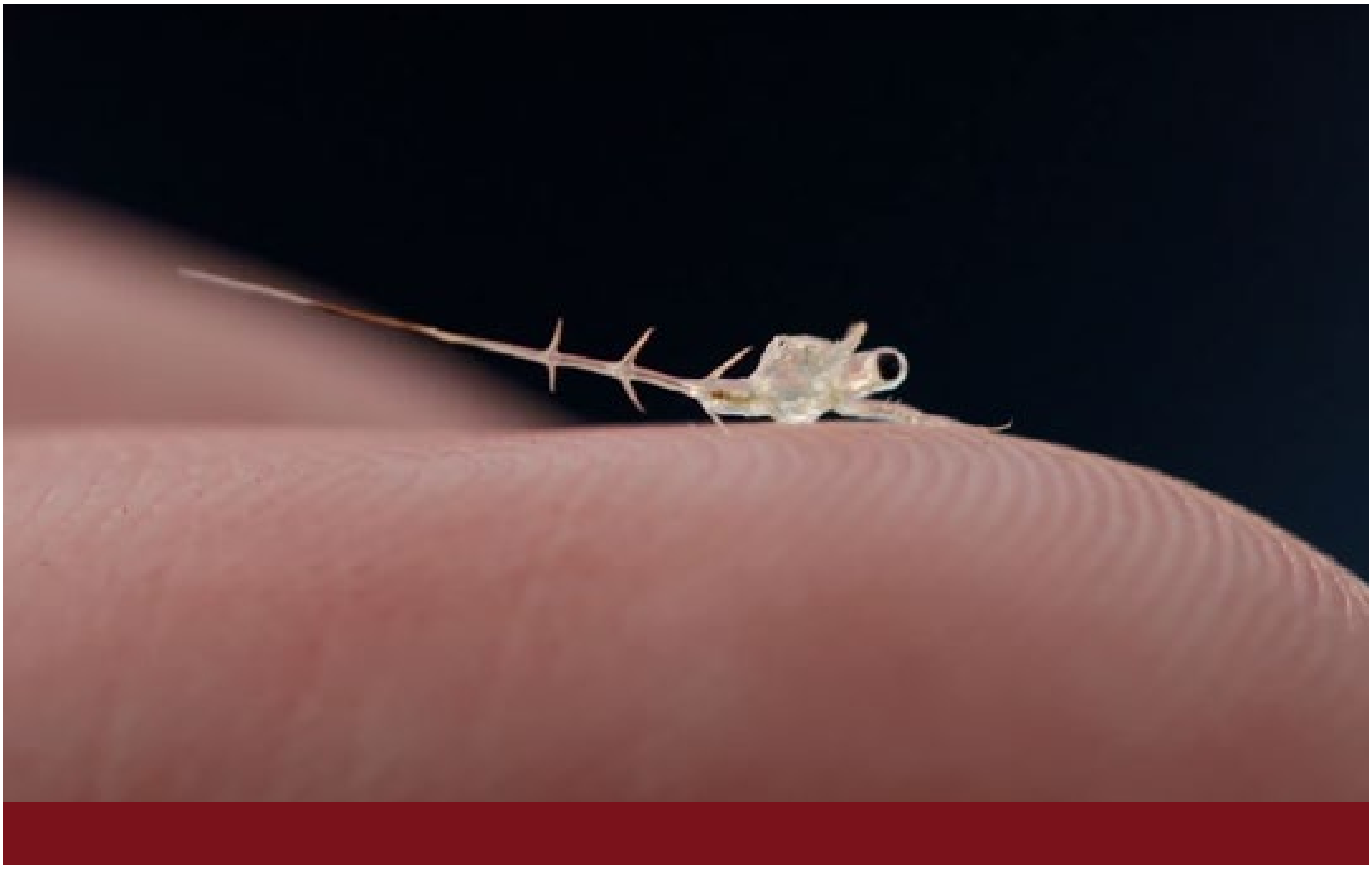
SPINY WATER FLEA *(BYTHOTREPHES LONGIMANUS)* SURVEILLANCE:
A GUIDE FOR MINNESOTA VOLUNTEERS AND MANAGERS

Written and compiled by Meg Duhr, Dr. Donn Branstrator, and Dr. Valerie Brady



MINNESOTA AQUATIC INVASIVE SPECIES RESEARCH CENTER

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BACKGROUND

Spiny water fleas (SWF) have been confirmed in 40 Minnesota lakes and 26 connected streams and rivers (MN DNR infested waters database, June 29, 2022) with the most recent infestation documented in 2016. Given our knowledge about how easily SWF can contaminate fishing gear and boats, coupled with regular boater movement between infested and non-infested lakes, it is unlikely that SWF have not spread to any new lakes in the past six years. Furthermore, SWF detection is particularly challenging: few entities in MN conduct surveillance monitoring for SWF; adults are less than half an inch long; and peak SWF abundance occurs in late summer and even fall, later than most AIS surveillance efforts (e.g., for zebra mussel veligers).

A more complete picture of the extent of the SWF invasion in Minnesota would help prioritize education and prevention efforts for this species. Fortunately, conducting surveillance monitoring for this species does not require specialized skills or expensive equipment, a significant time commitment, or laboratory analysis of samples. Research has also shown that volunteer monitoring can effectively detect SWF populations at high, moderate, and even low abundances (Boudreau and Yan, 2004). With Minnesota's large number of engaged lakeshore community members and local and tribal managers, there is potential to significantly enhance our knowledge of this species' range within Minnesota. Volunteers equipped with basic lake sampling equipment, training in SWF identification, and research-informed guidance about sampling timing and methods can contribute greatly to our knowledge, provide early warning of invasions, and help prevent further spread.

This protocol describes the equipment and effort required to monitor for the presence of SWF in lakes, as well as how to record findings and decontaminate equipment if multiple lakes are sampled. Whether you are a lakeshore resident interested in monitoring the lake you live on or are a manager seeking to implement monitoring over a larger landscape, your contributions will be extremely valuable towards increasing our understanding of the scale of the SWF invasion in Minnesota.

SPINY WATER FLEA IDENTIFICATION

While most zooplankton are microscopic, SWF are large enough to see with the naked eye. The image above shows two individual spiny water fleas on a fingernail. Each individual has a distinct black eye. The individual on the left is carrying a brood chamber which is an oval, transparent pouch that rests on her dorsal side like a backpack and holds developing embryos. Each embryo also has a distinct black eye (when they are close to hatching) and you can see that she is carrying 3 embryos. Most gravid females carry between 2-5 embryos at a time. The black eye of SWF is much larger than the eyes of native zooplankton. The individual on the right is a younger and smaller animal that does not have a brood chamber.

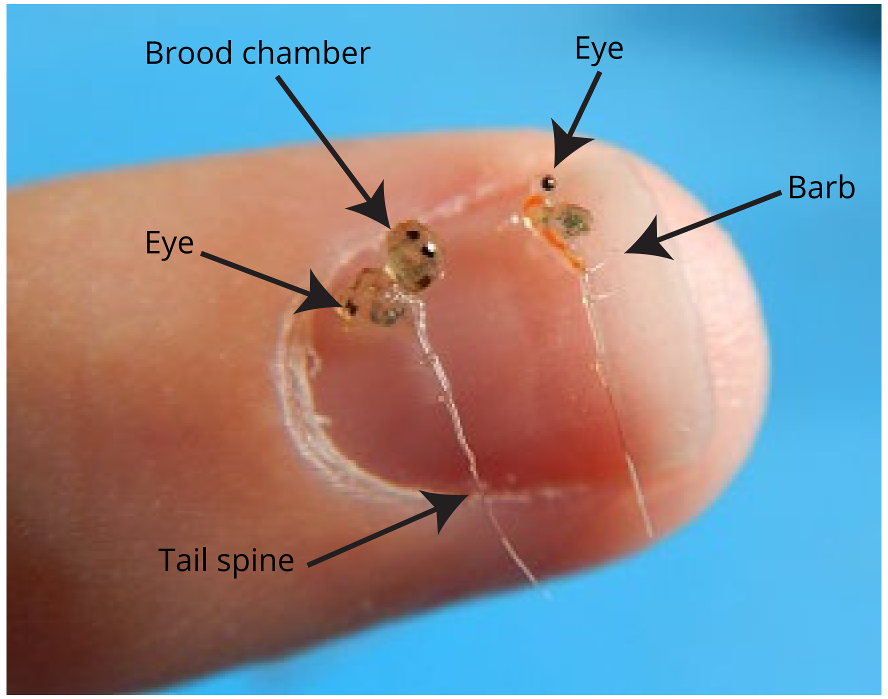


Photo credit: New York Department of Environment and Conservation.

Note that the tail spine, in addition to its incredible length, is red/maroon in color about midway down the spine in the depicted individuals. This coloration is common but does not always occur in every individual. SWF swim relatively slowly by using a pair of appendages (technically antennae) anchored to the body directly behind their black eye. It is common to see them swimming in water samples. Their swimming pattern can be jumpy and erratic which is why this tiny crustacean has the common name "water flea." The image above helps convey the size difference between SWF and native water fleas.

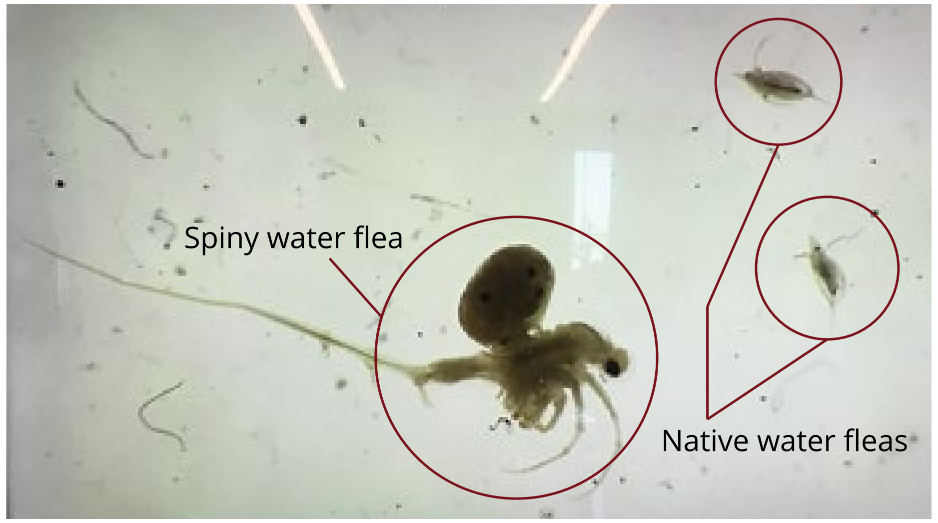


Photo credit: Meg Duhr, MAISRC

Along with the large body size, the large black eye and the uniquely long, barbed tail spine help distinguish SWF from all other zooplankton in North America. That said, zooplankton are highly diverse in size and shape, and in the beginning you may see things that you think are SWF that are not. There are several types of native zooplankton—Chaoborus, Leptodora, and Polyphemus, specifically—that share some visual features with spiny water fleas and have been sources of confusion for volunteer detectors in the past. Images and descriptions of these species can be found in Appendix A.

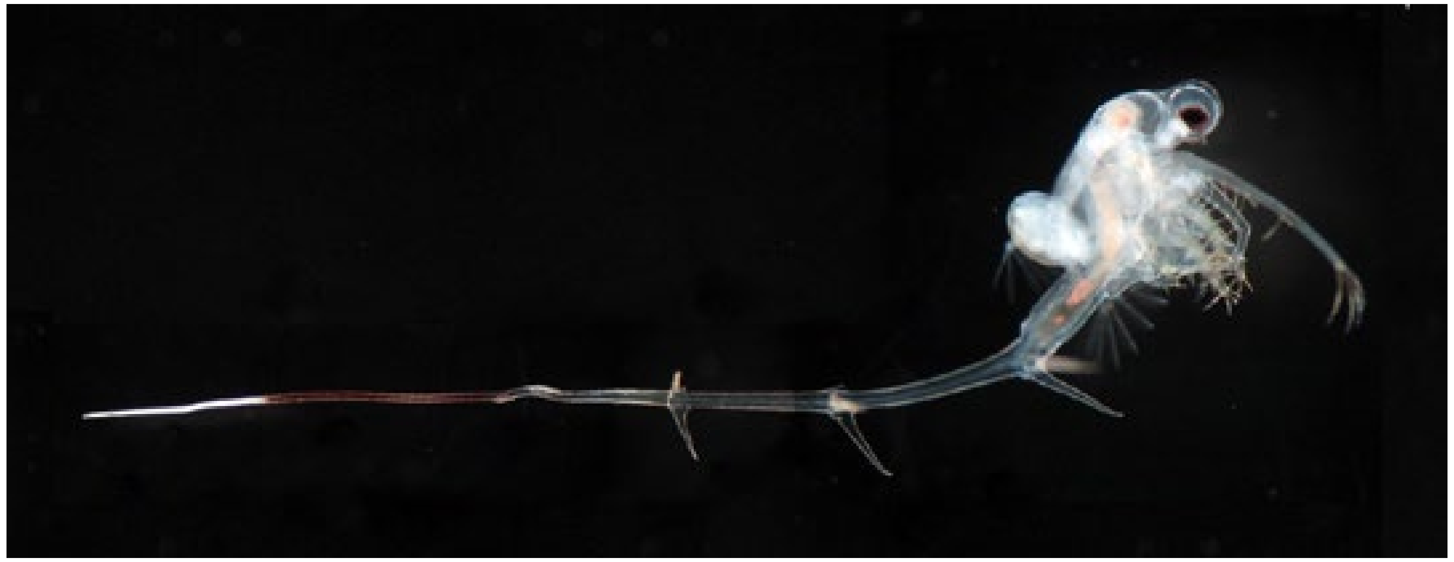


Photo credit: Daniel Hou

Though we want to help you accurately identify SWF in the field, if you are truly on the fence about a possible SWF finding, it is best to report this. Documenting the possible SWF with photos and preservation of samples in a small jar with alcohol will help ensure that AIS experts can correctly identify the specimen.

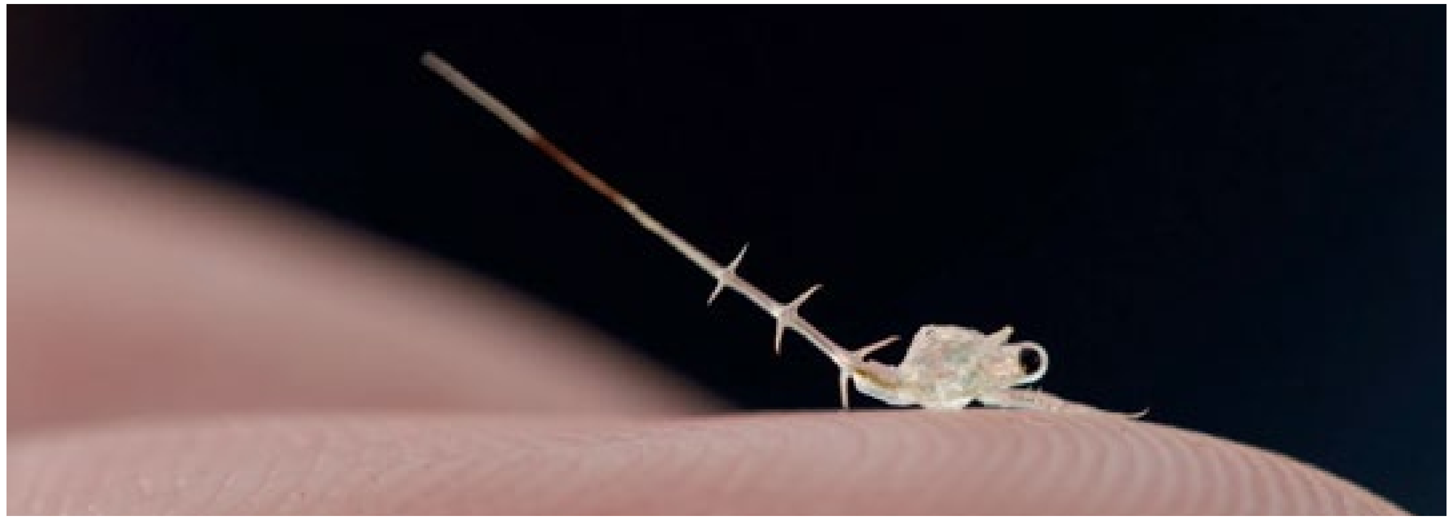


Photo credit: MAISRC

EQUIPMENT

Monitoring can be accomplished with a few standard pieces of equipment, plus a boat or canoe that will allow access to the deeper regions of a lake. While research shows that SWF can occasionally live in shallow water, they are typically found in deeper areas away from shore. Our goal is to conduct the monitoring in a way that maximizes the likelihood of detecting SWF if they are present.

To monitor you will need:

- A zooplankton net attached to a rope with meter (or feet) markings (details below)
- A white plastic dishpan or similar shallow tray (details below)
- A pair of tweezers or an instrument like a fork to move plankton around
- A squirt bottle or any sort of bottle with a spray nozzle to wash plankton off the net
- A camera (a smartphone camera is perfect) to document a positive or potential SWF
- Flashlight or headlamp
- Magnifying glass or loupe
- Pencil and paper
- Small, clear jar or vial to preserve SWF or suspected SWF specimens
- Rubbing alcohol (70% alcohol) or isopropyl alcohol (91% alcohol) to preserve specimens

Zooplankton nets come in a range of sizes, features, and price points, ranging from $150 to $500 and up. They are available through a wide selection of science supply vendors online. The net pictured here is the general shape and size of a zooplankton net that is sufficient to capture SWF.

NET SPECIFICATIONS

- **Size:** The mouth (opening) of the net can vary but one that is at least 12 inches (30 cm) in diameter is best. The length of the net may also vary but one that is about 3 feet (1 meter) in length is ideal.
- **Mesh:** The mesh walls of virtually all nets purchased from commercial suppliers are constructed of Nitex and they come in various gauges measured in microns. Anything from 300 to 500 microns is ideal for collecting SWF, if present. The number indicates the size of the holes in the mesh. For scale, 250 microns (or micrometers) is equivalent to 0.25 mm. SWF are huge (upwards of 100,000 microns in length), so even very large holes (e.g., 500 microns) will easily capture SWF.

Note: It is possible to use one net for both zebra mussel veliger and SWF surveillance, but depending on conditions at your lake, this could add significant time and complexity to the sampling and sorting. The mesh size required for veliger sampling (most protocols specify 63 microns), is significantly smaller than what is needed for SWF. Not only would you capture and need to sort through much more "stuff" in the fine mesh net (increasing the time it takes to look through samples) but mesh this fine may clog in some waters and result in an incomplete sample of the water column. If your organization is considering performing surveys for both species and can only purchase one net, please contact program leads for advice about how to adapt the protocols for this situation.

- **Net weight:** A weight at the bottom on the net is essential for ensuring that the net sinks to the bottom and remains vertical in the water as you pull it back to the surface. Higher end plankton nets may come with a weight and/or collection jar (technically called the 'cod end') mounted to the bottom, however, you can improvise your own set up by attaching 5-10 ounces of fishing weights to the lower end of the net with string or zip ties.
- **Rope:** Your plankton net may or may not come with a rope for doing the plankton tows. Whatever your starting set up, having the rope marked at each meter will be helpful for ensuring you're not dragging the net on the lake bottom. Tape or permanent marker work well for marking the line. If this rope is not easily detachable from the plankton net and you don't have a depth finder on your boat, you will need a second marked rope to check the depth before deploying the net (more details in the Methods section to come).

COLLECTION TRAY SPECIFICATIONS

A white plastic tray (or dish tub) of the type pictured here is needed. The sides should be high enough to contain the contents of a plankton tow and any rinse water needed to rinse the plankton out of the net, but low enough for you to be able to look closely at the plankton in the bottom. A bucket with tall sides is cumbersome and does not work well. A white colored tray is important to create the contrast necessary to see SWF, particularly for their large black eyes.

Photo credit: Meg Duhr, MAISRC

METHODS

This survey relies on vertical plankton tows, which involve lowering a plankton net to the bottom of a lake, then pulling it straight back to the surface in order to sample small organisms present in the water column. Research on the efficacy of a volunteer-based SWF surveillance program in Canada (Boudreau and Yan, 2004) determined that three sampling stations within a lake were sufficient to detect spiny water fleas at all but the lowest density populations. Therefore, a standard monitoring event includes completing three plankton tows at each of the three different locations in a lake. Preferably, one of these locations should be at or near the deepest point in the lake. The other two locations should be spaced widely away from the deep spot, but far enough from shore so that you are still in water at least 30 feet deep. If your lake is shallow and finding locations deeper than 30 feet is not possible, choose two additional locations that are relatively deep.

Sampling is best conducted in the early morning or late evening because SWF are often in higher abundance than during midday, when they may be hiding near the lake bottom. Sampling after dark has the potential to catch even more SWF but can make identification and documentation more challenging, not to mention safe boating.

1. At each location, first obtain a reasonably accurate measurement of depth using a depth finder or the rope that you marked the meter or foot increments on. This is an important step to help ensure that you do not inadvertently let the plankton net contact the lake bottom. A sample contaminated with muck or other debris from the lakebed will be extremely difficult to work with.
2. Deploy the zooplankton net by lowering it over the side of the boat, stopping at approximately one meter (~3 feet) from the bottom.
3. Immediately after the net reaches the desired depth, retrieve it at a speed of about 1 meter per second to the boat. This speed is a steady hand-over-hand pull of the net. The goal is to pull the net fast enough that the water keeps moving through the net without backwash.
4. Once the net is back on board, the contents need to be thoroughly rinsed into the dishpan. Often this is most easily accomplished by turning the net inside out, though some nets have a valve or opening at the bottom to allow rinsing right through the net. It is important to thoroughly rinse the net contents into the tub using the squirt bottle. The spines and barbs on spiny water fleas may snag in the net mesh, so be sure to carefully inspect the net for any animals.
5. Once the collection is in the dishpan, look through it carefully. Plankton can be sloshed around or pushed around with tweezers or a fork to help isolate and separate individuals. Leaving a small amount of water in the pan will make it much easier to view and manipulate the collection and see SWF, if present. Both too much and too little water will make it more difficult to spot SWF, so 1/4 -1/3-inch deep is best. If you end up with too much water, just dump it back through the plankton net and re-rinse it into the pan using less water.
6. If you find a SWF, document and preserve it (see instructions below). If you don't see any SWF, rinse the dishpan in the lake and collect two more vertical tows at this location, searching each tow's net content individually in the same fashion as described.
7. If no SWF are collected at the first location, move to the second and then third locations, collecting and then searching a total of three vertical tows from each location for a total of nine vertical tows per monitoring event. Be sure to record and document your sampling efforts, even if no SWF are found (see instructions below).

LEVEL OF SURVEY EFFORT

Researchers have observed that SWF abundance varies dramatically in Minnesota lakes through the summer and early fall, cycling through periods of high and low density. Monitoring every few weeks between July and mid-September and not necessarily on a set schedule is ideal. However, if you have limited resources and wish to sample during the times you are most likely to detect SWF (if they are present), peak densities tend to occur in late summer (August) and early fall (September).

DOCUMENTING A FIND

If you believe you have found SWF, first try to get a good picture with your smartphone camera. It may take multiple attempts to get a crisp image but a sharp photo is very helpful for verification. If your smartphone has multiple cameras on it, use the largest optical zoom setting. Do not use the digital zoom feature as this will simply result in a pixelated image.

Note your coordinates (or the location on a lake map if you do not have a GPS) , date, and time of day. Once you have a photo, it is essential to save a specimen (or several) in a small jar or bottle. Any small, clear container will suffice as long it has a well-sealing lid. Place the specimen(s) in the container using a tweezer and fill it with rubbing (or isopropyl) alcohol. In a pinch, alcohol-based hand sanitizer also works as a preservation medium. In pencil (NOT pen), write the lake name, date and time, and coordinates on a small piece of paper and put this in the bottle. This sample should be retained to help DNR AIS specialists confirm the ID.

HELPFUL VIDEOS

Scan the QR code to the left to find MAISRC's YouTube playlist with helpful videos regarding Spiny water flea monitoring.
z.umn.edu/SWFvideos

REPORTING FINDINGS TO DNR

The potential discovery of a new SWF infestation should first be reported to your local MN DNR AIS specialist. A list of who to contact based on your location can be found here: z.umn.edu/DNRexperts. This staff person will gather your information and use both the photographs and the preserved specimen to confirm the identification and communicate the information to the appropriate channels within the agency.

REPORTING SURVEY EFFORT AND FINDINGS TO MAISRC

MAISRC researchers are also extremely interested to know when and where you find SWF, however, information from the surveys that don't turn up any SWF is valuable, too! So called "negative data" are important because it gives us more information about the type and amount of survey effort needed to detect new SWF infestations. This will be very useful for informing future early detection programs for SWF. But we can only assess this if people monitoring for spiny water fleas record and report basic information about their sampling efforts.

Click here to report

Following all sampling events (three vertical plankton net tows completed at three sampling stations in one lake), please enter your information on this brief form (z.umn.edu/SWFapp) or click the button above. Participants should complete this form whether or not SWF were detected.

DECONTAMINATING GEAR IF SAMPLING MULTIPLE LAKES

We encourage participants to sample multiple lakes. However, this should only be done if the appropriate AIS spread prevention measures can be taken to ensure that moving equipment and boats between lakes does not transport any AIS. Boats and trailers should be cleaned, drained, and dried according to the MN DNR recommendations: z.umn.edu/cico. SWF can survive in tiny amounts of residual water, so the drying part is especially important!

Plankton nets, rope, and other in-water gear should be taken to an upland site that has a garden hose and a high-pressure nozzle. Thoroughly spray the net down, inside and out, then let the net fully dry in a sunny spot for a minimum of 24 hours. All other sampling gear should also be cleaned and allowed to fully dry. If you do not have a high-pressure nozzle, hot water plus dish soap followed by air drying can suffice.

If you are a local government or tribal manager who needs to sample multiple lakes in one day, it would be best to have multiple sets of sampling gear to rotate through. Failing that, the only confirmed effective method to kill both adult SWF and their eggs is a true hot water decontamination using 140°F water. While Virkon Aquatic disinfectant is effective at killing SWF, its efficacy has not been established for SWF resting eggs, which are the highly durable life stage that may be carried by females or found in lake sediments after the females drop the eggs. Until more research is done on Virkon's effect on resting eggs, we cannot recommend this decontamination approach.

OTHER SAFETY CONSIDERATIONS

- It may be possible to conduct this monitoring from a kayak or canoe. However, the stable, working platform provided by a motorboat is optimal.
- Nighttime sampling will increase the likelihood of detecting SWF if they are present. But this should only be attempted if you have the proper nighttime operating gear (lights, navigation equipment, etc.) on your boat and are highly familiar with the water body to be sampled.

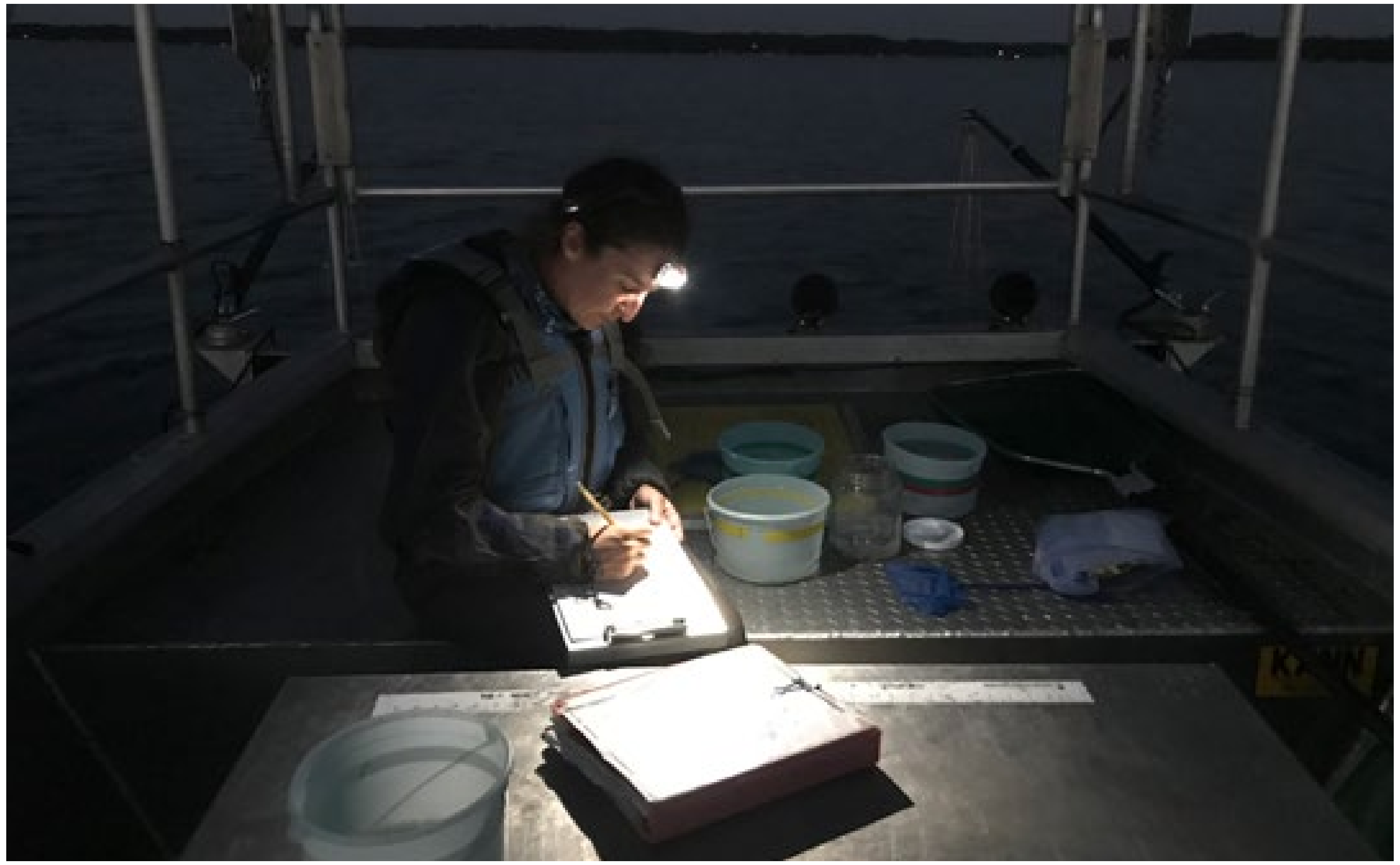


Photo credit: Meg Duhr, MAISRC

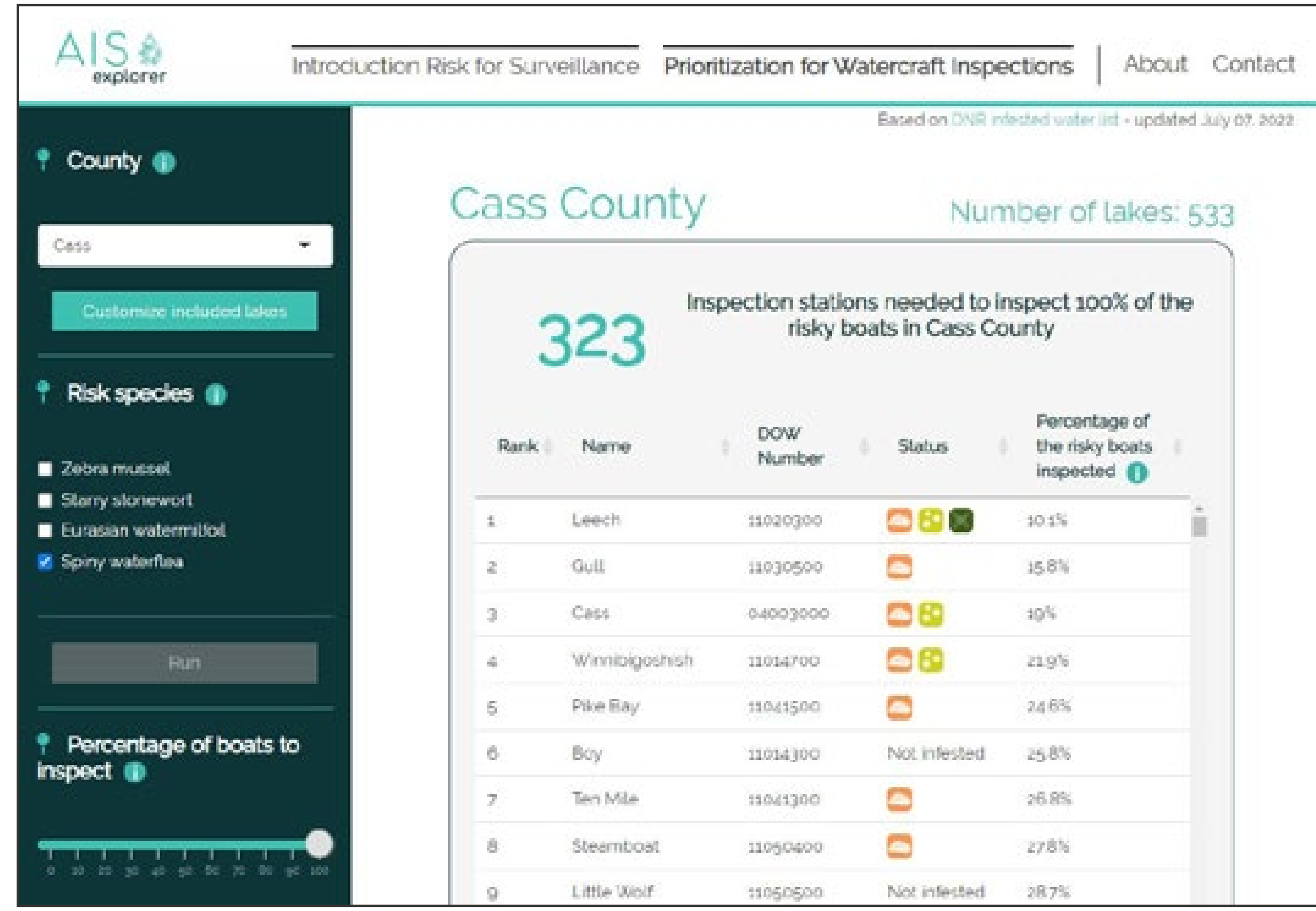
WHICH LAKES TO SAMPLE

Obviously, lakes with known SWF infestations should not be surveyed. Not only would this be wasted effort, but it would needlessly contaminate sampling gear and boats. Appendix B contains county level tables of infested lakes. Review this information before undertaking any surveillance planning.

MAISRC has modeling and data visualization tools available to help with surveillance planning for some species, but because no new SWF infestations have been reported since 2016, it is difficult to model SWF risk to the same resolution that we have for zebra mussels and starry stonewort. While the AIS Explorer's Introduction Risk for Surveillance model (z.umn.edu/risk_model) is designed for this very function (prioritizing lakes to search) it does not currently include SWF. However, the data behind AIS Explorer's Watercraft Inspection Prioritization model (z.umn.edu/inspect_model) can be used to generate information that could be used to focus survey efforts on the lakes at highest risk of SWF invasion. This model uses movements of 'risky boaters' (boaters that move from infested to uninfested lakes) to help managers decide where to place a watercraft inspector in order to intercept the greatest number of risky boaters. In our case, we can look at boater movement patterns from currently known SWF-infested lakes to presumed uninfested lakes to generate a ranked list of lakes most at-risk for SWF.

There is a critical distinction in how the models function for counties with known SWF-infested lakes vs. counties without lakes listed for SWF in the DNR's Infested Waters Database. For counties without any known SWF-infested lakes, use the instructions below to generate a ranked list of lakes most at-risk for SWF.

1. Click on the 'Prioritization for Watercraft Inspections' tab within the AIS Explorer
2. Select the desired county from the drop-down menu
3. Select SWF (and no other species) in the 'Risk species' menu
4. Set the inspection threshold to 100% and click 'run'
5. The dashboard will then display a ranked list of priority lakes for inspection under the stated goal of 100% intervention of all risky boats.
6. You can easily export this list as an Excel table by clicking on the 'Export table (CSV)' button near the bottom of the menu.
7. Once you have opened the Excel file, hit Ctrl+A, then Ctrl+T, and click Okay. You will now have a ranked table of at-risk lakes for the selected county.



Managers or lake association leaders in counties that do have known SWF-infested lakes (Cook, Koochiching, Lake, Lake of the Woods, Mille Lacs, St. Louis, and Roseau Counties), should refer to the tables in Appendix C, because a more reliable prioritization can be created by modifying the models outside the online dashboard. We created custom outputs to identify locations for surveillance considering the movement of risky boats from SWF infested to (presumed) uninfested waterbodies and the movement of boats within and into the county of interest.

While this may be the most research-informed prioritization method currently available, your own local knowledge is important here, too. Research in Ontario, Cananda watersheds and elsewhere have found that the strongest predictor of SWF presence is the human footprint on and around a lake. Unsurprisingly, lakes with the highest density of houses and most public access to water were the most likely to be invaded (Weisz and Yan, 2010). Proximity to invaded lakes is also a strong predictor (MacIsaac, et al. 2004), with a strong pattern of local spread documented in Canadian studies and apparent in Minnesota, too (z.umn.edu/spread). Though the model outputs will likely reflect these patterns, manager and stakeholder knowledge about proximity and access to known invaded lakes and their popularity with anglers, tourists, and lake hoppers may be equally important.

WHAT THIS MONITORING CAN AND CAN'T TELL US

Finding SWF during a survey will confirm that a lake has been invaded. Not finding SWF during plankton tows, however, does not guarantee that a lake is SWF-free. Following the described methods of three sampling locations with three vertical tows each provides high confidence for most invasion scenarios and net types on a given day, especially if sampling occurs in August or September. Repeating surveys throughout the summer and into early fall, as well as continuing to do surveillance every summer will significantly increase our confidence that the lake is uninvaded by SWF. However we will not be able to declare that a lake is definitely uninvaded using this approach.

RESOURCES AND SUPPORT FROM MAISRC

This protocol was developed by MAISRC researchers and staff who will remain available to provide technical support via phone and email for project participants. Videos will become available in late July that demonstrate the use of nets, how to identify SWF, and how to report your findings. We will also host a researcher Q+A over Zoom for program participants to learn more about the program and ask questions.

Because this is the first season of a new program, your feedback is very valuable to us. As the program grows, we will continually refine our materials and methods to improve outcomes and the participant experience, so please stay in touch and let us know how it goes out on the lake!

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APPENDIX A. NATIVE ZOOPLANKTON LOOKALIKES

Chaoborus: This is a relatively common type of native zooplankton that is about the size of SWF. Like SWF, Chaoborus has a black eye but it also has two darkened structures in its body, one at the fore and one near the hind end. These are air sacs used to regulate buoyancy and are not present in SWF. Note also that although Chaoborus has a long body, it does not have a long tail spine. More info: z.umn.edu/chaoborus or scan the QR code:

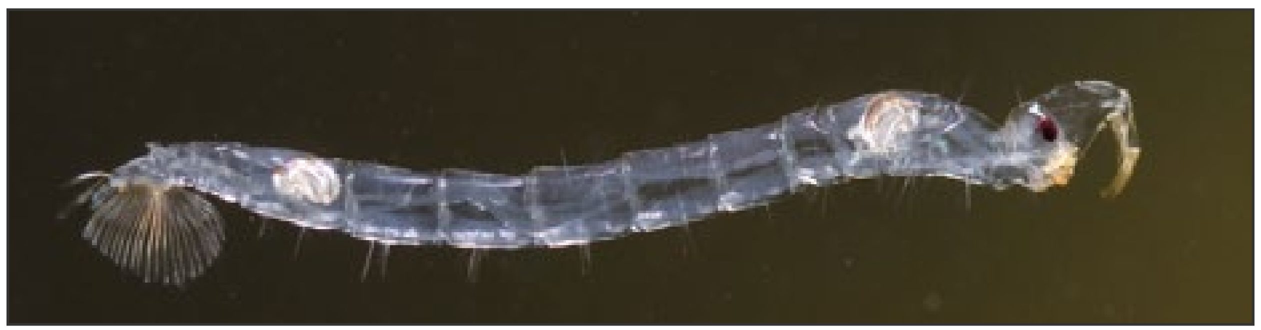

Photo credit: Jan Hamrsky, lifeinfreshwater.net

Leptodora: Leptodora is a genus of zooplankton that is common and abundant in many Minnesota lakes. While the body shape bears some resemblance to SWF, note that this species does not have a long tail spine like SWF. It has a small eyespot. While Leptodora may exhibit some diffuse coloration, they tend to be much more transparent than SWF. More info: z.umn.edu/leptodora or scan the QR code:

Photo by Kenny and David Gifford, the Microscopic Life of Shetland Lochs project. Image used with permission.

Polyphemus: This genus is less common than Leptodora or Chaoborus, but it could still end up in a sample. Polyphemus has a large eye, round brood chamber, and claw-like antennae that may cause confusion when looking for SWF. As with the previous two species, the lack of a distinct tail spine is the key feature that sets Polyphemus apart from SWF. In all respects, Polyphemus looks like SWF without a long tail spine. More info: z.umn.edu/polyphemus or scan the QR code:

Photo by Kenny and David Gifford, the Microscopic Life of Shetland Lochs project. Image used with permission.

Photo by Kenny and David Gifford, the Microscopic Life of Shetland Lochs project. Image used with permission.

APPENDIX B.

COUNTY-LEVEL TABLES OF KNOWN SWF-INFESTED WATER BODIES. (MNDNR, LIST OF INFESTED WATERS, JUNE 28, 2022)

Cook County

Water body name	County or counties	Listed for aquatic invasive species	Year listed as infested	Year species was first confirmed, or connected water body	DOW number
Caribou (in the Boundary Waters Canoe Area, just west of Pine)	Cook	spiny waterflea	2007	year unknown	16-0141
Devil Track	Cook	spiny waterflea	2008	2007	16-0143
Devilfish	Cook	spiny waterflea	2016	2016	16-0029
Flour	Cook	spiny waterflea	2005	2004	16-0147
Greenwood	Cook	spiny waterflea	2005	2004	16-0077
Gunflint	Cook	spiny waterflea	2007	2007	16-0356
Little John	Cook	spiny waterflea	2009	2009	16-0026
McFarland	Cook	spiny waterflea	2005	year unknown	16-0027
North Fowl	Cook	spiny waterflea	2010	2010	16-0036
Pigeon River downstream of South Fowl	Cook	spiny waterflea	2010	2010	NA
Pine	Cook	spiny waterflea	2005	2004	16-0041
Royal (on the Royal River)	Cook	spiny waterflea	2010	2010	16-0025
Royal River between Little John and North Fowls	Cook	spiny waterflea	2010	connected to Little John (16-0026)	NA
Saganaga	Cook	spiny waterflea	2004	2003	16-0633
South Fowl	Cook	spiny waterflea	2010	2010	16-0034
Trout	Cook	spiny waterflea	2013	2012	16-0049

Koochiching County

Water body name	County or counties	Listed for aquatic invasive species	Year listed as infested	Year species was first confirmed, or connected water body	DOW number
Big Fork River from 500 feet upstream of the public water access on Highway 11 downstream to the Rainy River	Koochiching	spiny waterflea	2007	connected to Rainy River	NA
Black River, the south branch downstream of Highway 11 and the west branch downstream of Highway 147	Koochiching	spiny waterflea	2007	connected to Rainy River	NA
Little Fork River, from 100 feet upstream of Highway 11 downstream to the Rainy River	Koochiching	spiny waterflea	2007	connected to Rainy River	NA

Lake County

Water body name	County or counties	Listed for aquatic invasive species	Year listed as infested	Year species was first confirmed, or connected water body	DOW number
Basswood	Lake	spiny waterflea	2014	2014	38-0645
Basswood River between Basswood Lake and Crooked Lake	Lake	spiny waterflea	2014	connected to Basswood (38-0645)	NA
Crooked	Lake	spiny waterflea	2014	connected to Basswood (38-0645)	38-0817
Fall	Lake	spiny waterflea	2014	2014	38-0811
Newton	Lake	spiny waterflea	2014	connected to Fall (38-0811)	38-0784

Lake of the Woods County

Water body name	County or counties	Listed for aquatic invasive species	Year listed as infested	Year species was first confirmed, or connected water body	DOW number
Baudette River from 500 feet upstream of Highway 11 downstream to the Rainy River	Lake of the Woods	spiny waterflea	2007	connected to Rainy River	NA
Hooper Creek from 500 feet upstream of State Highway 172 downstream to the Rainy River	Lake of the Woods	spiny waterflea	2007	connected to Rainy River	NA
Johnson Creek from the Rainy River upstream to 500 feet beyond the first road crossing	Lake of the Woods	spiny waterflea	2007	connected to Rainy River	NA
Lake of the Woods, including the portions of Zipple Bay to Zipple Creek in S9 and S10, T162N, R33W, and to Bostic Creek at County Highway 8	Lake of the Woods	spiny waterflea	2007	year unknown	39-0002
Miller Creek from 500 feet upstream of State Highway 172 downstream to the Rainy River	Lake of the Woods	spiny waterflea	2007	connected water	NA
Rapid River from 500 feet upstream of Highway 11 to Clementson Bay of the Rainy River	Lake of the Woods	spiny waterflea	2007	connected to Rainy River	NA
Sensky Creek from 500 feet upstream of State Highway 172 downstream to the Rainy River	Lake of the Woods	spiny waterflea	2007	connected water	NA
Silver Creek from 500 feet upstream of Highway 11 to the Rainy River	Lake of the Woods	spiny waterflea	2007	connected water	NA
Wabonica Creek from 500 feet upstream of State Highway 172 downstream to the Rainy River	Lake of the Woods	spiny waterflea	2007	connected water	NA
Winter Road River from 500 feet upstream of State Highway 172 downstream to the Rainy River	Lake of the Woods	spiny waterflea	2007	connected to Rainy River	NA

Mille Lacs County

Water body name	County or counties	Listed for aquatic invasive species	Year listed as infested	Year species was first confirmed, or connected water body	DOW number
Mille Lacs	Mille Lacs	spiny waterflea	2009	2009	48-0002

Roseau County

Water body name	County or counties	Listed for aquatic invasive species	Year listed as infested	Year species was first confirmed, or connected water body	DOW number
Swift Ditch from 500 feet upstream of Highway 12 downstream to Lake of the Woods	Roseau	spiny waterflea	2011	connected water	NA
Warroad River from 500 feet upstream of Highway 11 downstream to Lake of the Woods	Roseau	spiny waterflea	2007	connected water	NA

St. Louis County

Water body name	County or counties	Listed for aquatic invasive species	Year listed as infested	Year species was first confirmed, or connected water body	DOW number
Ash River downstream of the northern section line of S8 T68N, R19W	St. Louis	spiny waterflea	2007	connected to Kabetogema (69-0845)	NA
Bottle	St. Louis	spiny waterflea	2014	connected to Basswood (38-0645)	69-1064
Bottle River between Bottle Lake and Lac La Croix	St. Louis	spiny waterflea	2014	connected to Basswood (38-0645)	NA
Burntside	St. Louis	spiny waterflea	2010	2010	69-0118
Burntside River between Burntside and Shagawa	St. Louis	spiny waterflea	2010	connected to Burntside (69-0118)	NA
Cloquet River from Island Lake to the St. Louis River	St. Louis	spiny waterflea	1995	1990	NA
Crane	St. Louis	spiny waterflea	2007	2007	69-0616
Dead River	St. Louis	spiny waterflea	2010	connected to Burntside (69-0118)	NA
East Twin	St. Louis	spiny waterflea	2010	connected to Burntside (69-0118)	69-0174
Fish	St. Louis	spiny waterflea	1995	1990	69-0491
Iron	St. Louis	spiny waterflea	2014	connected to Basswood (38-0645)	69-0121
Island	St. Louis	spiny waterflea	1995	1990	69-0372
Kabetogama	St. Louis	spiny waterflea	2007	2007	69-0845
Lac La Croix	St. Louis	spiny waterflea	2009	2008	69-0224
Little Vermilion	St. Louis	spiny waterflea	2007	2007	69-0608
Loon	St. Louis	spiny waterflea	2009	2008	69-0470
Namakan	St. Louis	spiny waterflea	2007	2006	69-0693
Pike River from Pike River Dam at CSAH 77 near Peyla to Vermilion	St. Louis	spiny waterflea	2015	connected to Vermilion (69-0378)	NA
Rainy	St. Louis	spiny waterflea	2007	2006	69-0694
Sand Point	St. Louis	spiny waterflea	2007	2007	69-0617
Shagawa	St. Louis	spiny waterflea	2014	year unknown	69-0069
Vermilion	St. Louis	spiny waterflea	2015	2015	69-0378
Vermilion River from Vermilion to Crane	St. Louis	spiny waterflea	2015	connected to Vermilion (69-0378)	NA
West Twin	St. Louis	spiny waterflea	2010	connected to Burntside (69-0118)	69-0167

Multiple Counties

Water body name	County or counties	Listed for aquatic invasive species	Year listed as infested	Year species was first confirmed, or connected water body	DOW number
Mille Lacs tributaries from their mouths upstream to the posted boundaries	Multiple (Aitkin, Crow Wing and Mille Lacs)	spiny waterflea	2009	connected to Mille Lacs (48-0002)	NA
Rainy River from Rainy Lake to Lake of the Woods	Multiple (Koochiching, Lake of the Woods)	spiny waterflea	2007	2007	NA
Shagawa River between Shagawa Lake and Fall Lake	Multiple (St. Louis and Lake)	spiny waterflea	2014	connected to Shagawa (69-0069)	NA
St. Louis River downstream of the Cloquet River	Multiple (Carlton and St. Louis)	spiny waterflea	1995	connected water	NA
Superior	Multiple (Cook, Lake and St. Louis)	spiny waterflea	1995	1987	16-0001

APPENDIX C.

SWF RISK TABLES FOR COUNTIES WITH CURRENTLY-INFESTED LAKES

Cook County
Only the top 50 lakes are displayed here. The full list is available on request.

Rank	DOW number	Lake name	Rank	DOW number	Lake name
1	16034800	Brule	26	16024400	South
2	16062900	Sea Gull	27	16015900	Junco
3	16025300	Deer Yard	28	16009300	Mountain
4	16034600	Cascade	29	16022700	Hungry Jack
5	16002300	Esther	30	16022800	Bearskin
6	16014500	East Twin	31	16036900	White Pine
7	16017400	Ram	32	16080900	Little Saganaga
8	16075900	Alpine	33	16021500	Swamp
9	16023900	Poplar	34	16007100	Carrot
10	16023500	McDonald	35	16025200	Pike
11	16001900	Tom	36	16079300	Red Rock
12	16023300	Partridge	37	16061000	Marabaeuf
13	16007900	Sunfish	38	16063200	Gull
14	16048600	Baker	39	16009800	Binagami
15	16018600	West Twin	40	16022000	Morgan
16	16003500	John	41	16008600	West Pike
17	16019400	Pine	42	16080500	Elbow
18	16046000	Long Island	43	16004200	East Pike
19	16018200	Ball Club	44	16064500	Toohey
20	16013500	Jim	45	16009000	Crystal
21	16052400	Cherokee	46	16081300	Zephyr
22	16020400	Aspen	47	16003800	Long
23	16019600	Wampus	48	16019800	Leo
24	16036500	Clara	49	16011200	Canoe
25	16024500	Dunn	50	16062300	Tuscarora

Koochiching County

Rank	DOW number	Lake name
1	36000100	Nett
2	36001800	Bartlett
3	36001100	Clear
4	36000800	Moose
5	36000900	Seretha
6	36001400	Dark
7	36000700	Myrtle
8	36004700	Unnamed
9	36000500	Franklin
10	36000400	Pocquette
11	36002400	Battle

Lake County
Only the top 50 lakes are displayed here. The full list is available on request.

Rank	DOW number	Lake name	Rank	DOW number	Lake name
1	38052900	Snowbank	26	38081000	Cedar
2	38078200	Garden	27	38020700	Ester
3	38039700	Insula	28	38077800	South Farm
4	38073800	North Branch Kawishiwi	29	38068700	Shamrock
5	38022600	Kekekabic	30	38081800	Papoose
6	38033000	Alice	31	38020600	Hanson
7	38077900	Farm	32	38063700	Bald Eagle
8	38049800	Ensign	33	38069100	August
9	38064400	Moose	34	38004200	Wye
10	38035100	Thomas	35	38068600	North McDougal
11	38081300	Fourtown	36	38067400	East Chub
12	38060000	Three	37	38040000	Ima
13	38022000	Perent	38	38047400	Starlight
14	38018000	Ogishkemuncie	39	38066400	Dunnigan
15	38065600	Greenwood	40	38064200	Wind
16	38039600	Isabella	41	38060500	One
17	38037200	Fraser	42	38022700	Amoeber
18	38049100	Vera	43	38064000	Ojibway
19	38048800	Disappointment	44	38038100	Skoota
20	38079200	Horse	45	38073600	Harris
21	38052800	Four	46	38004700	Wilson
22	38021900	Silver Island	47	38022900	Little Knife
23	38070100	Gabbro	48	38041900	Crown
24	38055200	Dragon	49	38061900	Newfound
25	38063800	Clearwater	50	38080900	Chippewa

Lake of the Woods County

Rank	DOW number	Lake name
1	39000500	Lost

Mille Lakes County

Rank	DOW number	Lake name
1	48000900	Onamia
2	48001200	Shakopee
3	48001800	Bass
4	48003600	Ernst Pool
5	48000700	Cranberry
6	48001100	Black Bass
7	48000300	Fog

Roseau County

Rank	DOW number	Lake name
1	68000400	Hayes

St. Louis County

Only the top 50 lakes are displayed here. The full list is available on request.

Rank	DOW number	Lake name	Rank	DOW number	Lake name
1	69000300	Birch	26	69000200	Seven Beaver
2	69000400	White Iron	27	69034300	Hustler
3	69037500	Whiteface Reservoir	28	69074800	Kjostad
4	69011500	Bear Island	29	69006100	One Pine
5	69049800	Trout	30	69076000	Little Johnson
6	69027800	Armstrong	31	69083100	Weir
7	69044800	Pine	32	69069100	Johnson
8	69028500	Eagles Nest	33	69049600	Embarrass
9	69019000	Big	34	69087100	Quill
10	69084100	Pelican	35	69079000	Dark
11	69021300	Toe	36	69061500	Echo
12	69087000	Shoepack	37	69041200	Comstock
13	69074600	Carlson	38	69007000	Low
14	69074400	Elbow	39	69069000	Winchester
15	69034200	Rocky	40	69048100	Fat
16	69074900	Myrtle	41	69075700	Net
17	69032500	Cummings	42	69128500	Unnamed
18	69027700	Clear	43	69068400	Mukooda
19	69093900	Sturgeon	44	69048700	Gun
20	69046100	Shell	45	69060400	Dovre
21	69046500	Upper Pauness	46	69010000	Boot
22	69086400	Ash	47	69083800	Oslo
23	69036900	Takucmich	48	69084200	Black Duck
24	69033500	Emerald	49	69080600	Moose
25	69022300	Agnes	50	69012300	Lieung

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