2018-03j Project Abstract
For the Period Ending June 30, 2021

PROJECT TITLE: Develop Sonar Data Mapping on Three Rivers to Assess Suitability for Native Mussel
PROJECT MANAGER: Nancy Duncan
AFFILIATION: National Park Service Mississippi National River and Recreation Area
MAILING ADDRESS: 111 E. Kellogg Blvd; Suite 105
CITY/STATE/ZIP: St. Paul, MN 55101
PHONE: (651) 293-8434
E-MAIL: nancy_duncan@nps.gov
WEBSITE: https://www.nps.gov/miss/index.htm
FUNDING SOURCE: Environment and Natural Resources Trust Fund
LEGAL CITATION: M.L. 2018, Chp. 214, Art. 4, Sec. 02, Subd. 03j as extended by M.L. 2020, First Special Session, Chp. 4, Sec. 2 [Insert relevant year's citation here]

APPROPRIATION AMOUNT: $200,000
AMOUNT SPENT: $199,999.99
AMOUNT REMAINING: $0.01

<u>**Sound bite of Project Outcomes and Results**</u>
Baseline information in the form of bathymetry and imagery were developed for the National Park Service for native mussel habitat suitability. These data have the analytic capabilities to be viewed and modeled in a digital environment to help understand mussel distribution, define preferred habitat parameters, and identify key habitat locations for restoring imperiled mussels.

<u>**Overall Project Outcome and Results**</u>
The U. S. Geological Survey (USGS) collected depth information and sidescan imagery for areas of the National Park Service (NPS) Mississippi National River and Recreation Area (MISS) and the St. Croix National Scenic Riverway (SACN). For known locations of preferred mussel habitat, additional collection efforts of river flow velocities and underwater video of bed composition were collected. Prior to this project, MISS had no accessible bathymetry data above Pool 1, and SACN did not have any accessible bathymetry (other than a small area near Prescott, Wisconsin). The LCCMR ENRTF provided the opportunity to acquire bathymetry data where needed and make this information available to NPS resource management to help aid decision-making for the conservation of native mussels. Goals for this project were to collect high-resolution sonar data of three rivers where none previously existed. The data is delivered in digital format for modeling hydraulic variables related to native mussel habitat suitability. The USGS provided usable information in the form of bathymetry and topography (hillshades and sidescan imagery) for areas of full collection, and habitat measures of flow velocities and bed characterization for priority areas. Initially implemented as a two-year project, data collection was planned for each park in consecutive years. Due to the pandemic, some data collection was delayed a year. Bathymetric surveys for the lower SACN consisted of approximately 1,775 hectares (4,385 acres), and approximately 1,358 hectares (3,335 acres) were collected for MISS. Outcomes consisted of high-resolution bathymetry in the form of 0.5-meter digital elevation models, 3-D hillshade representations of the surface (using patterns of light and shadow), and sidescan images mosaics — which provide an underwater view of geomorphic features. Flow velocities and bed composition combined with bathymetry can be used to locate areas with similar features as the NPS priority areas. In order to provide complete coverage for MISS, the U.S. Corps of Engineers (USACE) main channel data were used for Pools 1, 2, and 3. The resulting merged bathymetry were generated at a lower resolution (5 meters) due to USACE collection parameters. This project is significant because it provides bathymetry where none previously existed for Minnesotans, and it provides valuable information to the NPS for imperiled mussel habitat modeling by locating other suitable areas for conservation efforts. Natural resource management and policy makers face an increasing number of environmental issues. These data combined with other river conditions can be used to help inform decision-making for aquatic invasive species, agricultural practices, riverfront development, erosion, sedimentation, and climate change.

Project Results Use and Dissemination

Dissemination included a formal USGS review for data and metadata, prior to release on the USGS data repository https://www.sciencebase.gov. The St. Croix National Scenic Riverway datasets and metadata can be found at https://doi.org/10.5066/P9X9I5QJ. The Mississippi National River and Recreational Area datasets and metadata can be found at https://doi.org/10.5066/P9BYGUQL. This project was posted as a resource for current USGS projects at Develop Sonar Data Mapping on Three Rivers to Assess Suitability for Native Mussel Habitat (usgs.gov).

The information resulting from this project is currently being incorporated into a Freshwater Mussel Database (NPS Focused Condition Assessment) for MISS and SACN, which will further be linked to a Freshwater Mussel Decision Support System (USGS Natural Resource Preservation Program) for resource management. Furthermore, the NPS and USGS partnership plan to pursue additional funding for MISS to map untapped information that can be derived from the sonar data; and to collect additional bathymetry and flow data where none still exists on SACN.

Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2018 ENRTF Work Plan Final Report

Today's Date: July 28, 2021

Final Report

Date of Work Plan Approval: June 05, 2018

Project Completion Date: June 30, 2021

PROJECT TITLE: Develop Sonar Data Mapping on Three Rivers to Assess Suitability for Native Mussel

Habitat Project Manager: Nancy Duncan

Organization: National Park Service Mississippi National River and Recreation Area

College/Department/Division:

Mailing Address: 111 E. Kellogg Blvd; Suite 105

City/State/Zip Code: St. Paul, MN 55101

Telephone Number: (651) 293-8434

Email Address: nancy_duncan@nps.gov

Web Address: https://www.nps.gov/miss/index.htm

Location: Anoka, Chisago, Dakota, Hennepin, Ramsey, Washington

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Total Project Budget: $200,000

Amount Spent: $199,999.99

Balance: $0.01

Legal Citation: M.L. 2018, Chp. 214, Art. 4, Sec. 02, Subd. 03j as extended by M.L. 2020, First Special Session, Chp. 4, Sec. 2

Appropriation Language: $200,000 the second year is from the trust fund to the commissioner of natural resources for an agreement with the National Park Service to create high-resolution sonar data maps to identify critical native mussel habitat for the designated Lower St. Croix National Scenic Riverway and the Mississippi National River and Recreation Area including part of the Minnesota River.

M.L. 2020 - Sec. 2. ENVIRONMENT AND NATURAL RESOURCES TRUST FUND; EXTENSIONS. [to June 30, 2021]

I. PROJECT STATEMENT:

The Mississippi National River and Recreation Area and the St. Croix National Scenic Riverway have established high-value habitat corridors for native freshwater mussels, including the Higgins' eye, *Lampsilis higginsii* and winged mapleleaf, *Quadrula fragosa* which are 2 of 28 species listed as either extirpated, endangered, threatened, or of special concern in Minnesota. Understanding what constitutes mussel habitat is vitally important for identifying suitable habitat for the conservation and restoration of freshwater mussels in Minnesota. Mussel habitat has not been well quantified partly due to the lack of information on benthic conditions in turbid, complex riverine systems. Benthos is the community of organisms that live on, in, or near the bottom of water bodies, also known as the benthic zone. The primary goal for this project is to collect high-resolution sonar information of benthic characteristics which may be used to identify native mussel habitat corridors. This project builds on past Minnesota mussel surveys, and will provide information useful to future survey efforts.

Sonar is a remote sensing technology used to map benthic environments. High-resolution sonar datasets provide baseline information, or building blocks that are necessary for understanding important spatial ecological relationships regarding how and why certain habitat corridors supply habitat for freshwater mussels. Recent advances in hydroacoustic technologies can provide information useful for developing key physical and hydrological variables needed to model mussel habitat. Mapping these variables will provide resource managers information to more accurately assess environmental factors that influence mussel distributions. The development of these spatial decision tools provides viewing of modeled datasets in a digital environment to interpret mussel habitat to better understand the complex benthic habitat corridors where freshwater mussels reside. The tools developed from the acquired sonar datasets could provide relevant information useful to other Minnesota rivers supporting native freshwater mussels.

While the direct purpose of these datasets and tools will be used for modeling mussel habitat, potential applications for these data are numerous for other natural resource agencies, academia, non-profit organizations, and policy makers in Minnesota. The information derived from high-resolution sonar is necessary for aquatic habitat assessments, habitat improvement projects, and quantifying submersed aquatic plant volume. Currently, hydroacoustic data is being utilized in fisheries research for mapping Asian carp habitat and preferred sturgeon spawning habitat. In addition to aquatic invasive species, other emerging issues hydroacoustic data can be applied to include channel sedimentation work such as channel formation and migration, island erosion, sand dune migration, and sediment load estimates.

The National Park Service, with the U.S. Geological Survey will acquire high-resolution hydroacoustic data, where no current data exists, to develop high-grade bathymetry and imagery. The term bathymetry refers to water depth relative to sea level, and bathymetry maps illustrate the land that lies under water. Additionally, acoustic Doppler current profilers measuring river current velocities will be collected in high priority areas, a necessary component needed to model physical and hydraulic variables in relation to native mussel habitat. The combined datasets will provide key components to interpreting benthic conditions and characterizing native mussel habitat. This will provide resource managers information to more accurately access environmental factors that influence mussel distributions. The newly acquired sonar datasets will be beneficial to other natural resource agencies in Minnesota, using the information as tools for the conservation and effective management of habitats for these ecologically important animals.

II. OVERALL PROJECT STATUS UPDATES:

First Update February 28, 2019

Hydroacoustic surveys were completed for the lower St. Croix River study area. This includes areas from the shoreline to depths up to 7.5 meters. River velocities around the designated high priority area near Hudson, Wisconsin, were also collected. The acquired sonar data was processed for various locational variables and is currently being processed for development into product outcomes.

The hydroacoustic data (multibeam, sidescan, and acoustic Doppler current profiles) was collected and processed for the St. Croix River Folsom Island study area. Ground-truthing for riverbed substrate and mussels was completed using a GoPro camera. The videos have been analyzed and the resulting information has been transferred to a spatial vector dataset. Developments to date include the following raster data: high-resolution bathymetry, sidescan sonar image mosaic, roughness, slope, backscatter, and digital surface (relief) model. The benthic mapping methodology is currently being developed. Automated methods are being explored for segmentation and classification.

Amendment Request February 4, 2019.
This amendment request is to extend the completion dates of the following Activity Outcomes:

- Activity 1 Outcome 2 completion date will be extended to September 30, 2019.

These changes are being requested because the U.S. government had a 35-day shutdown that resulted in furlough status for the U.S. Geological Survey Upper Midwest Environmental Science Center. This has resulted in related project work to fall behind. Also, we are rapidly approaching the new field season, and the staff working on the project will soon be travelling in order to complete sonar data acquisition this summer.

- Activity 2 Outcome 1 completion date has been changed to October 31, 2019, and Outcome 2 completion date has been changed to June 30, 2020.

These outcome dates may have previously been a typo or were initially submitted incorrect. The new outcome dates reflect realistic timeframes to collect sonar data during the summer of 2019 and complete all data products by the project completion date.

- Activity 1, 2, and 3 methods for collecting riverbed data for validation have changed.

The U.S. Geological Survey Upper Midwest Environmental Sciences Center has acquired an underwater camera to capture video clips of the riverbed. The National Park Service will provide their time for this collection method rather than diving for substrate data. This methodology will provide evidence in the form of digital video for accessing map accuracy.

- Activity 3 Outcome 2 benthic map classification will not include collaboration with NatureServe and the National Oceanic and Atmospheric Administration.

We did not receive additional funding and/or in-kind time for collaboration with these agencies.

Please note that the project completion date of June 30, 2020 has not changed.

The budget will remain the same as the original requested. No changes are necessary.

Second Update June 30, 2019

The St. Croix River hydroacoustic data (multibeam, sidescan, and acoustic Doppler current profiles) is being cleaned/edited for noise (unacceptable data), and developed into bathymetry and sidescan mosaics. QC/QA is being conducted on completed bathymetry and sidescan mosaics per field collection day.

Hydroacoustic surveys were delayed somewhat due to the long flood/high water events this spring/early summer. Hydroacoustic surveys began on the Mississippi River June 10th. To date, we have collected bathymetry and sidescan raw data for most of the area above Minneapolis. This includes the Coon Rapids pool, and much of the St. Anthony Falls pool. The acquired sonar data was processed for various locational variables.

Third Update January 31, 2020
The bathymetry, relief models, and sidescan images of the St. Croix River have undergone U.S. Geological Survey internal review. Once disseminated, the published datasets will be available on the U.S. Geological Survey ScienceBase-Catalog. Because river conditions were unfavorable for underwater viewing until late summer/early fall, recordings of underwater videos near the bed surface (to validate sediment type) where completed for areas near Hudson and Prescott in September 2019. Additionally, measures of river velocities near Prescott were completed. Due to the late data collection and additional issues processing backscatter data (used for substrate classification), map efforts for the priority areas of the St. Croix National Scenic Riverway (river velocities, validation images, and substrate maps) area currently undergoing U.S. Geological Survey review.

Due to extended flooding, hydroacoustic surveys began early June of 2019 for the Mississippi National River and Recreation Area, Coon Rapids pool once the water and discharge levels were safe to survey. Multibeam and sidescan surveys were completed for the navigable portions of the Mississippi River (where no current bathymetry exists) by late fall of 2019. The upper half of the St. Anthony pool is hazardous, and required certain river conditions to survey without damaging multibeam equipment. Because of a shorter field season (due to early and late flooding), and rigorous survey schedule, the U.S. Geological Survey failed to collect data for the upper half of the St. Anthony Falls pool. The U.S. Geological Survey intends to complete the surveys for this area during the spring of 2020. Surveys for river velocities and underwater video collection are complete for the approved priority area near Hidden Falls Park. Locational variables for the multibeam sonar data have been processed, and data development continues for the Mississippi National River and Recreation Area sonar mapping products.

The suite of data products for the "pilot" Folsom Island benthic map project is complete. All data products, including bathymetry, sidescan, relief model, slope, terrain ruggedness, contours, river velocities, video locations (interpretation), validation still images, and a substrate map have undergone U.S. Geological Survey internal review. Once disseminated, the published datasets will be available on the U.S. Geological Survey ScienceBase-Catalog.

Project extended to June 30, 2021 by LCCMR 6/18/20 as a result of M.L. 2020, First Special Session, Chp. 4, Sec. 2, legislative extension criteria being met.

Fourth Status as of July 31, 2020:
The bathymetry, relief models, and sidescan images of the Mississippi River are complete with the exception of the remaining area that requires data collection (upper half of St. Anthony Falls). Due to the development of COVID-19 pandemic, data collection could not occur during the Spring of 2020. River levels have remained too low during the summer of 2020 to complete the remaining surveys. Once river conditions are favorable (fall or spring of 2021), the remaining surveys will be completed and data will be processed to complete the planned data deliverables. Map efforts to for the priority area of the Hidden Falls are partially complete. The river velocities and validation images have been completed, and analysis to complete the substrate maps are currently underway.

The St. Croix River data products and Folsom Island "pilot" benthic map products have undergone an internal formal review. Due to some reorganization of staff at the U.S. Geological Survey Upper Midwest Environmental Sciences Center, the data have not been posted to the U.S. Geological Survey ScienceBase-Catalog yet.

Fifth Status as of January 31, 2021:

No further work has been completed for this project since the last update.

Final Update Between June 30 and August 15, 2021
The U. S. Geological Survey (USGS) collected depth information and sidescan imagery for areas of the National Park Service (NPS) Mississippi National River and Recreation Area (MISS) and the St. Croix National Scenic Riverway (SACN). For known locations of preferred mussel habitat, additional collection efforts of river flow velocities and underwater video of bed composition were collected. Prior to this project, MISS had no accessible bathymetry data above Pool 1, and SACN did not have any accessible bathymetry (other than a small area near Prescott, Wisconsin). The LCCMR ENRTF provided the opportunity to acquire bathymetry data where needed and make this information available to NPS resource management to help aid decision-making for the conservation of native mussels. Goals for this project were to collect high-resolution sonar data of three rivers where none previously existed. The data is delivered in digital format for modeling hydraulic variables related to native mussel habitat suitability. The USGS provided usable information in the form of bathymetry and topography (hillshades and sidescan imagery) for areas of full collection, and habitat measures of flow velocities and bed characterization for priority areas. Initially implemented as a two-year project, data collection was planned for each park in consecutive years. Due to the pandemic, some data collection was delayed a year. Bathymetric surveys for the lower SACN consisted of approximately 1,775 hectares (4,385 acres), and approximately 1,358 hectares (3,335 acres) were collected for MISS. Outcomes consisted of high-resolution bathymetry in the form of 0.5-meter digital elevation models, 3-D hillshade representations of the surface (using patterns of light and shadow), and sidescan images mosaics — which provide an underwater view of geomorphic features. Flow velocities and bed composition combined with bathymetry can be used to locate areas with similar features as the NPS priority areas. In order to provide complete coverage for MISS, the U.S. Corps of Engineers (USACE) main channel data were used for Pools 1, 2, and 3. The resulting merged bathymetry were generated at a lower resolution (5 meters) due to USACE collection parameters. This project is significant because it provides bathymetry where none previously existed for Minnesotans, and it provides valuable information to the NPS for imperiled mussel habitat modeling by locating other suitable areas for conservation efforts. Natural resource management and policy makers face an increasing number of environmental issues. These data combined with other river conditions can be used to help inform decision-making for aquatic invasive species, agricultural practices, riverfront development, erosion, sedimentation, and climate change.

III. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1:
Description: St. Croix National Scenic Riverway sonar survey, data processing, interpretation & modeling, and development of map products.

The U.S. Geological Survey Upper Midwest Environmental Sciences Center will acquire high-resolution sonar data of the lower 48 kilometers of the St. Croix River. Hydroacoustic surveys will be done according to U.S. Geological Survey standards during the summer of 2018. The study area for the lower St. Croix River includes the area from the shoreline to depths up to 7.5 meters, an accumulated area of approximately 1620 hectares. Once collected the sonar data requires processing for various locational variables and development into products using geographic information systems.

Predetermined high priority areas will have an additional mapping effort, which consists of acoustic Doppler current profiles measuring river current velocities, and substrate interpretation. While actual mussel habitat likely consists of a suite of physical, chemical, and biological traits, by combining the river current velocities

with bathymetry and substrate type, physical inputs for modeling mussel habitat can be developed.

Validation efforts (underwater video) for mussel beds and substrate type will be collected courtesy of the National Park Service. These datasets will provide additional accuracy assessment for mussel habitat inputs, like substrate type, a necessary component of modeling mussel habitat.

Product outcomes will consist of high-resolution bathymetry, sonar image mosaics, and underwater digital terrain models (relief) for the study area. Priority areas will have additional products (mussel habitat model inputs) consisting of sonar imagery, acoustic Doppler current profiles, and substrate maps. All data will be developed according to U.S. Geological Survey and Federal Geographic Data Committee standards. Once review and dissemination are complete, products will be posted online for shared use with additional stakeholders. Presentations and/or publications of this project will be carried out.

ENRTF BUDGET: $85,860

Outcome	Completion Date
1. Hydroacoustic surveys completed for the lower St. Croix River.	October 31, 2018
2. High-resolution bathymetry, digital surface models, and sonar image mosaics developed.	September 30, 2019
3. Mussel substrate maps, and mussel habitat inputs developed.	October 31, 2019
4. Presentations and/or publications of project.	June 30, 2020

First Activity 1 Update February 28, 2019
Hydroacoustic surveys were completed for the lower 48 kilometers of the St. Croix River. This includes areas from the shoreline to depths up to 7.5 meters. River velocities around the high priority area of Hudson were also collected. The acquired multibeam sonar data was processed for various locational variables and is currently being processed (edited) for development into product outcomes. There has been a delay in processing due to the U.S. Federal government shutdown.

With the purchase of a new acoustic Doppler Current profiler, we will be able to collect river velocities for the high priority area near Prescott, Wisconsin. We will collect this additional data during the summer of 2019. Additionally, with the purchase of an underwater camera, the National Park Service will collect random site videos of the riverbed substrate to be used as validation (accuracy assessment).

Second Activity 1 Update June 30, 2019
The St. Croix River data has been processed (edited) for development into product outcomes. QC/QA has begun on completed sidescan mosaics, and bathymetry.

The project was included in a presentation at the "Multibeam Echo Sounders in Rivers" workshop, held in Portland, Oregon, March 4-7, 2019.

Third Activity 1 Update January 31, 2020
The bathymetry, relief models, and sidescan images of the St. Croix River have undergone U.S. Geological Survey internal review. Development, review, approval, and release of data follow the U.S. Geological Survey Fundamental Science Practices. Once dissemination is complete for the bathymetry, relief models, and sidescan images, the data release will be on the U.S. Geological Survey ScienceBase-Catalog.

During the previous summer (2019), additional surveys for river velocities near Prescott and underwater videos of the riverbed substrate were collected at random sites near Hudson and Prescott. Favorable conditions for underwater

video are normal to low river levels, with low suspended sediment measures. Due to high water conditions earlier in the survey season, these additional surveys (river velocities and underwater video) were not completed until September 2019. Interpretation of underwater videos was completed, and clipped still images were used to validate substrate signatures during development of the substrate map. The river velocity data has been processed and developed as a raster image. Due to issues processing backscatter data (used for substrate classification), a rigorous field season, and late data collection (underwater video and river velocities), the priority area map efforts are currently undergoing U.S. Geological Survey internal review.

Fourth Activity 1 Update July 31, 2020:
The data products for the St. Croix National Scenic Riverway have undergone U.S. Geological Survey review. The products require dissemination in order to be released and published on the U.S. Geological Survey ScienceBase-Catalog.

Fifth Activity 1 Update January 31, 2021:
No further work has been completed for this project since the last update.

Final Update Between June 30 and August 15, 2021
Hydroacoustic surveys were completed during the summer of 2018 for approximately 1,775 hectares (4,385 acres) of the lower 48 kilometers of the St. Croix River. Shallow areas from the shoreline to depths up to 7.5 meters were collected. The data were processed for positional variables using the Continuously Operating Reference Stations (CORS) system. The processed bathymetry positional uncertainty was very low with a horizontal standard deviation error measurement of 0.012-meters, and vertical standard deviation error of 0.027-meters. Outcomes consisted of high-resolution bathymetry in the form of a 0.5-meter digital elevation model, a 3-D representation (hillshade) of the surface by using patterns of light and shadow, and sidescan images mosaics. The hillshade and sidescan mosaics enhance the appearance of the riverbed terrain making it easier to identify riverbed features.

The St. Croix National Scenic Riverway chose two essential habitat areas known for self-sustaining mussel populations. These areas were located near Hudson, Wisconsin, and Prescott, Wisconsin. Flow velocities were collected using an acoustic Doppler current profiler in 2018 for the Hudson area. During the summer of 2019, flow velocities were collected near Prescott, Wisconsin. The flow velocities were modeled into a flow diffusion raster — showing how the flow changes within the area. Underwater videos were collected for random pre-selected random GPS locations of the Hudson and Prescott priority areas. The videos were used to ground-truth or validate bed composition (substrate). Bed composition was mapped using object-based image analysis of multibeam backscatter (amount of sonar reflectance) combined with bathymetry derivatives of slope and roughness.

Natural resource management and policy makers face an increasing number of complex stressors including aquatic invasive species, rising water temperatures, floodplain development, erosion, sedimentation, and increased nutrient loading. Sonar data has been widely used as a remote sensing technology to map benthic and marine environments providing natural resource information for information management. Mapping the bathymetry provides more information than just depth– derivatives such as slope and roughness provide physical measures that can be applied to characterize habitat. The shape of the shoreline and locations of shallow environments provide resource managers information for protection of cultural environment resources, such as the Higgins' eye, *Lampsilis higginsii* and winged mapleleaf, *Quadrula fragosa*. Measures of depth, flow velocities, and bed composition provide information to researchers to help explain important ecological spatial information to how and why these valued habitat corridors are able to provide protected habitat for threatened and endangered perseverance. Combining the physical habitat measures (outcomes with this project) with biological measures of the river, habitat suitability can be modeled.

ACTIVITY 2:
Description: Mississippi National River and Recreation Area sonar survey, data processing, interpretation &

modeling, and development of map products.

The U.S. Geological Survey Upper Midwest Environmental Sciences Center will acquire high-resolution sonar data of the Mississippi National River and Recreation Area where no current bathymetry exists. Hydroacoustics will be surveyed according to US Geological Survey standards during the spring of 2019. The study area excludes areas of bathymetry already collected by the U.S. Army Corps of Engineers. Instead of duplicating those areas, the U.S. Army Corps of Engineers' data will be integrated with the new bathymetry. Post collection, the sonar data requires processing for locational variables, and development into products using geographic information systems.

Predetermined high priority areas will have additional hydroacoustic and mapping efforts consisting of acoustic Doppler current profiles measuring river current velocities, and substrate interpretation. While actual mussel habitat likely consists of a suite of physical, chemical, and biological traits, by combining the river current velocities with bathymetry and substrate type, physical inputs for mussel habitat models can be developed.

Validation efforts (underwater video camera) for mussel beds and substrate, will be collected courtesy of the National Park Service. These datasets will provide additional accuracy assessment for mussel habitat inputs, like substrate type, a necessary component of modeling mussel habitat.

Product outcomes will consist of high-resolution bathymetry and underwater digital surface models for newly acquired multibeam data combined with the U.S. Army Corps of Engineers' bathymetry data. Digital sonar image mosaics from new areas surveyed will be developed. For areas of high priority, mussel habitat model derivatives will include sonar imagery, river current profiles, and substrate maps. All data will be developed according to U.S. Geological Survey and Federal Geographic Data Committee standards. Once data review and dissemination are complete, data will be posted online. Presentations and/or publications will be carried out.

ENRTF BUDGET: $114,140

Outcome	Completion Date
1. Hydroacoustic surveys completed for the Mississippi National River and Recreation Area.	October 31, 2019
2. High-resolution bathymetry, digital surface models, and sonar image mosaics developed.	June 30, 2020
3. Mussel substrate maps, and mussel habitat inputs developed.	June 30, 2020
4. Presentations and/or publications of project.	June 30, 2020

First Activity 2 Update February 28, 2019
This activity has not yet begun. The hydroacoustic surveys for the Mississippi National River and Recreation Area will begin this year.

Second Activity 2 Update June 30, 2019
Hydroacoustic surveys have begun on the Mississippi River. The Coon Rapids pool has been completely surveyed, and processed for location variables. Much of the hydroacoustic surveys for the St. Anthony Falls pool has been completed. Planned surveys were delayed somewhat due to high water levels and discharge.

Third Activity 2 Update January 31, 2020
Completion of hydroacoustic surveys for the navigable portions of the Mississippi River (where no current bathymetry exists) for the Mississippi National River and Recreation Area occurred during the summer and fall of 2019. Surveys began in early June of the Coon Rapids pool, once the water and discharge levels were safe to survey. While surveying

the Coon Rapids Pool, the survey team was warned that the area north of the I694 bridge in the St. Anthony Falls pool were "unnavigable", and to proceed with extreme caution. In order to prevent equipment damage, the U.S. Geological Survey contacted the Mississippi Watershed Management Organization for contour data (collected by sidescan) helpful for navigation of this pool. Surveys proceeded with caution, by working from the lower pool on up. Upon arriving at the hazardous area, water levels were too low to continue, without risking equipment, so the survey team decided to wait on this area, intending to come back later in the fall when water levels rose again. Instead, Pool 2 was targeted for data collection because it contains wing dams, and the survey team preferred to collect data before water levels lowered much and impeded data acquisition. Unfortunately, due to unusual water level fluctuations throughout the survey season, inclement weather, and multiple project survey commitments, the hydroacoustic survey team failed to collect data for the upper half of St. Anthony Fall's pool. The U.S. Geological Survey intends to complete the area not surveyed during the spring of 2020. Since no additional map efforts for this pool are necessary, the data will quickly be processed to develop the bathymetry and sidescan image mosaics by June 30, 2020. Additional survey efforts for river velocities and underwater video collection in the approved priority area near Hidden Falls Park was completed.

Processing of the Mississippi River multibeam sonar data for various locational variables was completed. Currently, work continues to develop sonar data products for the Mississippi National River and Recreation Area.

Fourth Activity 2 Update July 31, 2020:
Due to the COVID-19 pandemic, the remaining area that requires data collection (upper half of St. Anthony Falls) could not occur during the Spring of 2020. River levels have remained too low during the summer of 2020 to complete the remaining surveys. Once river conditions are favorable (fall of 2020 or spring of 2021), the remaining surveys will be completed, and data will be processed and undergo formal review to complete the planned data deliverables.

The other areas with previous sonar data collection (Coon Rapids Pool, lower half of St. Anthony Falls, Pool 2, and Pool 3) have been completed for bathymetry, relief models, and sidescan images. Map efforts for the priority area of the Hidden Falls are partially complete. The river velocities and validation images have been completed, and analysis to complete the substrate maps are currently underway.

Fifth Activity 2 Update January 31, 2021:
No further work has been completed for this project since the last update.

Final Update Between June 30 and August 15, 2021
Hydroacoustic surveys were completed during the summer of 2019 and spring of 2021 for approximately 1,358 hectares (3,335 acres) of 116 kilometers (72-miles) of the Mississippi River where no current bathymetry existed (except along shorelines for a continuous dataset). The upper St. Anthony Falls pool proved challenging, as the area is persistent with many navigational hazards (rock piles), and shallow areas (less than 1.5 meters) that were avoided while completing field surveys. For this reason, two small areas remain un-surveyed.

The data were processed for positional variables using the Continuously Operating Reference Stations (CORS) system. The processed bathymetry positional uncertainty were low with a horizontal standard deviation error measurement of 0.037-meters and vertical standard deviation error of 0.091-meters for the Coon Rapids pool, 0.054-meter horizontal and 0.118-meters vertical for the Saint Anthony Falls pool, 0.054-meters horizontal and 0.13-meters vertical for the Minnesota River and Mississippi River Pool 2, and 0.014-meters horizontal and 0.04-meters vertical for Pool 3. Outcomes consisted of high-resolution bathymetry in the form of a 0.5-meter digital elevation model, a 3-D representation (hillshade) of the surface by using patterns of light and shadow, and sidescan images mosaics. The hillshade and sidescan mosaics enhance the appearance of the terrain making it easier to identify riverbed features.

To keep funding costs lower and not duplicate efforts, the U.S. Geological Survey bathymetric data were merged with the U.S. Corps of Army Engineers main channel hydro data for Pools 2 and 3. The data were collected using single beam

sonar at a lower resolution (transects versus swath data). Due to these collection parameters, the resulting Pool 2 and Pool 3 bathymetry coverages had to be generated at a lower resolution (5.0-meters). While these lower resolution datasets can be utilized by some agencies for general purposes or geomorphology studies, higher-resolution data is favored over low-resolution for mussel habitat studies. Five-meter resolution is too coarse to determine distinct physical measures for benthic habitat associations.

The Mississippi National River and Recreation Area chose one essential habitat area known for self-sustaining mussel populations. This area was located by the Hidden Falls Regional Park, near St. Paul, Minnesota. Flow velocities were collected using an acoustic Doppler current profiler in 2019 and modeled into a flow diffusion raster — showing velocity change within the river where higher numbers equals higher flows and vice versa. Underwater videos were collected for random pre-selected GPS locations and the videos were used to ground-truth or validate bed composition (substrate). Bed composition was mapped using object-based image analysis of multibeam backscatter (amount of sonar reflectance) combined with bathymetry derivatives of slope and roughness.

Rivers are hydrodynamic and constantly changing. High discharge events such as flooding and human activities move and settle sediment, changing bedforms. Human activities such as construction, pipelines, riverfront development, and agriculture all change topography, affecting submerged cultural resources. High-resolution sonar datasets provide baseline information, or building blocks needed in applications for protecting and conserving imperiled native mussels, understanding invasive species establishment, channel sedimentation, and many other uses. Survey-grade bathymetry map topography of riverbed and provide valuable habitat information for resource management. To broadly analyze river habitat, remote sensing technologies such as hydroacoustics (sonar) are a non-invasive way to collect information on hydraulic measures (i.e. depth and water flow velocities). Hydraulic measures (such as shear velocity and shear stress) may allow improved identification of potentially critical mussel habitat. Depth and water flow velocities can vary spatially within a river and can be combined to describe baseline habitat conditions. Habitat characteristics are important for habitat associations between host fish and juvenile mussels (that require a host fish). Applying physical measures of depth (bathymetry) combined with measures of river flow velocities for known preferred habitat for host fish can help identify key locations of the glochidia environment throughout its life stage, and better understand the distribution of mussels and host fish throughout the river corridor. The outcomes from this project can be applied by other agencies interested in assessing physical and hydraulic variables that correlate with the distribution and abundance of imperiled freshwater mussels, and other priority native and invasive species.

ACTIVITY 3:
Description: Freshwater Riverine Benthic Map Pilot Study
The U.S. Geological Survey Upper Midwest Environmental Science Center will collaborate with the National Park Service for a pilot study developing a benthic map of a small, high priority area within the St. Croix National Scenic Riverway.
Hydroacoustics will be surveyed according to US Geological Survey standards. The U.S. Geological Survey Upper Midwest Environmental Science Center will map riverine features and abiotic elements of the pilot study area according to the Servicewide Benthic Mapping Program.

Validation efforts (underwater video camera) for mussel beds and substrate type will be collected at random points within the riverbed survey area. These datasets will provide additional accuracy assessment for all benthic habitat map components.

Product outcomes will consist of a digital benthic map classified according to the Coastal and Marine Ecological Classification Standard. This freshwater river benthic map will be applicable to future benthic mapping efforts for both the Mississippi National River and Recreation Area and the St. Croix National Scenic Riverway. The digital map products will be developed according to U.S. Geological Survey, National Park Service, and Federal Geographic Data

Committee standards. Once review and dissemination of digital data are complete, the dataset will be posted online for shared use. Presentations and/or publications of this pilot study will be carried out.

ENRTF BUDGET: $ 0 (National Park Service in-kind $14,500)

Outcome	Completion Date
1. Field efforts (sonar collection, ground-truthing) completed.	September 30, 2018
2. Riverine Benthic Map (pilot study) developed.	June 30, 2020
3. Presentations and/or publications of pilot study.	June 30, 2020

First Activity 3 Update February 28, 2019
The hydroacoustic data (multibeam, sidescan, and acoustic Doppler current profiles) was collected and processed of the St. Croix River Folsom Island study area. Validation, or ground-truthing for riverbed substrate and mussels was completed using a GoPro camera. The videos have been analyzed and the resulting information has been transferred to a spatial vector dataset. Developments to date include the following raster data: high-resolution bathymetry, sidescan sonar image mosaic, roughness, slope, backscatter, and digital surface (relief) model. The benthic mapping methodology is currently being developed. Automated methods are being explored for segmentation and classification.

Second Activity 3 Update June 30, 2019
Automated methods using backscatter and bathymetry have been developed to classify sediment type. These methods are being further fine-tuned to increase map accuracy.

The project was included in a presentation at the "Multibeam Echo Sounders in Rivers" workshop, held in Portland, Oregon, March 4-7, 2019. Automated methods that were previously explored for mapping the Folsom Island riverbed was highlighted.

Third Activity 3 Update January 31, 2020
The suite of data products for the "pilot" Folsom Island benthic map project was completed. All data products are complete, including the following datasets: bathymetry, sidescan, relief model, slope, and terrain ruggedness rasters; contours, river velocities, bed observations (random sample locations) and substrate map; and validation still images. While the data is complete, it is still under U.S. Geological Survey review. For ease of viewing, KML files are also included. This data will soon become available on the U.S. Geological Survey ScienceBase-Catalog

Fourth Activity 3 Update July 31, 2020:
The suite of data products for the "pilot" Folsom Island benthic project requires the final dissemination step of U.S. Geological Fundamental Science Practices review process before being published on the ScienceBase-Catalog.

Fifth Activity 3 Update January 31, 2021:
No further work has been completed for this project since the last update.

Final Update Between June 30 and August 15, 2021
Hydroacoustic data (multibeam, sidescan, and acoustic Doppler current profiles) were collected in 2017 of the Folsom Island study area for the St. Croix National Scenic Riverway. A GoPro camera attached to a pole was used to collect underwater videos of bed composition and mussels in select random locations using GPS. The resulting videos were assessed, and the information was transferred to a spatial vector dataset.

The hydroacoustic data was processed into the following deliverables: high-resolution bathymetry (0.5-meter),

sidescan sonar image mosaic, roughness, slope, backscatter, and hillshade model. Automated methods using backscatter and bathymetry were developed to classify bed composition, or substrate type.

The suite of data products for the "pilot" Folsom Island benthic map project were delivered to the St. Croix National Scenic Riverway in January of 2020. The following datasets were provided in raster format: high-resolution bathymetry, sidescan mosaic, hillshade, slope, and terrain ruggedness. Vector data included contours, river (flow) velocities, bed observations (random sample locations) and a substrate map. Additionally, still images produced from the underwater videos were provided. Methods from this project were developed, built upon and improved for Activities 1 and 2.

IV. DISSEMINATION:

Description: Prior to dissemination, all products will be thoroughly reviewed following protocols by each organization. Nancy Duncan (Mississippi National River and Recreation Area) and Byron Karns (St. Croix National Scenic Riverway) will provide in-kind data reviews. All data and metadata will undergo formal U.S. Geological Survey data review. Once the reviewed datasets are disseminated, the data will be published on the following website: https://www.sciencebase.gov. The U.S. Geological Survey will maintain, store, and host the data for the public to download. The USGS will host the data for two years after project is complete, but then will turn the data and web services over to the State of Minnesota.

Any presentations, publications, or final reports developed from the project will be reviewed and disseminated according to each organizations' protocols. Raw data will be available upon request.

First Update February 28, 2019
No products are ready for review yet.

Second Update June 30, 2019
No products are ready for review yet.

Third Update January 31, 2020
Currently, St. Croix River sonar datasets and pilot Folsom Island Benthic Mapping project are undergoing review by the U.S. Geological Survey. Once disseminated, the data release will be available on the U.S. Geological Survey ScienceBase-Catalog, a collaborative scientific data and information management platform.

Fourth Update July 31, 2020:
Currently, St. Croix River sonar datasets and pilot Folsom Island Benthic Mapping project have undergone review by the U.S. Geological Survey. Once the data has been disseminated, the data release will be available on the U.S. Geological Survey ScienceBase-Catalog, a collaborative scientific data and information management platform.

Fifth Update January 31, 2021:
Due to some reorganization of staff at the U.S. Geological Survey Upper Midwest Environmental Sciences Center, and the nature of the size of datasets, the data have not been posted to the U.S. Geological Survey data repository (ScienceBase-Catalog) yet.

Final Update Between June 30 and August 15, 2021
The outcomes from Activities 1 and 2 have undergone an internal U.S. Geological Survey formal review. The datasets, complete with metadata have been posted to the U.S. Geological Survey data repository ScienceBase Catalog Home. The St. Croix National Scenic Riverway datasets and metadata can be found at https://doi.org/10.5066/P9X9I5QJ. The Mississippi National River and Recreational Area datasets and metadata can be found at https://doi.org/10.5066/P9BYGUQL. The outcomes from Activity 3 have undergone a U.S. Geological Survey internal

formal review. Post dissemination, the data was delivered to the St. Croix National Scenic Riverway by product to partner. The data may be available upon request.

This ENRTF project was included in a presentation for the "Multibeam Echo Sounders in Rivers" Workshop, held in Portland, Oregon, March 4-7, 2019. The automated methods explored for benthic mapping were highlighted.

A brief description of the project can also be found among the USGS project web pages: Develop Sonar Data Mapping on Three Rivers to Assess Suitability for Native Mussel Habitat (usgs.gov).

V. PROJECT BUDGET SUMMARY:

A. Preliminary ENRTF Budget Overview: See attached budget spreadsheet

Explanation of Capital Expenditures Greater Than $5,000: NA **Explanation of**

Use of Classified Staff: NA

Total Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation:

Enter Total Estimated Personnel Hours: N/A	Divide by 2,080 = TOTAL FTE: N/A

Total Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation: 1.38
Year 1:

Enter Total Estimated Personnel Hours: 560	Divide by 2,080 = TOTAL FTE: 27%
Enter Total Estimated Personnel Hours: 560	Divide by 2,080 = TOTAL FTE: 27%
Enter Total Estimated Personnel Hours: 40	Divide by 2,080 = TOTAL FTE: 2%
Enter Total Estimated Personnel Hours: 80	Divide by 2,080 = TOTAL FTE: 4%

Year 2:

Enter Total Estimated Personnel Hours: 760	Divide by 2,080 = TOTAL FTE: 36.5%
Enter Total Estimated Personnel Hours: 760	Divide by 2,080 = TOTAL FTE: 36.5%
Enter Total Estimated Personnel Hours: 40	Divide by 2,080 = TOTAL FTE: 2%
Enter Total Estimated Personnel Hours: 80	Divide by 2,080 = TOTAL FTE: 4%

B. Other Funds:

SOURCE OF AND USE OF OTHER FUNDS	Amount Proposed	Amount Spent	Status and Timeframe
Other Non-State $ To Be Applied To Project During Project Period:			
National Park Service St. Croix National Scenic Riverway - Interagency agreement to fund Activity 3 to develop the Benthic Mapping Pilot Study	$ 14,500	$ 14,500	Secured March 1, 2018 – September 30, 2018

National Park Service Mississippi National River and Recreation Area - In-kind Project management and Data review efforts and funds relating to project.	$9,403	$9,403	Secured July 1, 2018 – June 30, 2021
National Park Service St. Croix National Scenic Riverway & National Park Service Mississippi National River and Recreation Area - In-kind validation efforts and funds relating to project efforts.	$21,412	$21,412	Secured July 1, 2018 – June 30, 2021
US Geological Survey Upper Midwest Environmental Sciences Center - In-kind support for equipment and software maintenance for data collection, and center indirect costs.	$189,912	$189,912	Secured July 1, 2018 – June 30, 2021

Other State $ To Be Applied To Project During Project Period:			
none	$	$	
Past and Current ENRTF Appropriation:			
none	$	$	
Other Funding History:			
none	$	$	

VI. PROJECT PARTNERS:

A. Partners receiving ENRTF funding

Name	Title	Affiliation	Role
Jenny Hanson	Biologist	US Geological Survey Upper Midwest Environmental Sciences Center	USGS Contract Lead

B. Partners NOT receiving ENRTF funding

Name	Title	Affiliation	Role
Nancy Duncan	Natural Resource Program Manager	National Park Service Mississippi National River and Recreation Area	Project Manager
Byron Karns	Aquatic Biologist	National Park Service St. Croix National Scenic Riverway	Diver/Validation Lead

VII. LONG-TERM- IMPLEMENTATION AND FUNDING:

12/13/2021

The outcomes or products from this project can be used by resource managers for habitat applications including protecting and conserving imperiled native mussels, understanding invasive species establishment, sedimentation, and many other uses. The available datasets can be applied by other agencies interested in assessing physical and hydraulic variables that correlate with the distribution and abundance of imperiled freshwater mussels, and other priority native and invasive species. For the Mississippi National River and Recreation Area and the St. Croix National Scenic Riverway, these datasets are the foundation for pursuing additional funding to further develop the hydroacoustic products from this project into benthic habitat maps using the Servicewide Benthic Mapping Program protocols for National Park Service. Benthic habitat maps are important as they provide ecological information that supports management and protection of submerged National Park natural and cultural resources. Expansion of this project does not have funding secured, but the National Park Service and U.S. Geological Survey intend to apply to funding opportunities, utilizing existing partnerships and inter-agency efforts to broaden the development of this important tool needed for protecting, conserving, reintroducing, and managing dwindling freshwater mussel populations.

Similar work has been funded on the St. Croix River by the Ecosystems Mission Area of the U.S. Geological Survey and Minnesota State Conservation Wildlife Grant using hydroacoustics to help characterize imperiled mussel habitat. Additionally, the National Park Service is seeking funding through the Natural Resources Preservation Program (U.S. Geological Survey) to collect bathymetry on a stretch of the St. Croix National Scenic Riverway from the High Bridge (Zebra Mussel Access Point) to Highway 8 (St. Croix Falls) to associate habitat conditions for the host fish of the Winged Mapleleaf (*Q. fragosa*).

Since the U.S. Army Corps of Engineers data was not high-resolution (collected via single-beam in transects instead of swath multibeam), the U.S. Geological Survey and National Park Service Mississippi National Recreation Area may seek additional funding to survey these main channel areas. An opportunity to survey the low-resolution areas would not only supply high-resolution bathymetry but would also enable the opportunity to acquire backscatter and sidescan imagery, which combined with hydraulic variables of depth and water velocities can be used to examine habitat associations of imperiled mussels. Backscatter and sidescan image mosaics can provide more habitat information such as bottom characteristics like wing dams, sand dunes, vegetated areas, and even bottom composition of sand vs gravel. Physical measures, or habitat variables such as depth, flow velocities, and bed composition have the analytic capabilities to view modeled datasets in a digital environment to help define preferred mussel or host fish habitat, and identify key locations for restoring endangered and threatened species, and to better understand the distribution of mussels and host fish throughout the river corridors.

VIII. REPORTING REQUIREMENTS:

- **The project is for 3 years, will begin on July 1, 2018, and end on June 30, 2021.**
- **Periodic project status update reports will be submitted January 31 and June 30 of each year.**
- **A final report and associated products will be submitted between June 30 and August 15, 2021.**

IX. SEE ADDITIONAL WORK PLAN COMPONENTS:

A. Budget Spreadsheet
B. Visual Component or Map
C. Parcel List Spreadsheet - NA
D. Acquisition, Easements, and Restoration Requirements - NA
E. Research Addendum - NA

Attachment A:
Environment and Natural Resources Trust Fund
M.L. 2018 Final Project Budget

Project Title: Develop Sonar Data Mapping on Three Rivers to Assess Suitability for Native Mussel
Habitat **Legal Citation:** M.L. 2018, Chp. 214, Art. 4, Sec. 02, Subd. 03j
Project Manager: Nancy Duncan
Organization: NPS Mississippi National River and Recreation
Area **College/Department/Division:**
M.L. 2018 ENRTF Appropriation: $200,000
Project Length and Completion Date: 3 years/June 30,2021

Date of Report: June 30, 2021

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Professional/Technical/Service Contracts			
USGS Upper Midwest Environmental Science Center - contract for Activity 1 data collection and products	$85,860	$85,860	$0
USGS Upper Midwest Environmental Science Center - contract for Activity 2 data collection and products	$114,140	$114,139.99	$0.01
COLUMN TOTAL	$200,000	199,999.99	$0.01