

Michigan Freshwater Mussel Survey & Relocation Protocols for Projects in Lakes & Reservoirs

2022



Michigan Mussel Committee

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Introduction and Purpose

In North America, native freshwater mussels (Order: Unionoida) have been identified as the most imperiled of any major group of animals (Williams *et al.* 1993; Master *et al.* 2000; Strayer 2008). Of the 44 mussel species found in Michigan, 19 (43%) are listed as either endangered or threatened pursuant to Part 365, Endangered and Threatened Species, of the Michigan Natural Resources and Environmental Protection Act (1994 PA 451) (MDNR 2009). Four of these species are also federally-listed and receive additional protection pursuant to the Endangered Species Act (87 Stat. 884, as amended 16 U.S.C. § 1531 *et seq.*) (ESA). An additional 12 species are in decline and are identified as species of special concern (“River Protocol”, Hanshue *et al.* 2021).

The Michigan Freshwater Mussel Survey & Relocation Protocols for Projects in Lakes & Reservoirs (“Lakes & Reservoirs Protocol”) is intended to supplement the Michigan Freshwater Mussel Survey Protocol and Relocation Procedures (“River Protocol”, Hanshue *et al.* 2021) and the Michigan Mussel Rescue and Relocation Protocol for Reservoir Drawdowns (“Drawdown Protocol”, Gulotty *et al.* 2022).

- The River Protocol is designed to document the potential presence or absence of state or federally-listed mussel species that may be affected by construction projects or other human disturbances in discrete river locations. The River Protocol provides guidance for survey and relocation activities to minimize effects to native mussels in Michigan including guidance to minimize effects to mussel species that are currently identified as threatened or endangered by the State of Michigan or U.S. Government.
- The Drawdown Protocol is intended for mussel rescue and relocation methods specific to reservoir drawdowns.
- The Lakes & Reservoirs Protocol is intended for mussel survey and relocation methods specific to lakes and reservoirs (or impoundments).

While freshwater mussels are commonly associated with lotic ecosystems, they are also an important component of lentic ecosystems. As filter feeders, freshwater mussels play a pivotal role in the uptake of nutrients (Strayer 2017). Not only are they part of the benthic community but they also provide habitat for other benthic organisms that use their spent shells. Similar to lotic systems, freshwater mussels are negatively affected by water quality degradation, habitat alterations and aquatic invasive species (Williams *et al.*, 1993; Watters 2000; Strayer 2008). Declines in habitat and water quality can lead to declines of freshwater mussels, especially at early life stages when they are most vulnerable. Shoreline alterations, substrate alterations, and aquatic vegetation treatments/removals, are among some of the human effects that could adversely affect a mussel population.

The protocols herein are designed to document the potential presence or absence of state or federally-listed mussel species in the context of a proposed project requiring a permit as well as provide guidance for surveying and relocating state or federally-listed mussel species to minimize effects to native mussels in Michigan. The following mussel survey and relocation protocols are applicable to Michigan inland lakes and reservoirs. Streams, rivers, the Great Lakes, Lake St. Clair, or any Great Lakes connecting waters are not covered by these protocols. Projects that may adversely affect mussels in these waters will require project-specific survey, relocation, and monitoring plans.

The Lakes & Reservoirs Protocol provides project proponents with guidance to minimize effects to mussel species that are currently identified as threatened or endangered by the State of Michigan or

U.S. Government. It is intended to be updated as knowledge of mussel distributions increases, and relocation techniques are refined. Michigan’s native mussels and their current federal and state conservation status are listed in Table 1. Project managers should consult the online county maps maintained by the Michigan Natural Features Inventory (<http://mnfi.anr.msu.edu/data/mussels.cfm>) and University of Michigan Museum of Zoology (<http://animaldiversity.ummz.umich.edu>) to determine if listed freshwater mussels are previously documented to occur in a particular lake or reservoir.

Applicants are advised that lack of survey information at a particular location does not mean that mussels are absent. Project proponents are advised to contact the Michigan Department of Natural Resources Fisheries Division (MDNR) and the U.S. Fish and Wildlife Service (USFWS) early in the project planning process to plan any necessary mussel survey and relocation. If federally-listed mussels have been reported previously from the project location, coordination with USFWS will be required (Figure 1).

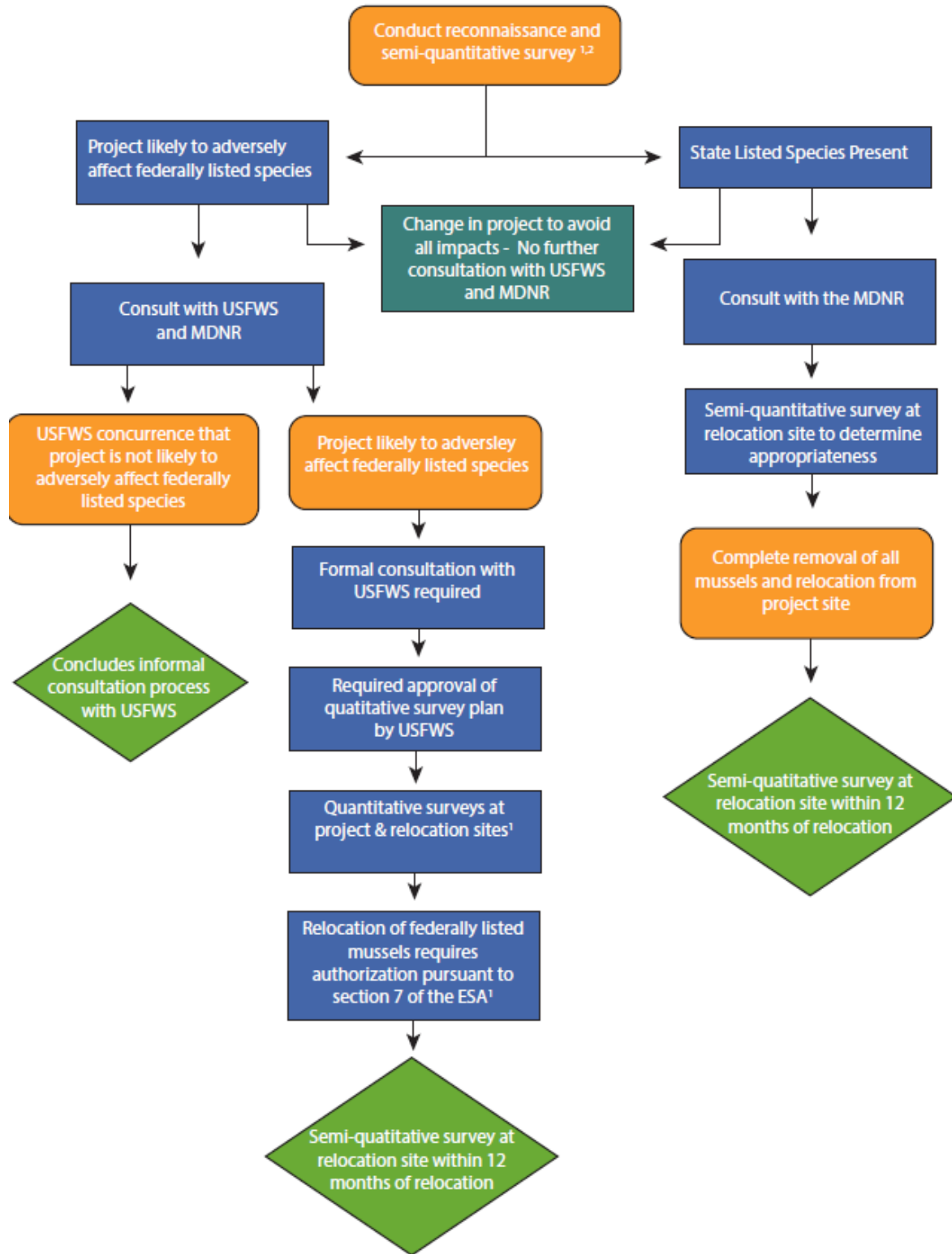
Table 1: List of freshwater mussels in Michigan and their current conservation status.

Species	Common Name	Michigan Status	U.S. Status
<i>Actinonaias ligamentina</i>	Mucket		
<i>Alasmidonta marginata</i>	Elktoe	Special Concern	
<i>Alasmidonta viridis</i>	Slippershell	Threatened	
<i>Amblema plicata</i>	Threeridge		
<i>Anodontoides ferussacianus</i>	Cylindrical papershell		
<i>Cambarunio iris</i>	Rainbow	Special Concern	
<i>Cyclonaias pustulosa</i>	Pimpleback		
<i>Cyclonaias tuberculata</i>	Purple wartyback	Threatened	
<i>Elliptio complanata</i>	Eastern elliptio	Special Concern	
<i>Epioblasma perobliqua</i>	White catspaw	Endangered	Endangered ¹
<i>Epioblasma rangiana</i>	Northern riffleshell	Endangered	Endangered
<i>Epioblasma triquetra</i>	Snuffbox	Endangered	Endangered
<i>Euryntia dilatata</i>	Spike		
<i>Fusconaia flava</i>	Wabash pigtoe		
<i>Lampsilis fasciola</i>	Wavy-rayed lampmussel	Threatened	
<i>Lampsilis siliquoidea</i>	Fatmucket		
<i>Lampsilis cardium</i>	Plain Pocketbook		
<i>Lasmigona complanata</i>	White heelsplitter		
<i>Lasmigona compressa</i>	Creek heelsplitter	Special Concern	
<i>Lasmigona costata</i>	Fluted-shell	Special Concern	
<i>Leptodea fragilis</i>	Fragile papershell		
<i>Leptodea leptodon</i>	Scaleshell	Endangered	Endangered ²
<i>Sagittunio nasutus</i>	Eastern pondmussel	Endangered	

¹ Extirpated in Michigan, USFWS. 2013. White Cat’s Paw Pearly Mussel (*Epioblasma obliquata perobliqua*) 5-Year review: Summary and Evaluation. Ohio Ecological Services Field Office, Columbus, Ohio. 14pp.

² Thought to be extirpated in Michigan.

Species	Common Name	Michigan Status	U.S. Status
<i>Ligumia recta</i>	Black sandshell	Endangered	
<i>Obliquaria reflexa</i>	Three-horned wartyback	Endangered	
<i>Obovaria olivaria</i>	Hickorynut	Endangered	
<i>Obovaria subrotunda</i>	Round hickorynut	Endangered	
<i>Paetulunio fabalis</i>	Rayed bean	Endangered	Endangered
<i>Pleurobema clava</i>	Clubshell	Endangered	Endangered
<i>Pleurobema sintoxia</i>	Round pigtoe	Special Concern	
<i>Potamilus alatus</i>	Pink heelsplitter	Special Concern	
<i>Potamilus ohiensis</i>	Pink papershell	Threatened	
<i>Ptychobranchnus fasciolaris</i>	Kidney-shell	Special Concern	
<i>Pyganodon grandis</i>	Giant floater		
<i>Pyganodon lacustris</i>	Lake floater	Special Concern	
<i>Pyganodon subgibbosa</i>	Round Lake floater	Threatened	
<i>Quadrula quadrula</i>	Mapleleaf		
<i>Sagittunio nasuta</i>	Eastern pondmussel	Endangered	
<i>Simpsonaias ambigua</i>	Salamander mussel	Endangered	
<i>Strophitus undulatus</i>	Strange floater		
<i>Toxolasma lividum</i>	Purple Lilliput	Endangered	
<i>Toxolasma parvum</i>	Lilliput	Endangered	
<i>Truncilla donaciformis</i>	Fawnsfoot	Threatened	
<i>Truncilla truncata</i>	Deertoe	Special Concern	
<i>Utterbackia imbecillis</i>	Paper pondshell	Special Concern	
<i>Venustaconcha ellipsiformis</i>	Ellipse	Special Concern	



¹ ESA Section 10(a)1(A) permit required for Group 3 waters

² MDNR Scientific Collectors permit and State Threatened and Endangered Species permit required for Group 2 waters

Figure 1: Flow diagram for coordination with USFWS and MDNR

Identifying Lake and Reservoir Group

Michigan lakes and reservoirs have been grouped according to existing knowledge of mussel distribution and individual species conservation status (Appendix A). These lake and reservoir groups determine the survey effort and appropriate survey protocol(s) to conduct a mussel survey at the project site.

Group 1: Lakes and reservoirs known or expected to support mussels considered to be special concern by the State, but lacking mussel occurrence data at the project site.

Group 2: Lakes and reservoirs known or expected to support populations of State threatened and endangered mussels (Figure 2).

Group 3: Lakes and reservoirs that support populations of federally-listed mussels (Figure 3).

Pre-survey Guidelines and State and Federal Permit Requirements

State and Federal Permit Requirements

All mussels in the state of Michigan are protected either by State laws or by the federal Endangered Species Act (ESA). Those individuals undertaking survey and relocation efforts are required to obtain permits in advance of any work. The type of permits required will depend on whether state and/or federally-listed species are present.

State of Michigan Permits are required before conducting any mussel surveys or relocations. Contact MDNR at (517) 599-5734 or visit the [website](#) to obtain the Cultural and Scientific Collector's Permit. Additionally, if state-threatened or endangered mussels are anticipated at the site (i.e., in Group 2 waters), a Threatened and Endangered Species Permit is required. Contact the MDNR Endangered Species Program Staff at (517) 284-6210 or visit the [website](#) prior to the start of work. Applicants should apply for these permits at least 30 days prior to the anticipated start date of a project to allow time for proper review.

If federally-listed species are anticipated at the site (i.e., in Group 3 waters), a USFWS permit will be required before conducting any mussel surveys. Contact the USFWS Michigan Field Office in East Lansing (517) 351-2555 or visit the [website](#). Information on the presence of federally-listed mussel species can be found at the following [website](#). If federally-listed species are unexpectedly encountered in non-Group 3 watersheds, immediately stop the field work and contact USFWS for further instructions. Please note, the ESA's implementing regulations provide a limited exception that allows for any employee or agent of the USFWS, any other Federal land management agency, or a State conservation agency, who is "designated by his agency for such purposes, may, when acting in the course of his official duties" to take endangered wildlife without a permit if such action is necessary to aid a sick, injured, or orphaned specimen (50 CFR 17.21(c)(3)(i)). Use of this provision may be applicable in some emergency draw-down situations and has additional limitations and reporting requirements (see 50 CFR 17(c)(4) and (5)).

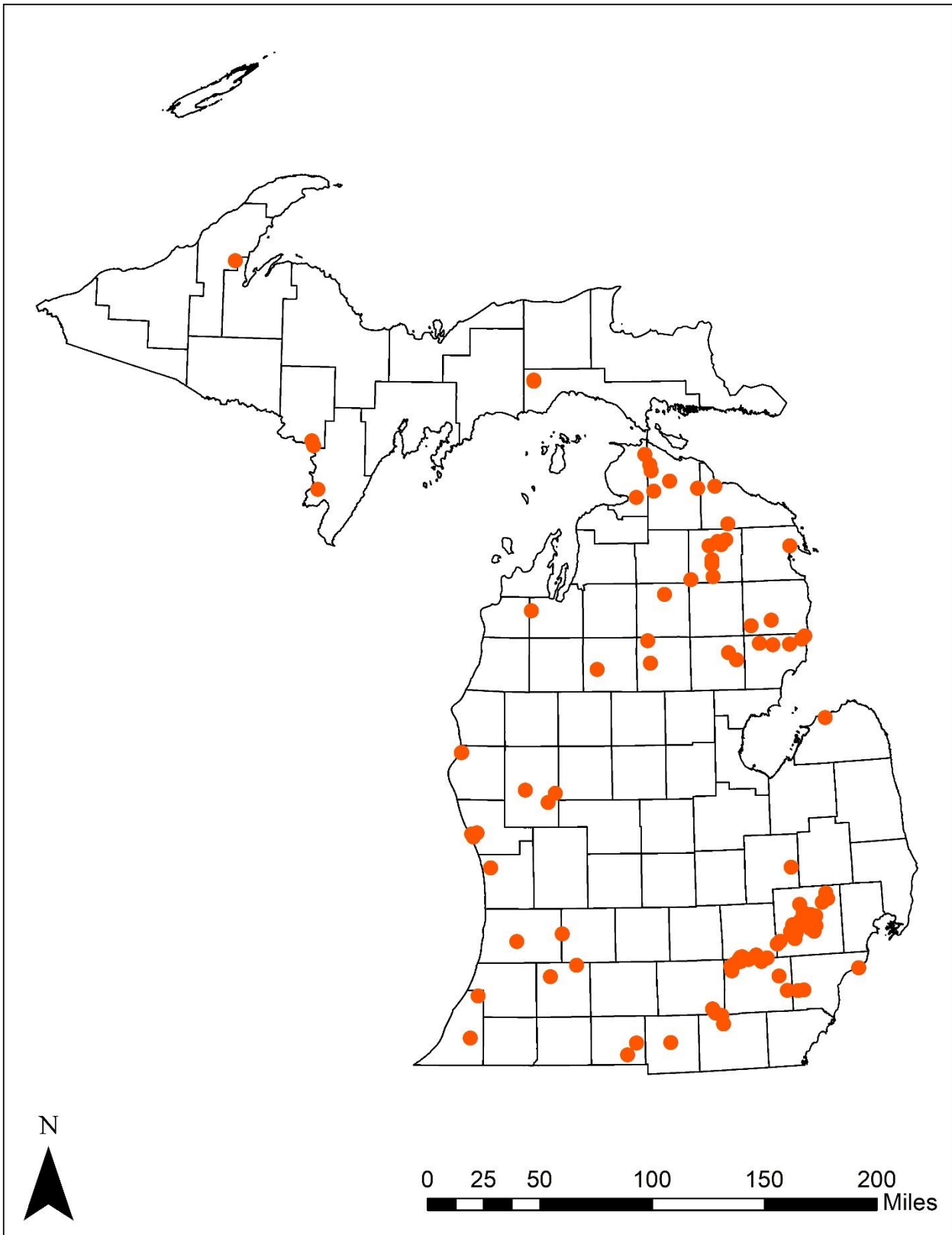


Figure 2: Group 2 lakes and reservoirs known or expected to support populations of state threatened and endangered mussels (source MDNR unpublished data).

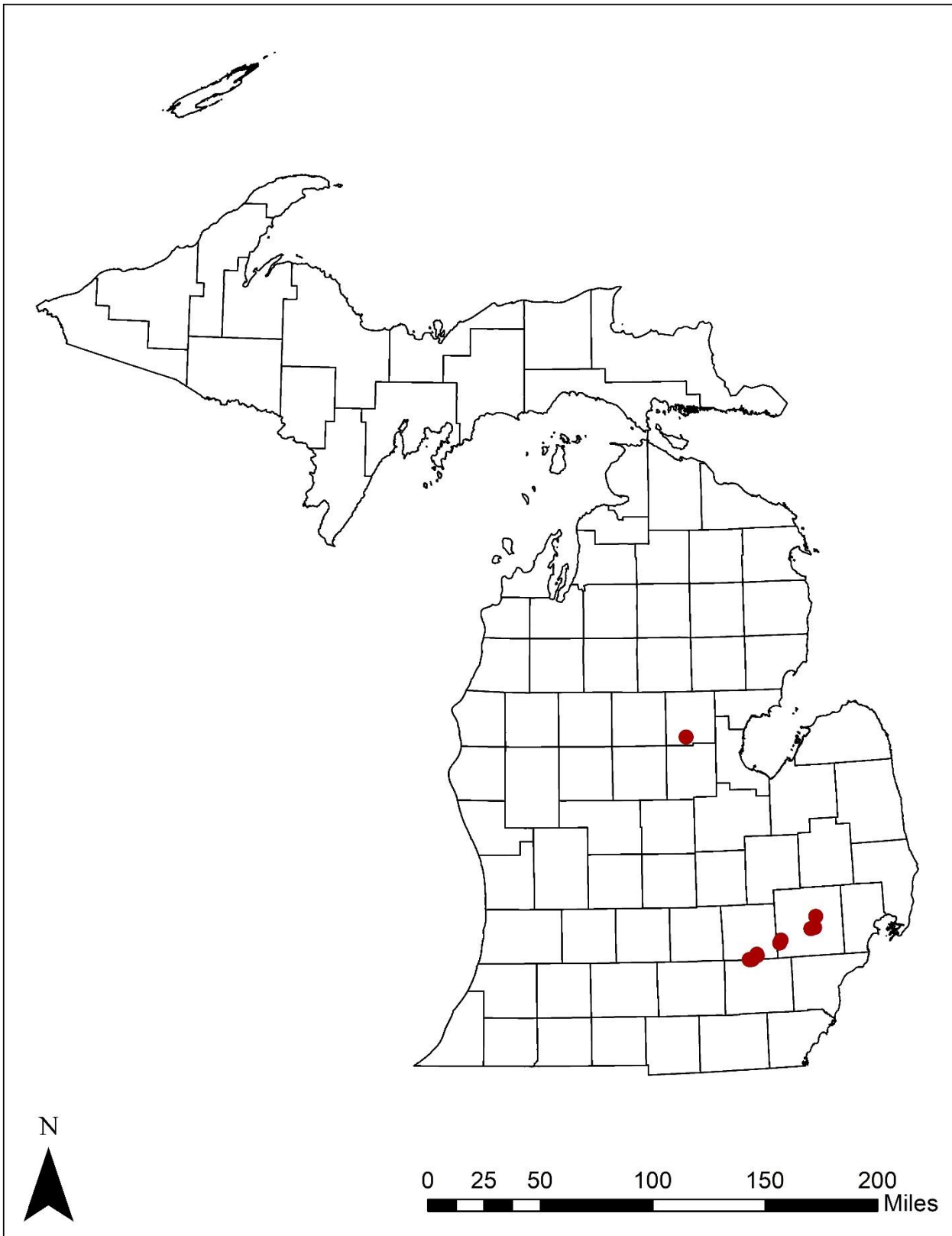


Figure 3: Group 3 lakes and reservoirs known to have supported populations of federally endangered mussels (source MDNR unpublished data).

Prior Notification

Survey plans must be provided to MDNR and Department of Environment, Great Lakes, and Energy (EGLE; all waters) and USFWS (Group 3 waters only) for advanced review. To coordinate with the appropriate MDNR Fisheries management unit, refer to the following [website](#). To coordinate with the appropriate EGLE staff, refer to the following [website](#). This will allow agency staff to review existing data to help inform survey efforts and review relocation sites. **MDNR and EGLE staff shall be notified at least 90 days prior to the time the actual survey will occur**, and as soon as possible after potential for an emergency condition is identified. USFWS staff shall be notified at least 15 days prior to the time the actual survey will occur. Surveys conducted in Group 3 lakes and reservoirs must have received written concurrence from the USFWS prior to conducting any surveys. Relocation of federally-listed mussels will require authorization through Section 7 consultation (for federally funded or permitted projects) or issuance of a Section 10 permit. Consultation with the USFWS is necessary to determine which authorization process is appropriate depending on the nature of the project. Effects to federally-listed species and their habitats must be avoided or minimized to the maximum extent practicable. Conservation measures in addition to relocation efforts may be required if the proposed project may adversely affect federally-listed species. All applicable state and federal permits must be obtained prior to starting any survey and relocation work.

Data Longevity

Survey data collected on a specific site will generally be considered valid for 5 years from the date the survey was conducted. In certain situations where significant habitat alteration has occurred within the 5-year period, additional surveys may be required. Facilities/areas that have been dredged within the past 5 years do not need to be resurveyed unless the dredged area is to be expanded or moved.

Surveyor Qualifications

Mussel surveyors must have sufficient experience, including documented fieldwork, to execute these survey protocols and to locate and identify state and federally protected mussel species. The survey leader(s) must possess a Bachelor of Science degree in biology, natural resources, or a related field or possess sufficient experience as evidenced by documented fieldwork and have demonstrated knowledge of the biology and ecology of freshwater mussels. Surveyors must hold a valid permit to handle native mussels as outlined above. Additionally, in Group 3 lakes and reservoirs surveyors must also hold an ESA Section 10(a)(1)(A) permit from the USFWS. Pursuant to their ESA permit, surveyors must receive site-specific authorization from the USFWS Michigan Ecological Services Field Office prior to conducting surveys in any Group 3 reservoirs.

Survey and Relocation Season Guidelines

Mussel surveys and relocations in Michigan may be conducted only when the water temperature is greater than 50°F and the air temperature is between 50-90°F. Given the potential for mussels to burrow during the colder months, all surveys and relocations must be conducted between **June 1 and October 15**. Requests to conduct mussel surveys and relocations outside of this time period will require prior approval from MDNR and/or USFWS and will be reviewed on a case by case basis.

Reporting

A final report will be provided to the MDNR and EGLE within 45 days following the survey and relocation operation. Survey, relocation, and post-relocation monitoring reports must be provided to USFWS in accordance with federal permit requirements or terms and conditions of a Biological Opinion. Refer to

Appendices B and C for a checklist of data that must be included these reports. Data must be reported in accordance with the requirements of any other state and/or federal permits.

Survey Guidelines

Workable Visibility Requirements

Surveys must be conducted during periods of adequate visibility. Qualitative surface surveys must have a minimum visibility of 0.5 meter (m) (approximately 20 inches). If the area cannot be effectively surveyed due to poor visibility, then the survey must be rescheduled. In lakes or reservoirs with high background turbidity, modified survey methods and/or tactile surveys may be required.

Minimum Data to be Recorded

Refer to Appendices B and C for a checklist of data that must be included in the final survey and/or relocation report. Habitat data to be collected at each transect, cell, or quadrat includes water depth, visual estimates of percent areal coverage of macrophytes, percent areal coverage of woody material, and substrate particle composition (silt and clay, sand, gravel, cobble, boulder, rubble, detritus). Estimates of the percent of unsuitable mussel habitat (e.g., areas of scour, bedrock, etc.) in the project area must also be reported. The final report shall include a map of the survey and/or relocation area(s) along with the proposed project activities and a copy of the valid collecting permit(s). Preliminary findings must be submitted to MDNR within 30 days of completion of survey and relocation activities. Final survey reports must be submitted within 45 days of survey and relocation completion. Survey and relocation reports for projects involving federally-listed mussel species must also be submitted to the USFWS in accordance with their Section 10(a)(1)(A) permit requirements and/or Section 10(a)(1)(B) incidental take permit or terms and conditions of a Biological Opinion. Data must also be reported in accordance with the requirements of any other state and/or federal permits.

Survey Area

Survey coverage shall include the area of direct impact (ADI) and all applicable buffers e.g., offshore, left and right (Figure 4). The size of the buffer areas will be determined on a project-specific basis and must include consideration of direct and indirect impacts (e.g., sediment resuspension, reduced water quality, etc.) and construction methods. Project proponents should consult with MDNR and USFWS to delineate the ADI and appropriate buffers early in the project planning process. In general, projects involving construction equipment operating on the lakebed will require larger ADIs and buffer zones than projects performed from the shore (e.g., seawall installations), by floating equipment (e.g., aquatic plant harvesters) or by divers (e.g., benthic mat installations); see examples in Table 2.

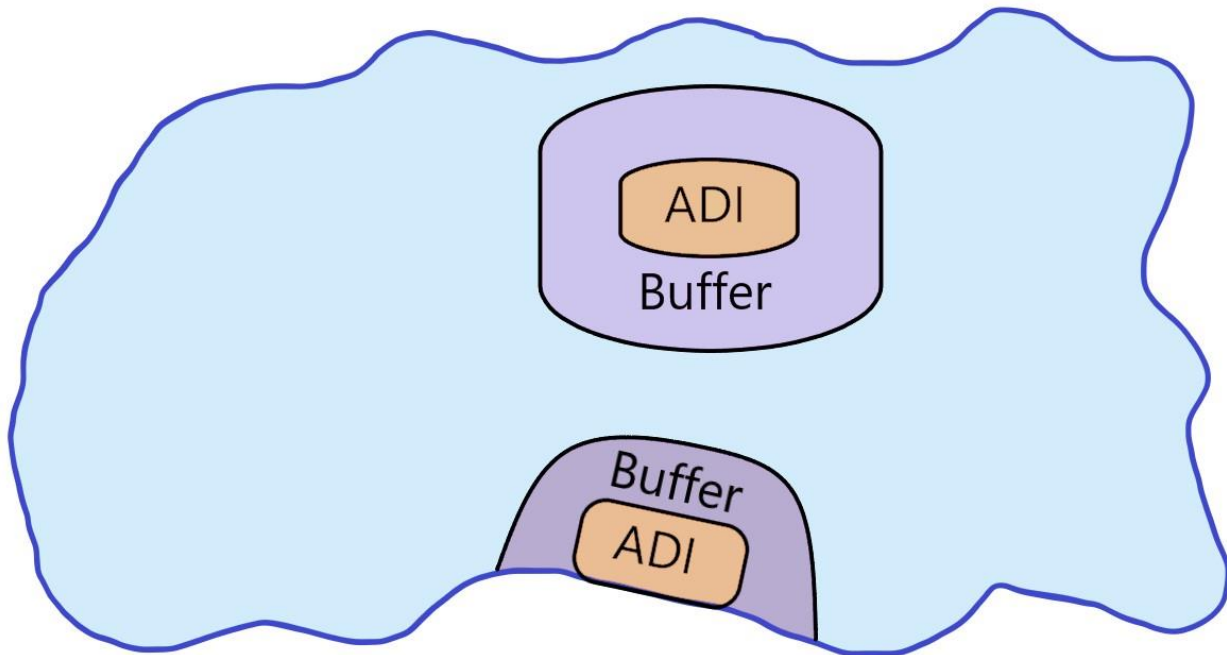


Figure 4: Survey extent shall include the area of direct impact (ADI) and all applicable buffers.

Table 2: Examples of project types with required buffer zones. It should be noted that buffers can be minimized with the use of turbidity curtains. This list is not inclusive, other projects not listed here may require an additional buffer.

Project
Piers & docks installed by equipment in the lake
Sea walls installed by equipment in the lake
Boat ramps
Dredge/fill
Beach sanding (mussel surveys not required if thickness of added sand is <10 cm (4 in))
Wood removal or additions if equipment is in the lake

Survey Techniques

Reconnaissance Survey

A reconnaissance survey can be used to confirm the presence or absence of unionid mussels within a project area. Survey work must be conducted when water conditions are favorable for detecting mussels (see Section I.V. Workable Visibility Requirements). Lake or reservoir habitat with features that preclude searching the lake/reservoir bottom throughout the entire survey area cannot be surveyed using this technique. Those lakes/reservoirs will require the use of timed search protocols described below. First contact the MDNR to discuss specific features that are inhibiting the surveyor to conduct the survey.

Beginning at one end of the buffer zone (at the downstream end of the zone if ripples are present or at the inlet or outlet of the waterbody), the lake/reservoir substrates and shoreline should be visually searched for evidence of shells, shell fragments, and live mussels. All lake/reservoir habitats (not just suitable habitats) must be visually inspected, but special attention should be paid to heterogeneous substrates where living mussels may be difficult to see (e.g., sand and gravel interspersed with cobbles). Mussel viewing tubes or glass-bottom

buckets may be used in depths up to 2-3 feet (Nedeau et al. 2005). In cases where there is sufficient water clarity, depths up to 4 feet may be searched by tubes or buckets. Live mussels should not be removed from the substrate for identification unless the surveyor has valid permits. The site should be searched for at least 60 minutes for smaller project areas (< 3875ft² ADI) or 90 minutes for larger project areas (> 3875ft² ADI), unless evidence of a mussel population is found. Once the presence of live mussels or fresh dead shells is confirmed, the survey does not have to continue. If only weathered dead shells or shell fragments are observed, the entire survey time (either 60 or 90 minutes based on project area) should be used to determine mussel presence within the survey area (Hanshue *et al.* 2021). No species list will be generated from these surveys unless the surveyor possesses the qualifications to accurately identify mussels to species. Representative photos of the survey area and shell material observed must be taken. If no mussels are found (shell or live individuals) and habitat is determined to be unsuitable, no other surveys are recommended. The reconnaissance survey should be documented using the Michigan Mussel Habitat Assessment Form (Appendix C). The presence of fresh dead mussel shells or live mussels will trigger a mussel survey by a qualified surveyor as described below.

Semi-Quantitative Methods

Visual-Tactile Timed Search Surveys consist of a visual and tactile search of all microhabitat types throughout the defined project area including the ADI and buffers for a given period of time. This type of survey is used to determine if mussels are present and to generate species richness curves. The visual search includes moving cobble and woody debris; hand sweeping away silt, sand and/or small detritus; and disturbing/probing the upper 5-10cm (2-4in) of substrate to increase the likelihood of mussel detection. Tactile searching and viewing buckets should be used in waters less than 20 inches in depth. In project areas where the water exceeds this depth, mask and snorkel combined with hand grubbing should be used. In habitats deeper than 32 inches, surveying may require the use of SCUBA or other dive gear.

Transect Surveys consist of visual and tactile searches along transects. Transects shall be established throughout the proposed site and placed perpendicular to the shoreline. Transect spacing in smaller project areas (< 3875ft² ADI) should not exceed 33ft (10m) and in larger project areas (>3875ft² ADI) transects will be spaced 82ft (25m) apart (Hanshue *et al.* 2021). Each transect will be sub-divided into 16ft (5m) segments. Along each transect, surveyors shall visually and tactilely search an area 3ft (1m) wide for mussels. If no mussels (live or shells) are observed in two adjacent transects, with at least one of the transects containing suitable mussel habitat, then a timed visual–tactile search will occur between the two transects in the area of suitable habitat. If any live or recent dead mussels are found between the two transects during the search, then an additional transect will be placed there and searched (Figure 5). Transect spacing should result in survey data that adequately represents the total survey area. Deviation from the above prescribed transect spacing may be necessary depending on site specific conditions and should be discussed with MDNR and/or USFWS.

Cells may be used in lieu of transects. Cells are more appropriate for smaller projects (e.g., shoreline protection, outfalls, etc.). Rather than transects spaced throughout the project site, each affected area would be divided into a series of cells in which each would be completely surveyed using visual-tactile methods. Maximum acceptable cell size is 1076ft² (100m²) with the dimensions determined by the surveyor based on the dimensions of the ADI and buffers (Hanshue *et al.* 2021).

Survey Effort

Habitat complexity will determine search effort. A minimum of 0.5 minute/m² of visual searching shall be expended in homogenous substrates and 1 minute/m² in areas of with heterogeneous stable substrates. Deviation from this level of effort will be handled on a case by case basis in coordination with MDNR and USFWS. **Note: In waters known to support small-bodied mussels i.e., ≥4 cm long (e.g., slippershell, salamander mussel, purple lilliput fawnsfoot, rayed bean, and lilliput) level of survey effort should be increased to 2 minutes/m² to enhance detection.**

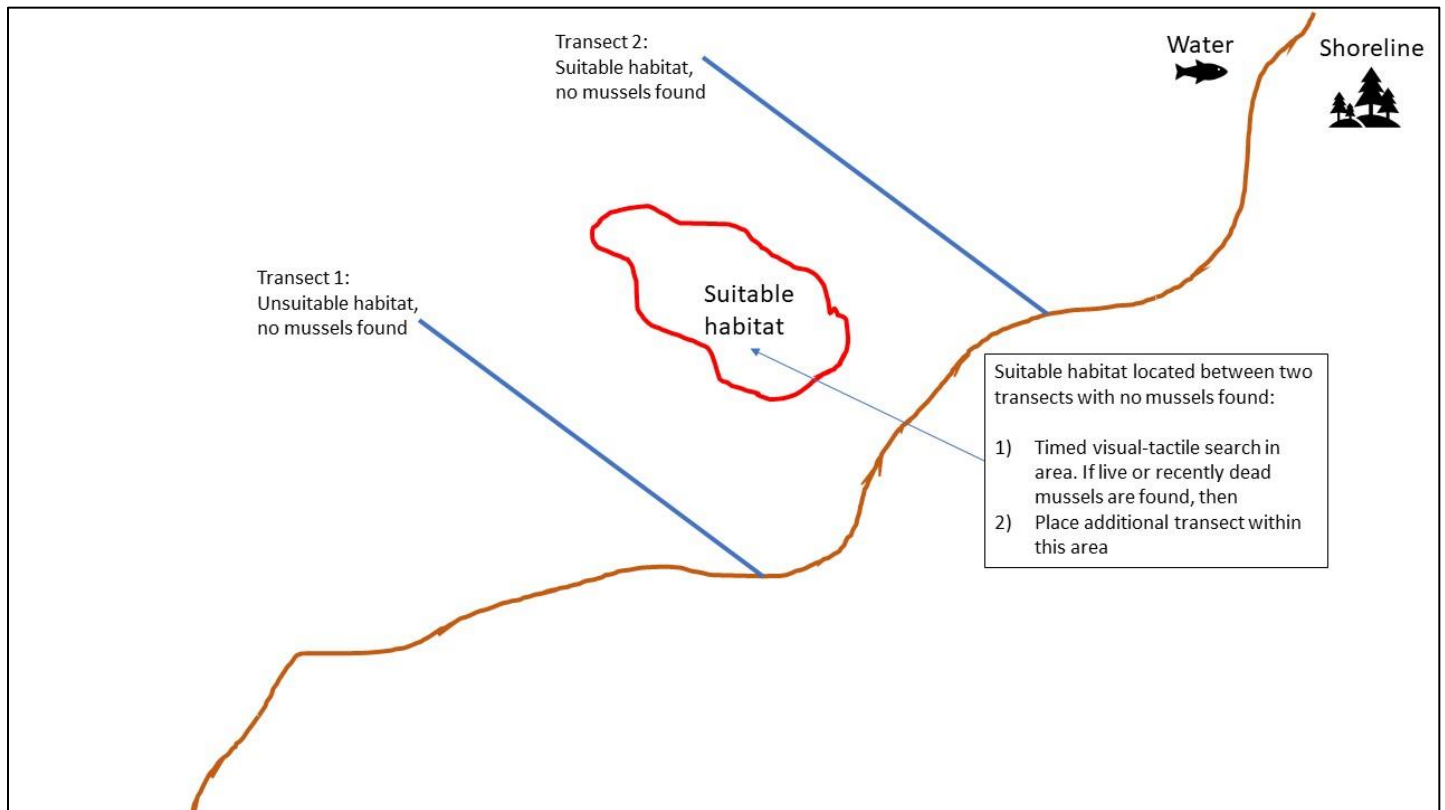


Figure 5: Visual depiction of two adjacent transects with no mussels observed. One transect has suitable habitat and the other does not. By surveyor observation, the red area between the two transects was determined to have suitable mussel habitat. This area should be searched for mussels by a timed visual-tactile method. If mussels are found, method should be switched to a transect.

Quantitative Methods

Quantitative Surveys provide more detailed information about sites. Quantitative sampling will be conducted using 1-m² or 0.25m² quadrats and a systematic sampling design with three random starts in 3m by 5m blocks in accordance with the methodology as described by Strayer and Smith (2003). Regardless of quadrat size used, survey results should adequately represent the total survey area. Blocks will be arranged in a continuous manner to provide complete coverage of the ADI and buffer areas. Quantitative samples to be collected shall be 3 quadrats per 3m by 5m block. Quadrat surfaces will be visually inspected for mussels prior to excavation to 15cm (6 inches) followed by post-excavation visual searches. Data shall be reported separately for each quadrat sampled in the ADI and applicable buffers. In locations with high-density mussel communities (>2.5/m²), 0.25m² quadrat size may be reduced to with excavation depth remaining 15cm (6in). Overall survey coverage must remain equivalent.

Species Richness Curve

Species richness curves (i.e., species accumulation curves) will be developed during semi-quantitative surveys for Group 2 and 3 lakes and reservoirs to confirm sampling effort adequately represents the number of species present at the project site (see Figure 6). A sufficient number of timed visual-tactile searches should be conducted such that a plateau is reached on a plot of cumulative number of individuals (x axis) vs. cumulative number of species (y axis) with 90% confidence intervals. Sampling in the project area shall be conducted until at least 5 timed searches are completed without the addition of new species. A chart depicting the curve and associated regression line should be provided. The number of individuals required to be collected for recovery

of an additional species should be calculated. Note: surveys using cells do not need additional survey effort to develop a species richness curve because the entire area will be searched.

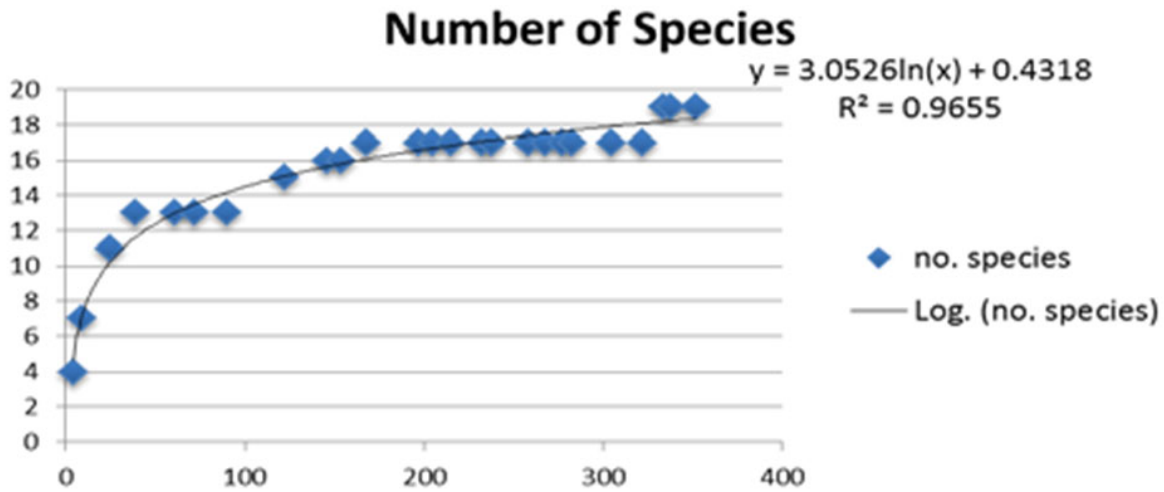


Figure 6: Species Richness Curve. The Y-axis is the number of species represented in collection. The X-axis is the number of individuals collected. In this example, a total 352 individuals were collected, representing 19 species. Using the regression formula, it would require the collection of 611 individuals to find one additional species.

Mussel Processing

For survey methods other than reconnaissance, any observed mussels or shells will be placed in a mesh bag and brought to the surface for further processing and positive identification. Mussels observed along a transect or within a cell will be recorded as occurring in a particular segment or cell. Mesh bags, perforated buckets, or comparable containers may be used to temporarily hold mussels prior to identification, measuring, photographing, and marking. While being held in appropriate containers, mussels should be placed in the water to maximize dissolved oxygen concentrations and minimize temperature around the mussels. To minimize handling stress, collected mussels should be kept in water at all times, except for the brief period needed for processing. All live mussels will be identified to species and sexed where possible (see Appendix D for recommended field guides). To document the size distribution of the populations and potential recruitment, mussel shell lengths shall be measured to the nearest millimeter using vernier calipers (Figure 7). Photographic vouchers (live and shell) of all native species must be provided to MDNR and/or USFWS. To confirm identifications, photographs of individuals representative of species found should include a close-up view of the umbo and one of the valves. Any questionable species should include photographs of the left valve, right valve, and dorsal view as well to provide adequate reference for verification. Dead mussels (empty shells) should be saved for vouchering purposes. All mussels will be returned to the lake or reservoir alive, either at the sample location or to the pre-approved relocation site (see **Mussel Relocation Procedures** below). Unique or out of known range specimens shall be forwarded to the University of Michigan Zoological Museum collections for cataloging.



Figure 7: Freshwater mussel measured for length using calipers. Photo by Pete Badra, MNFI.

Diverse Mussel Community

Failure to detect a state or federally-listed mussel species during a survey does not confirm absence of a listed species. The presence of a diverse bed or high mussel concentrations indicates the potential for a listed species to be present. For reservoirs and streams, a diverse mussel community is defined as one that includes at least four mussel species within the ADI and associated buffers. This value is based on mussel survey data from several Michigan watersheds known to support federally-listed species (unpublished data provided by R. Sherman Mulcrone, J. Rathbun, D. Woolnough, D. Zanatta). If a diverse mussel community is found, then listed species may be present and the project proponent should, wherever possible, develop/modify project plans to avoid effects to mussels. If avoidance is not possible, the project proponent must then submit a survey proposal to the MDNR and USFWS (for Group 3) and receive approval before beginning work. For inland lakes, diversity is typical low (1-3 species).

Lake and Reservoir Type Specific Guidance

Note: Reconnaissance surveys are recommended for all lake groups where conditions are wadable and where the substrate is visible to confirm the presence or absence of unionid mussels within the project area. This includes Group 1 waters lacking mussel occurrence data and Groups 2 and 3 waters where presence of listed mussels is expected but site-specific data is lacking or survey information is dated. Collection of recently dead individuals of any listed species should be interpreted as species presence and additional survey work will be required.

Group 1 Waters: Lakes and reservoirs known or expected to support mussels considered to be special concern by the State, but lacking mussel occurrence data at the project site.

Visual-tactile timed search surveys are recommended, but not required, for Group 1 waters when the presence of mussels has been confirmed. The survey area must include ADI and applicable buffers. The surveys should first assess the areas to be searched, determine areas of suitable mussel habitat, and determine if conditions

(e.g., flow, turbidity, etc.) are suitable for conducting the survey. The survey should begin by conducting a visual search for dead valves along the shoreline, point bars, and other exposed bottomlands and muskrat middens. Tactile and visual searching should include all microhabitat types within the ADI and applicable buffers. If state-listed mussels are encountered during the survey, contact MDNR to develop a relocation strategy. If federally-listed mussel species are encountered, surveyors must stop the survey, return the individuals to the substrate, and contact USFWS and MDNR for further consultation. Note: the collection of recently dead individuals (e.g., complete periostracum, lustrous nacre) of any listed species should be interpreted as species presence and additional survey work will be required. Relocation of non-listed mussels from the project area in Group 1 waters to pre-approved sites can occur at the time of the initial survey (see **Mussel Relocation Procedures** below).

Group 2 Waters: Lakes and reservoirs known or expected to support populations of State threatened and endangered mussels (Figure 2).

Mussel surveys within Group 2 waters include semi-quantitative methods. If state-listed species are detected mussel relocation efforts will be required and surveyors must contact MDNR for further guidance (See **Mussel Relocation Procedures**). If federally-listed mussels are encountered, surveyors must stop the survey, return the individuals to the substrate, and contact USFWS and MDNR for further coordination. Prior to conducting the mussel survey, acceptable justification for not avoiding the area must be provided to the MDNR and should be included in the survey proposal. If the above efforts do not detect state threatened or endangered mussels, timed search surveys will be conducted within the project site for development of a species richness curve. All mussels will be returned to the waterbody alive, either at the sample location or to the pre-approved relocation site. Notification of preliminary survey results (e.g., species detected) must be provided to the permitting agencies (MDNR and/or EGLE) within 30 business days of completion of the survey.

Group 3 Waters: Group 3: Lakes and reservoirs that support populations of federally-listed mussels (Figure 3).

Surveys in these waterbodies require prior consultation with USFWS and MDNR. In most cases, these efforts will require completion of semi-quantitative surveys of the project area (ADI and appropriate buffers). The objective of a semi-quantitative survey is to determine if a federally-listed mussel species or diverse mussel community is present in the project area. If a trigger is met (see below) and avoidance is not an option, then the project proponent must submit a quantitative survey proposal to MDNR and USFWS for approval and receive approval before beginning the quantitative survey (Hanshue *et al.* 2021).

Survey results that trigger a quantitative survey for Group 3 include:

1. Presence of a federally-listed species;
2. Mussel density of $> 0.25/m^2$ within any area of the survey; and/or
3. Presence of a diverse mussel community (> 4 species) indicative of the likely presence of federally-listed species.

The objective of a quantitative survey for Group 3 waterbodies is to collect sufficient data to quantify the densities of live mussels in the ADI and buffer areas. The project proponent must receive approval for the survey scope of work before any sampling is conducted.

Notification of preliminary survey results (e.g., species detected) must be provided to the MDNR within 30 days of completion of the survey. The presence of federally-listed mussels will require immediate consultation with the USFWS.

Mussel Relocation Procedures

Mussel relocation efforts will typically be required when state or federally threatened or endangered mussel species are found at the project site and effect avoidance options have been exhausted. Relocation is also recommended for non-listed mussel species that may be negatively affected by the proposed construction activities. No mussels are to be moved without prior authorization from MDNR and USFWS for federally-listed mussels. If mussels are assumed to be present in Group 1 and 2 waterbodies, a relocation plan can be submitted with the survey plan for review and approval from MDNR. Coordination with the USFWS and MDNR must occur prior to any relocation efforts on Group 3 waterbodies. Relocation of federally-listed mussels will require authorization through Section 7 consultation for federally funded or permitted projects or issuance of a Section 10 permit. Consultation with the USFWS is necessary to determine which authorization process is appropriate depending on the nature of the project. Effects to federally-listed species and their habitats must be avoided or minimized to the maximum extent practicable. Conservation measures in addition to relocation efforts may be required if the proposed project may adversely affect federally-listed species.

The general goals of mussel relocation efforts are to:

- Maximize survival and fitness of the relocated individuals, including genetic diversity.
- Minimize risk to the resident mussel fauna at the relocation site.
- Document relocation outcomes to inform future relocation efforts.

The procedures described below are intended to maximize attainment of these goals.

Site Selection

Selecting an appropriate relocation site is the most important decision in any mussel relocation project. In all circumstances, mussels shall not be moved into waters so deep that, during the summer, they are below the thermocline/oxycline.

A hierarchy of preferred destinations for relocations for lake or reservoir projects is:

1. Within the same lake or reservoir adjacent to the construction site but outside the ADI and buffer zones, at similar depth and substrate type.
2. Elsewhere in the same lake or reservoir but not adjacent to the construction site, at similar depth and substrate type.
3. In a stream or river draining to or from the lake or reservoir, at similar depth and substrate type. This option will be approved only in very rare circumstances. Note that small tributaries draining into reservoirs are not suitable relocation sites, since all reservoirs will eventually be drawn down and drawdowns sometimes trigger destabilizing channel incision in small tributaries. This is usually not a problem in natural lakes, unless changes in lake elevation via a lake level control structure trigger tributary incision.

More specific attributes for a relocation site are in Table 3.

Table 3: Recommended attributes of potential mussel relocation sites in lakes and reservoirs.

-
- The presence of a similar mussel community comprised of all or most of the species to be moved from the salvage area.
 - Evidence of recruitment as indicated by the presence of juvenile mussels.
 - Habitat at the relocation site should be as similar as possible to the project area in terms of sediment composition, water depth, water quality, and overall site area. Multiple relocation sites may be necessary if the project area is particularly large.
 - Appropriate fish host species must be present. If juvenile mussels are present at the relocation site, or if the relocation site is in the same lake or reservoir as the project site, host fish presence is assumed.
 - The relocation site should be secure for the foreseeable future from disturbances (e.g., dredging or nuisance aquatic plant control treatments).
 - If zebra mussels (*Dreissena polymorpha*) and quagga mussels (*D. rostriformis bugensis*) are absent from the salvage area, they must also be absent at the relocation site.
-

Visual-tactile and/or quantitative surveys will be required to assess the composition of the mussel community at the relocation site (see Sections IV and V for details). An estimate of the size of the relocation site must be included in the survey report. This survey may be performed up to 5 years prior to the relocation. The relocation site survey may have to be repeated if an event or affect (e.g., dredging, or a reservoir drawdown) has occurred during the time between the original survey and the proposed relocation that could have affected the resident mussel community or altered environmental conditions. For projects involving state or federally-listed species, relocation sites lacking these species should be avoided unless no other suitable sites are found and permission is obtained from the MDNR for Group 2 watersheds and USFWS and MDNR for Group 3 watersheds.

If the project area from which mussels will be relocated is large, it may be necessary to use more than one relocation site. In this case, the combined total area of the relocation sites should be equal to or greater than the area from which mussels are salvaged. The location of the relocation site(s) must be documented as indicated in the report checklist (Appendix B).

Prior to the relocation activities, a report on the relocation site(s) will be prepared and submitted for approval to MDNR for state-listed species or MDNR and USFWS for federally-listed species. This report shall include summaries of the site attributes listed in Table 3.

Relocation methods

The intention of the collection scheme described below is to collect a high percentage of the mussels at the sediment surface and in the near-surface sediments (Strayer and Smith 2003). In shallow water, mussels shall be collected by wading using view scopes or snorkeling, while SCUBA should be used in deeper water. To facilitate finding mussels, cobble and woody material should be moved and silt, sand, and small detritus swept away.

A moving transect may be used to ensure the project area is cleared of mussels. When using a moving transect, a defined area is cleared and the transect line is moved to define a new area for clearing. For example, a 3ft (1m) area adjacent to an established transect line is marked off, searched, and mussels salvaged. A minimum effort of 0.5 minute/m² is required per pass if mussels are observed. Successive passes are to be made through the area until two or fewer mussels, or less than 5 percent of the original number of mussels collected in the first pass is recovered on the last pass. Once the area is cleared, the transect is moved in 3ft (1m) increments,

and the new area is now cleared sequentially. The process is repeated until the entire salvage area is cleared of mussels.

The collection process entails three steps:

1. A visual-tactile search of the surficial substrate.
2. Excavation of the substrate to a depth of 15 cm (6 inches).
3. A second visual-tactile search. If the second visual-tactile search yields more than 5 percent of the listed mussel species found in the first visual-tactile search, additional searches will be required until less than 5 percent of the numbers in the initial search are recovered.

If a federally-listed species not previously known to occur at the project site is found, stop work and contact the USFWS for guidance.

Relocated mussels must be marked or tagged to facilitate post-relocation monitoring. Specifically, the shells of:

- All relocated state- and federally-listed species must be tagged.
- All relocated non-listed species (or a subsample if high densities are encountered during relocation) must be marked.

Both valves will be marked. A file or small rotary tool can be used to etch a number on both shells of non-listed species. Do not use this method for very thin shelled species (e.g. *P. lacustris* and *grandis*, *U. imbecillis*). A paint pen or numbered shellfish tags may also be used to mark non-listed species. Great care must be taken while etching shells to not damage the mussel, as adults of some species and juveniles of all species have thin shells. The final report should detail methods used to mark relocated mussels. Listed mussels shall be tagged with shellfish or passive integrated transponder (PIT) tags as described by Woolnough and Barnett (2013) and Kurth et al. (2007).

Transporting and placement

On the day(s) of the relocation, minimum expected air temperatures should be greater than 50°F, and maximum expected air temperatures should be less than 90°F. Also, relocations should be performed when turbidity is low. Mussels shall be transported in containers that minimize jostling or affect. It is not necessary to transport the mussels in water, but they must be kept cool and moist, which is best accomplished by covering with wet towels or burlap bags. Do not place the mussels on ice, which may cause temperature shock. Exposure to air during measuring, marking, and transporting must be minimized, and should be kept to less than 5 minutes. Temperature should also be taken during transport if mussels are being relocated outside of the lake/reservoir. Maximum processing time from collection to relocation should not exceed 24 hours (see Section III Mussel Processing). If a longer processing time is unavoidable, consultation with the permitting agency (MDNR, EGLE and/or USFWS) is required prior to the relocation. Signs of physiological stress include shell gaping, foot extension, and mucus secretion. Stress can be reduced by holding mussels in water prior to processing (measuring and marking), reducing the number of mussels held and processed at one time, processing mussels in the shade, and having a short distance between the project site and the relocation site.

Mussels shall be placed into the sediment at the relocation site by hand, posterior end up, and buried half in the sediment. If necessary, use a trowel to dig a small pit.

Post relocation monitoring

Post-relocation monitoring is recommended for special concern and common species encountered in Group 1 watersheds. In Group 2 and 3 watersheds, at least one post-relocation monitoring survey of state or federally-listed species is required to assess survival of all mussels moved to the relocation site. In the case of large relocation efforts (e.g., greater than 500 individuals), additional post-relocation monitoring efforts may be required (Hanshue *et al.* 2021). The post-relocation survey must occur within 12 months of relocating the mussels. The post-relocation report should include percent tagged found alive, percent of tagged not found, and percent found dead (should add up to 100% tagged individuals). Elevated post-relocation mortality (> 40 percent) of all relocated mussels (not each species) may indicate that conditions at the relocation site are inappropriate for long-term survival. If this occurs, the permitting agency should be contacted to determine what follow up action may be necessary.

The appropriate post-relocation monitoring survey methodology should be determined in consultation with the MDNR for Group 1 watersheds (if performed) and Group 2 watersheds, and with the USFWS for Group 3 watersheds. If greater than 500 mussels are relocated, consult with the appropriate permitting agency on the percentage of relocated mussels that must be marked. An effort to relocate all tagged individuals should be made and should include searching a buffer area to account for mussel movement.

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Appendix A: List of Lakes and Reservoirs Categorized into Groups 1,2, or 3

A list of lakes and reservoirs categorized into Groups 1, 2 or 3, as defined in the *Michigan Freshwater Mussel Survey & Relocation Protocols for Projects in Lakes & Reservoirs* and sorted by county. This information was updated January 2021.

Group 1: Lakes and reservoirs known or expected to support mussels considered to be special concern by the State, but lacking mussel occurrence data at the project site.

Group 2: Lakes and reservoirs known or expected to support populations of State threatened and endangered mussels.

Group 3: Lakes and reservoirs that support populations of federally-listed mussels.

County	Lake/Reservoir Name	Group
Alcona	Alcona Dam Pond	2
Alcona	Tubbs Lake	2
Allegan	Lake Allegan	2
Alpena	Ninth Street Pond	2
Barry	Crooked Lake	1
Barry	Lower Crooked Lake	1
Barry	Gun Lake	2
Barry	Mud Lake (42.479, -85.391)	1
Bay	Unnamed waterbody (43.533, -83.914)	1
Berrien	Lake Chapin	2
Berrien	Paw Paw Lake	2
Berrien	Pipestone Lake	1
Branch	Coldwater Lake	2
Branch	Marble Lake	2
Cass	Mill Pond	1
Cass	Shavehead Lake	1
Cheboygan	Black Lake	2
Cheboygan	Burt Lake	2
Cheboygan	Douglas Lake	2
Cheboygan	Lancaster Lake	2
Cheboygan	Mullett Lake	2
Clare	Doc and Tom Lake	1
Crawford	Jones Lake	2
Dickinson	Red Dam Lake	2
Dickinson	Sturgeon Lake	2
Emmet	Alke Paradise	2
Emmet	Crooked Lake	2
Genesee	C S Mott Lake	1
Genesee	Goodrich Millpond	1
Genesee	Holloway Reservoir	1

County	Lake/Reservoir Name	Group
Genesee	Lobdell Lake	1
Genesee	Long Lake	2
Genesee	Thread Lake	1
Gladwin	Lancer Lake	1
Gladwin	Ross Lake	1
Gladwin	Secord Lake	1
Gladwin	Smallwood Lake	1
Gladwin	Wiggins Lake	1
Gladwin	Wixom Lake	3
Grand Traverse	Lake Dubonnet	2
Hillsdale	Baw Beese Lake	2
Hillsdale	Lake Diane	1
Houghton	Otter Lake	2
Huron	Rush Lake	2
Iosco	Cedar Lake	2
Iosco	Cooke Dam Pond	2
Iosco	Five Channels Dam Pond	1
Iosco	Foot Dam Pond	2
Iosco	Loud Dam Pond	2
Iosco	Van Etten Lake	2
Iron	Mallard Lake	1
Iron	Michigamme Lake	1
Iron	Michigamme Reservoir	1
Iron	Peavy Pond	1
Isabella	Lake Isabella	1
Jackson	Brooklyn Pond	2
Jackson	Center Lake	1
Jackson	Vineyard Lake	2
Jackson	Wolf Lake	1
Kalamazoo	Fox and Bears Dam Pond	1
Kalamazoo	Gull Lake	2
Kalamazoo	Morrow Lake	1
Kalamazoo	Unnamed waterbody (42.332, -85.644)	2
Kalamazoo	Sunset Lake	1
Lapeer	Dollar Lake	1
Lapeer	Holloway Reservoir	1
Lapeer	Lake Lapeer	1
Lapeer	Seven Ponds Lake	1
Lenawee	Fry Lake	1
Lenawee	Lake Erin	2
Lenawee	Unnamed waterbody (42.065, -84.159)	2
Lenawee	Red Millpond	1
Livingston	Base Line Lake	3
Livingston	Unnamed waterbody (42.438, -83.984)	2
Livingston	Unnamed waterbody (42.440, -83.970)	2

County	Lake/Reservoir Name	Group
Livingston	Patterson Lake	1
Livingston	Portage Lake	3
Livingston	Shannon Lake	1
Livingston	Whitewood Lakes	1
Livingston	Whitmore Lake	2
Livingston	Zukey Lake	3
Mackinac	Black Creek Flooding	1
Mackinac	South Manistique Lake	2
Marquette	Lake Michigamme	1
Mecosta	Martiny Lake	1
Mecosta	Rogers Dam Pond	1
Menominee	Ann Lake	2
Menominee	Grand Rapids Impoundment	2
Midland	Sanford Lake	1
Missaukee	Dead Stream Flooding	1
Missaukee	Michigan State University Dam #1 Pond	2
Montcalm	Mud Lake	1
Montcalm	Unnamed waterbody (43.449, 85.507)	1
Montmorency	Atlanta Pond	2
Montmorency	Crooked Lake	2
Montmorency	Grass Lake	2
Montmorency	Little Brush Lake	2
Montmorency	Rush Lake	2
Montmorency	Sage Lakes	2
Montmorency	Valentine Lake	2
Montmorency	West Twin Lake	2
Muskegon	Bear Lake	2
Newaygo	Croton Dam Pond	2
Newaygo	Hardy Dam Pond	2
Newaygo	Robinson Lake	2
Oakland	Brendel Lake	1
Oakland	Cass Lake	3
Oakland	Cedar Island Lake	2
Oakland	Clear/Squaw Lake	1
Oakland	Dawsons Millpond	2
Oakland	Duck Lake	1
Oakland	Forest Lake	1
Oakland	Fox Lake	2
Oakland	Greens Lake	2
Oakland	Indian Lake	2
Oakland	Indianwood Lake	1
Oakland	Kent Lake	3
Oakland	Lake Angelus	3
Oakland	Lake Michelson	1
Oakland	Lake Orion	2

County	Lake/Reservoir Name	Group
Oakland	Lakeville Lake	1
Oakland	Lotus Lake	1
Oakland	Neva Lake	2
Oakland	Unnamed waterbody (42.633, -83.519)	2
Oakland	Unnamed waterbody (42.835, -83.225)	2
Oakland	Unnamed waterbody (42.639, -83.527)	1
Oakland	Unnamed waterbody (42.589, -83.324)	1
Oakland	Unnamed waterbody (42.843, -83.379)	1
Oakland	North Commerce Lake	2
Oakland	Oakland Lake	2
Oakland	Pine Lake	2
Oakland	Pontiac Lake	2
Oakland	Proud Lake	2
Oakland	Sherwood, Lake	2
Oakland	Sylvan Lake	3
Oakland	Townsend Lake	1
Oakland	Twin Sun Lakes	2
Oakland	Wau-Me-Gah Lake	2
Oakland	Wolverine Lake	1
Oceana	Pentwater Lake	2
Ogemaw	Devoe Lake	2
Ogemaw	Sage Lake	2
Oscoda	Mio Dam Pond	1
Ottawa	Pottawattomie Bayou	2
Ottawa	Spring Lake	1
Presque Isle	Moores Lake	2
Presque Isle	Ocqueoc Lake	2
Roscommon	Dead Stream Flooding	1
Roscommon	Higgins Lake	2
Roscommon	Houghton Lake	2
Roscommon	Houghton Lake Flats South Unit Dam Pond	1
Roscommon	Lake James	1
Roscommon	Mud Lake	1
Saginaw	Linton, Lake	1
Schoolcraft	A-Two Pool	1
Schoolcraft	B Pool	1
Schoolcraft	C-Three Pool	1
Schoolcraft	C-Two Pool	1
Schoolcraft	E Pool	1
Schoolcraft	I Pool	1
Schoolcraft	J Pool	1
Schoolcraft	Jamestown Slough	1
Schoolcraft	M Pool	1
Schoolcraft	Stanley Lake	1
Schoolcraft	Upper Goose Pen Pool	1

County	Lake/Reservoir Name	Group
St. Joseph	Ayers Lake	1
St. Joseph	Centerville Mill Pond	1
St. Joseph	Lake Templene	1
St. Joseph	Mill Pond	1
St. Joseph	Unnamed waterbody (41.950, -85.658)	1
St. Joseph	Palmer Lake	1
St. Joseph	Sturgeon Lake	1
Washtenaw	Barton Pond	1
Washtenaw	Crooked Lake	2
Washtenaw	Ford Lake	2
Washtenaw	Hi-Land Lake	2
Washtenaw	Independence Lake	2
Washtenaw	Long Lake	2
Washtenaw	Unnamed waterbody (42.380, -84.072)	2
Washtenaw	Pickerel Lake	2
Washtenaw	Silver Lake	2
Washtenaw	Sullivan Lakes	2
Washtenaw	Whittaker And Gooding Dam Pond	2
Wayne	Belleville Lake	2
Wayne	Blue Heron Lagoon	2

Appendix B: Report Checklist

Introduction

- Description of the waterbody and watershed including:
 - Name
 - Inlets & Outlets
 - Location, including:
 - Coordinates – at center of ADI
 - Township Range Section
 - County
 - Summary of any water quality data or previous mussel survey reports near the area of impact
 - Surrounding land use

Methods

- Personnel
- Date(s) of survey
- Area surveyed, including:
 - Description of ADI and buffer areas
 - Coordinates of ADI and buffer areas
 - Map delineating survey areas (ADI and buffer). Map can be included within text or in Figures & Tables section.
- Survey method, including:
 - Type of mussel survey completed (e.g., visual-tactile, transects, cells)
 - Length and spacing of transects or size of the cells
 - Time searched
 - Method of detection (e.g., SCUBA, view bucket, quadrats)
 - Whether or not shorelines were searched for shells
 - Trigger – for quantitative studies
 - Description of additional transects (for quantitative studies), including coordinates and delineated map
- Mussel handling and processing procedures
- Quality Control Procedures (includes taking representative photos of each species and video of any questionable specimens).

Results

- Habitat assessment within each transect, cell, or timed search area, including:
 - Substrate composition (include information about the stability of the substrates)
 - Unique lake features
 - Average water depth
 - Visibility (say what the visibility was, not just that it met the minimum requirements)
 - Water temperature
 - Suitable habitats within the area of the survey
 - Photos of waterbody and substrate
- An overview of the results, including:
 - Number of individuals found
 - Number of species found
 - Any notable species found
- A description of the results of the semi-quantitative and quantitative surveys separately

- Tables of results, including (either within text or attached in Appendix):
- Species data for each transect and/or cell
 - Relative abundance
 - Condition (living/fresh dead/weathered/subfossil)
 - Sex of individuals if determinable
 - Morphometric data (optional if not required by permit or site-specific authorization)

Mussel Relocation (include this section when salvage and relocation was completed)

- Relocation site, including:
 - Location (coordinates at center)
 - Map delineating area. Map can be included within text or in Figures & Tables section.
 - Results of required semi-quantitative and quantitative surveys
 - Method of salvaging mussels from survey area
 - Environmental characteristics (water depth, velocity, sediment composition, etc.) of the relocation site
 - Number of each species relocated to the site
 - Type of mark used (paint pen, shellfish tag, PIT tag, etching)

Post Relocation

Relocation site monitoring

- Environmental conditions at the relocation site(s) including the same parameters documented prior to relocation
- Percentages of tagged individuals (should equal 100%)
 - ___% tagged found alive
 - ___% tagged found dead
 - ___% tagged not found
- Observations on the condition of the mussels and the relocation site(s).

Conclusion

- Summary of findings, and conclusions

References

- Include citations for any literature cited within the text of the report.

Figures and Tables

- If not provided in text, provide a separate section for Figures (including maps and aerial photos showing extent of survey) and Tables (transect and quadrat data, morphometric data)

Appendices

- Photos of waterbody and substrates
- Representative photos of each mussel species found
- Video of questionable species
- Raw Data Sheets
- Copy of State and/or Federal permits
- Site-specific authorization from USFWS for Group 3 stream surveys

Appendix C: Habitat Assessment Form

Michigan Freshwater Mussel Habitat Assessment Form

Project Information

Project Name _____

Waterbody _____ Group (see Appendix A) _____

County _____ Township/Range/Section _____

Latitude (DD.DDDDD) _____ Longitude (DD.DDDDD) _____

Methods

Name of Surveyors _____

Qualification of Surveyor(s): USFWS Permit Number _____
MDNR Scientific Collectors Permit Number _____

Date(s) of Survey _____ Distance Surveyed _____

Total Survey Effort (minutes X No. of Surveyors) _____

Describe in detail any deviations from the Michigan Mussel Habitat Assessment Methods:

Habitat Description of Survey Area

Water Temp. (°F): _____ Air Temp. (°F): _____

Substrate Types (include %):

- | | | | | |
|--|---------------------------------------|--|---|---|
| <input type="checkbox"/> Boulder _____ | <input type="checkbox"/> Gravel _____ | <input type="checkbox"/> Bedrock _____ | <input type="checkbox"/> Detritus _____ | <input type="checkbox"/> Silt _____ |
| <input type="checkbox"/> Cobble _____ | <input type="checkbox"/> Sand _____ | <input type="checkbox"/> Hardpan _____ | <input type="checkbox"/> Muck _____ | <input type="checkbox"/> Artificial _____ |

Water Level: High Elevated Normal Low Dry/Interstitial

Visibility: 0-15 cm 15-30 cm 30-50 cm >50 cm Visible to Bottom

Average Depth (cm): _____

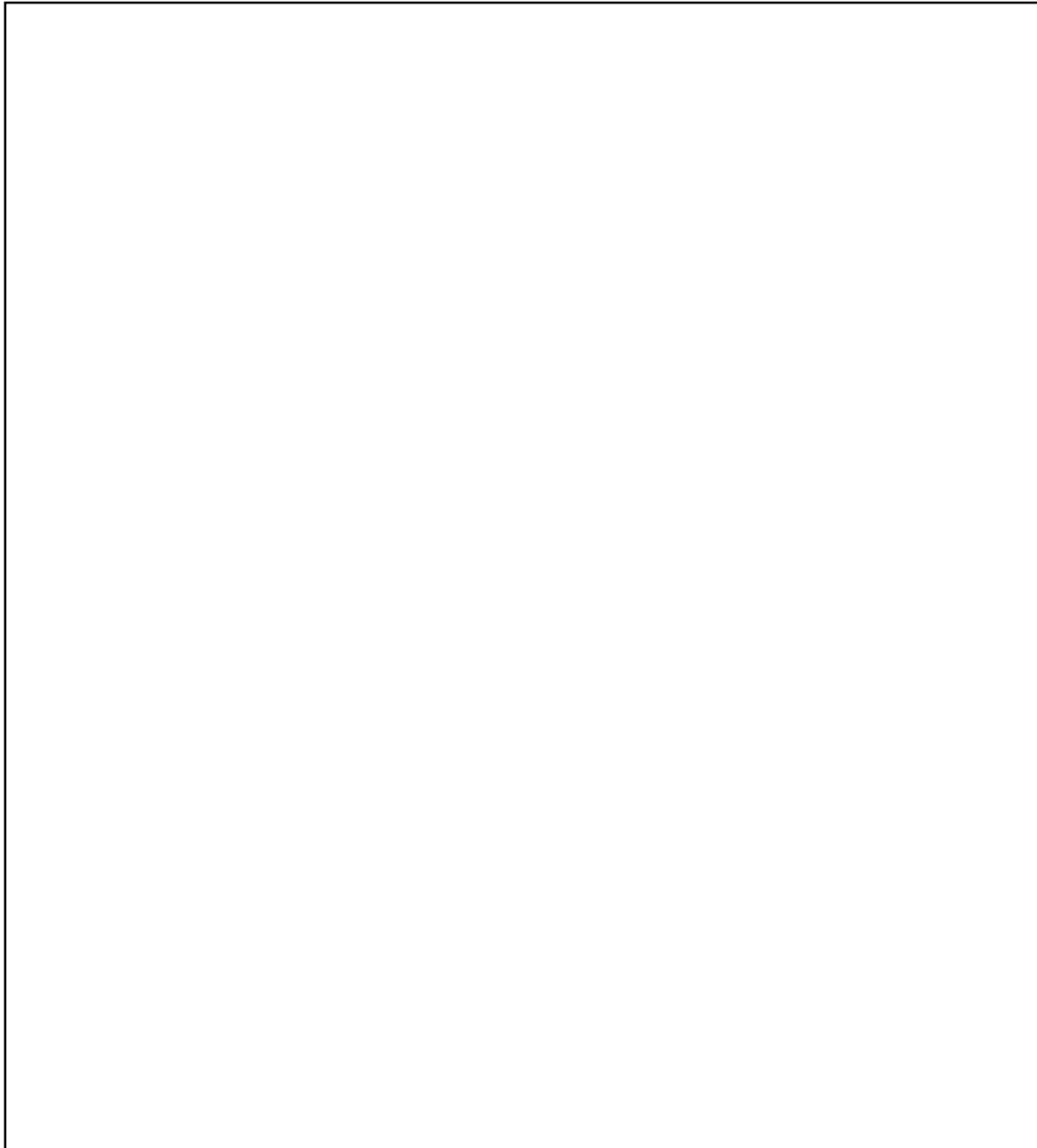
Max Depth (cm): _____

Results

Evidence of Mussels: Presence of fresh dead mussel shells and living mussels will trigger a full mussel survey.

- None
- Mussel Shell Only-Subfossil
- Mussel Shell Only-Weathered
- Mussel Shell Only-Fresh Dead
- Living Mussels

Site Sketch. Approximate numbers and locations of shells and live mussels. Include species list if possible. Required attachments 1)Location Map and 2) Photo Log.



Appendix D: Recommended Guides for Michigan Mussels

Mulcrone, R. S. and J. E. Rathbun. 2020. *Field Guide to the Freshwater Mussels of Michigan* (2nd ed.). Michigan Department Natural Resources.

Other useful references:

Clarke, A. 1981. *The Freshwater Molluscs of Canada*. National Museums of Canada. National Museums of Science.

Cummings, K., and C. Mayer. 1992. *Field Guide to Freshwater Mussels of the Midwest*. Illinois Natural History Survey.

Klocek, R., J. Bland, and L. Barghusen. Undated. *A Field Guide to the Freshwater Mussels of Chicago Wilderness*. Available at: <http://fm2.fieldmuseum.org/plantguides/guideimages.asp?ID=360>

Metcalfe-Smith, J., A. MacKenzie, I. Carmichael, and D. McGoldrick. 2005. *Photo Field Guide to the Freshwater Mussels of Ontario*. St. Thomas Field Naturalists Club, St. Thomas, Ontario Canada.

Metcalfe-Smith, J., J. Di Maio, S. Staton, and M. Gerald. (2000). Effect of Sampling Effort on the Efficiency of the Timed Search Method for Sampling Freshwater Mussel Communities. *Journal of the North American Benthological Society*. 19. 725.

Watters, G., M. Hoggarth, and D. Stansbery. 2009. *The Freshwater Mussels of Ohio*. Ohio State University Press.

Freeware-R Software for the development of Species Richness Curves
<http://cc.oulu.fi/~jarioksa/softhelp/vegan/html/specaccum.html>