the survival of* R. rutilus*, but it is hypothesized that the swimming speed and metabolism would be lowered and the feeding habits would be affected (Linlokken et al., 2010).*
- *This species occurs in waters in France, which experience water temperatures of 4-6°C in the winter (Geraudie et al., 2010).*
- *This species occurs in the Baltic Sea, and spawn shortly after ice breakup (Härmä et al., 2008).*
- *The optimum factors for reproduction are temperatures between 4° to19.5 °C and salinity ranges from 0% to 3.5%, allowing it to reproduce up to 100,000 pale yellow eggs that are adhesive to submersed aquatic vegetation (Härmä et al., 2008).*
- *Other temperatures beneficial to R. rutilus' survival are 8° to 28°C because they are known to thrive in those waters (Nõges and Jarvet 2005)*
- *Rutilus rutilus is found in a variety of waters such as the Baltic, Caspian, Black Sea and Aral Sea with a temperature tolerance of <12°C -28°C and an optimum growth temperature of 20-27°C (Linlokken et al., 2010)*

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

- *Rutilus rutilus prefers a diet consisting of primary producers and small plankton but can also widen its spectrum to things such as detritus in the presence of other competitors such as perch (Horppila 2000). It also likes to feed on algae, crustaceans, water plants and insect larvae based on the life stage it is in (Ferguson 2008).*
- *Rutilus rutilus has the ability to shift its diet from the littoral to the pelagic zones in order to avoid high predation and competition (Froese and Pauly 2015). Research in Finland showed that juvenile roach feed on zooplankton and switch their diet to plant material during their adult stage (Horppila 2000)*

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

- Rutilus rutilus *is a dominant competitor and it has been shown to reduce abundance of species such as Atlantic salmon, brown trout, pollan, and its biggest competitor, perch (Ferguson 2008).*
- Rutilus rutilus *can comprise up to 70% of the fish biomass due to the feeding habits that can directly and indirectly deplete food resources (Ferguson 2008, Griffiths 1997).*
- *Ireland had the latest invasion of* R. rutilus*, and it was found that zebra mussels act as a control for the roach population by eating the plankton which is the roach's primary food source (Minchin et al., 2003).*
- *After the introduction of* R. rutilus*, the once common tufted duck (*Aythya fuligula*) experienced a decline in their population (Winfield et al., 1992).*

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

- Rutilus rutilus *has a high fecundity that can vary with the different regions and habitats. In Ireland it was found to reproduce <100,000 eggs, which can tend to have dramatic variations from year to year (Ferguson 2008).*
- Rutilus rutilus *has a high fecundity compared to fish in the same taxon. Rutilus rutilus has a relative fecundity of 87 eggs/g (Jamet 1994) while* R. frisii kutum *has a relative fecundity of 57 eggs/g (Yousefian and Mosavi 2008).*

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

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

- *The roach has a high rate of reproduction and can spawn from April to June. It produces adhesive eggs that can stick to plants and stones in shallow waters (Ferguson 2008).*

- *Its schooling behavior can be beneficial by protecting its young and keeping the abundance high (Linlokken et al., 2010).*
- *The Great Lakes would provide an optimum habitat for reproduction because* R. rutilus *prefers ranges of 0 to 3.5ppt during its spawning season, therefore the freshwater of Great Lakes would be ideal (Härmä et al., 2008).*
- *Research has shown that* R. rutilus *spawns at temperatures between 8° -19.4 °C optimally (Nõges and Jarvet 2005).*

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 R. rutilus native range has been found to be in latitude 68-71°N, but can tolerate ranges of 71°N to 36°N (Froese and Pauly 2015). The Great Lakes latitudes are around 41° -49° N, which matches the ranges of the Caspian Sea (40° N), where R. rutilus can be found in high abundance.*
- *R. rutilus prefers backwaters or deep parts of lakes to live in over the winter (Froese and Pauly 2015).*
- *Climate, of locations where R. rutilus is documented, is highly matched with that of the continental United States (USFWS 2012).*
- *Rutilus rutilus is found in a variety of waters such as the Baltic, Caspian, Black Sea and Aral Sea. The Great Lakes and Ponto-Caspian region are climatically compatible,which is one of the contributing 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
	6

- *The Ponto-Caspian (Caspian, Azov, and Black seas) have similar climate and surface water temperature ranges as the Great Lakes (Grigorovich et al., 2003, Reid and Orlova 2002, USEPA 2008).*
- *Great Lakes underwent similar anthropogenic eutrophication as the Ponto-Caspian region (Reid and Orlova 2002).*
- *Rutilus rutilus primarily occurs in brackish and estuarine waters, but it has become abundant in the freshwater Lower Lough Erne (Griffiths 1997).*

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

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

- *Although this species prefers mainly lowland areas, it can also be seen abundantly in nutrient-rich lakes and large to medium sized rivers and backwaters (Froese and Pauly 2015). Roach prefer eutrophic lakes because it gives them the benefit to capture more zooplankton because of their ability to switch from submerged vegetation to primary producers in the instance of increased turbidity or decrease in vegetation (Horppila et al., 2000). Adult roach will move to the pelagic zone during growing season in the early summer due to metabolic requirements and feeding habits (Horppilla et al., 2000).*

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

- *Climate change would be beneficial in many ways for adult roach. Studies have shown that with increasing temperatures, shorter winters, and lower salinity,* R. rutilus *is able to spawn sooner for longer periods of time (Nõges and Jarvet 2005)*
- *Predictions on how climate change affects* R. rutilus *are contradictory (Härmä et al., 2008). Shorter duration of ice cover and warmer temperatures may benefit reproductive success; however, salinity negatively impacts embryonic development, so salinization may reduce its ability to establish in the Great Lakes.*

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

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

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

- Rutilus rutilus *initially feeds on plankton and in the case of predators or other environmental changes, it can broaden their feeding range. Being an omnivorous fish, it has the advantage to feed on zooplankton, zoobenthos, detritus, macrophytes, and aquatic vegetation (Horpilla et al., 2000; Winfield 1986).*
- *In eutrophic lakes, in the presence of predators or other competitors such as perch,* R. rutilusis *able to switch to detritus and primary producers (Horppila et al., 2000).*

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*

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
	6

- *Feeds on zebra mussels (Lappalainen et al., 2005)*

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%

- *Stokes et al., (2006) suggest that the recent invasion of zebra mussels may reduce plankton and somewhat control* R. rutilus *populations, but there is no current evidence that this is effective at reducing* R. rutilus *populations.*

PROPAGULE PRESSURE

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

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

- *Typically introduced for sportfishing or accidentally when used as bait (USFWS, 2019) Not currently found anywhere in the United States.*

HISTORY OF INVASION AND SPREAD

B16) 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

- *Roach has been introduced to Spain, northern Italy, Ireland, the Lakes region of the United Kingdom, the Azores Islands, Portugal, Kazakhstan, Cyprus, Morocco, Australia, and Madagascar (USFWS 2012).*
- Rutilus rutilus *is established and expanding in almost all introduced locations except for Madagascar (Froese and Pauly 2015).*

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

- *The first roach in the Erne river system was collected in 1963, and by 1966 roach were common (Mercer, 1968; Kennedy and Fitzmaurice, 1973). By 1973, they had colonised the entire upper Erne system, and rapidly became the dominant fish by biomass in the whole system (Cragg-Hine, 1973; Rosell, 1994).*

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

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

No control methods have been set to prevent the establishment and/or spread of this species	0
Unknown	U
	0

- *No control methods present.*

Establishment Potential Scorecard				
Points	**Probability for Establishment**	Total Points (pre-adjustment)		105
>100	High	Adjustments		
		Critical species	A (1- 0%)	105
51-99	Moderate	Natural enemy	B (1-10%)	89.5
		Control measures	C (1-0%)	**89.5**
0-50	Low	Probability for Establishment		Moderate
# of questions answered as "unable to determine"	**Confidence Level**			
0-1	High	Total # of questions unknown		0
2-5	Moderate			
6-9	Low	Confidence Level		High
>9	Very low			

Qualitative Statements for GLANSIS Fact Sheet:

Rutilus rutilus has a moderate probability of establishment if introduced to the Great Lakes (Confidence level: high).

Section C: Potential for Impact

IMPACT POTENTIAL RESULTS

Environmental: High
Socio-Economic: Moderate
Beneficial: High

POTENTIAL BENEFICIAL EFFECT

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

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

Yes, it has succeeded significantly as a control agent	6

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

- *Not reported.*

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

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

- *There is only little commercial fishing for this species, but valued for recreational fishing (Froese and Pauly 2019).*

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

- *Freshwater angling tourists visit Ireland seeking high-quality roach (Hickley and Tompkins, 1998).*

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

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

- *Not reported.*

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

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

- *Not reported.*

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

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

- *Not reported.*

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

5.0 REFERENCES

Adams, S., G. A. Schuster, and C. A. Taylor. 2010. Orconectes limosus. The IUCN Red List of Threatened Species, version 2015.1. Available: http://www.iucnredlist.org/details/153764/0. (Accessed: October 2, 2018).

Ahyong, S. T., and D.C. Yeo. 2007. Feral populations of the Australian red-claw crayfish (Cherax quadricarinatus von Martens) in water supply catchments of Singapore. *Biological Invasions.* 9(8): 943-946.

Alas ¸, A., and Solak, K. 2004. The reproductive biology of the Tench (*Tinca tinca L.*,1758) in Kayabog˘azi (Kütahya, Turkey) Dam Lake. Turk. *J. Vet. Anim. Sci.* 28:879–885.

Alderman, D. J. 1996. Geographical spread of bacterial and fungal diseases of Crustaceans. *Reviews of the Science and Technology Office for International Epizootiology*. 15:603-632.

Aldridge, D. 2011. Spinycheek crayfish, *Orconectes limosus*. GB Non-native species secretariat.Available: http://www.nonnativespecies.org/factsheet/downloadFactsheet.cfm?speciesId=2441. (Accessed: October 1, 2018).

Anson, K. J., and D.B. Rouse. 1994. Effects of Salinity on Hatching and Post-Hatch Survival of the Australian Red Claw Crayfish Cherax quadricarinatus. *Journal of the World Aquaculture Society.* 25(2): 277-280.

Austin, C.M., C. Jones and M. Wingfield. 2009. Cherax quadricarinatus. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.1. Available: www.iucnredlist.org. Accessed October 2018.

Australian Bureau of Rural Sciences. 2008. CLIMATCH. Available: https://climatch.cp1.agriculture.gov.au/climatch.jsp (April 2014, June 2015).

Australian Bureau of Rural Sciences. 2010. CLIMATCH. Available https://climatch.cp1.agriculture.gov.au/climatch.jsp. 7 August 2014.

Avlijaš, S., A. Ricciardi, and N. Mandrak. 2018. Eurasian tench (Tinca tinca): the next Great Lakes invader. *Canadian Journal of Fisheries and Aquatic Sciences*. 75:169-179

Balashev, L.S., N.A. Parakhonskaja. 1977. Extension of Typha laxmannii Lepech. Area of distribution in the south of the Ukrainian SSR in connection with construction of large canals. *Ukrain'skyi Botanichnyi Zhurnal.* 34(6):612-616.

Banarescu, P., and B.W. Coad. 1991. Cyprinids of Eurasia, In: Cyprinid Fishes: Systematics, Biology, and Exploitation. Chapman & Hall, London: 127-155

Baryla, J., E. Broz, A. Czylok, A. Michalewska, A. Nikel, M. Nobis, R. Piwowarczyk, A. Poloczek. 2005. Typha laxmannii Lepech. The new, expansive kenophyte in Poland: distribution and taxonomy. *Acta Societatis Botanicorum Poloniae.* 74(1):25-28.

Baughman, J.L. 1947. The tench in America. *Journal of Wildlife Management.* 11(3): 197-204.

Beklioglu, M.,and B. Moss. 1998. The effects of tench (Tinca tinca(L.)) and sticklebacks (Gasterosteus aculeatusL.) on planktonic and benthic communities in mesocosms in a shallow lake. *Aquatic Ecology.* 32: 229-240.

Berg, L.S. 1949. The freshwater fishes of the USSR and adjacent countries. 4th edition. Academy of Sciences of the USSR, Moscow.

Buřič, M., M. Hulák, A. Kouba, A. Petrusek, and P. Kozák. 2011. A successful crayfish invader is capable of facultative parthenogenesis: a novel reproductive mode in decapod crustaceans. *PLoS One.* 6(5):e20281.

CABI, 2019. *Ludwigia grandiflora* [original text by A. Mikulyuk]. In: Invasive Species Compendium. Wallingford, UK: CAB International. www.cabi.org/isc.

CABI. 2014. *Astacus astacus*. Centre for Agricultural Bioscience International, Wallingford,UK. Available: http://www.cabi.org/isc/datasheet/92629. (April 2014, June 2015).

Carter, V., R. Pierce, S. Dufour, C. Arme, and D. Hoole. 2005. The tapeworm *Ligula intestinalis* (Cestoda: Pseudophyllidea) inhibits LH expression and puberty in its teleost host, Rutilus rutilus. *Reproduction* 130(6): 939-945.

Cocking, A.W. 1958. The effects of high temperatures on roach (*Rutilus rutilus*) I. The effects of constant high temperatures. *Journal of Experimental Biology*. 36: 203-216.

COSEWIC 2006. COSEWIC assessment and update status report on the river redhorse Moxostoma carinatum in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 31 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

Coughran, J., and S. Leckie. 2007. Pest or Guest: the zoology of overabundance. Royal Zoological Society of New South Wales, Mosman, NSW. ISBN: 978-0-9803272-1-2

Cragg-Hine, D. 1973. Coarse fish and fishery management in Northern Ireland. Proceedings of the 6th British Freshwater Fisheries Conference, University of Liverpool.

Crandall, K. A., S. De Grave. 2017. An updated classification of the freshwater crayfishes (Decapoda: Astacidea) of the world, with a complete species list. J*ournal of Crustacean Biology*. 37(5), 615-653.

Crawford, L., W.E. Yeomans, and C.E. Adams. 2006. The impact of introduced signal crayfish Pacifastacus leniusculus on stream invertebrate communities. *Aquatic Conservation*. 16: 611-626.

DAISIE. 2011. Typha laxmannii. Retrieved September 21, 2011 from: https://www.gbif.org/species/5289503

Dandelot, S., C. Robles, N. Pech, A. Cazaubon, and R. Verlaque. 2008. Allelopathic potential of two invasive alien *Ludwigia spp. Aquatic Botany*. 88: 311-316

Dandelot, S., R. Verlaque, A. Dutarte, and A. Cazaubon. 2005. Ecological, dynamic and taxonomic problems due to *Ludwigia* (Onagraceae) in France. *Hydrobiologia*. 551:131-136

Dave's Garden. 2011. Graceful Cattail, Narrow-leaved European Cattail, Typha laxmannii. Retrieved September 21, 2011 from: http://davesgarden.com/guides/pf/go/62381

DeVaney, S.C., McNyset, K.M., Williams, J.B., Peterson, A.T., and Wiley, E.O. 2009. A tale of four "carp": invasion potential and ecological niche modeling. PLoSONE,4(5): e5451. doi:10.1371/journal.pone.0005451. PMID:1942131

EDDMapS. 2019. Early Detection & Distribution Mapping System. The University of Georgia - Center for Invasive Species and Ecosystem Health. Available online at http://www.eddmaps.org; last accessed April 16, 2019.

Edsman, L., L. Füreder, F. Gherardi, and C. Souty-Grosset. 2010. *Astacus astacus*. The IUCN Red List of Threatened Species, version 2015.1. Available: http://www.iucnredlist.org/details/2191/0. (June 2015).

Encyclopedia of Life (EOL). 2014. *Astacus astacus* Linnaeus, 1758. Available: http://eol.org/pages/1021866/details (April 2014, June 2015).

EPPO 2011. Current status of management actions on invasive alien plants in Poland. Retrieved September 21, 2011 from: http://archives.eppo.org/EPPOReporting/2011/Rse-1105.pdf

EPPO 2011. *Ludwigia grandiflora and L. peploides* Onagraceae – Water primroses. OEPP/EPPO Bulletin 41, 414–418

Everard, M. 2013. Britain's Freshwater Fishes. Princeton University Press, Princeton, NJ, pp. 54-56.

FAO. 2011-2013. Cultured Aquatic Species Information Programme. Cherax quadricarinatus. Cultured Aquatic Species Information Programme. Text by Jones, C. In: FAO Fisheries and Aquaculture Department [online]. Rome. Updated 13 January 2011. [Cited 6 September 2013], http://www.fao.org/fishery/culturedspecies/Cherax_quadricarinatus/en.

Findlay, John & Riley, William & Lucas, Martyn. (2014). Signal crayfish (Pacifastacus leniusculus) predation upon Atlantic salmon (Salmo salar) eggs. *Aquatic Conservation: Marine and Freshwater Ecosystems*. 25. 10.1002/aqc.2480.

Freeman, M.A. J.F. Turnbull, W.E. Yeomans, and C.W. Bean. 2010. Prospects for management strategies of invasive crayfish populations with an emphasis on biological control. *Aquatic Conservation: Marine and Freshwater Ecosystems.* 20:211-223.

Freyhof, J. & Kottelat, M. 2008. *Tinca tinca*. *The IUCN Red List of Threatened Species* 2008: e.T21912A9339248. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T21912A9339248.en.

Froese, R., and D. Pauly, editors. 2019. *Rutilus rutilus* (Linnaeus, 1758). FishBase. Available: https://www.fishbase.de/summary/Rutilus-rutilus.html. 20 September 2019.

Fuller, L.M., and Taricska, C.K., 2012, Water-quality characteristics of Michigan's inland lakes, 2001–10: U.S. Geological Survey Scientific Investigations Report 2011. 5233, 53 p.

Fusaro, A. Emily Baker, Whitney Conard, Alisha Davidson, Kyle Dettloff, Jane Li, Gabriela Núñez, Rochelle Sturtevant, Ed Rutherford. A Risk Assessment of Potential Great Lakes Aquatic Invaders. NOAA TM-169.

Gallardo, B., and D. Aldridge. 2013. The 'dirty dozen': socio-economic factors amplify the invasion potential of 12 high-risk aquatic invasive species in Great Britain and Ireland. *Journal of Applied Ecology.* 50: 757-766

Geeraerts, C., M. Ovidio, H. Verbiest, D. Buysse, J. Coeck, C. belpaire, and J. Philippart. 2007. Mobility of individual roach *Rutilus rutilus* (L.) in three weir-fragmented Belgian rivers. *Hydrobiologia.* 582: 143-153

Geraudie, P., M. Gerbron, E. Hill, and C. Minier. 2010. Roach (*Rutilus rutilus*) reproductive cycle: a study of biochemical and histological parameters in a low contaminated site. *Fish Physiol Biochem.* 36: 767-777.

Tinca tinca (Linnaeus, 1758) in GBIF Secretariat (2019). GBIF Backbone Taxonomy. Checklist dataset https://doi.org/10.15468/39omei Accessed via GBIF.org. (August 2014).

Astacus astacus (Linnaeus, 1758) in GBIF Secretariat (2019). GBIF Backbone Taxonomy. Checklist dataset https://doi.org/10.15468/39omei accessed via GBIF.org. (April 2014, June 2015).

Global Invasive Species Database (2020) Species profile: *Tinca tinca.* Downloaded from http://www.iucngisd.org/gisd/species.php?sc=618. (August2014).

Global Invasive Species Database (2020) Species profile: *Pacifastacus leniusculus*. Downloaded from http://www.iucngisd.org/gisd/species.php?sc=725. (June 2015).

Griffiths, D. 1997. The status of the Irish freshwater fish fauna: a review. *J. Appl. Ichthyol*. 13: 9-13.

Griffiths, S. W., P. Collen, and J. D. Armstrong. 2004. Competition for shelter among over-wintering signal crayfish and juvenile Atlantic salmon. *Journal of Fish Biology*. 65(2):437-44

Guan, R-Z., and P. R. Wiles. 1997. Ecological impact of introduced crayfish on benthic fishes in a British lowland river. *Conservation Biology*. 11(3):641-647.

Gürbüz, Ö. A. (2011). Age and reproduction features of Tench (Tinca tinca) (L., 1758)) from Hirfanli dam lake, Kirsehir, Turkey. Journal of FisheriesSciences.Com, 5(2), 153-163.

Hamdi, S., M. Assadi, A. Iranbakhsh. 2010. Micromorphological studies on leaf, fruit and pollen of four species from Typhaceae (*Typha laxmannii, T. azerbaijanensis, T. minima and T. lugdunensis*) from Iran, and their thematic significance. *Acta Biologica Szegediensis*. 54(2):117- 125.

Härmä, M., A. Lappalainen, and L. Urho. 2008. Reproduction areas of roach (*Rutilus rutilus*) in the northern Baltic Sea: potential effects of climate change. *Canadian Journal of Fisheries and Aquatic Sciences.* 65: 2678-2688.

Hein, C., J. Vander Zanden, J.J. Magnuson. 2007. Intensive trapping and increased fish predation cause massive population decline of an invasive crayfish. *Freshwater Biology.* 52(6): 1134-1146

Hirsch, P. E., and P. Fischer. 2008. Interactions between native juvenile burbot (*Lota lota*) and the invasive spinycheek crayfish (*Orconectes limosus*) in a large European lake. *Canadian Journal of Fisheries and Aquatic Sciences*. 65(12):2636-2643.

Hogan, C.M. 2008. Signal Crayfish Pacifastacus leniusculus. Encyclopedia of Life. Available: https://eol.org/pages/1021882/articles

Holdich, D., and J. Black. 2007. The spiny-cheek crayfish, *Orconectes limosus* (Rafinesque, 1817) [Crustacea: Decapoda: Cambaridae], digs into the UK. *Aquatic Invasions*. 2(1):1-15.

Horoszewicz, L. 1983. Reproductive rhythm in Tench, *Tinca tinca* (L.), in fluctuating temperatures. *Aquaculture.* 32(1-2):79-92.

Horppila, J., and T. Kairesalo. 1992. Impacts of bleak (*Alburnus alburnus*) and roach (*Rutilus rutilus*) on water quality, sedimentation, and internal nutrient loading. *Hydrobiologia*. 243-244(1): 323-331.

Horppila, J., and T. Kairesalo. A fading recovery: the role of roach (*Rutilus rutilus* L.) in maintaining high phytoplankton productivity and biomass in Lake Vesijärvi, southern Finland. *Hydrobiologia. 200-201: 153-165.*

Horppila, J., J. Ruuhijärvi, M. Rask, C. Karppinen, K. Nyberg, and M. Olin. 2000. Seasonal changes in the diets and relative abundances of perch and roach in the littoral and pelagic zones of a large lake. *Journal of Fish Biology.* 56: 51-72.

Hyatt, W. Matthew. 2004. Investigation of Crayfish Control Technology. Arizona Game and Fish Department. Pheonix, AZ.

Integrated Taxonomic Information System (ITIS). 2014. *Astacus astacus*. Integrated Taxonomic Information System, Reston, Virginia. Available: http://www.itis.gov/servlet/SingleRpt/SingleRpt?search_topic=TSN&search_value=9733. (April 2014, June 2015).

Invasive Alien Species – NOBANIS www.nobanis.org, (November 5, 2018)

Jamet, J.L., and F. Desmolles. 1994. Growth, reproduction, and condition of roach (*Rutilus rutilus* (L.)), perch (*Perca fluviatilis*, L.) and ruffe (*Gymnocephalus cernuus* (L.)) in eutrophic Lake Aydat (France). *Internat. Rev. ges. Hydrobiol.* 70(2): 305-322.

Jiravanichpaisal, P., K. Söderhäll, and I. Söderhäll. 2004. Effect of water temperature on the immune response and infectivity pattern of white spot syndrome virus (WSSV) in freshwater crayfish. *Fish & Shellfish Immunology*. 17(3):265-275.

Johnsen, S.I. and Taugbøl, T. (2010): NOBANIS – Invasive Alien Species Fact Sheet –Pacifastacus leniusculus.–From: Online Database of the European Network on

Kargıoğlu, M., Cenkci, S., Serteser, A., Evliyaoğlu, N., Konuk, M., Kök, M.Ş. and Bağcı, Y. 2008. An Ethnobotanical Survey of Inner-West Anatolia, Turkey. *Human Ecology* 36: 763-777.

Kolar, C.S., and D.M. Lodge. 2002. Ecological predictions and risk assessment for alien fishes in North America. Science 298: 1233-1236.

Lambert, E., A. Dutarte, J. Coudreuse, and J. Haury. 2010. Relationships between the biomass production of invasive *Ludwigia* species and physical properties of habitats in France. Hydrobiologia 656: 173-186

Lappalainen, A., M. Rask, H. Koponen, and S. Vesala. 2001. Relative abundance, diet, and growth of perch (*Perca fluviatilis*) and roach (*Rutilus rutilus*) at Tvärminne, northern Baltic Sea, in 1975 and 1997: responses to eutrophication? *Boreal Environment Research*. 6: 107-118.

Lappalainen, A., M. Westerbom, and O. heikinheimo. 2005. Roach (Rutilus rutilus) as an important predator on blue mussel (*Mytilus edulis*) populations in a brackish water environment, the northern *Baltic Sea. Marine Biology.* 147: 323-330.

Lewis, S. D. 2002. Pacifastacus, in Holdich, D. M. (Ed.), Biology of freshwater crayfish. Blackwell Science, Oxford: 511-540

Longshaw, M. 2011. Diseases of crayfish: a review. *Journal of Invertebrate Pathology*. 106(1):54-70.

Mann, R.H.K. 1996. Environmental requirements of European non-salmonoid fish in rivers. *Hydrobiogia*. 323: 223-235.

Manual of the Alien Plants of Belgium. 2011. *Typha laxmannii*. Retrieved September 21, 2011 from: http://alienplantsbelgium.be/content/typha-laxmannii .

Marcogliese, D., Gendron, A., and Dumont, P. 2009. Parasites of illegally intro-duced Tench (Tinca tinca) in the Richelieu River, Quebec, Canada. *Comp. Parasitol*.76: 222–228. doi:10.1654/4362.1

Masser, M.P. and D.B. Rouse. 1997. Australian red claw crayfish. Southern Regional Aquaculture Center. SRAC Publication No. 244. 8 pp.

Mavrodiev E.V. 2000. Typha X smirnovii E. Mavrodiev (T. latifolia L. S. Str. X T. laxmannii Lepechin) and some other cattails from Russian Southeast. *Byulleten' Moskovskogo Obshchestva Ispytatelei Prirody Otdel Biologicheskii*. 105(4):65-69.

McAllister, H.A. 1999. *Lysimachia punctata L.* and *L. verticillaris Sprengel* (Primulaceae) naturalised in the British Isles. *Watsonia*. 22: 279-28.

Medley P.B., R.G. Nelson, L.U. Hatch, D.B. Rouse, and G.F. Pinto. 1994. Economic feasibility and risk analysis of Australian red claw crayfish Cherax quadricarinatus aquaculture in the southeastern United States. *Journal of the World Aquaculture Society*. 25(1):135-146.

Missouri Botanical Garden. 2019. *Lysimachia punctata*. http://www.missouribotanicalgarden.org/PlantFinder/PlantFinderDetails.aspx?taxonid=285541

Missouri Botanical Garden. 2019. *Typha laxmanii.* Retrieved from: http://www.missouribotanicalgarden.org/PlantFinder/PlantFinderDetails.aspx?kempercode=a647

Moorhouse, T.P., A.E. Poole, L.C. Evans, D.C. Bradley, and D.W. Macdonald. 2014. Intensive removal of signal crayfish (Pacifastacus leniusculus) from rivers increases numbers and taxon richness of macroinvertebrate species. *Ecology and Evolution.* 4(4): 494-504.

Moorhouse, TP., A.E. Poole, L.C. Evans, D.C. Bradley, D.W. Macdonald. Intensive removal of signal crayfish (*Pacifastacus leniusculus*) from rivers increases numbers and taxon richness of macroinvertebrate species. *Ecology and Evolution.* 4(4): 494-504.

Moshiri, G.A. C.R. Goldman, G.L. Godshalk, and D. R. Mull. 1970. The effects of variations in oxygen tension on certain aspects of respiratory metabolism in *Pacifastacus leniusculus* (Dana) (Crustacea: Decapoda). *Physiological Zoology.* 43:1, 23-29

National Ballast Information Clearinghouse 2009. NBIC Online Database. Electronic publication, Smithsonian Environmental Research Center & United States Coast Guard. Available from http://invasions.si.edu/nbic/search.html; Searched 5 August 2014.

Nico, L., P. Fuller,and M.Neilson. 2014. *Tinca tinca.* USGS Nonindigenous Aquatic Species Database, Gainesville, Florida. Available: http://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=652.

Nobis, M., A. Nobis, A. Nowak. 2006. Typhetum laxmannii (Ubrizsy 1961) Nedelcu 1968 – the new plant association in Poland. *Acta Societatis Botanicorum Poloniae*. 75(4):325-332.

Okada, M., B. Grewell, M. Jasieniuk. 2009. Clonal spread of invasive *Ludwigia hexapetala* and *L. grandiflora* in freshwater wetlands of California. *Aquatic Botany*. 91: 123-129.

Pârvulescu, L., A. Schrimpf, E. Kozubíková, S.C. Resino, T. Vrålstad, A. Petrusek and R. Schulz. 2012. Invasive crayfish and crayfish plague on the move: first detection of the plague agent *Aphanomyces astaci* in the Romanian Danube. *Diseases of Aquatic Organisms.* 98:85-94.

Patillo, A. 2010. Improving Redclaw Crayfish (*Cherax quadricarinatus*) Aquaculture: Assessment of Invasive Impacts and Production of All-male Broods. Auburn University Department of Fisheries and Aquaculture.

Peay S, Hiley PD (2001) Eradication of alien crayfish. Phase II. Environment Agency Technical Report W1–037/TR1. Environ Agency, Bristol. 118 pp..

Peay, S. 2009. Invasive non-indigenous crayfish species in Europe: Recommendations on managing them. *Knowledge and Management of Aquatic Ecosystems*. 394-395.

Plants for a Future Database. 2010. Typha laxmannii – Lepech. Retrieved September 21, 2011 from: http://www.pfaf.org/user/Plant.aspx?LatinName=Typha+laxmannii.

Rejamánková, E. 1992. Ecology of creeping macrophytes with special reference to *Ludwigia peploides* (H.B.K.) Raven. *Aquatic Botany*. 43: 283–299.

Ruaux, B., S. Greulich, J. Haury, and J. Berton. 2009. Sexual reproduction of two alien invasive *Ludwigia* (Onagraceae) on the middle Loire River, France. *Aquatic Botany*. 90: 143-148

Rubino, M., N. Alon, C. Wilson, D. Rouse and J. Armstrong. 1990. Marron aquaculture research in the United States and the Caribbean. *Aquacult. Mag.* 16(3):27-44

Sabapathy, U. S. 2014. *Tinca tinca* (Tench). CAB International, Wallingford, United Kingdom. Available: http://www.cabi.org/isc/datasheet/61160. (August 2014)

Sanders, S., C. Castiglione, and M. Hoff. 2014. Risk Assessment Mapping Program: RAMP. US Fish and Wildlife Service.

Sandodden, R., and S. I. Johnsen. 2010. Eradication of introduced signal crayfish Pacifastacus leniusculus using the pharmaceutical BETAMAX VET ®. *Aquatic Invasions*. 5-1: 75-81.

Sandström, A., and P. Karås. 2002. Effects of eutrophication on young-of-the-year freshwater fish communities in coastal area of the Baltic. *Environ. Biol. Fishes.* 63(1): 89-101.

Schrimpf, A., C. Chucholl, T. Schmidt, and R. Schulz. 2013. Crayfish Plague agent detected in populations of the invasive North American crayfish *Orconectes imunis* (Hagen, 1870) in the Rhine River, Germany. Aquatic Invasions 8(1): 103-109

Schuster, G. A., C. A. Taylor, and J. Cordeiro. 2010. Pacifastacus leniusculus. The IUCN Red List of Threatened Species, version 2015.1. Available: http://www.iucnredlist.org/details/153648/0. (June 2015).

Sheppard, A., R. Shaw, R. Sforza. 2006. Top 20 environmental weeds for classical biological control in Europe: a review of opportunities, regulations and other barriers to adoption. *Weed Research*. 46: 93-117

Souty-Grosset, C., D. M. Holdich, P. Y. Noël, J. D. Reynolds, and P. Haffner, editors. 2006. Atlas of crayfish in Europe. Muséum National d'Histoire Naturelle, Paris.

Stace, C. A. (2010). New Flora of the British Isles (Third ed.). Cambridge, U.K.: Cambridge University Press. ISBN 9780521707725.

Stiers, I., K. Coussement, and L, Triest. 2014. The invasive aquatic plant *Ludwigia grandiflora* affects pollinator visitants to a native plant at high abundances. *Aquatic Invasions*. 3: 357-367

Stiers, I., N. Crohain, G. Josens, L. Triest. 2011. Impact of three aquatic invasive species on native plantsand macroinvertebrates in temperate ponds. *Biological Invasions*. 13: 2715-2726

Stokes, K., K. O'Neill, and R. McDonald. 2006. Invasive species of Ireland. Unpublished report to Environment & Heritage Service and National Parks & Wildlife Service. Quercus, Queens University Belfast, Belfast.

Stueber, K. 2003. Retrieved September 21, 2011 from: http://www.biolib.de/.

Thouvenot, L., C. Puech, L. Martinez, J. Haury, G. Thiebaut. 2013. Strategies of the invasive macrophyte *Ludwigia grandiflora* in its introduced range: Competition, facilitation or coexistence with native and exotic species? *Aquatic Botany*. 107: 8-16

Thurston County Noxious Weed Control. 2016. Garden Loosestrife (*Lysimachia vulgaris*). https://www.growsmartgrowsafe.org/Documents/IPM/Garden%20Loosestrife_2016.pdf

United States Department of Agriculture, Natural Resource Conservation Service. 2011. The PLANTS Database. National Plant Data Center, Baton Rouge, LA, USA. Retrieved September 21, 2011 from: http://plants.usda.gov/java/profile?symbol=TYPHA.

United States Fish and Wildlife Service. 2015 Spiny-Cheek Crayfish (*Orconectes limosus*) Ecological Risk Screening Summary. (Accessed: September 29, 2018).

USDA, ARS, National Genetic Resources Program. Germplasm Resources Information Network - (GRIN) [Online Database]. National Germplasm Resources Laboratory, Beltsville, Maryland. Retrieved September 21, 2011 from: http://www.ars-grin.gov/cgibin/npgs/html/taxon.pl?40801

USFWS. 2012. Australian Redclaw (Cherax quadricarinatus) Ecological Risk Screening Summary. Available: https://www.fws.gov/injuriouswildlife/pdf_files/Cherax_quadricarinatus_web_9-18-12.pdf Accessed: October 2018

USFWS. 2014. Ecological Risk Screening Summary-Web Version. Available: https://www.fws.gov/fisheries/ans/erss/uncertainrisk/Tinca-tinca-WEB-09-05-2014.pdf

Vidéki, R. 2009. Typha laxmannii. Retrieved September 21, 2011 from: Bugwood.org

Vojkovská, R., I. Horká, and Z. Ďuriš. 2014. The diet of the spiny-cheek crayfish *Orconectes limosus* in the Czech Republic. Central European Journal of Biology. 9(1): 58-69.

Volta, P., and N. Jepsen. 2008. The recent invasion of *Rutilus rutilus* (L.) (Pisces: Cyprinidae) in a large south-alpine lake: Lake Maggiore. *J. Limnol.* 67(2): 163-170.

Williams, E.H., Jr., L. Bunkley-Williams, C.G. Lilyestrom and E.A.R. Ortiz-Corps. 2001. A review of recent introductions of aquatic invertebrates in Puerto Rico and implications for the management of nonindigenous species. *Caribbean Journal of Science*. 37(3-4):246-251.

Winfield, I.J., D.K. Winfield, and C.M. Tobin. 1992. Interactions between the roach, *Rutilus rutilus*, and waterfowl populations of Lough Neagh, Northern Island. *Environmental Biology of Fishes*. 33(1-2): 201-214.

Winfield, I.J., J.M. Fletcher, and J. Ben James. 2008. The Arctic charr (*Salvelinus alpinus*) populations of Windermere, UK: population trends associated with eutrophication, climate change, and increased abundance of roach (Rutilus rutilus). *Environmental Biology of Fishes.* 83: 23-35.

Wingfield, M. 2002. An overview of the Australian freshwater crayfish farming industry. *Freshwater Crayfish*. 13: 177-184.

Wisconsin Department of Natural Resources. 2016. Wisconsin Water Quality Report to Congress 2016. Division of Environmental Management.

Wisconsin Department of Natural Resources. 2017. Graceful Cattail/*Typha laxmanii*. Retrieved from: https://dnr.wi.gov/topic/Invasives/fact/GracefulCattail.html

Yousefian, M., and H. Mosavi. 2008. Spawning of South Caspian Kutum (*Rutilus frisii kutum*) in most migratory river of South Caspian Sea. *Asian Journal of Animal and Veterinary Advances*. 1-6.

Zuckerman, L.D., and R.J. Behnke. 1986. Introduced fishes in the San Luis Valley, Colorado. Pages 435-452. R.H. Stroud, editor. Fish culture in fisheries management. Proceedings of a symposium on the role of fish culture in fisheries management at Lake Ozark, Missouri, March 31-April 3, 1985. American Fisheries Society, Bethesda, Maryland.