

Michigan Freshwater Mussel Survey Protocols and Relocation Procedures for Rivers and Streams

May 2021, Version 3

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****Note to Readers**

Michigan river and stream reaches have been grouped according to existing knowledge of mussel distribution and individual species conservation status (Appendix A). These stream groups determine the survey effort and appropriate survey protocol(s) to conduct a mussel survey at the project site. They are described in detail in these protocols.

The spatial data that outlines these river and stream groupings as well as the associated element occurrence data is publically available through the Michigan Natural Features Inventory: <https://mnfi.anr.msu.edu/resources/michigan-mussels>.

****Substantive Revisions in Version 2 (May 2019)**

The first field season for implementation of these Protocols was 2018. Following the 2018 field season the U.S. Fish and Wildlife Service and Michigan Department of Natural Resources decided to make the following substantive changes:

- changed recommendations on the number of post-relocation monitoring events in Group 2 and Group 3 rivers from “*Two post-relocation monitoring surveys are required*” (February 2018, version 1) to “at least one post-relocation monitoring survey...” and “In the case of large relocation efforts (e.g. great than 500 individuals), additional post-relocation monitoring efforts may be required.” (May 2019, version 2);
- changed timeframe of post relocation monitoring event from “*30 to 45 days after relocation*” to “*within 12 months of relocating mussels*”;
- changed language in Table 2 (*Required attributes of potential mussel relocation sites*) from “*Required*” to “*Recommended*”;
- clarified recommendations on the level of effort for streams with small-bodied mussels (page 13); and
- clarified language on State and Federal permitting processes and associated reporting.

****Substantive Revisions in Version 3 (May 2021)**

Following the 2019 and 2020 field season the U.S. Fish and Wildlife Service and Michigan Department of Natural Resources decided to make the following substantive changes:

- added language to “*Species Richness Curves*” section to include the “*Survey plans submitted to MDNR and USFWS should outline the need for species richness curves. If necessary to confirm adequate sampling effort, they should be submitted as part of any survey reporting to both agencies.*”;
- survey and relocation season were changed to align to be June 1- October 15;
- added language to clarify that post relocation mortality is indicated by moribund animals as opposed to failure to find individuals that have potentially moved out of the relocation areas; and
- removed maps and county level list referencing river Groups 1, 2, 3 mapped reaches and replaced those figures and tables with a reference to Michigan Natural Features Inventory Mussel Map Viewer.

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I. Introduction and Purpose

In North America, 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). Five 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.). An additional 12 species are in decline and are identified as species of special concern. The primary reasons for decline of unionid mussels include habitat loss as a result of dam and road construction, stream channelization, water quality degradation, siltation, alterations to natural streamflow, and the introduction of non-indigenous species such as zebra mussels (Williams *et al.* 1993; Watters 2000; Strayer 2008). Many of these reasons for declines occur concurrently and more evidence is required to determine causation (Downing *et al.* 2010).

Freshwater mussels are an important component of the biodiversity of Michigan's aquatic ecosystems. They have a unique ecological role in both rivers and lakes and are valuable indicators of ecosystem integrity and function (Adkinson *et al.* 2013). Mussels are of significant value to the health of aquatic ecosystems (Vaughn 2017). They are a food source for some fish and terrestrial animals and often comprise a significant amount of the total biomass of all benthic invertebrates (Strayer *et al.* 1994, Strayer 2008). The spent shells also serve as physical habitat and are often colonized by a variety of aquatic insects and other macroinvertebrates. Since they are filter feeders, they play an important role in nutrient uptake and increasing water clarity (Strayer 2017). Freshwater mussels are sensitive to declines in physical habitat and water quality; this is especially true during early life stages which are likely one of the most sensitive of aquatic organisms (Newton *et al.* 2008). Because mussels are generally long-lived, relatively immobile, and reliant on fish hosts for reproduction and dispersal, their community status can provide an integrative view of physical, chemical, and biological changes in a watershed.

The protocols herein are applicable to projects whose potential impacts are limited spatially to a few hundred meters of river or less (e.g. streambed disturbance, or temporarily increased sedimentation), not for projects or events impacting multiple kilometers of river (e.g. chemical or oil spills, mussel kills, or large dredging projects). Such large-scale surveys will require alternative survey designs. Recommended references include Strayer and Smith (2003), Metcalfe-Smith et al (2000), and Smith et al (2001).

These protocols are designed to document the potential presence or absence of state or federally listed mussel species as well as provide guidance for survey and relocation activities to minimize impacts to native mussels in Michigan. The following mussel survey and relocation protocols are applicable to most Michigan streams and rivers; however, inland lakes, impoundments, the Great Lakes, Lake St. Clair, or 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 survey and relocation protocols described in this document were adapted for Michigan from the West Virginia Mussel Survey Protocols (Clayton *et al.* 2015) and the Ohio Mussel Survey Protocols (ODNR 2020). The Michigan protocols provide project proponents with guidance to minimize impacts to mussel species that are currently identified as threatened or endangered by the State of Michigan or U.S. Government. This Protocol document represents the second iteration of standardized mussel protocols for Michigan and is intended to be updated as knowledge of mussel distributions increase 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 distribution maps maintained by the Michigan Natural Features Inventory (<https://mnfi.anr.msu.edu/resources/michigan-mussels>) to determine if listed freshwater mussels are likely to be present in a particular river or stream. **Applicants are advised that lack**

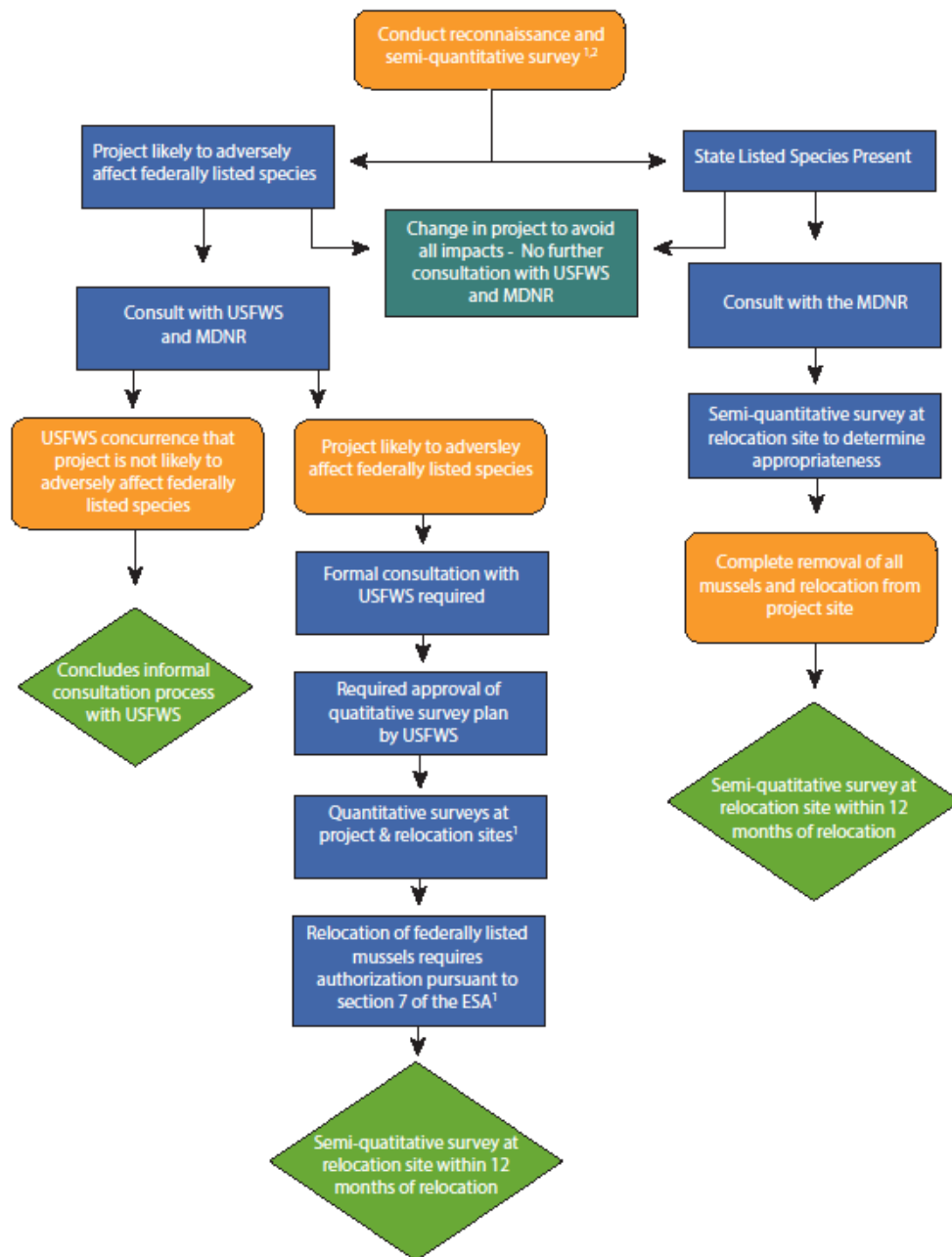
of survey information at a particular location does not mean that mussels are not likely to be present. Project proponents are advised to contact the Michigan Department of Natural Resources (MDNR) and/or the U.S. Fish and Wildlife Service (USFWS) early in the project planning process to determine if mussel survey and relocation work may be necessary. If listed mussels have been reported previously from the project location, coordination with USFWS and/or MDNR, 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	Threatened	
<i>Cyclonaias tuberculata</i>	Purple wartyback		
<i>Elliptio complanata</i>	Eastern elliptio	Special Concern	
<i>Epioblasma obliquata perobliqua</i>	White catspaw	Endangered	Endangered
<i>Epioblasma torulosa rangiana</i>	Northern riffleshell	Endangered	Endangered
<i>Epioblasma triquetra</i>	Snuffbox	Endangered	Endangered
<i>Eurynia 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>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>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>Ptychobranchus fasciolaris</i>	Kidney-shell	Special Concern	
<i>Pyganodon grandis</i>	Giant floater		
<i>Pyganodon lacustris</i>	Lake floater	Special Concern	
<i>Pyganodon subgibbosa</i>	Lake floater	Threatened	
<i>Quadrula quadrula</i>	Mapleleaf		
<i>Sagittunio nasutus</i>	Eastern Pondmussel	Endangered	
<i>Simpsonaias ambigua</i>	Salamander mussel	Endangered	

Species*	Common Name	Michigan Status	U.S. Status
<i>Strophitus undulatus</i>	Strange floater		
<i>Toxolasma lividus</i>	Purple Lilliput	Endangered	
<i>Toxolasma parvus</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	
<i>Villosa fabalis</i>	Rayed bean	Endangered	Endangered

*Follows Williams et al 2017.



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

II. Identifying Stream Group

Michigan river and stream reaches have been grouped according to existing knowledge of mussel distribution and individual species conservation status (refer to MNFI Mussel Map Viewer for modeled river and stream reaches: <https://mnfi.anr.msu.edu/resources/michigan-mussels>). These stream groups determine the survey effort and appropriate survey protocol(s) to conduct a mussel survey at the project site.

Group 1: Stream and rivers likely to support mussels considered to be special concern by the State, but lacking mussel occurrence data at the project site (refer to MNFI Mussel Map Viewer for modeled Group 1 reaches: <https://mnfi.anr.msu.edu/resources/michigan-mussels>).

Group 2: Streams and rivers likely to support populations of State threatened and endangered mussels (refer to MNFI Mussel Map Viewer for modeled Group 2 reaches: <https://mnfi.anr.msu.edu/resources/michigan-mussels>).

Group 3a: Small and medium streams and rivers with a drainage area less than 300 mi² likely to support populations of federally listed mussels (refer to MNFI Mussel Map Viewer for modeled Group 3 reaches: <https://mnfi.anr.msu.edu/resources/michigan-mussels>).

Group 3b: Large rivers (drainage area greater than 300 mi²) likely to support populations of federally listed mussels (refer to MNFI Mussel Map Viewer for modeled Group 3 reaches: <https://mnfi.anr.msu.edu/resources/michigan-mussels>).

III. 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. Those individuals undertaking surveys 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. The MDNR and USFWS encourage all project proponents to consider ways to avoid and minimize adverse effects to listed mussels to the maximum extent practicable prior to conducting surveys.

State of Michigan Permits

All native mussels are protected in Michigan and cannot be handled without a Cultural and Scientific Collectors Permit issued by the MDNR Fisheries Division. Before conducting any mussel surveys or relocations, contact the program coordinator at (517) 284-5830.

In addition, if it is anticipated that state threatened or endangered mussels will be encountered at the project site, a Threatened and Endangered Species Permit is required. Before conducting any survey work, consult with the MDNR Endangered Species Program staff to obtain the necessary permits (517) 284-6210.

Federal Permits

The potential presence of federally listed species will also require coordination with the USFWS (<http://www.fws.gov/midwest/Endangered/lists/michigan-cty.html>). A federal permit will be required to survey for listed species. For more information contact the Endangered Species Coordinator at the USFWS Michigan Field Office in East Lansing, (517) 351-2555 or visit: <https://www.fws.gov/midwest/Endangered/permits/index.html>.

Prior Notification

Even though standardized protocols are established, survey plans must be provided to MDNR (all rivers/streams) and/or USFWS (Group 3a and 3b only) for review in advance. To coordinate with the appropriate MDNR management unit please consult the following link: https://www.michigan.gov/dnr/0,4570,7-350-79136_79236_80245---,00.html. This is to ensure that the appropriate protocol is being applied for a given stream type and construction activity and to allow time for agency staff to review existing data and work with the applicant to design the appropriate survey. MDNR and/or USFWS staff shall be notified at least 15 days prior to the time the actual survey will occur. In addition, MDNR shall be given at least 30 days to review final survey results prior to the anticipated start of the construction activities. Activities conducted in Group 3 rivers and streams must have received written concurrence from the USFWS prior to conducting any project activities including, surveys, relocations, and/ or construction activities.

Data Longevity

Survey data collected on a specific site will generally be considered valid for five 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.

IV. Survey Guidelines

Surveyor Qualifications

Personnel conducting mussel surveys and relocations must possess a Bachelor of Science degree in biology, natural resources, or a related field, and knowledge of the biology and ecology of freshwater mussels. A mussel surveyor must have sufficient experience, including documented fieldwork, to execute these survey protocols and locate and identify state and federally protected mussel species. Surveyors must hold a current permit to handle native mussels from the MDNR Fisheries Division and in Group 2 streams, surveyors must also have a Threatened and Endangered Species Permit from the MDNR Endangered Species Program. Additionally, in Group 3 streams surveyors must also hold a 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 on any Group 3 streams.**

Survey and Relocation Season

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 relocation must be conducted between **June 1 and October 15**. Requests to conduct mussel surveys and relocations outside of this time period will be reviewed on a case by case basis. Any survey work conducted outside of this time frame will be conducted only under extenuating circumstances and with prior approval from MDNR and/or USFWS.

Workable flow and visibility requirements

Surveys must be conducted during periods of stable flow and 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 high flow or poor visibility, then the survey must be rescheduled. In streams with high background turbidity, modified survey methods and/or excavation surveys may be required.

Minimum Data to be Recorded

Refer to Appendix B 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 must be submitted to the USFWS in accordance with their section 10a1A permit requirements and/or section 10a1B 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: upstream (USB), downstream (DSB), and laterally (LB) (Figure 4). If the project will affect the natural hydrology of the stream upstream and/or downstream of the ADI (e.g., installation or removal of instream structures, stormwater outfalls, etc.), the affected area must be included in the ADI. In these instances hydraulic modeling may be necessary to delineate the bounds of the ADI. Likewise, the mixing zone of stormwater and other outfalls shall be included within the ADI. The size of the buffer areas will be determined on project specific basis and must include consideration of substrate particle size, indirect impacts (e.g., changes in flow regime, 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.

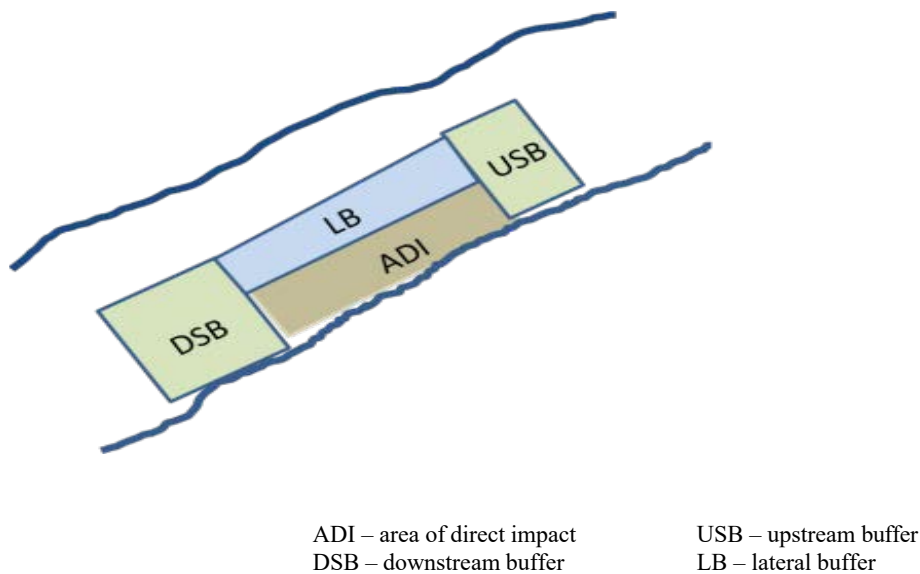


Figure 4.- Survey extent shall include the area of direct impact (ADI) and all applicable buffers.

V. 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 levels at the site are at normal or low flows and water clarity must be good. Streams that are very deep, consistently turbid, or with other issues that preclude searching the stream bottom throughout the entire survey reach cannot be surveyed using this technique. Those streams will require the use of timed search protocols described below. Beginning at the downstream end of the buffer zone, the stream substrates, stream banks, and gravel bars should be visually searched for evidence of shells, shell fragments, or live mussels. All stream 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 during the survey to aid in viewing the substrates. 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 streams and medium streams (10-100 square miles), or 90 minutes for larger streams (above 100 square miles), 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 stream size) should be used to determine if mussels are still present within the survey area. No species list will be generated from these surveys, unless the biologist possesses the qualifications to accurately identify mussels to species. **Representative photos of the survey area, and shell material observed and live mussels should 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 and live mussels will trigger a mussel survey by a qualified surveyor as described further in Section V.**

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, USB, DSB, and LB buffers for a given period of time. This type of search 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 5cm (2in) of substrate to increase the likelihood of mussel detection. Hand grubbing and viewing buckets should be used in waters less than 0.5m (20in) in depth. In project areas where the water exceeds this depth, mask and snorkel combined with hand grubbing should be used. In large, deep rivers, surveying may require the use of SCUBA.

Transect Surveys consist of visual and tactile searches along transects. Transects shall be established throughout the proposed site and placed perpendicular to river flows. Transect spacing in small and medium rivers (drainage area less than 300 square miles) should not exceed 10m and in large rivers transects will be spaced 25m apart. Each transect will be sub-divided into 5-m segments. Along each transect, surveyors shall visually and tactilely search an area 1m wide for mussels.

Cells may be used in lieu of transects. The establishment of cells is more appropriate for smaller projects (e.g., placement of scour protection around bridge piers, 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 100 m² with the dimensions determined by the surveyor based on stream channel morphology.

Survey Effort

Habitat complexity will determine search effort. A minimum of 0.5 minute/m² of visual and tactile searching shall be expended in homogenous substrates or shifting bedloads and 1 minute/m² in areas of 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, Slippershell, Salamander mussel, Purple Lilliput, Lilliput, Rayed Bean) level of survey effort should be increased to 2 minutes/m² to enhance detection.**

Quantitative Methods

Quantitative Surveys provide more detailed information about sites. Quantitative sampling will be conducted using 1-m² or .25m² quadrats and a systematic sampling design with three random starts in 3m by 5m blocks oriented perpendicular to stream flow 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 bank-to-bank coverage. 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

Survey plans submitted to MDNR and USFWS should outline the need for species richness curves. If necessary to confirm adequate sampling effort, they should be submitted as part of any survey reporting to both agencies. Species richness curves (i.e., species accumulation curves) will be developed during semi-quantitative surveys for Group 2 and 3 rivers and streams to confirm sampling effort adequately represents the number of species present at the project site (see Figure 5). 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. In the example below, 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.

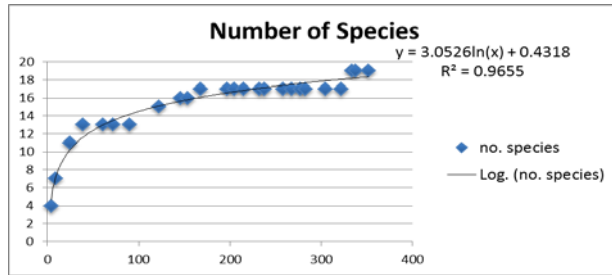


Figure 5: Example of a species richness curve (*Y axis- number of species represented in collection; X axis- number of individuals collected*)

Mussel Processing

For survey methods other than reconnaissance, any mussels or valves observed 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. Bags or buckets should be placed in shaded flowing 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. 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 valve. Any questionable species should include photographs of the left valve, right valve, and dorsal view as well to provide adequate reference for verification. All mussels will be returned to the river 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.

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. At this time, 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 impacts to mussels. If avoidance is not possible, the project proponent must then submit a survey proposal to the MDNR and USFWS and receive approval before beginning work.

VI. Stream Type Specific Guidance

Note: Reconnaissance surveys are recommended for all stream groups where conditions are wadeable and where the substrate is visible to confirm 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 are river or stream segments known to support special concern mussel species and have suitable habitat but lack mussel occurrence data at the project site.

Visual-tactile timed search surveys are recommended, but not required, for Group 1 river and stream segments 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 shorelines, 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 streams to pre-approved sites can occur at the time of the initial survey (see **Mussel Relocation Procedures** below).

Group 2 Waters are stream and river segments with state threatened or endangered species expected. Mussel surveys within Group 2 river segments include semi-quantitative methods. If state listed species are detected mussel relocation efforts will be required and surveyors must contact MDNR for further guidance (**Section V. 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 river 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 within 5 business days of completion of the survey.

Group 3 Waters are stream and river segments where federally listed mussel species are expected. Surveys in these river segments 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 a 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.

Group 3a survey design shall consist of transects, 1m in width, spaced no more than 10m apart, placed perpendicular to stream flow, or cells not to exceed 100 m². If the stream width is 20m or less, the survey design shall consist of complete cell coverage. For streams greater than 20m wide, the preferred survey method is by cells; however, transects may be used to delineate the habitats that require further survey effort by cells. Data shall be compiled separately for the ADI and applicable buffers. Data shall be recorded by 5m segments along the transect or by cell position. 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 as described above.

Group 3b survey design shall consist of transects, 1m in width, spaced no more than 25m apart, placed

perpendicular to stream flow, or cells not to exceed 100 m². 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 as described above.

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

1. Presence of a federally listed species;
2. Mussel density of $\geq 0.25/\text{m}^2$ 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 streams 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 5 days of completion of the survey. The presence of federally listed will require consultation with the USFWS.

VII. 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 impact 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/or USFWS for federally listed mussels. If mussels are assumed to be present in Group 1 and 2 streams, 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 3a and 3b streams. 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. Impacts 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. Careful consideration must be given to the location of the relocation site in the landscape. A hierarchy of preferred destinations, modified from the USFWS (2008), is:

1. Same reach (*i.e.*, between two stream confluences).
2. Within the same watershed, but in a different reach or tributary.

3. A hatchery or other holding facility.
4. Presence of a diverse mussel community reflective of the community from which the individual was moved and that has evidence of recruitment.

More specific attributes for a relocation site are listed in Table 2.

Table 2.-Recommended attributes of potential mussel relocation sites.

- Relocation sites shall be upstream (preferred) and of equal or better habitat. Alternate locations will be reviewed on a case-by-case basis.
- The presence of a similar mussel community comprised of most or all of the species to be moved from the salvage area.
- Evidence of good recruitment as indicated by the presence of juveniles mussels.
- Habitat conditions should be as similar as possible to the project site, in terms of sediment composition and stability, water quality, water depth, flow regime, distribution of habitat features (pools, riffles, etc.), overall area (multiple relocation sites may have to be identified if the source site is particularly large), and upstream drainage area.
- Appropriate fish host species must be present.
- It should be secure for the foreseeable future from disturbances (e.g., dredging).
- If zebra mussels (*Dreissena polymorpha*) and Quagga mussels (*Dreissena rostriformis bugensis*) are absent from the project site, they must not be present either at the relocation site or upstream of the relocation site.

Visual-tactile and/or quantitative surveys may be required to assess the composition of the mussel community at the relocation site (see Section III for details). An estimate of the size of the relocation site must be included in the survey. This survey may be performed no more than 5 years prior to the relocation. The relocation site survey may need to be repeated if an event or impact (e.g., a chemical spill) has occurred during the time between the original survey and the proposed relocation that could have impacted the resident mussel community or altered environmental conditions. Relocation sites lacking the listed species that need to be relocated should be avoided unless no other suitable sites are found and permission is obtained from the MDNR for Group 2 streams and USFWS and MDNR for Group 3 streams.

If the ADI and buffers areas are large, it may be necessary to select 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 of the project site. 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 to MDNR for state listed species or MDNR and USFWS for federally listed species for approval. This report shall include summaries of the site attributes listed in Table 2.

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 within the relocation area (Strayer and Smith 2003). Mussels shall be collected by wading using view scopes or snorkeling in shallow water, or with SCUBA in deeper water. To facilitate mussel detection, cobble, and woody material should be moved; silt, sand and small detritus should be swept away. A moving transect may also be used to ensure the project area is

cleared of all mussels.

When using a moving transect a defined section is cleared, and then the line is moved to define a new area for clearing. For example, a 1m area upstream of an established transect line is marked off, searched and mussels are salvaged. A minimum effort of 1 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 observed on the first pass is recovered on the last pass. Once the area is cleared, the transect is moved upstream in 1m increments, and the new areas are 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 in some fashion 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. 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 and/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 stream discharge is stable and turbidity is low. Mussels shall be transported in containers that minimize jostling or impact. 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. 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 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 flowing 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 source 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 streams. If non-listed species are moved, a paint pen or shellfish tags may be used to mark the relocated mussels. In Group 2 and Group 3 streams, at least one post-relocation monitoring survey may be required to assess survival of all mussels moved to the relocation site when state or federally listed species are found. In the case of large relocation efforts (e.g. greater than 500 individuals), additional post-relocation monitoring efforts may be required. The post-relocation survey must occur within 12 months of relocating the mussels. 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. This would be documented by actual moribund animals as opposed to an inability to find animals due to movement out of the relocation area. 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 streams (if performed) and Group 2 streams, and with the USFWS for Group 3 streams. If greater than 100 mussels are relocated, consult with the appropriate permitting agency on the percentage of relocated mussels that must be marked. An effort to locate all PIT-tagged individuals should be made and should include searching a buffer area to account for mussel movement.

A determination on the appropriate methodology should consider the scale of the relocation and the type of tags used on the relocated individuals. An effort to locate all pit tagged individuals should be made and should include searching a buffered area to account for movement. Shell dimensions of the marked mussels will be measured during the second post-relocation survey only.

Reporting

A report will be provided to MDNR for all surveys within 45 days of completion of the relocation and subsequent monitoring activities. 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 Appendix B for a checklist of data that must be included in these reports.

VIII. References

- Atkinson, C.L., C. Vaughn, K.J. Forshay, and J. T. Cooper. 2013. Aggregated filter-feeding consumers alter nutrient limitation: consequences for ecosystem and community dynamics. *Ecology* 94(6) pp. 1359-1369.
- Clayton, J.L., B. Douglas, P. Morrison, and R. Villella. 2013. West Virginia Mussel Survey Protocols. Unpublished document.
- Downing, J.A., P. Van Meter, and D.A. Woolnough. 2010. Suspects and evidence: a review of the causes of extirpation and decline in freshwater mussels. *Animal Biodiversity and Conservation* 33.2: 151-185.
- Kurth, J., C. Loftin, J. Zydlewski, and J. Rhymer. 2007. PIT tags increase effectiveness of freshwater mussel recaptures. *J. N. Am. Benthol. Soc.* 26(2):253-260
- Master, L. L., B. A. Stein, L. S. Kutner, and G. A. Hammerson. 2000. Vanishing assets: Conservation status of U.S. species. Pages 93-118 in B. A. Stein, L. S. Kutner, and J. S. Adams editors. *Precious heritage: The status of biodiversity in the United States*. Oxford University Press, New York.
- MDNR (Michigan Department of Natural Resources). 2009. Endangered and Threatened Species. http://www.state.mi.us/orr/emi/admincode.asp?AdminCode=Single&Admin_Num=29901021&Dpt=NE&RngHigh=.
- 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.
- Newton, T.J., D.W. Woolnough, D. L. Strayer. 2008. Using landscape ecology to understand and manage freshwater mussel populations. *J. N. Am. Benthol. Soc.* 27(2): 424.
- Ohio Department of Natural Resources, Division of Wildlife and USFWS. Ohio Mussel Survey Protocol, April 2020. 57 pp.
- Smith, D. R., R.F. Villella, D. P. Lemarie. 2001. Survey Protocol for Assessment of Endangered Freshwater Mussels in the Allegheny River, Pennsylvania. *J. N. Am. Benthol. Soc.* 2(1): 118-132.
- Smith, D. R. 2006. Survey design for detecting rare freshwater mussels. *J. N Am. Bentholo. Soc.* 25(3):701-711.
- Strayer, D. L. 2008. *Freshwater mussel ecology: A multifactor approach to distribution and abundance*. University of California Press, Berkely.
- Strayer, D. L. 2017. What are freshwater mussels worth? *Freshwater Mollusk Biology and Conservation* 20:103-113.
- Strayer, D. L., and D. R. Smith. (2003). *A guide to sampling freshwater mussel populations*. American Fisheries Society Monograph 8. Bethesda, Maryland.
- Strayer, D. L., D. C. Hunter, L. C. Smith, and C. K. Borg. 1994. Distribution, abundance, and roles of freshwater clams (*Bivalvia*, *Unionidae*) in the freshwater tidal Hudson River. *Freshwater Biology* 31:239-248.

- U.S. Fish and Wildlife Service. 2008. (Draft) USFWS discussion paper for drought contingency planning for freshwater mussels in Southeast U.S. Draft version 1.0 4-22-08. 19 pp .
- Vaughn, C. 2017. Ecosystem services provided by freshwater mussels. *Hydrobiologia*
doi:10.1007/s10750-017-3139-x
- Watters, G. T. 2000. Freshwater mussels and water quality: A review of the effects of hydrologic and instream habitat alterations. Pages 261-274 in *Proceedings of the conservation, captive care, and propagation of freshwater mussels symposium*. Ohio Biological Survey, Columbus.
- Williams, J. D., M. L. Warren Jr., K. S. Cummins, J. L. Harris, and R. J. Neves. 1993. Conservation status of freshwater mussels of the United States and Canada. *Fisheries* 18(9):6-22.
- Williams, J. D., A. E. Bogan, R. S. Butler, K S Cummings, J. T. Garner, J. L. Harris, N A. Johnson, and G. T. Watters. 2017. A revised list of the freshwater mussels (Mollusca: Bivalvia: Unionida) of the United States and Canada. *Freshwater Mollusk Biology and Conservation* 20:33-58.
- Woolnough and Barnett. 2013. Detection and quantification of Snuffbox (*Epioblasma triquetra*) in Grand River Lyons, MI: Section 7 permit requirements. Report for Ionia Conservation District. 26 pp.
- Zorn, T. G., P. W. Seelbach, E. S. Rutherford, T. C. Wills, S.T. Cheng, and M. J. Wiley. 2008. A regional-scale habitat suitability model to assess the effects of flow reduction on fish assemblages in Michigan streams. Michigan Department of Natural Resources, Fisheries Research Report 2089, Ann Arbor.

Recommended Guides for Identifying Michigan Mussels

Mulcrone, R. S. and J. E. Rathbun. 2018. Field Guide to the Freshwater Mussels of Michigan. 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>

Metcalf-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.

Metcalf-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>

Report Checklist

Introduction

- Description of the stream and watershed including:
 - Name (if stream is named)
 - Receiving waters of surveyed stream
 - Location, including:
 - Coordinates – at center of ADI
 - River mile (if available)
 - Township Range Section
 - County
 - Drainage area at survey site
 - Summary of any water quality data or previous mussel surveys reports near the area of impact
 - Surrounding land use

Methods

- Personnel
- Date(s) of survey
- Area surveyed, including:
 - Description of survey/buffer areas (e.g., length, bank-to-bank)
 - Coordinates of survey/buffer areas (ADI, USB, DSB)
 - Map delineating survey/buffer areas (ADI, USB, DSB, LB). 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 banks 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)
 - In-stream features (e.g., channel alterations, impoundments)
 - Average stream depth
 - Water velocity (cubic feet per second)
 - 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 stream 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):

Appendix A

- 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 (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
- The numbers, lengths, and calculated percent of living, dead, and missing mussels for each marked relocated species
- Tag ID numbers for living, dead, and missing mussels.
- 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 stream 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

Michigan Freshwater Mussel Habitat Assessment Form

Project Information

Project Name _____
 Water body _____ Stream 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 (Yes/No)
 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

Drainage Area at Survey Location (if known) (mi²): _____ Water Temp. (°F): _____ Air Temp. (°F): _____

Substrate Types (include %):

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

Hardpan

Water Level:	<input type="checkbox"/> High	<input type="checkbox"/> Up	<input type="checkbox"/> Normal	<input type="checkbox"/> Low	<input type="checkbox"/> Dry/Interstitial
Visibility:	<input type="checkbox"/> 0-15 cm	<input type="checkbox"/> 15-30 cm	<input type="checkbox"/> 30-50 cm	<input type="checkbox"/> >50 cm	<input type="checkbox"/> Visible to Bottom

Average Depth (cm):	Riffle _____	Run _____	Pool _____
Max Depth (cm):	Riffle _____	Run _____	Pool _____

Results

Evidence of Mussels: Presence of fresh dead mussel shells and living mussels will trigger a full mussel survey				
<input type="checkbox"/> None	<input type="checkbox"/> Mussel Shell Only - Subfossil	<input type="checkbox"/> Mussel Shell Only - Weathered Dead	<input type="checkbox"/> Mussel Shell Only - Fresh Dead	<input type="checkbox"/> Living Mussels
Site Sketch. Approximate numbers and locations of shells and live mussels. Include species list if possible.				
<div style="border: 1px solid black; min-height: 450px;"></div>				
Required Attachments 1) Location Map and 2) Photo Log				