



Quality Assurance Plan for Bat Monitoring in the Great Lakes Inventory and Monitoring Network

Version 1.0

Natural Resource Report NPS/NRSS/GRD/NRR—2020/2122



ON THE COVER

NPS biologist deploying bat acoustic monitoring equipment at Sleeping Bear Dunes National Lakeshore. National Park Service photo.

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Natural Resource Report NPS/NRSS/GRD/NRR—2020/2122

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Revision History Log

The following table lists all edits and amendments to this document since the original publication date. Information entered in the log must be complete and concise. Users of this protocol will promptly notify the GLKN protocol lead about recommended and required changes. The protocol lead must review and incorporate all changes, complete the revision history log, and change the date and version number on the title page and in the header of the document file. For complete instructions, please refer to SOP #11, Procedure for Revising Protocol.

Previous Version #	Revision Date	Author (with title and affiliation)	Location in Document and Concise Description of Revision	Reason for Change	New Version #
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Add rows as needed for each change or set of changes tied to an updated version number					

Abstract

In accordance with guidelines set forth by the National Park Service Inventory and Monitoring Division, this quality assurance plan has been created for use by the Great Lakes Inventory and Monitoring Network in the implementation of its bat monitoring program. This quality assurance plan documents the standards, policies, and procedures used by the Great Lakes Inventory and Monitoring Network for activities related to the collection, processing, storage, analysis, and publication of bat monitoring data. This quality assurance plan complements the quality assurance plans for other monitoring activities conducted by the Great Lakes Inventory and Monitoring Network and supplements the National Inventory and Monitoring Division Quality Management Plan.

Acknowledgments

Much of the verbiage in this document was first written in the protocol narrative and associated standard operating procedures, and I wish to thank the authors of those sections. I also appreciate the input of A. Kirschbaum, E. Gillam, D. Licht, and J. Siemers who reviewed a preliminary version of this document. Portions of this document were based on quality assurance plans prepared for other monitoring protocols including the following:

- Quality Assurance Plan for Amphibian Monitoring in the Great Lakes Network. Natural Resource Report NPS/GLKN/NRR—2018/1713
- Vegetation Monitoring in the Eastern Rivers and Mountains Network. Quality Assurance Plan Version 1.0. Natural Resource Report NPS/ERMN/NRR—2018/1799
- Quality Assurance Plan for Anchialine Pool Monitoring in the Pacific Island Network. Version 1.0. Natural Resource Report NPS/PACN/NRR—2018/1811
- Breeding Bird Monitoring Protocol for the Mid-Atlantic Network. Quality Assurance Plan Version 1.0. Natural Resource Report NPS/MIDN/NRR—2018/1815

Introduction

The National Park Service's (NPS) Inventory and Monitoring Program, established in 1999, encompasses both point-in-time inventories to identify what resources are present in our national parks, and consistent long-term monitoring to identify changes over time. The overall goal of the program is to develop scientifically sound information on the current status of and long-term trends in the composition, structure, and function of park ecosystems, in order to inform natural resource management decisions. As part of this program, the Great Lakes Inventory and Monitoring Network (GLKN) coordinates and conducts inventory and monitoring projects across nine national park units located in Minnesota, Wisconsin, Michigan, and Indiana.

The NPS Inventory and Monitoring Division is developing a program-wide quality management plan (DeVivo, in preparation) to ensure that all scientific work conducted by or for the program is suitable for its intended use and of documented quality. Similarly, individual networks are responsible for developing a quality assurance plan (QAP) to identify data quality procedures specific to each of their monitoring protocols. This includes thoroughly documenting the standards used for data collection, analysis, and reporting in order to provide transparency and promote continuity and comparability of data over time.

This QAP serves to document the data quality standards used by GLKN for activities related to the collection, processing, storage, analysis, and publication of bat monitoring data. This QAP is one component of the overall bat monitoring protocol, which also includes a narrative describing the objectives, sampling design, methodology, and operational requirements, and a set of Standard Operating Procedures (SOPs) that outline specific details of the monitoring program. This QAP is intended to complement the QAPs for other monitoring activities conducted by GLKN and supplement the NPS Inventory and Monitoring Division's quality management plan (DeVivo, in preparation).

In addition to serving as a guide for all personnel who are involved in implementing the bat monitoring program, this QAP will provide potential end-users of the data with adequate information to understand what data are being collected, how they are being collected and analyzed, and what standards are being used, so that they can independently assess the suitability of the data and interpret it appropriately.

Protocol Overview and Objectives

In recent decades, North American bat populations have been increasingly threatened by a number of environmental pressures including the disease white-nose syndrome (WNS), mortality from wind turbines, and changing land use and climatic conditions. Due to the increase in conservation concerns, many U.S. federal agencies have begun implementing or expanding bat research and monitoring programs (e.g., Loeb et al. 2015, Rodhouse et al. 2016, Rodriguez et al. 2019). The NPS has been very active in this area, funding over 150 bat-focused research, conservation, and education projects at 78 parks since 2013 (National Park Service 2016).

In 2015, GLKN and the network parks established a bat monitoring program to gather baseline data on the status of bat populations and assess changes over time as WNS continues to move west through the Great Lakes region. Acquiring this information will assist parks in filling gaps in knowledge and in making informed decisions when management actions may affect bats. Because obtaining direct abundance measures of bat populations is not feasible with acoustic methods (Miller 2001, Frick 2013), the focus will be on assessing species distribution patterns and activity levels. Surveys will utilize appropriate sampling design and methods to support the secondary goal of incorporation and/or comparison of our data with other large-scale monitoring projects.

Specific objectives include the following:

1. Identify what species are present in each park and where they are found within the park.
2. Track changes in activity levels and distribution patterns over time for each species.
3. Compare bat activity levels among species and among parks
4. Compare species distribution patterns among species and among parks.

Protocol Activities

The GLKN bat monitoring protocol encompasses five broad types of data collection or generation, broken down into fourteen specific activities (Table 1). Details of how each activity is conducted are provided in the SOPs. Each activity is assigned a number and described in the table below.

Numbering in subsequent tables refers to these activities, however not all activities are relevant to all sections.

Table 1. Protocol activity matrix for the Great Lakes Inventory and Monitoring Network bat monitoring program.

Category	Activity #	Activity	Description of Data Collected or Generated
Site Establishment and Maintenance	1	Site Reconnaissance and Establishment	Cells to be sampled are selected using GRTS methodology. Each selected cell is evaluated for feasibility based on access, safety, and habitat availability, using aerial imagery, land ownership data, and the like. If a cell is eliminated at this stage, the reasoning is documented. If a cell is retained, project personnel will make one or more field visits to the area to select a specific sampling location within the cell.
	2	Site Maintenance	During each deployment, information describing the specific sampling location is documented using the field datasheet, photos, and GPS coordinates.
	3	Site Modification	If a sampling location must be modified, the reasoning for the change is documented. Information describing the new sampling location is documented using the field datasheet, photos, and GPS coordinates.
Field Observations	4	Deployment Data	Recorded on field datasheet. Includes site name/number, observers, deployment date and time, detector model and serial number, microphone serial number, microphone height, microphone orientation, SD card numbers, battery type, battery voltage, mounting system.
	5	Site and Habitat Data	Recorded on field datasheet. Includes latitude/longitude, datum, clutter information, local and broad habitat classifications, site sketch, site access/habitat notes.
	6	Recovery Data	Recorded on field datasheet. Includes observers, recovery date and time, battery voltage, status of unit, significant weather events.
Sensor Data	7	Site Photos	Photos taken in the four cardinal directions from the sample point. Photo taken of area where microphone is pointing. Photo(s) taken of equipment set-up/mounting system. Photo taken of field datasheet. Additional photos as needed.
	8	Audio Data	Sound files recorded by acoustic detector.
	9	Detector Status Data	Status information automatically generated by the acoustic detector during the deployment and stored in a text file.
	10	Detector Program Data	Recording schedule and audio settings documented in a program file, saved to the SD card at time of deployment.
Data Processing	11	Automated Species Identifications	Audio files are processed using Kaleidoscope Pro software, which automatically generates output files that document the software settings, results at the file level, and results at the batch level.

Table 1 (continued). Protocol activity matrix for the Great Lakes Inventory and Monitoring Network bat monitoring program.

Category	Activity #	Activity	Description of Data Collected or Generated
Data Processing (continued)	12	Manual Species Identifications	A subset of audio files are manually reviewed by a qualified biologist. Species classification results are documented at the file level. Additional notes may also be documented.
Quality Control Data	13	Microphone Testing and Calibration	Pre-season assessment of microphone function. Results of voltage test and calibration test are documented. Microphones are discarded if they fail the calibration and/or voltage test.
	14	Deployment Data Checks	Review of deployment data during field season for completeness and accuracy. Missing items, incorrect settings, and other issues are documented.
	15	Database QA/QC	After information from field datasheets has been entered in database, 100% of data are crosschecked against the original. Any required corrections are documented.

Sampling Design

The GLKN bat monitoring program utilizes passive acoustic survey methods, in which ultrasonic recording devices are systematically deployed throughout a landscape to record the echolocation calls of passing bats. Acoustic survey locations are selected using a probabilistic sample design. We follow the master sample approach described by Larsen et al. (2008), using Generalized Random Tessellation Stratification (GRTS) to select a set of locations that are both randomized and spatially balanced (Stevens and Olson 2004). One advantage of this design is that sampling is spread across the geographic extent of the survey area, avoiding the bias that could result from sampling a group of sites in close proximity to each other. Secondly, it allows flexibility to add or delete sample sites from year to year, making it suitable for long-term studies where funds and personnel may vary over time.

To implement this sample design, the following steps were taken at each park: 1) a grid of 1-km² cells was overlaid on the park, 2) cells were arranged into an ordered list using the GRTS algorithm, and 3) cells to be sampled were then selected by starting with Cell #001 and working through the list in consecutive order. Some cells were eliminated based on poor access, safety concerns, or lack of suitable habitat. Within each 1-km² cell to be sampled, the specific sample site was selected by identifying an area that was reasonably accessible and had suitable bat habitat (travel corridors and/or proximity to water) with relatively low clutter to optimize recording quality.

A minimum sample size of 15 cells per park was selected based on the number of detector units available, the estimated time required to access and sample each location, and a power analysis (documented in Gruver et al. 2016). The final number of sites established ranges from 18–35 per park. This equates to an average of 20.4% of cells being sampled out of each park's sampling frame.

Acoustic monitoring is conducted using an “always revisit” design wherein the same sampling locations are visited every sampling season, to allow for optimal detection of trends (McDonald 2003, Urquhart et al. 1998). The “always revisit” design is preferred over sampling a new set of locations each year, because it allows us to separate out the differences attributable to location from the differences attributable to year.

Sampling occurs during the summer season, defined as 1 June–15 August. This time frame captures the period when resident bat species are most active and when activity levels are the least variable (because it excludes spring and fall migration periods), providing the best opportunity to estimate trends (Gruver et al. 2016) (Table 2). It is also very similar to the survey window recommended by the U.S. Fish and Wildlife Service for the federally listed Indiana bat and northern myotis (15 May–15 August) (U. S. Fish and Wildlife Service 2019).

Each location is sampled for a period of 7–14 consecutive nights, once per year. Sampling multiple nights per site will help account for night-to-night variation in bat activity due to weather conditions, insect abundance, or other factors (Hayes 1997). More nights of sampling may also increase the probability of documenting rarer species (Skalak et al. 2012). Additionally, because many of our sample locations are remote and not easily accessed, the range of 7–14 days allows field crews flexibility to accommodate logistical challenges.

Table 2. Activity-level sample design matrix for the Great Lakes Inventory and Monitoring Network bat monitoring program. Activity numbers correspond to those in the protocol activity matrix (Table 1).

Category	Activity #	Activity	Sampling Design	Revisit Design
Field Observations	4	Deployment Data	Probability; GRTS-based sample of 1-km ² cells; one sample site per cell; one acoustic detector per sample site; total of 18–35 sample sites per park	Revisit every site once per year between 1 June and 15 August
	5	Site and Habitat Data	Probability; GRTS-based sample of 1-km ² cells; one sample site per cell; one acoustic detector per sample site; total of 18–35 sample sites per park	Revisit every site once per year between 1 June and 15 August
	6	Recovery Data	Probability; GRTS-based sample of 1-km ² cells; one sample site per cell; one acoustic detector per sample site; total of 18–35 sample sites per park	Revisit every site once per year between 1 June and 15 August
Sensor Data	7	Site Photos	Probability; GRTS-based sample of 1-km ² cells; one sample site per cell; one acoustic detector per sample site; total of 18–35 sample sites per park	Revisit every site once per year between 1 June and 15 August
	8	Audio Data	Probability; GRTS-based sample of 1-km ² cells; one sample site per cell; one acoustic detector per sample site; total of 18–35 sample sites per park	Revisit every site once per year between 1 June and 15 August; Deploy equipment for 7–14 nights; Audio data recorded continuously from 18:00–08:00 each night
	9	Detector Status Data	Probability; GRTS-based sample of 1-km ² cells; one sample site per cell; one acoustic detector per sample site; total of 18–35 sample sites per park	Detector status data recorded once per minute while detector is active
	10	Detector Program Data	Probability; GRTS-based sample of 1-km ² cells; one sample site per cell; one acoustic detector per sample site; total of 18–35 sample sites per park	Detector program file saved once at beginning of deployment

Detectors will be programmed to record every night from 6:00 p.m. to 8:00 a.m. Because total bat activity varies over the course of the night (Hayes 1997) and because different species have different nightly patterns of activity (Kurta 2017, Skalak et al. 2012), it is important to sample the entire night rather than only a few hours. The schedule we have selected covers the active foraging period of all local bat species and allows a consistent recording schedule across all locations and times of year.

Data Quality Objectives

There are two main data quality objectives for this protocol. First, we aim to produce data that are sufficiently complete, accurate, and representative to meet the project objectives defined above. Second, we aim to collect data in a consistent manner to allow comparisons across years and locations. To achieve these desired objectives, certain data quality values were taken into consideration and certain data quality standards specific to the bat monitoring protocol were developed.

Data Quality Values

The data quality values include accuracy, representativeness, completeness, comparability, consistency, and security. These are outlined in Table 3 below.

Table 3. Data quality values for the Great Lakes Inventory and Monitoring Network bat monitoring program.

Data Quality Value	Definition	Protocol Considerations
Accuracy	Measurements reflect the true value of the parameter being observed. This applies to measures (length, width, position) or classes (species, types, or categories). Includes components of precision and bias.	Methods for measurement of calibration and deployment parameters are specified in SOPs. Audio files are identified to the greatest specificity possible (i.e., if not to the species, then to the species pair/group).
Representativeness	Measurements represent conditions at the time of sampling. Combined with accuracy, leads to repeatable data collection.	Sampling locations are selected using the spatially balanced GRTS method to ensure a representative sample of the park as a whole. Sampling occurs for multiple nights per site to account for imperfect detection.
Completeness	All data required to evaluate accuracy and representativeness are present; incomplete data sets (either at a location, across sampling locations, or over time) lose utility or relevance. Data records contain all values that were planned to be collected.	Incompleteness is avoided by real-time review of deployment data throughout the field season. Data gaps are expected to occur occasionally due to logistical problems, vandalism, or equipment failure. Where gaps occur, they are identified and documented.
Comparability	The degree to which data can be compared among sample locations, data sources, or periods of time.	Monitoring schedule and methods are specified in detailed SOPs. Locations, dates, and equipment setup are kept as similar as possible each year. Methods are compatible with other sampling efforts (e.g., NABat) to allow contribution of data to regional or continental scale datasets.
Consistent Representation	Use of standard definitions when describing data quality or resource quality based on data	Terms are defined and detailed instructions for completing field datasheets are provided in SOPs. Datasheet and database contain the same set of terms/options to avoid inconsistency in interpretation.

Table 3 (continued). Data quality values for the Great Lakes Inventory and Monitoring Network bat monitoring program.

Data Quality Value	Definition	Protocol Considerations
Security	Access to data, products, and systems is limited to appropriate audiences.	Sensitive species location data are protected. GLKN and individual park managers coordinate to determine what data may be released.

Data Quality Standards

Data quality standards are specific requirements to ensure data are collected, documented, analyzed, and used appropriately. The four general categories of data quality standards are defined below. Details are provided in Tables 4-7.

- *Measurement quality objectives and performance standards.* Requirements specifying the level of precision, bias, sensitivity, and resolution that data must meet to be acceptable and usable in analyses. Describes the ability of equipment, sensors, or observers to make reliably measurements.
- *Taxonomic standards.* Requirements for how species identifications are made and what species names are used.
- *Accreditation standards.* Requirements related to individuals or organizations involved with data collection, analysis, or processing to ensure desired credibility and defensibility through certifications, trainings, and the like.
- *Policy and protected data standards.* Requirements related to ensuring appropriate management, use, dissemination, qualification, and documentation of protected data.

Table 4. Measurement quality objectives/performance standards for the Great Lakes Inventory and Monitoring Network bat monitoring program. Activity numbers correspond to those in the protocol activity matrix (Table 1).

Category	Activity #	Activity	Measure	Quality Objective/Performance Standard
Site Establishment and Maintenance	1	Site Establishment	Location	Collect GPS coordinates (latitude/longitude) with +/- 5 m horizontal accuracy.
	2	Site Maintenance	Location	Return to same sample location, within 10 m of established point. Collect GPS coordinates (latitude/longitude) with +/- 5 m horizontal accuracy.
	3	Site Modification	Location	Collect GPS coordinates (latitude/longitude) with +/- 5 m horizontal accuracy.
Field Observations	4	Deployment Data	Microphone Height	Measure height in meters with +/- 0.03 m (3 cm) accuracy. Match previous height within 0.1 m (10 cm).
	4	Deployment Data	Microphone Orientation	Measure compass bearing with +/- 2 degrees accuracy. Match previous compass bearing within 5 degrees.
	5	Site and Habitat Data	Distance to Clutter	Estimate distance in meters with +/- 2 m accuracy.
	5	Site and Habitat Data	Percent Clutter	Estimate percentage with +/- 10% accuracy.
Sensor Data	7	Site Photos	Image resolution	Collect image at ≥ 2 megapixel resolution.
	7	Site Photos	Image format	Collect image in .jpg format.
	7	Site Photos	Camera Orientation	Collect directional photos with +/- 5 degrees accuracy on desired compass bearing.
Quality Control Data	13	Microphone Testing and Calibration	Microphone Calibration	Record minimum and maximum decibel levels with +/- 0.5 dB accuracy.

Table 5. Taxonomic standards for the Great Lakes Inventory and Monitoring Network bat monitoring program. Activity numbers correspond to those in the protocol activity matrix (Table 1).

Category	Activity #	Activity	Standard to be Used	Reference/Authority
Field Observations	5	Site and Habitat Data	Field Subject Matter Expert	Field staff with proficiency in distinguishing basic habitat classifications and identifying common tree/understory species.
Data Processing	11	Automated Species Identifications	Software Output	Automated identifications resulting from software analysis. Identifications may be to the species level or to unknown bat or non-bat noise.
	12	Manual Species Identifications	Taxonomic Subject Matter Expert; Scientific Publications	Manual reviewer with proficiency in examining and classifying bat echolocation calls. Identifications may be to the species level or to a species pair/group or to unknown bat or non-bat noise. Manual reviewer may consult published keys or scientific literature to assist with the identification process.

Table 6. Accreditation standards for the Great Lakes Inventory and Monitoring Network bat monitoring program.

Personnel	Required Training/Certification
Field Staff	Participation in training provided by GLKN Protocol Lead. Following training, demonstrated ability to operate acoustic detector equipment and handheld GPS unit.
GLKN Protocol Lead	Working knowledge of acoustic detector equipment, acoustic analysis software, and Microsoft Access. Ideally, completion of one or more bat acoustic data management and/or data analysis courses*.
Acoustic Data Processor	Working knowledge of acoustic analysis software and Microsoft Access. Ideally, completion of one or more bat acoustic data management and/or data analysis courses*.
Acoustic Data Manual Reviewer	Working knowledge of acoustic analysis software. Completion of one or more bat acoustic data analysis courses* focusing on manual identification of bat calls, including species found in the Great Lakes region.

*Bat acoustic data management and/or data analysis courses may include those offered by Bat Conservation and Management (www.batmanagement.com), Wildlife Acoustics (www.wildlifeacoustics.com), Western Canada Bat Conservation Program (www.batsrus.ca), or similar.

Table 7. Protected data standards for the Great Lakes Inventory and Monitoring Network bat monitoring program. *Legally protected* data are covered under existing statute as exempt from dissemination. *Operationally protected* data are withheld from release at the discretion of park/network staff for the purposes of resource protection.

Data Category	Level of Protection	Rules for Dissemination
Federally Listed T&E Species Data	Legally Protected	Precise locations of protected species are not to be published; summary data at the park-level are permissible.
Sampling Location Data	Operationally Protected	Specific locations (i.e., GPS coordinates) may be included in internal NPS reports but will be excluded from publicly released reports. General maps are permissible for public release.
Personally Identifiable Information	Legally Protected	Names of non-NPS crew members will be excluded from publicly released reports.

Quality Assurance and Control

The ability to appropriately analyze long-term monitoring data to detect trends depends on the consistency and quality of data collection. Implementation of robust quality assurance and quality control (QA/QC) procedures can help ensure data meet required standards.

Quality Assurance Procedures

Quality assurance procedures are designed to prevent or minimize errors during data collection and data entry, through activities such as training and oversight, testing equipment, and reviewing data. Quality assurance procedures pertaining to the bat monitoring protocol are described in Table 8 below.

Table 8. Quality assurance procedures for the Great Lakes Inventory and Monitoring Network bat monitoring program. Activity numbers correspond to those in the protocol activity matrix (Table 1).

Category	Activity #	Activity	QA Procedure	Reference
Site Establishment and Maintenance	1	Site Reconnaissance and Establishment	Training and resources provided to help field staff evaluate suitability of sites.	SOP #1
	2	Site Maintenance	GPS coordinates are updated yearly and provided to field staff before field season.	SOP #6
	2	Site Maintenance	Site photos, site descriptions, and access notes are provided to field staff to assist in relocating sites.	SOP #6
	2	Site Maintenance	Checklist of required equipment to bring in field.	SOP #3
Field Observations	4–6	Deployment Data, Site and Habitat Data, and Recovery Data	SOPs updated yearly and provided to field staff before field season.	SOP #11
	4–6	Deployment Data, Site and Habitat Data, and Recovery Data	Separate fields provided on datasheet for each data type to prevent missing information.	SOP #4
	4–6	Deployment Data, Site and Habitat Data, and Recovery Data	Specific options provided on datasheet when there are a limited number of acceptable answers (detector model, mounting system, habitat type).	SOP #4
	4–6	Deployment Data, Site and Habitat Data, and Recovery Data	Instructions provided on datasheet for what to include in site/habitat map and notes.	SOP #4
Sensor Data	7	Site Photos	Checklist of required photos included on datasheet to prevent missing photos.	SOP #4
	7	Site Photos	Photo of datasheet required to help correctly associate photos to location.	SOP #4
	8	Audio Data	Training and resources provided to field staff on operation and set up of acoustic detectors.	SOPs #2, #3, #4
	8	Audio Data	Acoustic detectors and microphones tested prior to field season.	SOP #3

Table 8 (continued). Quality assurance procedures for the Great Lakes Inventory and Monitoring Network bat monitoring program. Activity numbers correspond to those in the protocol activity matrix (Table 1).

Category	Activity #	Activity	QA Procedure	Reference
Sensor Data (continued)	8	Audio Data	Acoustic detector program file provided by GLKN so that all audio and scheduling settings are consistent across parks.	SOP #3
	8	Audio Data	Step-by-step guide for field staff to follow during deployment and recovery visits.	SOP #4
	9–10	Detector Status Data; Detector Program Data	Acoustic detectors tested prior to field season.	SOP #3
Data Processing	11	Automated Species Identifications	List of allowable candidate species for each park is specified within the software settings.	SOP #8
	11	Automated Species Identifications	Step-by-step instructions and software setting provided in SOP.	SOP #8
	12	Manual Species Identifications	List of allowable candidate species for each park is provided to the manual reviewer.	SOP #8
Quality Control Data	13	Microphone Testing and Calibration	Microphone calibration and voltage test performed prior to field season. Microphones are discarded if they fail the calibration and/or voltage test.	SOP #3
	14	Deployment Data Checks	Data management plan set up at beginning of field season. Consistent folder/file structure and naming conventions used across all parks.	SOPs #5, #6
	14	Deployment Data Checks	Review of field datasheets for completeness.	SOPs #4, #6
	14	Deployment Data Checks	Comparison of GPS coordinates between current year and previous years to verify correct location was visited.	SOP #6
	14	Deployment Data Checks	Visual review of a small sample of acoustic files to identify possible problems caused by excessive noise or microphone malfunction.	SOP #6

Table 8 (continued). Quality assurance procedures for the Great Lakes Inventory and Monitoring Network bat monitoring program. Activity numbers correspond to those in the protocol activity matrix (Table 1).

Category	Activity #	Activity	QA Procedure	Reference
Quality Control Data (continued)	15	Database QA/QC	Personnel performing data entry are trained and provided with step-by-step instructions in SOPs.	SOP #7
	15	Database QA/QC	Database design incorporates look-up tables and validation rules to minimize errors during data entry.	SOP #7

Quality Control Procedures

Quality control procedures are designed to identify errors or problems with the data, make corrections when possible, and annotate data that do not meet standards. Quality control procedures pertaining to the bat monitoring protocol are described in Table 9 below.

Table 9. Quality control procedures for the Great Lakes Inventory and Monitoring Network bat monitoring program. Activity numbers correspond to those in the protocol activity matrix (Table 1).

Category	Activity #	Activity	QA Procedure	Reference
Field Observations	4–6	Deployment Data, Site and Habitat Data, and Recovery Data	Incomplete or ambiguous information on datasheets verified with field staff; notes and corrections made both on datasheets and in database.	SOP #6
	5	Site and Habitat Data	Geolocation check using ArcGIS to ensure site coordinates are in the correct location.	SOP #7
Sensor Data	7	Site Photos	Directional photos compared to previous years and to site/habitat map to verify they are labeled correctly.	SOP #6
	8	Audio Data	Acoustic file metadata compared to information recorded on datasheet (site name, detector serial number, coordinates) to verify data are associated with correct site in folder structure.	SOP #6
	8	Audio Data	Bulk rename of audio files using R script if incorrect prefix was used.	SOP #6
	8	Audio Data	Compare number of audio files in folder structure for each deployment to number entered in database using R script.	SOP #6
	9	Detector Status Data	Review of detector status text file to verify equipment was functioning properly throughout deployment period.	SOP #6
	10	Detector Program Data	Review of detector program file to verify correct recording schedule and audio settings were used.	SOP #6
Data Processing	11–12	Automated and Manual Species Identifications	Identify deployments that do not meet protocol specifications for date or duration; exclude these from processing.	SOP #8
	11–12	Automated and Manual Species Identifications	Prior to publishing data, manually verify identifications for species that are detected outside of known range OR include qualification that identifications are unverified.	SOPs #8, 9, 10

Table 9 (continued). Quality control procedures for the Great Lakes Inventory and Monitoring Network bat monitoring program. Activity numbers correspond to those in the protocol activity matrix (Table 1).

Category	Activity #	Activity	QA Procedure	Reference
Data Processing (continued)	11–12	Automated and Manual Species Identifications	Run database query to identify deployments with zero species identifications; add notes documenting why this occurred.	SOP #7
Quality Control Data	14	Deployment Data Checks	Compare the number, size, and modification date of files on the “working” vs. “corrected” hard drives to ensure most up-to-date versions are retained.	SOP #6
	15	Database QA/QC	Manual check of 100% of data by comparing a printed copy of database entries with the original field data. Following the manual check, corrections made and notes added to the database as needed.	SOP #7
	15	Database QA/QC	Run database queries to identify errors such as overlap in recording dates for a given detector serial number or disagreement between recording dates and deployment/retrieval dates.	SOP #7
	15	Database QA/QC	Spellcheck database entries and verify consistent terms are used.	SOP #7
	15	Database QA/QC	Document when QA/QC procedures are performed and by whom.	SOP #7
	15	Database QA/QC	Checkbox in database identifies when all QA/QC and corrections are complete and data is considered final.	SOP #7

Roles and Responsibilities

Many personnel are involved in the tasks of collecting, processing, storing, and analyzing data from the bat acoustic monitoring program and ensuring the data quality objectives and standards described above are satisfactorily met. The roles and responsibilities of participating individuals and organizations are described below in Table 10.

Table 10. Roles and responsibilities of personnel involved in the Great Lakes Inventory and Monitoring Network bat monitoring program.

Position	Affiliation	Role
Regional Program Manager	NPS Midwest Region	QAP and protocol approval; ensure data meet quality objectives
Network Program Manager	NPS GLKN	Program coordination; oversight of development and implementation of monitoring protocols; ensure data meet quality objectives; facilitate peer review of protocol
Network Protocol Lead	NPS GLKN	Protocol development; protocol implementation; oversee field crew hiring and training; coordinate data collection, entry, validation, verification, certification, analysis, and storage; ensure data meet quality objectives
Network Data Manager	NPS GLKN	Database development and maintenance; coordinate data entry, validation, verification, and certification; ensure data meet quality objectives
Park Natural Resource Manager	NPS individual parks	Oversight of field technicians; coordinate data management onsite at park
Field Technician	NPS individual parks or cooperating partners (e.g., university, tribal)	Prepare equipment, collect data, and manage data according to SOPs; submit data to GLKN for review
Acoustic Data Processor/Manual Reviewer	Contractor	Process acoustic data using both automated software and manual review; import results to database

Data Quality Evaluation

This QAP, along with the associated protocol narrative and SOPs, describes how the bat monitoring program will be implemented and how data quality objectives will be met. However, an important consideration is evaluating how well these procedures are working and what improvements may be warranted. Details of the data quality evaluation process are outlined below and in Table 11.

The protocol lead will conduct periodic (typically annual) reviews to assess the efficacy of data collection, data processing, and QA/QC methods. These evaluations should determine whether personnel are following the standards and procedures specified in the SOPs/QAP and whether data are meeting quality objectives and performance standards. The reviewer will identify any deficiencies, develop corrective actions, and document the results (for example, by revising the relevant SOP). These quality checks promote a cyclic process of continuous feedback and improvement of both the data and the planning process.

Additionally, all IMD Monitoring protocols must undergo periodic formal review including a full scientific review and overall assessment of whether the collected data are sufficient to meet protocol objectives. This type of review may be initiated when substantial changes are made to protocol objectives or processes, concurrent with a significant data analysis/trend detection report, or as requested by a supervisor, and typically occurs approximately every five years.

Table 11. Data quality evaluations to be conducted as part of the Great Lakes Inventory and Monitoring Network bat monitoring program.

Review	Purpose & Description	Frequency
Field Season Review	Protocol lead solicits feedback from field staff and park natural resource managers to identify “lessons learned”. May include discussion of what was successful, what logistical or technical challenges arose, or safety issues. Based on this information, SOPs and training procedures are clarified or updated as needed.	Annually
Data Completeness	Measure of the number of sites sampled compared to the anticipated number.	Annually
Data Quality Assessment	Measure of the number of sites sampled that do not meet data quality objectives or performance standards, compared to the overall effort.	Annually and cumulatively for the period of record
Certification Lag-time	Measure of the proportion of data collected during the prior year that have been certified.	Annually
Public Accessibility & Availability	Measure of the proportion of data disseminated (or used as the basis of disseminated science products) that have been withheld from public release for a period greater than two years.	Annually
Overall Protocol Review	Evaluate whether the protocol is meeting its stated objectives and producing the best available science. Determine the degree to which collected data are able to be used to support stated management goals.	Approximately every five years

Records Management and Documentation

Proper records management and documentation are an essential component of every monitoring protocol. Records management procedures identify what data must be retained and how they must be archived. Documentation procedures include certifying data, creating associated metadata, and providing data quality information to accompany datasets or publications when they are disseminated.

Records Management

The bat monitoring program will conform to records management requirements as specified by the NPS. *NPS Director's Order 11D: Records and Electronic Records Management* (2012) and its appendix, *NPS Records Schedule* (2010) describe activities and standards in maintaining and providing access to records at all levels of the NPS. Director's Order 11D states that all records of natural and cultural resources and their management are considered mission-critical records, that is, necessary for fulfillment of the NPS mission. The *NPS Records Schedule*, which provides guidelines on natural resource-related records including the results of Inventory and Monitoring Programs, indicates that all natural resource records are considered "permanent" and need to be retained either in an appropriate park museum facility or at the National Archives.

Records to be maintained include items such as protocol documents, field data, geospatial data, database files, data analysis code/scripts, and reports (Table 12).

Table 12. Required records to be maintained as part of the Great Lakes Inventory and Monitoring Network bat monitoring program.

Category	Record Type	Format	Archive Location(s)
Protocols	Protocol Narrative	PDF	GLKN Server, NPS DataStore
	Standard Operating Procedures	PDF	GLKN Server, NPS DataStore
	Quality Assurance Plan	PDF	GLKN Server, NPS DataStore
	Blank Field Datasheet	PDF and MS Word	GLKN Server
Field Data	Completed Field Datasheets	PDF	GLKN Server, GLKN Drive, Offsite Drive
	Site Photographs	JPG	GLKN Server, GLKN Drive, Offsite Drive
	Audio Files	WAV	GLKN Drive, Offsite Drive
	Song Meter Summary Files	TXT	GLKN Server, GLKN Drive, Offsite Drive
	Song Meter Program Files	PGM/SM4S	GLKN Server, GLKN Drive, Offsite Drive
	Deployment Notes	TXT	GLKN Server, GLKN Drive, Offsite Drive
Database	Database Front End	MS Access	GLKN Server, NPS DataStore
	Database Back End	MS Access	GLKN Server, NPS DataStore
	Database Development Notes	MS Word	GLKN Server
	Data Entry Tracking	MS Excel	GLKN Server
Geospatial Data	Sample Site Locations	Shapefile, KML, and MS Excel	GLKN Server
Data QA/QC	Manual Check Sheets	Hard copy	GLKN Office
	Manual Check Tracking	MS Excel	GLKN Server
	Quality Control Queries	MS Access	GLKN Server, NPS DataStore
	Quality Control Query Tracking	MS Excel	GLKN Server
	Corrections Tracking	MS Excel	GLKN Server
	Quality Control Codes	R Script	GLKN Server
	Data Certification Forms	PDF	GLKN Server
Data Analysis/Reporting	Data File Used in Analysis	MS Excel	GLKN Server
	Data Analysis Codes	R Script or other	GLKN Server

Table 12 (continued). Required records to be maintained as part of the Great Lakes Inventory and Monitoring Network bat monitoring program.

Category	Record Type	Format	Archive Location(s)
Data Analysis/Reporting (continued)	Draft Report (version submitted for peer review)	PDF	GLKN Server
	Peer Review Comments and Author's Response	PDF	GLKN Server
	Final Report	PDF	GLKN Server, NPS DataStore
	Manuscript Submittal Form	PDF	GLKN Server

Documentation

Data resulting from the bat monitoring program will typically undergo certification procedures prior to distribution. Data that have not been certified are considered provisional. All data reports, analyses, and dissemination of data for public use will be based on certified data. In general, data will be certified prior to internal use for supporting park-, regional-, or national-level resource management decisions. However, in some cases the use of provisional data may be warranted to base decisions on best-available science.

Data certification is the process confirming that:

- Data have been through all QA/QC procedures.
- Data are determined to either meet specified quality standards or not, at the “deployment” level. Data that do not meet those standards are appropriately identified and annotated.
- Data are suitable for general public use.

All subsequent changes to certified data are documented by providing a description of the change, the date of change, and the name of the individual who made the change.

Along with being certified, data that are being disseminated to the public or to other agencies/entities should be properly documented with accompanying metadata and data quality information. Metadata for all published data products must be FGDC compliant. The abstract for all metadata, and a descriptive paragraph for each report or document, must include the following link to the GLKN Bat Monitoring Project in the NPS DataStore: <https://irma.nps.gov/DataStore/Reference/Profile/2267762>. This will ensure that data can be connected back to the latest version of the protocol, QAP, and all associated standard operating procedures.

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The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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