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2019 UPDATE TO "AN IMPACT ASSESSMENT OF GREAT LAKES AQUATIC NONINDIGENOUS SPECIES"

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Secretary

NATIONAL OCEANIC AND
ATMOSPHERIC ADMINISTRATION

Dr. Neil Jacobs,
Acting Administrator

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2019 UPDATE TO "AN IMPACT ASSESSMENT OF GREAT LAKES AQUATIC NONINDIGENOUS SPECIES"

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1.0 SUMMARY

This report includes all major updates to the earlier Risk Assessments on nonindigenous species conducted by the GLANSIS project during the 2019 calendar year. All new assessments were conducted following the same methods outlined in the original technical memorandum, NOAA Technical Memorandum GLERL-161 "An impact assessment of Great Lakes aquatic nonindigenous species" (Sturtevant et al, 2014). All re-assessments are based on new literature surveys using the original as a baseline and conducted to the same methods. All assessments were reviewed by members of the GLANSIS Team (according to expertise) and by select external reviewers. Results of each risk assessment are incorporated into the species profiles found on the GLANSIS website (www.glerl.noaa.gov/glansis/).

To be included in the GLANSIS nonindigenous list, the species in question must meet a particular set of criteria:

1. Records of the species appeared suddenly and had not been recorded in the basin previously;
2. It subsequently spreads within the basin.
3. Its distribution in the basin is restricted compared with native species.
4. Its global distribution is anomalously disjunct (meaning it contains widely scattered and isolated populations).
5. Its global distribution is associated with human vectors of dispersal.
6. The basin is isolated from regions possessing the most genetically and morphologically similar species.

Additionally, to be listed on the nonindigenous list rather than the GLANSIS Watchlist, a species must have a reproducing population within the basin that is capable of overwintering, as inferred from multiple discoveries of adult and juvenile life stages over at least two consecutive years.

A total of 82 species were reassessed in 2019, with 10 of those species undergoing changes detailed in the following sections of this document.

Grass carp *(Ctenopharyngodon idella)* was listed in NOAA Technical Memorandum GLERL -169b (Lower et al, 2019) as a watchlist species, but has since been moved to the nonindigenous list. Grass carp have been periodically found in the Great Lakes since the 1970s as a result of stocking triploids for control of aquatic plants, but the first diploid was not confirmed until 2011. Populations of diploid grass carp have been found in the Maumee and Sandusky Rivers, and are both overwintering and reproducing (producing viable eggs) in these waterways, meeting the criteria for inclusion on our list of nonindigenous species present within the Great Lakes basin. As such, *Ctenopharyngodon idella* was re-assessed using the methods for this list, and its new organism impact assessment score is included here in full.

Northern bur-reed (*Sparganium glomeratum*) was listed in Sturtevant et al. (2014) as a nonindigenous species and is now considered to be native to portions of Minnesota proximate to the Great Lakes basin, based on the most up-to-date species distribution maps. As such, this species is now considered a range expander rather than nonindigenous. It is retained in the GLANSIS system, but designated as a range expander and will no longer be included in updates to this tech memo series.

Sweetscent (*Pluchea odorata odorata* and *Pluchea odorata succulent*) were previously listed separately in GLANSIS and had separate assessments in Sturtevant et al. (2014) but are now listed together under *Pluchea odorata*. These two subspecies are both nonindigenous to the Great Lakes, but do not differ significantly in their ecology, habitat, niche, or impact within the Great Lakes, so they have been combined as a single species in this assessment.

The impact assessment scores for the other seven species were updated upon reassessment based on review of the more recent literature. Five species previously designated as 'current research is inadequate to support proper assessment' for one or more portions of the impact assessment were able to be scored in the reanalysis. The environmental impact score for chinook salmon (*Oncorhynchus tshawytscha*) was changed from moderate to high based on additional literature highlighting its impacts on native species, including direct competition with lake trout and other native species and top-down effects on forage fish (Bunnell et al. 2014), as well as having served as a vector for the disease *Renibacterium salmoninarum*, which is now considered to be widespread in the Great Lakes (GLFHC 2015). The socioeconomic impact score for fishhook waterflea (*Cercopagis pengoi*) was changed from low to high based on literature detailing the annual economic cost of damages caused by and mitigation of *C. pengoi* at $5 million USD (Pimentel et al., 2005).

Two species were re-named in this assessment. The quagga mussel (*Dreissena bugensis*) was renamed *Dreissena rostriformis bugensis*, which is the preferred scientific name according to the CABI Invasive Species Compendium. Spotted ladysthumb (*Polygonum persicaria*) is now listed as its alternate synonym *Persicaria maculosa*.

Seventy-two additional species were re-assessed during this period, but the qualitative impact assessment categories (high, medium, low, or unknown for environmental, socio-economic, or beneficial impacts) did not change for any of these additional species.

An updated version of Table 1 from Sturtevant et al. (2019) is presented on the next page. General changes to the table include a net overall loss of one species from the nonindigenous list based on addition of one fish species (*Ctenopharyngodon idella*), the reclassification of one plant as a range expander (*Sparganium glomeratum*), and the collapse of the two *Pluchea odorata* subspecies into a single entry.

Table 1. Summary of impact assessment results by taxonomic group. For each impact category (i.e. environmental, socio-economic, beneficial), the number of species whose impact was assessed as high (H), moderate (M), low (L), or unknown (U) is given. Note: "Arthropods" refers to non-crustacean arthropods. Relative to Sturtevant et al. (2014), "+" indicates an increase in the number of species in the category, while "-" indicates a decrease.

	Environmental				**Socio-Economic**				**Beneficial**			
Taxon	H	M	L	U	H	M	L	U	H	M	L	U
Fishes (n=28) (+1)	8	5	0(-)	14	3	1	19(-)	4	8	2	12(-)	5
Annelids (n=6)	0	0	0	6	0	0	6	0	0	0	5	1
Arthropods (n=2)	0	0	0	2	0	0	2	0	0	1	1	0
Bryozoans (n=1)	0	0	0	1	0	0	0	1	0	0	1	0
Coelenterates (n=2)	0	0	0	2	0	0	1	1	0	0	2	0
Crustaceans (n=24)	2	2(+)	0	20(+)	0	1(+)	21(+)	2	0	1(+)	20(+)	3(+)
Mollusks (n=18)	3	2	1	12	2	2	11	3	0	0	16	2
Plants (n=55) (-2)	6(+)	20(+)	3	28	4	9(+)	41(+)	3	4	15(+)	33	5
Algae (n=27)	0	4	20	3	1	3	23	0	0	1	26	0
Amoebae (n=3)	0	0	0	3	0	0	3	0	0	0	3	0
Parasites and Diseases (n=20)	7	1	12	0	2	0	18	0	0	0	20	0
Total (n=186) (-1)	26(+)	34(+)	36(-)	91(+)	12	16(+)	145(+)	14	12	20(+)	139(+)	16(+)

In addition, none of the summary statements in the original Sturtevant et al. (2014) have substantively changed, and they are as follows:

1. Additional research is still needed to understand the environmental impacts of nonindigenous species. The state of knowledge is inadequate to assess the environmental impact for nearly half (now 48% instead of 49%) of the established species.
2. At least 32% (previously 31%) of the nonindigenous species found in the Great Lakes have significant (moderate to high) environmental impact. If the 91 species for which the state of scientific knowledge is insufficient to complete the assessment of environmental impact follow the trends of the assessed species this number will be closer to 50%. References in the literature (e.g., Williamson and Fitter 1996) and popular media of approximately 10% of non-native species becoming invasive is a severe underestimate for the Great Lakes.
3. We estimate between 14 and 16% of the nonindigenous species found in the Great Lakes have moderate to high socioeconomic impact.

Of the 32 species assessed as having significant (moderate to high) benefits, only one – *Puccinellia distans* – is still assessed as having low environmental and socioeconomic impact.

2.0 ADDENDA

Table 2. New species and major changes to the assessments, etc. originally published in Sturtevant et al. (2014).

Species	Addenda	Author, date added
Cercopagis pengoi	Socio-economic impacts changed from low to high.	Boucher, 2019
Ctenopharyngodon idella	Status changed from watchlist to nonindigenous list.	Boucher, 2019
Daphnia galeata galeata	Environmental impacts changed from unknown to high.	Boucher, 2019
Dreissena rostriformis bugensis	Species name change, scores unchanged from TM-161.	Sturtevant and Elgin, 2019
Hemimysis anomala	Environmental impacts changed from unknown to moderate	Boucher, 2019
Lepomis humilis	Beneficial impacts changed from unknown to low	Boucher, 2019
Oncorhynchus gorbuscha	Environmental impact changed from unknown to moderate.	Boucher and Lower, 2019
Oncorhynchus tshawytscha	Environmental impact changed from moderate to high.	Boucher and Lower, 2019
Pluchea odorata	Newly combined profile, scores unchanged.	Lower, 2019
~~*Pluchea odorata odorata*~~	**subspecies combined in one profile (*Pluchea odorata*)	Lower, 2019
~~*Pluchea odorata succulenta*~~	**subspecies combined in one profile (*Pluchea odorata*)	Lower, 2019
Persicaria maculosa	Species name changed from *Polygonum persicaria,* scores unchanged.	Lower, 2019
Schizopera borutzkyi	Environmental impacts changed from unknown to low.	Boucher, 2019

Table 3. Changes and additions to Tables 2-11 in Sturtevant et al. (2014).

Scientific Name	Common Name	Family	Environmental Impact		Socio-Economic Impact		Beneficial Impact	
			Score	# Unknown	Score	# Unknown	Score	# Unknown
Cercopagis pengoi	Fishhook waterflea	Cercopagidae	7	2	7	0	0	1
			High		High		Low	
Ctenopharyngodon idella	Grass carp	Cyprinidae	20	0	5	0	1	0
			High		Moderate		Low	
Daphnia galeata galeata	A waterflea	Daphniidae	7	0	0	0	0	0
			High		Low		Low	
Hemimysis anomala	Bloody red shrimp	Mysidae	3	2	0	1	1	0
			Moderate		Low		Low	
Lepomis humilis	Orange-spotted sunfish	Centrarchidae	0	2	0	1	0	0
			Unknown		Low		Low	
Oncorhynchus gorbuscha	Pink salmon	Salmonidae	3	2	1	0	2	0
			Moderate		Low		Moderate	
Oncorhynchus tshawytscha	Chinook salmon	Salmonidae	13	1	0	0	13	1
			High		Low		High	
Pluchea odorata	Sweetscent	Asteraceae	1	4	0	0	1	0
			Unknown		Low		Low	
Schizopera borutzkyi	An oarsman	Diosaccidae	0	1	0	0	0	1
			Low		Low		Low	

3.0 RISK ASSESSMENTS

Scientific Name: *Cercopagis pengoi*

Common Name: Fishhook waterflea

Organism Impact Assessment

IMPACT RESULTS

Environmental: High
Socio-Economic: High
Beneficial: Low

Comments: Socioeconomic impact score changed from low to high. Other scores unchanged.

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 AND/OR It has significantly affected human health in past invasions outside of the Great Lakes	1
Not significantly	0√
Unknown	U

- *Not reported.*

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

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

- *Not reported.*

Does it negatively affect water quality?

Yes, it has significantly affected water quality, and is costly or difficult to reverse	6
Yes, but the effects are negligible and/or easily reversed AND/OR It has a history of significantly affecting water quality in past invasions outside of the Great Lakes	1
Not significantly	0√
Unknown	U

- *Not reported.*

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

Yes, it has caused significant damage to one or more markets or economic sectors	6√
Yes, some damage to markets or sectors has been observed, but negative consequences have been small AND/OR It has a history of harming markets or economic sectors in past invasions outside of the Great Lakes	1
Not significantly	0
Unknown	U

- *Costs in damages and control associated with C. pengoi in the U.S. are currently estimated at about five million US dollars annually (Pimentel et al., 2005).*

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

- Cercopagis pengoi *fouls fishing lines, which acts both as a nuisance and as a possible mechanism of its dispersal and expansion. In a study by Jacobs and MacIsaac (2007), fouling was found to be most intense with longer lines and larger trolling distances; accumulation of* C. pengoion *a single fishing line towed 1 km in Lake Ontario was as high as 1,024 individuals and 106 diapausing eggs. Lines specially designed to reduce waterflea fouling experienced diminished* C. pengoi *accumulation (Jacobs and MacIsaac 2007).*

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

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

- *Not reported.*

Socio-Economic Impact Total	**7**
Total Unknowns (U)	**0**

Scientific Name: *Ctenopharyngodon idella*

Common Name: Grass carp

Organism Impact Assessment

IMPACT RESULTS

Environmental: High
Socio-Economic: Moderate
Beneficial: Low

Comments: This species was moved from the Watchlist to the Nonindigenous list in 2019.

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

- *Grass carp are known to be carriers of numerous parasitic organisms. Shireman and Smith (1983) thoroughly list a wide array of organisms, from viruses to protozoans to trematodes, which are parasites of Grass carp. Worth noting is* Bothriocephalus acheilognathi*, the Asian tapeworm. This parasite has been introduced by grass carp, to every continent except Antarctica (Bain 1993, Salgado-Maldonado and Pineda-Lopez 2003). Additionally, grass carp are the source of* Ergacilus *spp. in United Kingdom waters (Cowx 1997). However, disease and parasitism are not as prevalent in wild populations as in fish culture (Shireman and Smith 1983).*

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

- *Grass carp is known to out-compete native species for both food and habitat. Research in small closed systems has demonstrated that due to grass carp's preference for native aquatic plants over watermilfoil (*Myriophyllum *spp.); these fish compete with waterfowl, which feed on these plants as well (Fowler and Robson, 1978; McKnight and Hepp, 1995; Pine et al., 1990; Pine and Anderson, 1991).*

- *Furthermore, direct competition for plant material may also occur between grass carp and other native fishes that include macrophytes in their diet, such as gizzard shad (*Dorosoma cepedianum*), lake sturgeon (*Acipenser fulvescens*), as well as several species of buffalo (*Ictobius *spp.)(Cudmore and Mandrak, 2004; Coker et al., 2001).*
- *Grass carp may compete with planktonic and benthic species, including catfishes and hybrid sunfishes for aquatic plants (Shireman and Smith, 1983), especially during grass carp juvenile stages and at lower water temperatures (Fedorenko and Fraser, 1978).*
- *Direct competition for habitat has been found to occur between grass carp and other fish species, particularly bluegill. With their schooling habit, grass carp invade and disturb bluegill spawning areas, greatly reducing bluegill weight and numbers (Forester and Lawrence, 1978).*

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

- *Grass carp have environmental impacts on the ecosystems they have been introduced. For instance, grass carp is known to be the source of major alterations to the trophic structure and food chains of aquatic systems. Many of these changes in plant, invertebrate, and fish communities are largely secondary consequences of reductions in the density and composition of aquatic plant communities (Bain 1993, Cudmore and Mandrak 2004). When stocked at high densities, grass carp can eliminate all vegetation in even large aquatic systems (e.g., 8100-ha Lake Conroe, Klussman et al., 1988). Declines have occurred in the diversity and density of organisms that are dependent on structured littoral habitats and food chains based on plant detritus, macrophytes, and attached algae as a consequence of reduced plant surface habitat, increased invertebrate food supplies (i.e. plant detritus), altered substrate conditions, and increased dissolved oxygen conditions (Bain 1993, Martin and Shireman 1976, Vinogradov and Zolotova 1974).*

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 affecting native fish genetically.*

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

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

- *Grazing by grass carp has been associated with alterations of water quality. The decay of these large volumes of dead aquatic plants due to grass carp's grazing and waste production elevate nutrient levels in water, induce phytoplankton blooms, reduce water clarity, and decrease oxygen levels (Bain 1993, Boyd 1971, Vinogradov and Zolotova 1974).*

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 herbivorous grass carp has a significant impact on macrophyte communities through intense grazing pressure (Bain 1993).*

Environmental Impact Total	**20**
Total Unknowns (U)	**0**

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

- *Their contribution to increased algae blooms may affect drinking water quality.*

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

- *Has not been reported to damage 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

- *One of the undesirable consequences of stocking grass carp is increased turbidity, either algal or abiotic (Bonar et al. 2002, Lembi et al. 1978, Maceina et al. 1992, Water Environmental Services Incorporated 1994).*

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

- *When in excessive numbers it destroys existing food chain relationships (Petr and Mitrofanov 1998).*
- *May threaten yellow perch (*Perca flavescens*) spawning by consuming emerging macrophytes where Yellow perch lay their eggs (Kocovsky pers. com., 2019)*

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

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

- *May cause decline in recreational species through habitat modification, direct competition, or competition with species that act as forage fishes.*

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

- *Grazing can promote algal blooms and increased turbidity (Bonar et al., 2002; Lembi et al., 1978; Maceina et al., 1992; Water Environmental Services Incorporated 1994).*

Socio-Economic Impact Total	**5**
Total Unknowns (U)	**0**

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

- *Grass carp is being widely introduced throughout the United States to control aquatic vegetation in lakes and ponds (Chilton and Muoneke 1992, Page and Burr 1991). Grass carp can effectively control and eliminate aquatic plants in a variety of situations. Private fish farms have been producing large numbers of sterile, triploid grass carp as interest in stocking open systems increases (Bain 1993). Grass carp also are now routinely stocked in irrigation canals of the western United States (Bain 1993) and in Saskatchewan, Canada (Cudmore and Mandrak 2004).*
- *However, grass carp populations are below the necessary threshold to have an effect on submerged aquatic vegetation in the Great Lakes, and at the population level necessary to control SAV they could possibly contribute to eutrophication by releasing nutrients sequestered in wetlands (Cudmore and Mandrak, 2004).*

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 captured for food in its native range, however, they rarely comprise a large proportion of the catch and are taken incidentally in common or silver carp fisheries in the Amur basin (Shireman and Smith 1983)*
- *Not currently accepted as a food fish in the United States.*

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

- *No reported medicinal or research value.*

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

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

- *Not reported to remove toxins or pollutants from the water.*

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 ecological effects reported.*

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

Scientific Name: *Daphnia galeata galeata*

Common Name: A waterflea

Organism Impact Assessment

IMPACT RESULTS

Environmental: High
Socio-Economic: Low
Beneficial: Low

Comments: Environmental impacts changed from unknown to high.

ENVIRONMENTAL IMPACT

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

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

- *Not reported to threaten the health of native species.*

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

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

- *Hybrids appear much more successful than parents, as hybrids represented 90-100% of swarms in four 'mixed' lakes (Taylor and Hebert 1993).*

Does it alter predator-prey relationships?

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

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

- *The North American and European subspecies have hybridized in the Great Lakes basin. Morphologies and genetics of hybrid* D. g. galeata *x* D. g. mendotae *tend more toward the European* D. g. galeata *form in Lake Erie and more towards the North American* D. g. mendotae *form in the Lake Ontario drainage. Before, these populations were genetically distinct and mated non-randomly under sympatry. Hybrids appear much more successful than parents, as hybrids represented 90-100% of swarms in four 'mixed' lakes (Taylor and Hebert 1993).*

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

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

- *No reported effects on water quality.*

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

Yes, and it has had a widespread, long term, or severe negative effect on the physical ecosystem AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected the physical ecosystem to some extent, but the alterations and resulting adverse effects have been mild	1

AND/OR It has significantly altered physical ecosystems in past invasions outside of the Great Lakes	
Not significantly	0√
Unknown	U

Environmental Impact Total	**7**
Total Unknowns (U)	**0**

Scientific Name: *Hemimysis anomala*

Common Name: Bloody red shrimp

Organism Impact Assessment

IMPACT POTENTIAL RESULTS

Environmental: Moderate
Socio-Economic: Low
Beneficial: Low

Comments: Environmental impacts changed from unknown to 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√

- *A mysid introduction can increase the biomagnification of contaminants in piscivores through a lengthening of the food chain; for example, concentrations of polychlorinated biphenyls and mercury in fishes have been shown to be higher in lakes containing mysids than in mysid-free lakes (Cabana et al., 1994; cf. Rasmussen et al., 1990).*
- *Through direct transmission and indirect effects on the food web, introduced mysids may cause increased parasitism by nematodes, cestodes, and acanthocephalans in fishes (Lasenby et al., 1986; Northcote 1991).*

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

- Hemimysis anomalamay *compete with, or prey upon, other invertebrate predators, such as* Bythotrephes longimanus *and* Leptodora kindti*. Its omnivory may also reduce local phytoplankton if small-sized juvenile mysids are abundant (Ketelaars et al., 1999).*
- *Found to consume a broader diet than native zooplankton, including the ability to prey on larger diet items as juveniles (Evans et al., 2018).*
- *Displays high diet plasticity in the St. Lawrence River (Marty et al., 2012).*

Does it alter predator-prey relationships?

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

- *Based on its impacts in some European reservoirs (Ketelaars et al. 1999),* H. anomala *may reduce zooplankton biomass and diversity in invaded areas, with cladocerans, rotifers, and ostracods being most affected.*
- Hemimysis anomala *may compete with, or prey upon, other invertebrate predators, such as* Bythotrephes longimanus *and* Leptodora kindti. *Its omnivory may also reduce local phytoplankton if small-sized juvenile mysids are abundant (Ketelaars et al., 1999)*
- *Predatory functional responses were generally higher than those of the comparator native species (*Mysis salemaai and M. diluviana*). Had similar or higher attack rates, consistently lower prey handling times and higher maximum feeding rates compared to those of the two* Mysis *species, formerly known as* 'Mysis relicta'*, which itself has an extensive history of food web disruption in lakes to which it has been introduced. (Dick et al., 2012).*
- *In Europe,* Hemimysis *invasions have been associated with a decline in phytoplankton and zooplankton populations (Ketelaars etal., 1999), which in turn, may potentially lead to a reduction in energy flow to higher trophic levels of the food web (Marty et al., 2012).*
- *Sinclair et al., found* Hemimysis *strongly favors cladocerans over copepods due to copepods' stronger ability to avoid predation.*

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

- *Sinclair et al., (2016) demonstrated in a mesocosm experiment that* Hemimysis *predation selected for larger* Daphnia *spp.*

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√

- Hemimysis *feeds rapidly, even at low prey densities, and its fecal pellets may alter the local physico-chemical environment (Ketelaars et al., 1999; Olenin and Leppäkoski 1999; Pienimäki and Leppäkoski 2004).*

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	**3**
Total Unknowns (U)	**2**

Scientific Name: *Lepomis humilis*

Common Name: Orangespotted sunfish

Organism Impact Assessment

IMPACT POTENTIAL RESULTS

Environmental: Unknown
Socio-Economic: Low
Beneficial: Low

Comments: Beneficial impacts changed from unknown to low.

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

- *Consume mosquito larvae (Barney and Anson, 1923).*

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

- *Too small for commercial fishing, not a popular aquarium species.*

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

- *Smaller species than other centrarchids, not popular 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

- *No reported medicinal or research value.*

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

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

- *Not reported.*

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

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

- *Not reported.*

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

Scientific Name: *Oncorhynchus gorbuscha*

Common Name: Pink salmon

Organism Impact Assessment

IMPACT RESULTS

Environmental: Moderate
Socio-Economic: Low
Beneficial: Moderate

Comments: Environmental impact changed from unknown to moderate.

ENVIRONMENTAL IMPACT

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

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

- *Not reported.*

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

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

- *Pink salmon may displace native chubs by way of food competition and may also compete with native cisco (*Coregonus artedi*) (Becker 1983).*
- *Pink salmon has also been identified as utilizing spawning habitats similar to those used by brook trout (*Salvelinus fontinalis*), potentially providing another mechanism of competition (Kocik and Jones 1999).*

Does it alter predator-prey relationships?

Yes, and it has resulted in significant adverse effects	6

(e.g., added pressure to threatened/endangered species, significant reduction or extinction of any native species populations, creation of a dead end or any other significant alteration in the food web)	
Yes, and it has resulted in some noticeable stress to or decline of at least one native species 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

- *Individuals over one year old feed heavily on rainbow smelt (*Osmerus mordax*) and alewife (*Alosa pseudoharengus), *which are important components of the diets of other Great Lakes salmonids (Diana 1990; Kocik and Taylor 1987; Kocik et al., 1991).*

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

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

- *Genetic analysis of populations in the St. Marys River, Mich. indicates that pink salmon is capable of hybridizing with recreationally important chinook salmon (*Oncorhynchus tshawytscha*) (Kirkpatrick et al., 2007). Hybridization has the potential to create further competition for the parental species, especially since the hybrid appears to have growth rates that exceed those of pink and chinook salmon.*

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

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

- *Unknown.*

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

Yes, and it has had a widespread, long term, or severe negative effect on the physical ecosystem AND/OR	6

Yes, and it has resulted in significant negative consequences for at least one native species	
Yes, it has affected the physical ecosystem to some extent, but the alterations and resulting adverse effects have been mild AND/OR It has significantly altered physical ecosystems in past invasions outside of the Great Lakes	1
Not significantly	0
Unknown	U√

- *Unknown.*

Environmental Impact Total	**3**
Total Unknowns (U)	**2**

Scientific Name: *Oncorhynchus tshawytscha*

Common Name: Chinook salmon

Organism Impact Assessment

IMPACT RESULTS

Environmental: High
Socio-Economic: Low
Beneficial: High

Comments: Environmental impact changed from moderate to high.

ENVIRONMENTAL IMPACT

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

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

- Renibacterium salmoninarum *is believed to have been introduced to Lake Michigan when Chinook salmon (*Oncorhynchus tshawytscha*) stocking began in 1967 (Holey et al. 1998). The province of Ontario considers this species to be endemic - present in most samples at 1-33% without signs of clinical disease or gross lesions (GLFHC 2015).*
- *Great Lakes native species found harboring* R. salmoninarum *include lake whitefish (*Coregonus clupeaformis*), bloater (*C. hoyi*), lake herring (*C. artedi*), mottled sculpin (*Cottus bairdi*), white sucker (*Catostomus commersonii*), muskellunge (*Esox masquinongy*), channel catfish (*Ictalurus punctatus*), lake sturgeon (*Acipenser fulvescens*), and walleye (*Sander vitreus*) (COSEWIC 2005; GLFHC 2006; GLFHC 2012; Hay 2003; Jonas et al,. 2002; Nuhfer et al., 2005; Starliper et al., 1997).*

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

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

- *In the Great Lakes, Chinook salmon competes with native lake trout (*Salvelinus namaycush*)(Page and Laird 1993).*
- *Scott et al. (2003) found that the presence of Chinook salmon causes delayed nesting and reduced survival of Atlantic salmon (*Salmo salar*) during spawning in Lake Ontario.*

Does it alter predator-prey relationships?

Yes, and it has resulted in significant adverse effects (e.g., added pressure to threatened/endangered species, significant reduction or extinction of any native species populations, creation of a dead end or any other significant alteration in the food web)	6√
Yes, and it has resulted in some noticeable stress to or decline of at least one native species population 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

- *Chinook salmon is a predatory fish and may impact populations of smaller fish. Jones et al.(1993) predicted that maintaining high levels of predator demand by stocking Chinook and other top predators at the current rate would eventually lead to an alewife collapse, possibly followed by the further collapse of other small forage fish population.*
- *Bunnell et al., (2014) found that predation by Chinook salmon has top-down effects on forage fish in the Great Lakes which causes resource limitation for native piscivores.*

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

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

- *Not 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 mild AND/OR It has significantly affected water quality in past invasions outside of the Great Lakes	1
Not significantly	0√
Unknown	U

- *Not reported.*

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

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

- *Crawford et al. (2001) pointed out that salmonids have the potential to alter the energy and nutrient cycles of the Great Lakes system through increased energy transfer between open water and streams/tributaries. This energy transfer includes the addition of nitrogen and phosphorous to tributaries through decaying salmonine carcasses, as well as the addition of salmon eggs and dead fish as a food source in streams (Ivan et al., 2011; Parmenter and Lamarra 1991; Rand et al., 1992).*
- *The presence of live salmonids may have an even greater effect on nutrients in streams through the excretion of ammonium and soluble reactive phosphorus and their mechanical disturbance of the stream bottom (Ivan et al. 2011; Tiegs et al., 2009).*

Environmental Impact Total	**13**
Total Unknowns (U)	**1**

Scientific Name: *Schizopera borutzkyi*

Common Name: An oarsman

Organism Impact Assessment

IMPACT RESULTS

Environmental: Low
Socio-Economic: Low
Beneficial: Low

Comments: Environmental impact changed from unknown to low.

ENVIRONMENTAL IMPACT

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

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

- *Not reported.*

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

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

- Schizopera borutzkyi *has altered the species composition of nearshore harpacticoid communities, comprising up to 75% of the community at deep sites (15 m) in Lake Michigan. Impact on the food web in these communities is unknown, but it is likely that* S. borutzkyi *is competing with native species for similar resources or has the ability to exploit previously unused resources (Horvath et al., 2001).*
- *Dominant harpacticoid in Lake Michigan following introduction; no evidence that* S. borutzkyi *has altered food webs or ecosystem level processes where it has established in the Great Lakes; low consequences of establishment (Grippo et al., 2017).*

Does it alter predator-prey relationships?

Yes, and it has resulted in significant adverse effects (e.g., added pressure to threatened/endangered species, significant reduction or extinction of any native species populations, creation of a dead end or any other significant alteration in the food web)	6
Yes, and it has resulted in some noticeable stress to or decline of at least one native species population 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 which may be irreversible or has led to the decline or extinction of one or more native species	6
Yes, some genetic effects have been observed, but consequences have been limited to the individual level AND/OR It has genetically affected the same or similar species in past invasions outside of the Great Lakes	1
Not significantly	0√
Unknown	U

- *Not reported.*

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

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

- *Not reported.*

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

Yes, and it has had a widespread, long term, or severe negative effect on the physical ecosystem AND/OR Yes, and it has resulted in significant negative consequences for at least one native species	6
Yes, it has affected the physical ecosystem to some extent, but the alterations and resulting adverse effects have been mild AND/OR	1

It has significantly altered physical ecosystems in past invasions outside of the Great Lakes	
Not significantly	0√
Unknown	U

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

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