



Protocol for Monitoring Environmental Contaminants in Bald Eagles - Version 1.2

Great Lakes Inventory and Monitoring Network

Natural Resource Report NPS/GLKN/NRR—2009/092



ON THE COVER

An eight-week-old bald eagle nestling awaits sampling for environmental contaminants.
Photograph by: Bill Route, National Park Service.



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Natural Resource Report NPS/GLKN/NRR—2009/092

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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 and attached standard operating procedures should promptly notify the project leader and/or the data manager about recommended and required changes. The project leader 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 #9: Revising the Protocol.

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Date and Number of Previous Version	Date and Number of Revision	Author(s) of Revision (with title and affiliation)	Location in Document and Concise Description of Revision Reason for Change
March 2006, V 1.0	April 2008, V 1.1	Bill Route, lead investigator, NPS	Removed herring gull as a sentinel species and removed reference to six parks that are not being monitored under this protocol. Unable to obtain and cover costs of gull sampling and analysis. Other six parks are being monitored under a separate protocol using fish and dragonflies as sentinel species (Wiener et al. 2008).
April 2008, V 1.1	Dec. 2008, V 1.2	Bill Route, lead investigator, NPS	Addressed reviewer comments: minor edits throughout; removed power analysis from section 2.5 and replaced with illustrations of analysis and presentation using preliminary results of pilot work in 2006, 2007, and 2008. Power analysis was considered pointless by reviewers because contaminants data are highly variable. Data are more useful when analyzed and presented as bar charts with thresholds; trends lines and differences between areas with measures of variability; and assessments of spatial patterns with maps.
Add rows as needed for each change or set of changes tied to an updated version number.			

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Executive Summary

This protocol details the objectives, study design, and reporting requirements for monitoring levels of targeted environmental contaminants in national parks in the western Great Lakes region of the United States. Detailed methods are in standard operating procedures. The protocol involves taking blood and feather samples from bald eagle (*Haliaeetus leucocephalus*) nestlings to monitor trends in contaminants that are persistent, bioaccumulative, and toxic (PBTs) to fish, wildlife, and humans. The monitoring will take place at Apostle Islands National Lakeshore (APIS), Mississippi National River and Recreation Area (MISS), and the St. Croix National Scenic Riverway (SACN). A companion protocol involves sampling fish for contaminants at six other national parks in the region (Wiener et al. 2008). Both programs are part of a nation-wide effort by the U. S. National Park Service (NPS) to provide park managers with scientifically sound data to manage natural resources under their care. The monitoring is funded and conducted by the NPS Great Lakes Inventory and Monitoring Network.

Human-made contaminants that are released into water, air, or on land often end up in aquatic systems through aerial deposition, runoff, and ground water. Bald eagles are high on the aquatic food web and are known to accumulate PBTs to high levels. Hence they sample the aquatic environment and act as integrators of human-made contaminants.

This protocol will be repeated minimally on a two-years-on and two-years-off cycle. Depending on funding levels and contributions from partners, we may be able to sample during the intervening gap years. We will target six contaminants that are causing impairment to water bodies within the three parks or which have been identified by regulatory agencies as emerging contaminants of concern. The six contaminants are:

- Lead
- Mercury (total)
- DDT (including DDE & DDD)
- PCBs (total and 75 congeners)
- PBDEs (total and 9 congeners)
- PFCs (total and 16 telomers)

Specifically, the monitoring program is designed to answer the following questions:

1. What is the direction and magnitude of change in concentrations of DDT (including metabolites DDE and DDD), total PCBs, total PFCs, and PBDEs in blood plasma, and of total mercury and lead in feathers, from nestling bald eagles within the three parks?
2. What is the incidence of developmental deformities observed in live and dead nestlings of bald eagles within the three parks?
3. What is the direction and magnitude of change in the number of young produced per occupied bald eagle nest within the three parks?

Briefly, occupied bald eagle nests are located by a pilot/observer team from either a fixed-wing aircraft or a helicopter in the spring of each year. In May or June, field teams visit all occupied nests that can be safely climbed. Sampling is timed to target nestlings when they are five to nine weeks old. Each active nest will contain one to three, very rarely four, nestlings. We will take up to 11 ml of blood and three to four breast feathers from at least one, and often all, nestlings in each nest. Samples from one nestling will be sent in for laboratory analysis. Samples from the

remaining siblings will be archived. All eaglets will be measured, weighed, checked for general health, banded, and placed back in the nest. All handling and sampling data will be recorded on standardized forms.

Blood samples will be kept in a cooler on ice and then processed within eight hours. Processing involves centrifuging the whole blood and pipetting the serum into separate containers. The prewashed, chemically inert, and individually wrapped sample containers are provided by the lab. The serum will be frozen within 10 hours and kept frozen until delivery to the laboratory. Feather samples will be kept dry in individually marked envelopes. Following the field season both blood and feather samples will be delivered to the designated lab where they will be analyzed for concentrations of target contaminants.

Resulting data will be quality checked and stored in a Microsoft (MS) Access database and then up-loaded to the EPA STORET database. Copies of the MS Access database will be archived with each of the three parks. Field efforts and preliminary results will be summarized in short progress reports after each field season. On the third year following pilot work (2008) a synthesis report will be completed. Thereafter synthesis reports will be completed on the year following each two-year sample-set (i.e., 2012, 2016, 2020, and so on).

Acknowledgments

This protocol was developed under the guidelines of the National Park Service, Vital Signs monitoring program, and we would like to thank S. Fancy for his leadership and tireless efforts to make this program possible. The decision to monitor environmental contaminants was the result of numerous discussions and meetings with employees from the nine parks in the Great Lakes Network, especially the Technical Committee and Board members, Network staff, and numerous agency scientists. We thank all of them for their many hours in meetings, reviews, and informal discussions. Finally, we acknowledge J. Marburger, M. Meyer, M. Sandheinrich, C. Thomson, and J. Weiner for comments and suggestions which greatly improved the clarity and rigor of this protocol, and B. Brown for final edits and layout of the document.

1 Background and Objectives

1.1 Introduction

The National Park Service (NPS) has instituted a program to inventory and monitor natural resources at approximately 270 NPS units (parks) across the nation (Fancy 2004). The program is being implemented by forming 32 “Networks” of parks that share common management concerns and geography. The Great Lakes Inventory and Monitoring Network (GLKN) includes nine parks in four states surrounding the western Great Lakes: Apostle Islands National Lakeshore (APIS), Grand Portage National Monument (GRPO), Indiana Dunes National Lakeshore (INDU), Isle Royale National Park (ISRO), Mississippi National River and Recreation Area (MISS), Pictured Rocks National Lakeshore (PIRO), Sleeping Bear Dunes National Lakeshore (SLBE), St. Croix National Scenic Riverway (SACN), and Voyageurs National Park (VOYA). See Table 1.1 for a list of all acronyms used in this protocol.

The purpose of the overall NPS program is to identify and monitor indicators of park ecosystem health. These indicators, referred to as “Vital Signs”, are a select group of attributes that are particularly useful for understanding and managing NPS areas. The Great Lakes Network has developed a guiding document that details the goals, ecological context, and an implementation schedule for the Vital Signs selected by the nine parks (Route and Elias 2007). One of the Vital Signs identified by GLKN and its constituent parks is Trophic Bioaccumulation. Under this protocol we will monitor environmental contaminants that are persistent, bioaccumulative, and toxic (PBTs). This protocol, and the attached standard operating procedures (SOPs), provide the basis and methods for monitoring PBTs in three parks in the Great Lakes Inventory and Monitoring Network.

1.2 Goals and Objectives

The goal of this monitoring protocol is to collect data that will provide managers at APIS, MISS, and SACN with information on the temporal trends, spatial patterns, and where feasible the ecological effects, of targeted, anthropogenic PBTs in aquatic ecosystems. The monitoring will include new and emerging chemicals when they are identified by regulatory agencies as being of concern for ecosystem and human health.

Contaminants eventually accumulate in aquatic systems through wet and dry deposition from the air and through down-gradient transport in runoff, stream flow, and ground water. This monitoring protocol will focus on aquatic systems to increase the efficiency of sampling, and the greater ability to observe actual effects in wildlife. We will focus on PBTs that have been identified by state and/or federal regulatory agencies as contaminants that have caused impairment of one or more water bodies within a park. States are required to document causes of impairment to each water body by placing them on the 303(d) list, which is monitored by the U.S. Environmental Protection Agency (USEPA) under stipulations of the Clean Water Act.

In addition to these listed contaminants, many new and emerging chemicals are being released into the environment each year. The Network will consult with the USEPA, the International Joint Commission (IJC), the state Departments of Natural Resources and/or Departments of

Table 1.1. List of acronyms used in this protocol.

2,3,7,8-TCDD	2,3,7,8-tetrachlorodibenzo-p-dioxin
APIS	Apostle Islands National Lakeshore
BEST	Biomonitoring of Environmental Status and Trends
CSDGM	Content Standard for Digital Geospatial Metadata
CU-DEQ	Clemson University and Michigan Department of Environmental Quality
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DEQ	Department of Environmental Quality
DNR	Department of Natural Resources
EC	Environment Canada
EPA-STORET	Environmental Protection Agency Storage and Retrieval System
FGDC	Federal Geographic Data Committee
FWS	U.S. Fish and Wildlife Service
GLBTS	Great Lakes Binational Toxics Strategy
GRPO	Grand Portage National Monument
IADN	Integrated Atmospheric Deposition Network
IJC	International Joint Commission
IMS	Internet Mapping System
INDU	Indiana Dunes National Lakeshore
ISRO	Isle Royale National Park
MISS	Mississippi National River and Recreation Area
NBII	National Biological Information Infrastructure
NELAP	National Environmental Laboratory Accreditation Program
NPS	National Park Service
NPSTORET	National Park Service Storage and Retrieval System
PAH	Polycyclic aromatic hydrocarbon
PBDE	Polybrominated diphenyl ether
PBT	Persistent, bioaccumulative toxicant
PCB	Polychlorinated biphenyl
PCDD	Polychlorinated dibenzo-p-dioxin
PCDF	Polychlorinated dibenzofuran
PFC	Perfluorinated compounds
PFOS	Perfluorooctane sulfonate
PIRO	Pictured Rocks National Lakeshore
QA/QC	Quality assurance/quality control
RPD	Relative percent difference
SACN	St. Croix National Scenic Riverway
SLBE	Sleeping Bear Dunes National Lakeshore
SOLEC	The State of the Great Lakes Ecosystem Conference
SOP	Standard operating procedure
USEPA	U. S. Environmental Protection Agency
USGS	U. S. Geological Survey
VOYA	Voyageurs National Park
WRD	Water Resource Division

Environmental Quality, the USGS Biomonitoring of Environmental Status and Trends (BEST) Program, the USGS Toxic Substances Hydrology Program, and natural resource staff from Network parks to determine which new contaminants should be considered for monitoring under this protocol.

Specifically, the objectives of this protocol are threefold:

1. To monitor spatial patterns and temporal trends in exposure of bald eagles to targeted PBTs in three parks of the Great Lakes Network;
2. Where feasible, to measure spatial patterns and temporal trends in reproductive outcomes and incidence of developmental deformities of bald eagles at the three parks, and to assess the relation of these variables to contaminant exposure;
3. To archive tissue (blood, egg, and feathers) from bald eagles at the three parks and periodically investigate exposure to new and emerging contaminants.

1.3 Rationale for Monitoring Persistent, Bioaccumulative Toxicants

The nine Great Lakes Network parks are within one of the areas in the U.S. where environmental contaminants have been shown to impact wildlife reproduction adversely and to cause developmental deformities (IJC 1989; Gilbertson et al. 1998). Many of these chemicals are known or hypothesized to cause similar reproductive and developmental problems in humans (Gilbertson and Carpenter 2004; Hites et al. 2004; Foran et al. 2005). The chemicals of greatest risk to wildlife and humans are those that are persistent, bioaccumulate, and are toxic (PBTs). The pathways of PBTs into these NPS units are from both point and non-point sources, with transport to the NPS units by atmospheric, biotic, and water-borne routes (Figure 1.1).

A fraction of the PBTs found in park units may be from past use or emissions in or near park boundaries. However, long-range atmospheric transport accounts for a significant fraction of many pollutants (Engstrom and Swain 1997).

Reproductive failure and the resulting population decline of many species of birds began in 1947, with the introduction of the organochlorine pesticide DDT (dichlorodiphenyl-trichloroethane) in North America. DDE (dichlorodiphenyldichloroethylene), a metabolite of DDT, caused egg-shell thinning and resulted in eggs breaking when adults attempted to incubate them. With the ban on DDT in 1972 many bird populations began to recover (Newton 1979). Through at least the early 1980s the productivity of bald eagles was inversely correlated with DDE and PCB concentrations in eggs (Wiemeyer et al. 1984) and in blood plasma of nestlings (Bowerman et al. 2003). These chemicals may no longer limit bald eagle populations in the Lake Superior region (Dykstra et al. 2005); yet, recovery through the 1980s and 1990s was not uniform throughout the Great Lakes region. Bald eagles nesting along the shoreline of the Great Lakes and in Voyageurs National Park (VOYA) have lower reproductive success than inland populations in Minnesota, Wisconsin, and Michigan (Kozie and Anderson 1991; Grim and Kallemeyn 1995; Dykstra et al. 1998; Bowerman et al. 2003). The reasons for this difference in reproductive success are not fully understood.

Many chemicals manufactured and released by humans have been studied and implicated in environmental pollution. Mercury has been used and released into the environment for centuries (Wiener et al. 2003), and its organic form, methylmercury, is persistent, biomagnifies in aquatic food webs, and is highly toxic (Evers 2005; Clarkson and Magos 2006; Mergler et al. 2007; Scheuhammer et al. 2007). Growing awareness of the hazards of mercury has led to reductions in emissions in the Great Lakes basin, yet it remains the most pervasive environmental contaminant in parks of the Great Lakes Network. Indeed, mercury contamination has diminished the nutritional, recreational, and thus economic value of fish, as well as the goods and services

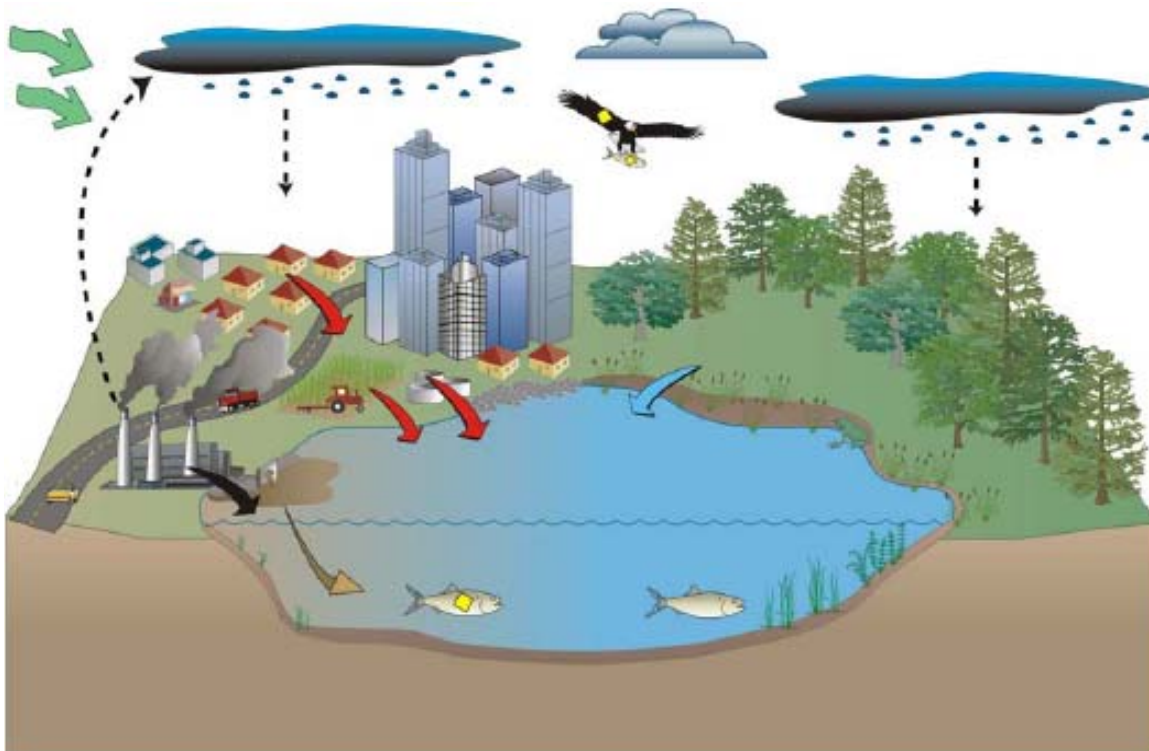


Figure 1.1. A simplified illustration of how anthropogenic contaminants enter the aquatic ecosystem. Prevailing winds (green arrows) drive polluted air masses over the landscape and precipitation deposits toxics (black dashed arrows) onto land and water. Rainwater runoff across urban, industrial, and agricultural lands (red arrows), combines with point-source pollution (black arrow) and sedimentation (brown arrow), to alter water quality. Some contaminants will bioaccumulate in higher trophic species (yellow diamond in fish and bald eagle). Effects of pollutants can be buffered by terrestrial and aquatic vegetation (blue arrow), or in the case of mercury, can be magnified by dry deposition off vegetative surfaces and subsequent production of toxic methyl mercury in wetlands.

provided by many aquatic ecosystems. Most parks in the Network have at least one water body with an advisory to limit fish consumption due to mercury. Moreover, several states in the Great Lakes region have issued statewide advisories for fish consumption in all lakes and rivers (Illinois, Indiana, Ohio, and Wisconsin) or for all lakes (Michigan, Minnesota) because of mercury contamination (USEPA 2005).

This protocol will serve APIS, MISS, and SACN; a companion protocol, with the same targeted contaminants, will employ fish as the sentinel species for the remaining six park units (Wiener et al. 2008). APIS is within the Great Lakes watershed, which is covered under the U.S./Canada Great Lakes Water Quality Agreement, administered by the International Joint Commission (IJC). Annex 2 of this Agreement defined 41 Areas of Concern where changes in the chemical, physical, or biological integrity of the system are sufficient to impair beneficial uses. Among the impairments listed were (1) bird or animal deformities or reproductive problems, and (2) fish tumors or other deformities. In the 1970s when the Agreement was formulated, such

impairments occurred at several locations across the Great Lakes (Figure 1.2; Aulerich et al. 1971; Gilbertson et al. 1976; Black 1983). Abnormalities in wildlife alerted biologists, human health professionals, and politicians to the potential effects on human health from chemicals such as DDT, PCBs, and dioxin. For mercury, public awareness and regulatory actions were prompted largely by human poisonings (including many fatalities) from consumption of mercury-contaminated fish, particularly in Minamata, Japan. The awareness created by monitoring PBTs continues to support the need for scientific investigations and remedial actions.

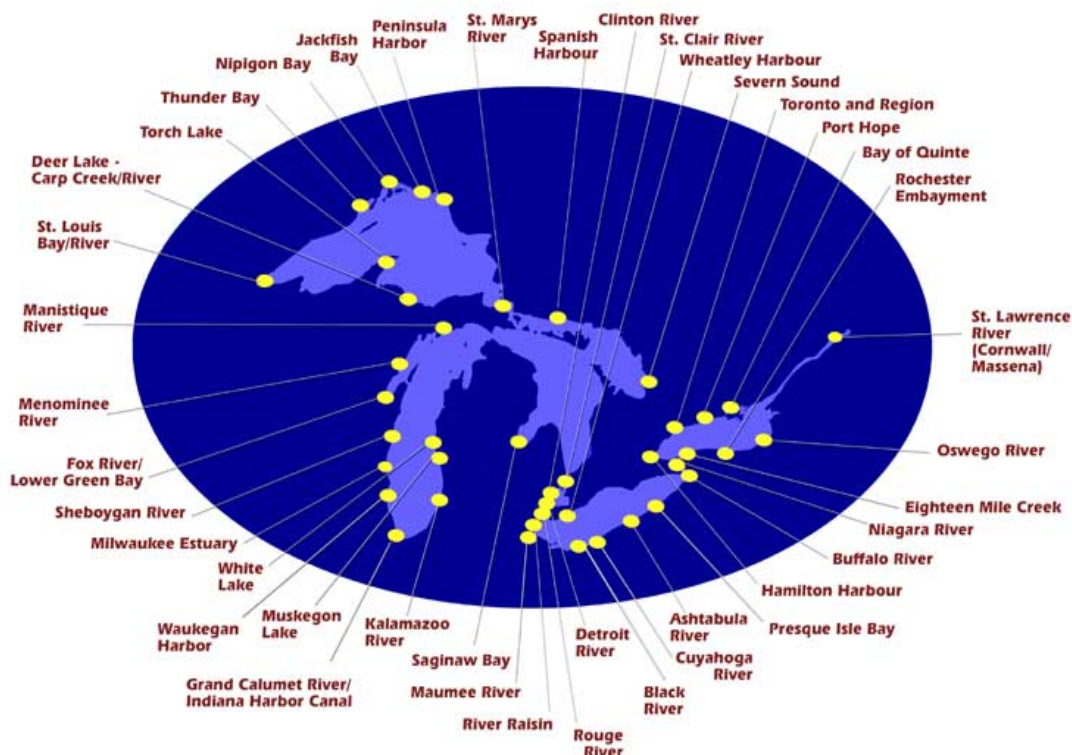


Figure 1.2. Areas of Concern (yellow dots) where toxic chemicals have been shown to cause reproductive problems in fish and wildlife, and the nine NPS units within the Great Lakes Network. Red stars = the three units being monitored under this protocol; green stars = the six units being monitored under a companion protocol.

With IJC leadership, the USEPA and Environment Canada (EC) developed the Great Lakes Binational Toxics Strategy (GLBTS; www.binational.net) to reduce PBTs in the Great Lakes ecosystem. Efforts toward meeting the goals of this strategy are monitored by federal (both U.S. and Canadian), state, provincial, and tribal agencies, and non-governmental organizations, who voluntarily adopt indicators identified and developed through a series of meetings and reports involving over 300 scientists from around the world. The results of these monitoring efforts are presented every other year at The State of the Great Lakes Ecosystem Conference (SOLEC) and

are presented broadly to stakeholders in a State of the Lakes Report on-line at <http://www.epa.gov/glnpo/solec/>.

1.4 Toxic Compounds of Concern

There are hundreds of anthropogenic compounds in water bodies of the three parks being monitored under this protocol. We have narrowed our scope to specific toxicants based on the following criteria:

1. Persistence, bioaccumulation, and toxicity to fish, wildlife, and humans.
2. Listing in section 303(d) of the federal Water Quality Act (including the cause of a fish consumption advisory).
3. Listing as a Level I Substance in Appendix I of the Great Lakes Binational Toxics Strategy.
4. Identification by state and federal authorities as a new and emerging chemical of concern.

All three parks have at least one water body listed as impaired under the state's 303(d) designation because of a bioaccumulative contaminant and/or listed as a Level I Substance in the Great Lakes Binational Toxics Strategy (Table 1.2).

We will periodically re-examine contaminants for inclusion in the monitoring protocol; however, annual monitoring of all chemicals in Table 1.2 would be cost prohibitive. Initially we will focus on the following six PBTs:

- | | |
|-----------------------------|---------------------------------|
| • Lead | • PCBs (total and 75 congeners) |
| • Mercury (total) | • PBDEs (total and 9 congeners) |
| • DDT (including DDE & DDD) | • PFCs (total and 16 telomers) |

These six chemical compounds account for most of the 303(d) and GLBTS listings or have been identified as new and emerging compounds of concern (Table 1.2). They are also some of the most toxic and pervasive compounds in the upper Midwest. Some of the remaining compounds, such as aldrin/dieldrin and chlordane, have either not been detected or have been found in low concentrations in Lake Michigan and Lake Superior (Roe et al. 2004). Additionally, legacy compounds such as DDT and PCBs have been found to be near or below the estimated threshold levels for impairment (Dykstra et al. 2005) and may be monitored infrequently in future years.

Table 1.2. Water bodies in three parks of the Great Lakes Inventory and Monitoring Network with persistent, bioaccumulative toxicants that are either state-listed 303(d), listed as a Level I Substance in Appendix I of the Great Lakes Binational Toxics Strategy (GLBTS), or designated by state or federal regulators to be a new and emerging contaminant of concern. Toxics in bold have been chosen for initial monitoring. State 303(d) listings can be found at <http://oaspub.epa.gov/>.

Park	Water Body	Contaminants and Reasons for Monitoring
APIS	Lake Superior	Level I Substances from GLBTS: Aldrin/dieldrin Alkyl-lead Benzo(a)pyrene {B(a)P} Chlordane Dichlorodiphenyltrichloroethane (DDT) & metabolites DDE and DDD Dioxins Hexachlorobenzene Mercury Mirex Octachlorostyrene Polychlorinated biphenyl (PCB) PBDE and PFCs (New and emerging)
MISS	Mississippi River	PCBs (State-listed 303(d)) PBDE and PFCs (New and emerging)
SACN	St. Croix Flowage Minong Flowage Yellow Lake Mud Hen Lake St. Croix River	Mercury (State-listed 303(d)) Mercury (State-listed 303(d)) Mercury (State-listed 303(d)) Mercury (State-listed 303(d)) Bioaccumulative toxics (State-listed 303(d)) PBDE and PFCs (New and emerging)
303(d) = state-listed, impaired water body PBDE = polybrominated diphenyl ethers		PCB = polychlorinated biphenyl PFCs = perfluorinated compounds

1.5 Use of Biosentinel Species for Monitoring

For over three decades, fish and wildlife that accumulate toxic compounds have been used for monitoring ecosystem quality in the Great Lakes (e.g., State of the Lakes 2005) and other regions of the world (Olsson et al. 2000; Whitehead et al. 2003; Hollamby et al. 2004). Many of the persistent contaminants in these ecosystems occur at biologically relevant concentrations, but some cannot be effectively monitored through sampling the water directly. The concentrations of contaminants in water are often measured in parts per billion or even quadrillion, which are costly to quantify -- if they can be detected at all. However, certain species of fish and wildlife atop aquatic food webs biomagnify these compounds to concentrations that can be readily measured. Sentinel species can be studied to detect changes in environmental quality and the potential for adverse effects for both wildlife and humans.

Species vary in their sensitivity to the same compound, and therefore the effects observed in one species may not be manifested in others, even when exposed to the same concentration. Yet,

fish-eating wildlife share with humans a common aquatic food web and similar complex physiologies; both can suffer adverse effects controlled through a similar mechanism. Hence we can make qualitative statements of risk to humans by monitoring contaminants in fish-eating birds such as the bald eagle.

We selected the bald eagle as a sentinel species for the following reasons:

1. Documented linkages between the reproductive health of bald eagles and PCBs, DDE, lead, and mercury, allow us to relate concentrations of these target PBTs in tissue samples to developmental deformities and/or impaired reproduction.
2. We have useful historical data on bald eagle population status and contaminant exposure from more than 20 years of monitoring in the Great Lakes and surrounding ecosystems (including several GLKN parks).
3. NPS is compelled to use the bald eagle as a sentinel species in monitoring programs when possible, because this species was selected for monitoring under the joint U.S. Canadian Great Lakes Water Quality Agreement.
4. State, provincial, and federal partners are willing to share the costs of monitoring this species.
5. Bald eagles are readily sampled with proven, published methods.
6. The bald eagle is an iconic species that can arouse public interest and help motivate park managers and elected officials to address problems elucidated by this monitoring effort.

1.6 Monitoring Questions

The following questions are derived from our monitoring objectives, from the list of PBTs, and from questions posed by park staff and other scientists (Route 2004). We have attempted to identify explicitly the contaminants, species, and tissues that will be monitored. We have excluded questions that will not be addressed through this monitoring program either due to prohibitive cost or because they will be addressed in other protocols.

This protocol is designed to answer the following questions for the parks being monitored:

1. What is the direction and magnitude of change in concentrations of target contaminants in nestling bald eagles?
2. What are the spatial patterns of target contaminants and are such patterns linked to ecosystem components or human development?
3. Is the direction and magnitude of change in bald eagle productivity correlated with levels of any target contaminant?
4. What is the incidence of addled eggs, developmental deformities, and mortality in bald eagle nestlings, and can these factors be linked to the target contaminants?

2 Monitoring Strategy

2.1 Sampling Design

Our sampling design builds upon other monitoring programs in the Great Lakes region. The bald eagle has been used to monitor levels of persistent chemicals in the aquatic environment of the upper Midwest for over 20 years (Kozie 1986; Best et al. 1990; Shapiro-Hurley 1990; Kozie and Anderson 1991; Ensor Giovengo 1997; Bowerman et al. 2003; Roe et al. 2004; Dykstra et al. 2005). The bald eagle was selected as the primary avian sentinel species by the Michigan Biosentinel Program, which has monitored the concentrations of organochlorine pesticides and PCBs in nestling eagle blood since 1986. We will adopt the methods of the Michigan Biosentinel Program (Roe et al. 2004) and those used by the Wisconsin Department of Natural Resources (Meyer et al. 1993) for collecting and analyzing blood and feather samples from bald eagle nestlings.

Concentrations of organic compounds in blood and feathers of bald eagle nestlings are a direct reflection of contamination in aquatic prey captured by adults within a foraging area around their nest (Bowerman et al. 2002). Bowerman et al. (2002) calculated that growth from egg to five weeks, the minimum age for sampling, diluted any residual contaminants found in the eggs. Even a concentration of 100 ppm (wet weight) in an egg would be undetected in nestling blood plasma because of dilution (change in volume) through normal growth (W. W. Bowerman, Clemson University, Clemson, SC, unpublished data). Hence contaminants in nestling blood plasma are derived from their diet in the local environment.

Each monitoring year, we will determine the number of nests occupied by bald eagles (occupancy survey) and the number of young produced in each occupied nest (productivity survey). Occupancy and productivity surveys can be attempted from the ground, but such surveys often take longer and the data are suspect due to the difficulty in seeing and counting chicks in a nest 60 to 80 feet up in a tree (Fuller et al. 1995).

The Wisconsin Department of Natural Resources (WDNR) will fly occupancy surveys for both APIS and SACN using a relatively slow, maneuverable fixed-wing aircraft such as a Supercub or Cessna 185. The WDNR has conducted these surveys for more than 20 years and we have reasonable expectation that they will continue in the future. For MISS we will contract a helicopter to fly occupancy surveys. A helicopter is required because several nests are near the Minneapolis/St. Paul International Airport and fixed-wing aircraft are not allowed within that air space. WDNR stopped flying statewide productivity surveys after the 2007 nesting season and the MN DNR reduced its statewide efforts by flying both occupancy and productivity surveys every five years (last flights in 2005, next in 2010). Hence, for all three parks we will climb all occupied nests to assess productivity. These nest visits will provide highly accurate productivity estimates.

2.2 Sampling Locations

Sampling will occur at the active nests of eagles that rely on the park's aquatic resources. Most sampling will occur within park boundaries, but occasionally we will sample nests in adjacent areas. Eagles occupy one nest per year, but have alternate nests within a territory. The active nest may be within a park one year and outside the boundaries the next. This is especially true in

long, narrow parks such as SACN and MISS with complex political boundaries and where alternate nests can occur on ridge tops or bluffs away from the river. Yet it is important to collect samples from the same territories each sample year to reduce bias. Nesting pairs mate for life and will use similar habitats and aquatic prey within their territory such that, regardless of nest location, samples from the same territory are not independent. To reduce sample bias, we will attempt to sample the same territories each year and use analytical techniques that account for the lack of independence (see section 2.5). To ensure adequate sample size for APIS, we will include Madeline Island (not park-owned) and extend sampling beyond park boundaries west along the Lake Superior shoreline to include the Bark Bay eagle territory and south into Chequamegon Bay to include the Barksdale eagle territory.

Sample sites (nests) will be determined each year by a pilot/observer team in a fixed-wing airplane or helicopter. These “occupancy” surveys will result in accurate GPS locations of all active bald eagle nests within and directly adjacent to the parks. A nest will be considered active if there is an incubating adult or if eggs or young are observed (Dykstra et al. 2005). This differs from occupancy surveys in some other programs which include as active those territories with two adults near an empty nest, or a recently repaired or new nest (e.g., egg cup, fresh lining material, green twigs, sticks with fresh breaks on top) even if the adult(s) are not observed (Postupalsky 1983). The State of Wisconsin has traditionally taken a more conservative approach to calling nests active. Since most of our sampling will occur in Wisconsin (all of APIS and about 75% of SACN), and because long-term contaminant data on Wisconsin eagles are available for comparison, we will continue to use their criteria for nest activity. Resulting productivity estimates may be higher than in some other studies, and this methodological difference must be taken into account in regional comparisons.

Ground crews will use GPS coordinates from the occupancy survey to locate and sample active nests. We will attempt to get a complete census of all active nests; however, some nests will be unsafe to climb (e.g., dead tree or unstable nest structure), and some landowners will deny access.

2.3 Sample Size

The number of active bald eagle nests each year will vary among parks and between years depending on habitat availability and health of the eagle population (Table 2.1). Past surveys suggest that both MISS and SACN will have at least 10 active nests each sample year, and by extending the bounds of APIS (see section 2.2), we will ensure a minimum of 10 nests there as well.

We will collect blood and feather samples from at least one nestling at each productive nest that is safe to climb. When there is more than one young in the nest we will attempt to collect samples from all nestlings. The number of young produced per active nest will vary from one to three and rarely four.

Samples from only one nestling will be analyzed for contaminants each monitoring year. Samples from siblings will be archived (serum in freezers at -20° C.; feathers dried in envelopes) for future assessments of new and emerging contaminants. Whether samples are destined for the

Table 2.1. Estimated number of bald eagle nests that will contain nestlings suitable for annual sampling for monitoring contaminants in and directly adjacent to parks of the Great Lakes Network.

Park	Est. # of active nests in the park	Est. # of nests that may be sampled from adjacent areas	Reference
APIS	6-12	4-7	Dykstra et al. 2005; WDNR unpublished data
MISS	12-20	0-2	MN Natural Heritage Program unpublished data
SACN	14-25	0-2	Dykstra et al. 2005; WDNR unpublished data

lab or for archive will be randomly determined each evening when samples are being processed (coin toss or random number). Occasionally only one nestling will be sampled from a multiple-brood nest because of impending darkness, an approaching storm, or other circumstances that warrant haste. In these cases we will sample the nestling nearest the climber as he/she enters the nest.

Our sample size is enhanced by the fact that each nestling integrates contaminants from a large number of prey. The adult eagles are effectively ‘sampling’ the environment for us. The average numbers of food items brought to a nest over two years on Outer Island, APIS, were 3.4 and 2.6 per day with two and one nestling, respectively, and the bulk of these prey items were fish (97% of 218 food items observed; Kozie 1986). Considering that we sample eaglets when they are five to nine weeks old (35 to 63 days), a single nestling will integrate contaminants from 90 to 160 prey items.

2.4 Sampling Frequency

We will sample bald eagles at each of the three parks on a two-years-on and two-years-off rotation (Table 2.2). In addition, we will seek funding from other sources to cover intervening years. Our minimum revisit design will allow year-to-year comparisons and should provide sufficient data for longer-term trends (Roe et al. 2004; Dykstra et al. 2005) while economizing sampling costs and effort.

Table 2.2. Initial schedule for sampling bald eagles for persistent, bioaccumulative toxicants at three national parks in the Great Lakes Inventory and Monitoring Network.

Park	2006	2007	2008	2009	2010	2011
APIS	X	X			X	X
MISS	X	X			X	X
SACN	X	X			X	X

2.5 Detection Limits, Transformations, and Summary Statistics

Samples for which a contaminant was detected but the concentration was below the analytical detection limit will be assigned a value of one-half the detection limit for analytical purposes (EPA 2000; Wiemeyer et al. 1984). Values will then be checked for normality and if necessary log transformed to correct for skewed distributions. If transformations will not adequately normalize distributions, non-parametric statistics will be used.

Raw or log-transformed data will be used to calculate the arithmetic or geometric mean contaminant concentrations and measures of variability (95% confidence intervals, standard deviations, or standard errors). Geometric means are usually a better measure of central tendency for contaminants in biota which tend to be log-normally distributed (Ginevan and Splitstone 2003). Means and measures of variability will then be back-transformed for use in various trends and comparisons.

In many cases, such as when annual sample sizes are small, we will combine multiple years of data to generate a single summary statistic for a park or subregion. In these cases it is not appropriate to calculate a simple geometric mean because eagle samples are often collected at the same nests each year and cannot be assumed to be independent. We will use geometric means of all the untransformed concentrations from a nest, producing a single value for each nest (Dykstra et al. 1998; DeSorbo and Evers 2006). That value will then be log-transformed. This technique satisfies the assumption of independence for statistical tests and ensures that nests with multiple samples will not bias means, although it reduces sample size and artificially decreases variance. We will summarize data using this technique in two-year increments following our two-year sampling schedule. This should provide adequate estimates of trends over time (Roe et al. 2004; Dykstra et al. 2005).

2.6 Data Analysis and Presentation

Bar charts or scatter plots will be used to compare levels of contaminants against known or hypothesized thresholds (Schmitt et al. 2008; Figure 2.1). Thresholds have been established in the literature for the legacy contaminants (DDE and PCBs); however, very few studies have documented the lethal and sub-lethal effects on bald eagles of many other contaminants. This is due to the bald eagle being federally endangered since the 1970s, which seriously limited controlled studies of lethality. Information is particularly sparse for new and emerging contaminants. Thus, for some contaminants we will simply report the concentrations and the magnitude and direction of change. Removal of the bald eagle from the federal endangered species list in 2007 should increase laboratory-based research and lead to development of new thresholds. For example, Scheuhammer et al. (2008) found a significant relationship between mercury levels in the liver and certain neurochemicals in the brain of bald eagles. Analysis of a similar relationship between mercury in blood and feathers (collected in this and other monitoring programs), and levels of these same neurochemicals is currently in progress (N. Basu, Department of Environmental Health Sciences, University of Michigan, Ann Arbor, personal communication).

Depending on variability within a geographic area, Roe et al. (2004) found that sampling as few as two nestlings per year can suffice to determine differences among watersheds and can detect a

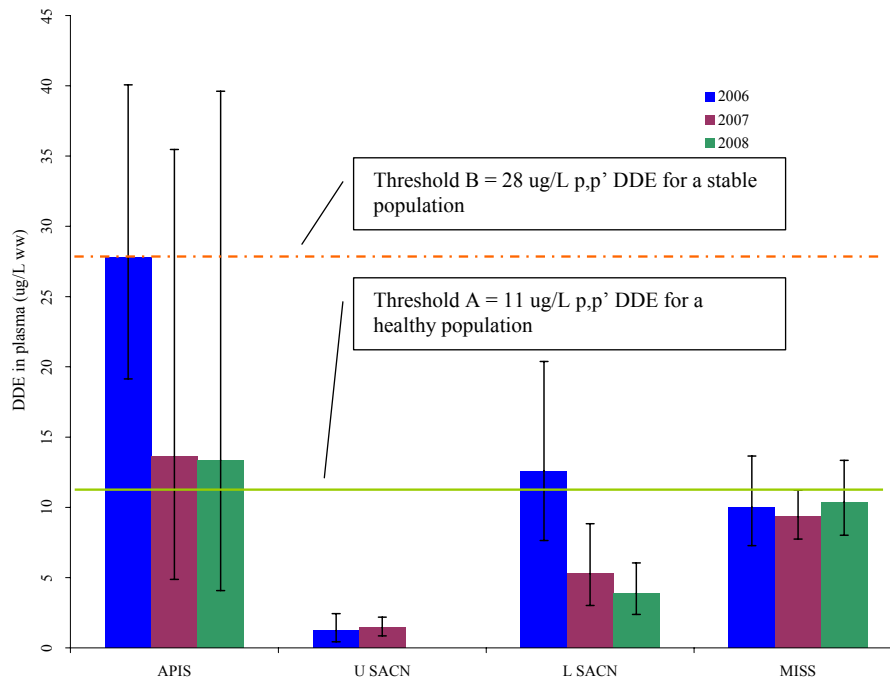


Figure 2.1. Example of bar chart showing geometric mean levels (+/- 95% CI) of p,p' DDE in plasma of bald eagle nestlings in four study areas in the Great Lakes Network in 2006-2008 compared with published p,p' DDE thresholds. Threshold A is based on a healthy bald eagle population producing 1.0 young per occupied nest; B is based on a stable population of 0.7 young per occupied nest. Results are preliminary from data collected during pilot work on this protocol.

10% difference in concentrations of PCBs or DDE over time periods with an alpha of 0.05 and power of 0.8. Our minimum sampling routine (20 for each two-year sample set) will provide about twice as many samples over a 10-year period.

Regression analysis will be used to estimate the magnitude of change (i.e., slope of the regression line) for the geometric mean annual concentration of each contaminant in each park over time (Figure 2.2).

For each contaminant we will examine spatial patterns by mapping concentrations found in individual nestlings across the three parks (Figure 2.3). When combined with land use data, these maps can help document point and non-point sources of pollution. For example, preliminary data suggest that PFOS in eagles at MISS and lower SACN may result primarily from point sources (left panel of Figure 2.3). This chemical is globally distributed in the environment, but has been manufactured by 3M™ Corporation in St. Paul, MN since the 1950s. The company has a chemical plant and several waste disposal sites along the Mississippi River just above the confluence of the St. Croix River with the Mississippi River. Moreover, PFOS has been used

locally in chrome plating. A study in 2007 by the Minnesota Department of Health and the Minnesota Pollution Control Agency found that ca. 95% of the PFOS found in influent, effluent, and sludge from a wastewater facility in Brainerd, MN (just upstream from MISS) was from a chrome plating facility (Kelly and Solem 2007). Moreover, the State of Wisconsin is investigating a similar facility along the lower St. Croix River below Taylors Falls.

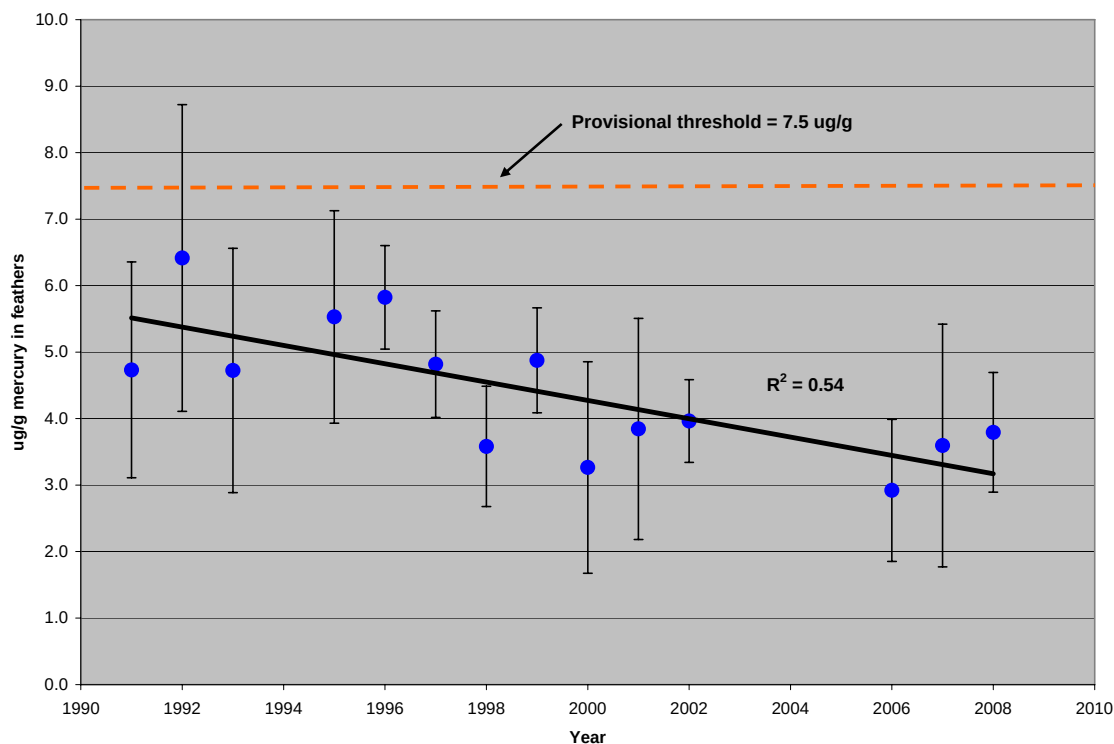


Figure 2.2. Example of regression analysis showing the changes in geometric mean levels (± 1 SD) of mercury in feather samples from bald eagle nestlings at APIS over time compared with a provisional threshold (Jagoe et al. 2002). Data are preliminary; from WDNR (1991 - 2002) and pilot work on this protocol (2006 - 2008); the regression line (slope = - 0.14 and $R^2 = 0.54$) shows the trend in geometric means over 18 years.

By contrast, PBDE levels may be associated with more dispersed sources (right panel of Figure 2.3). The patterns in our pilot data may reflect atmospheric deposition on the large surface area of Lake Superior (relatively high levels in APIS) and numerous municipal waste disposal sites around metropolitan areas (moderate to high levels at MISS and lower SACN).

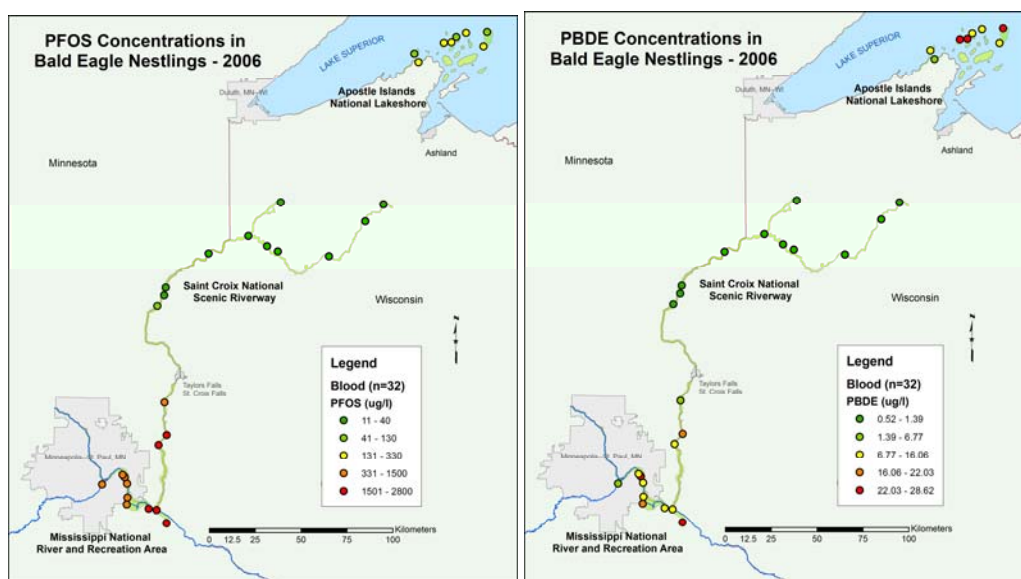


Figure 2.3. Spatial patterns of emerging contaminants, perfluorooctane sulfonate (PFOS; one of 16 PFC telomers being monitored) and polybrominated diphenyl ether (PBDE), in three parks in the Great Lakes Network in 2006. These are preliminary results from data collected during pilot work on this protocol.

2.7 Advanced Data Analysis and Use of Ancillary Data

In most cases there will be sufficient data and reason to warrant making comparisons between parks or other geographical areas (i.e., inland vs. Great Lakes). We completed preliminary tests using analysis of variance (ANOVA) to compare levels of mercury in bald eagles nesting in six areas in and adjacent to the three parks using our pilot data from 2006 to 2008 (Table 2.3). Using log-transformed data we found significant differences among areas ($F = 21.68$, $P < 0.001$). Residual plots suggested that the variance of residuals was homogeneous among regions.

Hg concentrations from nestlings in the Lake Superior shore (excluding Apostles) and Upper St. Croix River regions were highest, those from the Mississippi River pools 3 and 4 were lowest, and other areas were intermediate. Similar work elsewhere has shown differences in contaminant concentrations at multiple scales across states and among watershed subunits (Bowerman et al. 2003; Roe 2004).

In addition to area comparisons and regression analysis (including non-parametric equivalents), monitoring data may be evaluated through Monte Carlo simulations, Bayesian analyses, and comparisons of period means. For the latter-most approach, one is often interested in comparing values before and after an important event (e.g., change in management policy, known toxic release, or reduction in emissions), and considers years within each of the two periods as replicates. Trends in parameters that are analyzed with respect to biotic and abiotic covariates

Table 2.3. Sample sizes, means of log-transformed data, geometric means of raw data, and differences in mercury concentrations for six areas within and adjacent to three parks in the Great Lakes Network in 2006.

Area	N	Mean (log)	Geometric Mean ($\mu\text{g/g}$)	Comparisons ¹
Lake Superior shore	5	0.858	7.21	a
Upper St. Croix	19	0.838	6.89	a
Lower St. Croix	14	0.656	4.53	b
Apostle Islands	24	0.533	3.42	b c
Mississippi Nat'l River	36	0.528	3.37	b c
Mississippi pools 3&4	14	0.430	2.69	c

¹ Areas with the same letters are not significantly different; $F = 21.68$, $P < 0.001$.

may be examined and cause-effect relationships may be investigated more thoroughly by partners and collaborators (e.g., USGS or University investigators).

We will compare concentrations with water quality data, such as dissolved organic carbon (DOC) and pH, which are being collected under a separate Network protocol (Elias et al. 2008; Magdalene et al. 2008). These parameters are highly correlated with mercury. We will also consider using stable isotopes of nitrogen and carbon as ancillary data. Hebert and Weseloh (2006) showed that dietary differences caused temporal variation in the trophic position of herring gulls, and they concluded that adjusting for these changes using data from stable isotopes can provide more accurate assessments of trends in environmental contaminants [For a review of stable isotopes and their use in ecotoxicology, see Jardine et al. (2006)].

Chemical concentrations and other measures such as deformities may be analyzed collectively through multivariate ordinations (e.g., non-metric multidimensional scaling; NMS or NMDS) of resource conditions through time, following West and Yorks (2002). This approach effectively integrates information across many indicators and can suggest whether nesting pairs are all changing in the same direction in multidimensional ordination space. Furthermore, joint plots can be overlaid on the ordination to explore which variables correlate most strongly to the direction of changes.

2.8 Interpretations and Recommendations to Managers

This monitoring program is designed to document levels and monitor trends in concentrations of targeted PBTs in tissues of bald eagles. It is not designed for making conclusions about whether a contaminant has caused a biologically significant effect on wildlife or humans. Nonetheless, estimated threshold values are available in the literature for assessing population status and for comparing with documented cause-effect relationships for some of our targeted contaminants (Table 2.4). We will compare our data with these thresholds using bar charts (section 2.6), which can be presented to park managers with recommendations. When interpreting results and making recommendations, the following guidelines will apply:

1. A decline in a bald eagle population, even when negatively correlated with trends in one or more contaminants, is not reason in itself for concluding there is a cause and effect relationship. Rather, exposure to contaminants constitutes one of many variables to be

considered when assessing the health of the population. We may find that eagle populations are in decline, but that concentrations of the targeted contaminants are below known threshold values. Wildlife populations undergo natural fluctuations and we will be vigilant about assessing all natural and anthropogenic stresses. Indeed, another contaminant could be acting on the population and we may need to screen for new and emerging contaminants.

Table 2.4. Threshold values for contaminants that may impair bald eagle populations and minimum productivity of healthy populations.

Variable/Contaminant	Threshold value ¹	Reference
Population productivity	1.0 young per occupied nest; >50% of occupied nests successful for a healthy population	Wiemeyer et al. 1984
DDT	0.0 ug/L in blood as an alert to parks for potential local hotspots	Provisional; based on this pesticide being banned in North America in 1972
DDE	11 ppb ww p,p'-DDE in plasma; NOAEC for healthy reproduction	Bowerman et al. 2003
	28 µg/kg DDE in nestling plasma, corresponding to 6 mg/kg DDE in addled eggs and based on 0.7 young per active nest for a stable eagle population	Elliot and Harris 2001/2002
	3.5 ppm ww p,p'-DDE in eggs; NOAEC for eggshell thinning effects	Wiemeyer et al. 1984
PCBs	190 µg/kg total PCBs in nestling plasma, corresponding to 20 mg/kg PCBs in addled eggs and based on 0.7 young per active nest for a stable eagle population	Elliot and Harris 2001/2002
	4.0 ppm ww total PCBs in eggs; NOAEC for egg lethality	Wiemeyer et al. 1984
	33 ppb ww total PCBs in plasma; NOAEC based on 1.0 young per active nest for a healthy population	Bowerman et al. 2003
PBDEs	Thresholds in plasma are currently unknown	
PFCs	Thresholds in plasma are currently unknown	
Mercury	7.5 ug/g dw in breast feathers	Provisional; Jagoe et al. 2002
Lead	Thresholds for feathers are currently unknown	

¹Values are as reported in the literature. Conversions: ug/kg = ug/L = ppb = .001 ppm.
NOAEC = No Observable Adverse Effect Concentration.

2. We will compare the concentrations of targeted contaminants directly with studies where cause-effect relationships have been documented (e.g., Table 2.4). The surrounding states, USEPA, and Environment Canada continue to develop and refine meaningful thresholds for various contaminants and we will continually up-date our table of thresholds.
3. We will be concerned if we find reduced embryo viability (addled eggs), chick wasting, and/or developmental deformities clustered in space and time, whether in concert with our suite of contaminants or not. Such observations are suggestive of impairment and could indicate that significant concentrations of developmental toxins are present.

To the extent possible, we will compare our temporal and spatial patterns in contaminant levels in bald eagles with levels in the atmosphere surrounding the parks. Atmospheric transport and deposition is an important pathway for contaminants to enter park ecosystems. Sources for atmospheric data include:

- The Integrated Atmospheric Deposition Network (IADN), a long-term monitoring program that has measured atmospheric concentrations of PCBs, DDE, and several other contaminants in air over the Great Lakes since 1990 (Sun et al. 2007) and;
- The National Atmospheric Deposition Program (NADP), which has been in operation since 1996 and includes a Mercury Deposition Network (MDN) with stations across the Great Lakes region.

The foraging area for bald eagles is relatively small. Hence contaminants found in eagles, which result from biomagnification in the food web, can be directly related to the park or adjacent environments. Stalmaster (1987) summarized the literature by stating that normal bald eagle territory size is about 1-2 km². In Minnesota and Michigan territory size ranged from 1.09 to 1.55 km² (Mattsson 1974; Mahaffy 1981). Yet, some territories are larger and foraging areas can be greater than ‘defended’ territories. For example, the defended territory of a pair of radio-tagged bald eagles in Saskatchewan, Canada was 4 km² whereas the foraging area was 7 km² (Gerrard et al. 1992). Thus bald eagles will integrate contaminants from an area ranging from 1 to 7 km² around the nest.

Furthermore, results from this monitoring will reflect contamination of the park’s aquatic environment. Prey remains at 285 nests in northern Minnesota, Michigan, and Wisconsin indicated that fish (mainly suckers [*Catostomus* spp. and *Moxostoma* spp.], northern pike [*Esox lucius*], bullheads [*Ictalurus* spp.], common carp [*Cyprinus carpio*], and bowfin [*Amia calva*]) were the most common summer food items (77%), followed by birds (15%; mainly waterfowl and gulls), and mammals (5%) (Bowerman 1993). Dunstan and Harper (1975) found that fish comprised 90%, birds 8%, and mammals 1% of prey remains at nests on the Chippewa National Forest in Minnesota. In inland waters of Wisconsin, fish comprised 84%, birds 6%, and mammals 7% of the prey remains at nests (P. Keasling graduate student, University of Wisconsin-Madison, and C. Sindelar, private contactor, WDNR, Waukesha, WI, unpublished data).

In summary, results from this monitoring program can be used to recommend that park managers:

1. Apprise state and federal regulators when/if concentrations of target contaminants are increasing over a period of years and/or when they approach or exceed thresholds;
2. Investigate potential 'hot spots' where comparatively high levels of one or more contaminants are found;
3. Work with researchers and other science partners to assess causes of contamination and possible remedies;
4. Educate park visitors about the sources, pathways, and effects of contaminants in the environment, such as PCB and PBDE releases from burn-barrels and other poor waste disposal practices;
5. Educate park visitors about state and federal health advisories, such as fish and waterfowl consumption advisories based on mercury and PCB levels;
6. Work with researchers and other science partners to assess eagle population declines, high rates of egg or nestling mortality, disease, deformities, or other problems uncovered as a result of our examining bald eagle nestlings and monitoring their populations.

3 Overview of Sampling Methods

3.1 Field Season Preparations

Field season preparations are described in detail in SOP #2 (training, permits, and certifications) and #3 (logistics, maps, and contacts). The project manager will obtain all necessary state and federal permits to handle and band bald eagles. Occupancy surveys will be scheduled and conducted in early spring each year (late May for southern nests and early June for more northerly nests). The resulting survey data will be obtained from the pilot/observer team and then mapped to assist in locating each active nest on the ground. Once active nest sites are determined, park and Network personnel will observe several active sites to determine the approximate age of nestlings in order to estimate sampling dates. Cooperators will then be contacted, notified of sampling dates, and transportation (boats, vehicles) arranged. Private landowners also will be contacted for permission to access their property.

At minimum, the handling crew will consist of a climber and handler. Climbers should be hired (or contracted) and complete all safety training and certification well in advance of field operations. Primary handlers must be experienced and should secure all sampling materials and prepare all field equipment.

3.2 Field Measurements and Sampling

Handling, measuring, and collecting blood, feather, and egg samples from nestling bald eagles is described in detail in SOP #1. After the age of the eaglet(s) is determined to be within guidelines and the tree is judged to be safe, the climber will climb to the nest and lower the eaglet(s) to the ground in specially designed bags. The handler will weigh the eaglet(s) before removing them from the bags and record both total and tare weight. After removal, measurements of bill length and depth, and length of hallux claw and foot pad will be taken using calipers, and the eighth primary feather measured with a ruler (Bortolotti 1984a; 1984b; 1984c). Using a 10 cc plastic syringe, 10-12 cc of blood is drawn from the brachial vein. The blood is then transferred to a glass vacutainer which is labeled, placed in a zip-lock bag, and put on blue-ice in a cooler. The last few drops of blood from the syringe are put on a 4" x 4" piece of gauze, placed in a plastic bag, labeled, and put in the cooler. This small blood sample is dried and kept as a DNA sample to positively identify the nestling's sex. Finally, three to four breast feathers are collected from the eaglet(s) by pulling them out at the base of the feather. The feathers are placed in a labeled envelope, which is sealed and placed in a zip-lock bag in the cooler.

Before returning the eaglet(s) to the nest, each bird is examined for deformities, wounds or unusual markings, ear maggots, and fullness of crop. The eaglet is banded using #9 FWS rivet bands. Data sheets are checked to ensure all data was collected and that the data sheet is legible. While the eaglet(s) are being returned to the nest, tree species, tree and nest condition, and GPS coordinates of the tree are recorded, and the nest tree's height and diameter-at-breast-height are measured.

3.3 Sample Preparation and Laboratory Analysis

Each evening the vacutainers are centrifuged for 8 -12 minutes or until fully separated. One ml of serum is then drawn off using a glass pipette and placed in a vial provided by the lab for PFC analysis. The remaining serum is drawn off and placed in a separate vial provided by the lab for

PCBs, PBDEs and DDE, DDD, DDT analysis. Vials are labeled and frozen in an upright position. The remaining red blood cells in the original vacutainer and the DNA sample are also frozen. Envelopes containing feathers are labeled and stored in a dry, secure place.

All blood samples are kept frozen and hand delivered to the diagnostics lab in a portable freezer or shipped on dry ice in coolers with custody seals. If samples are shipped they will be sent FedEx overnight and the lab contacted to ensure they are secured on the receiving end. Detailed information on sample handling, labeling, and shipping can be found in SOP #5. The lab will retain the original chain of custody forms and they will send copies to GLKN. Copies of completed data forms will be sent to both the Wisconsin and Minnesota Departments of Natural Resources. Original data sheets will be archived at the Great Lakes Network Office.

All samples collected in the field are individually labeled with an assigned GLKN sample number and logged on field data sheets. Original field data forms are retained in a binder at the GLKN office and data are entered into an MS Access database.

The diagnostics lab determines the concentrations of target contaminants using methods approved by GLKN. When possible we will use the same lab to ensure comparable data are collected through time. At minimum, contract labs will use methods consistent with or substantially better than those used by the Wisconsin State Laboratory of Hygiene during pilot work from 2006-2008 as follows (detailed descriptions of methods are available upon request):

- PCBs and DDT - Gas chromatograph equipped with an electron-capture detector (ESS ORG Method 1810).
- PBDEs - Gas chromatograph-mass spectrometer operating in the negative ion mode (ESS ORG Method 1810).
- PFCs - Turbo ion spray, triple quadrupole mass spectrometer in the negative ionization mode (WSLH Method 1470).
- Mercury – Cold vapor atomic absorption (ESS INO Method 540.4).
- Lead – Inductively coupled plasma spectroscopy (ESS INO Method 620.2).

4 Data Handling, Archival Process, and Quality Control

4.1 Overview of Database Design

Internally, we will manage the data generated from this protocol in an MS Access relational database to generate summary reports and for up-loading to a national I&M program Internet Mapping System (IMS) used for exchange and visualization of NPS monitoring data.

Additionally, the NPS Water Resource Division (WRD) requires that all I&M water quality monitoring data be uploaded to the U.S. Environmental Protection Agency's (USEPA) STORET database. To assist with this upload, the WRD developed a Microsoft Access database tool, NPSTORET, which duplicates most of USEPA's data and table structures. Since data collected under this protocol are ecologically linked to aquatic health, we will use NPSTORET for uploading the data to the USEPA STORET. A similar NPSTORET to USEPA STORET transfer is done on GLKN's water quality data (Elias et al. 2008; Magdalene et al. 2008).

We will maintain one master copy of the MS Access database and another copy of NPSTORET at the Ashland (WI) office on a central server. Copies of the MS Access database will be provided to the three parks, but only one copy of NPSTORET will be used to export data (WRD, USEPA, GLKN's SQL Server). The MS Access database will be used by Network staff and cooperators for data entry, verification, and analysis.

4.2 Data Entry, Verification, and Editing

Detailed instructions for data entry procedures are given in SOP #4, Data Entry and Management. Two general classes of data will be collected. The first is field observations and measurements that are recorded on field forms. For eagle nests that have been visited in past years, certain elements of the field form will be pre-filled and printed from the database. This will help field teams get to the right tree (pre-filled GPS locations) and reduce multiple versions of nest names (especially alternates) that have plagued other bald eagle monitoring programs. The second class of data is the results of testing performed by contract analytical laboratories. An import routine has been created in MS Access to bring laboratory results, which are provided to GLKN in MS Excel, directly into GLKN's master Access database.

Quality assurance/quality control (QA/QC) begins as data are entered – checking against previous nest names, coordinates, and occupancy data. Any corrections to field forms are done without erasing (cross-out and insertions) and initialed. The MS Access database has drop-down menus and data range limits to reduce errors. After all field data have been entered they are re-checked by one person reading 100% of the entries from the database while a second person checks against the original field forms.

A second MS Access routine will allow direct upload of the Network's master database to NPSTORET. Only trained users with edit permissions are allowed to move data to NPSTORET. If data being uploaded to NPSTORET do not pass a form-based QA/QC test, NPSTORET prompts the user to make corrections and re-enter the data. Data that are outside the expected range for a parameter based on previous records and scientific literature will be flagged for further review by an expert. These procedures protect the integrity of the data and allow the history of each data record to be traced. All data are provisional until they are accepted by WRD for upload to USEPA STORET.

4.3 Data Archival Procedures

Data archiving serves two primary functions: it provides a source to retrieve a copy of any dataset when the primary dataset is lost or destroyed, and it provides a data record that is an essential part of the QA/QC process. For digital data (e.g., data maintained electronically in a GPS or laptop computer and transferred electronically), the unedited files are considered the original data.

All data will be recorded initially on hardcopy data forms to conform to USEPA standards. Hardcopy forms will be reviewed by the project manager within 30 days of collection in the field. Corrections will be made without erasing original data, dated, and initialed. We will make one photocopy and one digital replica (scanned version) of these corrected hardcopy data sheets. Following data entry and initial QA/QC in GLKN's master database, we will create duplicate files of all digital data.

The Network's master database will be maintained on a central server in the Ashland (WI) Office that is backed up daily and backed up off-site weekly. Complete details of the GLKN Server archiving procedure, as well as the general strategy for data archiving, are found in the Infrastructure chapter of GLKN's Data Management Plan (Hart and Gafvert 2006).

4.4 Metadata Procedures

Metadata allows potential data users to evaluate the quality and usefulness of the data based on the process under which it was collected and maintained. In this respect all of the protocol documentation, including SOPs, is part of a dataset's metadata. A reference to the appropriate version of these documents is part of the metadata. Although perhaps obvious, all data must have an associated value for the date and time they were collected.

For metadata associated with geospatial data, we will abide by Executive Order 12906, which mandates that every federal agency document all new geospatial data using the Federal Geographic Data Committee (FGDC) Content Standard for Digital Geospatial Metadata (CSDGM; www.fgdc.gov/metadata/contstan.html). The Network will generate FGDC-style metadata for both spatial and non-spatial datasets.

Although it is not required, we will make every effort to complete Biological Data Profiles (www.fgdc.gov/standards/status/sub5_2.html) for appropriate datasets and add associated metadata to the National Biological Information Infrastructure (NBII; www.nbio.gov/datainfo/metadata) Clearinghouse.

For more details on the Network's overall strategy for metadata generation, management, and distribution see chapter 8, Data Documentation, of GLKN's Data Management Plan (Hart and Gafvert 2006).

4.5 Quality Assurance and Quality Control

Quality assurance and quality control (QA/QC) procedures are detailed in SOP #8. Steps are taken at all stages of the program - from protocol documentation through data collection, entry, and analysis. These steps are highlighted throughout the protocol (e.g., sections 4.1, 4.2, 4.3) and

in each SOP. The crucial procedures are summarized in Table 4.1. Additionally, each analytical laboratory is required under contract to have written QA/QC standards that meet high scientific standards (USEPA, NELAP).

Table 4.1. Summary of quality assurance and quality control (QA/QC) procedures for the management of monitoring data at the Great Lakes Inventory and Monitoring Network.

Procedure	Description
Instrument calibration logs	Each instrument, such as GPS and weighing scales, are calibrated annually and results maintained in logbook.
Field forms	Field forms are required by USEPA for all water quality related data. Copies will be placed in site binders and originals kept on file indefinitely.
Manual data entry	Field data will be manually entered into computer forms that look similar to field forms to reduce transcription error.
Data verification	All (100%) manual entries from hardcopy field forms will be checked. Errors will be corrected and documented.
Data verification reports	A data verification report will be prepared each year to document transcription errors and steps to be taken to reduce such errors.
Data validation	Data validation is the checking of the data against known ranges for outliers. This will be done during verification (above), electronically within GLKN's master database and during uploads to NPSTORET and USEPA STORET.
Data validation reports	A data validation report will be produced annually to document deviations, if any, from QA/QC procedures and objectives and discuss the impacts of those deviations.
Data qualification codes	Data will be coded when fully qualified before uploads to NPSTORET and USEPA STORET.
Laboratory QA/QC	QA/QC at the analytical lab includes matrix spikes and surrogate standards added to all samples to monitor percent analytical error. Method blanks are also analyzed after every 10 samples to check instrument calibration and contamination. Each individual sample is coded as to its level of certainty based on these QA/QC procedures.
Data archiving	Data and associated records will be archived at the GLKN Ashland (WI) office in 3-ring binders numbered consecutively by year.

4.6 Reporting Schedule

Data summaries will occur annually with an Annual Summary Report produced for each park where sampling occurred. The primary audience for these reports is park managers. Depending on the availability of laboratory data, these reports may be limited to brief summaries of total sampling effort as a progress report of the monitoring effort. An Executive Summary of this report will be submitted to the NPS web-based Investigators Annual Report (IAR) system by the end of March each year. The final Annual Summary Report will be provided to parks and partners by 30 August. Handling and banding reports must also be generated for the U.S. Fish & Wildlife Service (FWS) each year, usually in January, as a requirement of collecting and banding permits.

More comprehensive analyses and synthesis reports will occur after the third year (completion of pilot work) and then on the year following each two-year sampling set. Thus the initial analysis and synthesis report will be completed in 2008 followed by reports in 2012, 2016, 2020 and so on. The target audience of the analysis and synthesis reports will be the parks, the Network, both regional and Service-wide I&M, and the broader scientific community. Drafts will be completed

by 31 January of the appointed year. These drafts will be reviewed internally and sent to the parks, and to outside scientists for peer review. The extent of review will depend on how analytically complicated the methods are and the gravity of results and recommendations. The final reports will be due on 1 April of the appointed year.

4.7 Report Format

Both annual summaries and analyses and synthesis reports will follow the format of the NPS Natural Resource Technical Report Series. At a minimum these reports will be included in the on-going series of Technical Reports produced by the Great Lakes Network and made available as PDF documents on the Network's web site. When the information has broad application to the scientific community the report will be submitted to the NPS Natural Resource Technical Report Series and made available on the national website in PDF format. Reports will include tabular and graphic displays of summary data and a brief review of pertinent published literature. Additional information and lengthy tables will be attached as appendices or data supplements. When applicable, data and findings will be published in peer-reviewed scientific journals.

5 Personnel Requirements and Training

5.1 Roles and Responsibilities

This monitoring program is funded primarily by the NPS Great Lakes Inventory and Monitoring Network who has primary responsibility for the data collection, analysis, and reporting. The three parks where the monitoring takes place assist with logistics, field work, and interpretation of results. The Wisconsin Department of Natural Resources (WDNR) is a full partner. The Network and WDNR collaborate under a Master Cooperative Agreement signed by the two agencies specifically for this program. WDNR conducts annual nest occupancy surveys for eagles nesting on the Wisconsin portions of the parks (all of APIS and over 75% of SACN). They also oversee the acquisition and interpretation of laboratory results on samples analyzed by their sister agency, the Wisconsin State Laboratory of Hygiene. The WDNR has over 20 years of experience monitoring contaminants in bald eagles and their review of data quality, as well as consultation on its interpretation, is critical. Audubon Minnesota, based in St. Paul, MN provides valuable logistical support on the Mississippi River and a biologist for handling eagles at MISS; Ramsey County Parks, Minneapolis, MN provides a biologist, in-kind, to conduct helicopter occupancy surveys along the Mississippi River; the FWS, Ashland Fisheries Resource Office, provides logistical support at APIS. Climbing of nest trees is under contract, which was with Eco-ascension Research and Consulting during pilot work from 2006 through 2008.

Specific responsibilities for the principals are as follows:

Project Manager

The project manager is an NPS biologist who has overall responsibility for program administration, data collection, and reporting. The project manager coordinates activities with other cooperators and park staff. Specifically, the project manager:

- Ensures all permits are acquired prior to field work;
- Documents changes to this protocol and standard operating procedures;
- Coordinates field schedules and associated activities with cooperators, contractors, and park staff;
- Ensures field personnel and contractors have sufficient support and training;
- Ensures QA/QC measures are followed and performs periodic review of quality standards for field, lab, and office work;
- Contracts for climbing services and for analytical laboratories;
- Ensures laboratory results meet specified minimum detection limits, reproducibility of replicate samples, and other performance indicators;
- Supervises or performs data entry and ensures that data are verified and validated;
- Ensures data are analyzed fully using appropriate statistical procedures;
- Reports results to parks, partners, and other scientists in a timely manner.

The project manager also works with the Network data manager to:

- Create, and periodically update, metadata on the master MS Access database and NPSTORET database;
- Develop data verification and validation measures for quality assurance;
- Provide training in the use of database software and quality assurance procedures;

- Coordinate changes to field forms and user interface for the project database;
- Identify sensitive information requiring special consideration prior to distribution;
- Ensure regular archiving of metadata, original field data, databases, reports, summaries, and other products;
- Provide automated data queries and output from the master Access database that can be used in statistical and graphical software and written reports.

Field Personnel

At a minimum, the field crew will include an eagle handler and a tree climber. These two can efficiently capture, handle, and take samples from eaglets at two to four nests per day. The handler is normally an NPS employee and is responsible for coordinating field activities. The responsibilities of this two-person field crew include:

- Completing all required training, certifications, and permit applications;
- Assembling field equipment and supplies and ensuring they are up-to-date and in working order;
- Collecting data and samples according to the most recent protocol, SOPs, and QA/QC procedures;
- Climbing nest trees and acquiring samples in a manner that is safe to the climber, ground crew, and eaglets;
- Ensuring samples are processed and frozen within 24 hours of collection;
- Packing and shipping samples to analytical lab within maximum holding times;
- Maintaining accurate field data records and sample handling notes including explanations of all deviations from standard procedures;
- Maintaining and calibrating equipment according to SOPs and manufacturers' directions;
- Communicating with the project manager and FWS when there are significant deviations from sampling protocols or injury to humans or birds;
- Entering and quality checking field data into databases.

Data Manager

Data management is the shared responsibility of the field crew, project manager, and the network data manager. Typically, field personnel are responsible for data collection, data entry, data verification, and validation. The data manager is responsible for database design, data security, and data archiving. The data manager, in collaboration with the project manager, also develops data entry forms, data upload and download tools, and other database features (as part of quality assurance) and automates routine data summaries through queries and report generation.

5.2 Crew Qualifications

The eagle handler must have a bachelor's or advanced degree in biology, chemistry, or a related physical or biological science. Field experience and training with handling and taking blood samples from bald eagle nestlings is mandatory (see training below). The handler must be permitted (directly or under sub-permit) on a valid scientific collecting permit from the FWS. Additionally, at least one crew member, normally the handler, must have a valid banding permit from the FWS or be listed as a sub-permittee under a Master Bird Bander. Prior leadership experience and good decision-making skills are highly desirable, as is experience with boats, motors, and canoes.

Those authorized to be the lead climber to retrieve nestlings from nests must pass one of the following criteria:

1. Have prior experience safely climbing and retrieving eaglets from 50 or more separate nest trees under permit from a state or federal agency; OR
2. Have obtained two days of instruction from a professional climber including the use of ropes, knots, safety equipment, and climbing technique, AND must have mentored with an experienced climber while climbing at least 10 nests with nestlings and safely transporting them to the ground.

5.3 Training Procedures

All crew members who are authorized to handle bald eagles must be under valid state and federal permits, including both a banding permit and a handling permit from the FWS. Additionally, those individuals who are authorized to collect blood must either mentor with a trained, experienced professional for the first 10 nestlings or undergo training by one of the following: the Raptor Rehabilitation and Research Program at the University of MN; the Raptor Education Group Inc. in Antigo, WI; or the Small Animal Clinical Sciences Facility, College of Veterinary Medicine at Michigan State University.

As stated in section 5.2 (Qualifications) those authorized to climb nest trees must either have extensive previous experience or get training in combination with mentoring for the first 10 active nest trees. Training will be provided by individuals who possess an extensive record of safe climbing. At least two individuals in Wisconsin and Minnesota have climbed over 2,000 bald eagle nest trees and handled over 3,000 nestlings over the past 20+ years. These individuals are available as contract climbers and for training and mentoring new climbers. The U.S. Forest Service also provides a tree climbing certification course.

Before data collection, field personnel must become familiar with the SOPs and the equipment to be used in the field. Specific training procedures are covered in SOP #2 and will include the following:

- Review of this protocol and all SOPs with special attention to human safety, emergency contacts, and safe handling of nestlings;
- Calibration, operation, and maintenance of equipment;
- Current status of avian influenza virus (H5N1) and how to identify sick birds and handle birds and other potentially bio-hazardous material safely;
- Methods for measurements and sample collection;
- Methods for handling and preserving samples;
- Completion of field data forms, sample labels, chain-of-custody forms, and analytical lab request forms;
- Completion of field and calibration logbooks;
- NPS-specific training as applicable (e.g., boat operation, computer use, radios, credit card, travel).

6 Operational Requirements

6.1 Annual Work Load and Schedule

Bald eagle nestlings must be handled when they are between five and nine weeks old. At five weeks they can thermo-regulate in a reasonable range of weather conditions without continuous attention from an adult. At ages older than nine weeks there is increasing concern that the nestling will fledge (jump from the nest) prematurely. This five to nine week sampling window drives all field work. Bald eagle nesting chronology varies by latitude and year (weather). Normally our sampling will occur in May for southerly areas (MISS and lower SACN) and could be as late as late June in more northerly areas (upper SACN and APIS). The WDNR will fly over eagle nests in April or May to determine nest occupancy and nestling age, which will assist with determining field season dates.

The estimated workload and schedule shown in Table 6.1 are based on three years of pilot work at APIS, MISS, and SACN.

Table 6.1. Projected timing of events, lead role, and effort required for conducting bald eagle monitoring of environmental contaminants at three parks in the Great Lakes Network.

Tasks	Dates ¹	Lead ²	Person-hrs
Apply for permits (6 mo in advance)	November of prior year	PM	8
Secure contracts and agreements	December of prior year	PM	20
Order field supplies	March	PM	4
Planning logistics	February through mid-May	PM	30
Occupancy flight for MISS	*Early to mid-April	WDNR	8
Occupancy flight for SACN	*Mid- to late April	WDNR	16
Occupancy flight for APIS	*Late April or early May	WDNR	6
Prepare field maps and forms	Following occupancy surveys	DM	24
Field sampling at MISS	*Late May to early June	PM/C/AM	60
Field sampling at SACN	*Early to mid-June	PM/C	90
Field sampling at APIS	*Mid- to late June	PM/C/FWS	40
Prepare, deliver/ship samples to lab	Late June to early July	DM/PM	24
Clean and put away field equipment	July	PM	8
Data entry and verification	July	DM	40
Analytical lab work on samples	August through November	Lab	
Data analysis, tables, and graphs	October through December	PM	80
Write annual summary report	January of year following	PM	32
Write synthesis report (every 4th year)	January of year following	PM	120
Prepare FWS collecting report	January of year following	DM/PM	2
Prepare FWS banding reports (2)	January of year following	DM/PM	4
Prepare Annual Investigator Reports (3)	March of year following	PM	4
Total person-hrs =			620

¹ Dates marked with an asterisk depend on weather which dictates nesting chronology

² PM = Project Manager; WDNR = Wisconsin Department of Natural Resources; DM = Data Manager; C = Climber; AM = Audubon Minnesota; FWS = US Fish & Wildlife Service.

Bald eagle sampling will be conducted by one or two crews. Depending on the experience of individual crew members, a crew will consist of two to four individuals (see section 5.1, Roles

and Responsibilities). Annual work flow for field sampling will begin with productivity flights by state DNR (Table 6.1). Close coordination between flight staff and the program manager will be essential to ensure efficiency (reduce potential for hiking to nest trees that are not occupied) and safety of the birds (decrease chances of nestlings jumping from the nest). The field season ends in late June after samples are collected at the most northerly park. All of the accumulated samples are then inventoried, logged in the database, and packaged for submission to the analytical laboratory. Normally we will transport the samples by vehicle in a portable freezer directly to the lab. This is the best way to ensure they arrive in good condition. Occasionally we may need to ship samples on dry ice. Analytical work by the lab can take between three and twelve months depending on their workload.

Analysis and reporting on results is the most time consuming part of the program. State and federal agencies, as well as park staff and partners, require the information in a variety of reports and formats. The reporting requirements are listed in Table 6.1, but formal and informal presentations, briefing statements, and other personal communication to convey the information will occur as well.

6.2 Facility and Major Equipment Needs

The Network sampling crew will be primarily stationed in Ashland (WI), but park staff and facilities will be used when necessary. Most travel will be accomplished with one GSA lease vehicle. Motor boats will be required to access nests along the Mississippi and lower St. Croix rivers as well as nests on the Apostle Islands. We will contract with Audubon Minnesota for a boat and operator to assist with sampling the Mississippi River and the lower St. Croix. Audubon has boat operators with extensive experience on the Mississippi River as well as staff with the necessary permits to handle and band eagles in Minnesota. Canoes are readily available at GLKN and SACN for sampling the upper St. Croix and Namekagon rivers. GLKN has purchased a 21 foot twin-engine boat that can safely navigate Lake Superior to sample the Apostle Islands, and the FWS Ashland Fisheries Resource Office will provide assistance when needed.

Blood samples from bald eagles must be frozen within 24 hours of being collected. Adequate freezers are available at the following strategic locations:

- The St. Croix Watershed Research Station, Marine on the St. Croix, MN
- The SACN Water Quality Lab, Osceola, WI
- Crex Meadows State Wildlife Area, Grantsburg, WI
- A private cabin (The Field Mouse Hilton), Minong, WI
- GLKN office, Ashland, WI

In addition, we have purchased portable freezers that plug in to vehicles to ensure samples are kept frozen during long transports. The Wisconsin State Laboratory of Hygiene, Madison, WI will provide long-term archival of plasma samples at -20° C. in freezers that are protected with alarms and backup power. Red blood cells that are often discarded by many investigators will be kept frozen at the GLKN office in Ashland, WI. These samples may prove useful in the future with advances in analytical methods. Unused feather samples will be kept dried in envelopes at the GLKN office for archival. All archived samples will be cataloged and individually marked.

6.3 Startup Costs

Initial equipment and supply costs for two full field crews are estimated at approximately \$3,600 (Table 6.2). A centrifuge, a chest freezer, two portable freezers, and two GPS devices are the largest investments in equipment. This does not include the purchase of boats and motors, which have been acquired by the Network to support all programs.

Table 6.2. Equipment and supply costs for sampling bald eagles for bioaccumulative contaminants at three parks in the Great Lakes Inventory and Monitoring Network. An asterisk (*) indicates start-up expenses; other expenses will reoccur periodically.

Type of supplies	Items	Cost
General field gear	*Day pack (2)	130.00
	*Tackle box (2)	50.00
	*Clipboard (2)	24.00
	Pencils & Sharpies™ (4 ea)	10.50
	*GPS (2)	700.00
	*First-aid kit (2)	90.00
Banding	*Rivet gun (2)	16.00
	Rivets (1/8") (3 boxes of 25)	15.00
	*Needle nose pliers (2)	12.00
	*Wire cutters (2)	15.00
Eagle handling	*Eagle bags (4)	200.00
	*Calipers (2)	94.00
	*Spring scales (2)	130.00
	*Rulers (2)	10.00
Blood & feather collection	Syringes and needles (100 ea)	95.00
	Alcohol swabs (100)	9.00
	Heparinized Vacutainers (100)	56.00
	Zip-loc bags (200)	25.00
	Biohazard boxes	19.00
	Coin envelopes	8.00
	Whirlpacks	47.00
	Gauze pads (4")	9.00
	*Small cooler & ice packs (2)	35.00
	*Portable freezer (2)	900.00
Lab equipment	*Centrifuge	500.00
	*Chest freezer with alarm	350.00
	Packing material, tape, boxes	25.00
	*Forceps	3.50
Total		\$3,578.00

6.4 Total Annual Budget

The expected annual cost of the program to the Great Lakes Network is approximately \$77,000 (Table 6.3). Partners provide an additional \$16,000 of in-kind support for occupancy surveys and

assistance with lab QA/QC and interpretation of results. The NPS project manager will serve as GLKN's crew leader. Wages and benefits for the project manager and data manager are covered by the general GLKN monitoring program and are not itemized here. A seasonal biological technician, Student Conservation Associate (SCA), NPS volunteer, or other temporary appointee will be the only hired staff.

6.5 Service Contracts

We will require the assistance of a contract climber to safely climb nests and retrieve the young for sampling. The estimated cost for contracting an experienced climber is \$250 per nest tree climbed. Blood serum and feather samples will be sent to an analytical laboratory, which in 2006-2008 was accomplished under a cooperative agreement with the Wisconsin Department of Natural Resources. The WDNR, with 20 years of experience with contaminants data, facilitated the submission, quality control, and interpretation of data from their sister agency, the Wisconsin State Laboratory of Hygiene (WSLH). The WSLH conducted much of the historical work on bald eagle blood serum and feathers (e.g., Dykstra et al. 2005), and using them in this current program greatly enhances our comparability with this past work. The Wisconsin laboratory is also accredited by the federal National Environmental Laboratory Accreditation Program (NELAP).

Table 6.3. Estimated annual budget for monitoring bioaccumulative contaminants at three parks in the Great Lakes Network, excluding costs of the project manager and data manager. Start up costs are addressed in section 6.3.

Item	Cost	GLKN	Partners
Occupancy flights	32 hrs @ \$250		8,000.00
Occupancy observer	MISS only, 10 hrs @ \$45/hr		450.00
Vehicle mileage and fuel	800 mi @ \$0.445/mi +\$70	426.00	
Per diem	20 days @ \$91/day	1,820.00	
Tree climbers	50 nest trees @ \$250 ea	12,500.00	
Seasonal technician	5pp @ \$1,549	7,745.00	
Plasma lab analysis	35 samples @ \$1,200 ea	42,000.00	
Feather samples	35 samples @ \$65 ea	2,275.00	
Equipment replacement	See Table 6.2	500.00	
Shipping	Estimate	500.00	
Supplies	See Table 6.2	700.00	
Boat transportation	40 gal @ \$3.50	140.00	
Biological support	Contract (Audubon MN)	6,000.00	
Field and lab consultation	Cooperative Agreement (WDNR)		2,500.00
Lab data QA/QC	Cooperative Agreement (WDNR)		2,500.00
Statistical consultation	Cooperative Agreement (WDNR)	2,500.00	2,500.00
Totals		\$77,106	\$15,950

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Appendix A. Index to Standard Operating Procedures.

- SOP #1. Handling, Measuring, and Collecting Blood, Feather, and Egg Samples from Nestling Bald Eagles
- SOP #2. Training, Permits, and Certifications
- SOP #3. Logistics, Maps, and Contacts
- SOP #4. Data Entry and Management
- SOP #5. Sample Handling, Labeling, and Shipping
- SOP #6. Methods for Analyzing and Presenting Bald Eagle Productivity and Contaminants
- SOP #7. Safety Plan
- SOP #8. Quality Assurance and Quality Control
- SOP #9. Revising the Protocol and SOPs

Appendix B. Summary information on selected contaminants.

Organochlorine compounds

This group includes DDT and its metabolites (breakdown products such as DDE), several persistent pesticides such as chlordane, dieldrin/aldrin, and heptachlor, and PCBs including many congeners (congeners are chemically related compounds with slightly different formulations). PCBs and DDT are listed as contaminants causing impairment of water bodies in seven and six respectively of the nine parks in the Great Lakes Inventory and Monitoring Network. PCBs and DDT have been steadily declining in the Great Lakes and elsewhere in the region since they were banned in the 1970s. These contaminants are often referred to as ‘legacy’ contaminants because production has been banned; yet stocks can still legally be used (at least for PCBs) and they continue to persist and re-enter the food chain when contaminated sediments are disturbed by dredging and extreme weather events. Bowerman et al. (2003) showed that bald eagle productivity and success rates were inversely correlated to PCB and DDE levels in blood of nestling bald eagles around the Great Lakes and in Voyageurs National Park. However, Dykstra et al. (2005) argue that, at least as of 2001, concentrations of these two contaminants in blood from bald eagles on the Wisconsin shoreline of Lake Superior (including samples from the Apostle Islands) are near or below threshold levels. Still, these and other organochlorine contaminants continue to be near or above the levels believed to be safe for wildlife and human consumption of fish (Dykstra et al. 2005). It is likely that synergistic effects, weather, prey availability, and other stressors confound any clear cause-effect relationship. Nonetheless, attendees to a binational workshop on chemical integrity of the Great Lakes contend that continued monitoring of these legacy chemicals is needed to assess the health of the Great Lakes ecosystem (State of the Lakes 2005).

DDE

Dichlorodiphenyldichloroethylene (DDE) is a metabolite, or breakdown product, of a synthetic pesticide known as dichlorodiphenyltrichloroethane (DDT). DDT was first introduced for widespread use as an insecticide just after World War II. Most uses of DDT were banned in Canada in 1969 under the Pest Control Products Act. Three years later they were banned in the United States. However, the use and the sale of existing stocks of DDT products were allowed until the end of 1990. Unfortunately, DDT is still used in many parts of the world (especially in developing countries) mainly for tsetse fly control and to reduce insect damage to crops. According to estimates from the World Health Organization, Mexico and Brazil each used almost 1,000 tons of DDT in 1992.

DDE, the most persistent DDT metabolite, is routinely detected or encountered instead of DDT. DDE is produced in most animals when the body attempts to metabolize or digest DDT. DDE is also highly fat soluble. For these reasons, top predators, such as bald eagles, are more likely exposed to DDE than DDT from the food they consume. Very little DDT has been found in Great Lakes bald eagle eggs, except during periods of high use of this pesticide in the early 1970s.

PCBs

Polychlorinated biphenyls (PCBs) have been in use since 1929. There are 209 possible types of PCBs, termed “congeners,” which differ slightly from each other in their chemical and physical properties. A small number of these congeners are highly toxic and probably account for most PCB-induced toxicity in animals. PCBs, like DDT and dieldrin, are organochlorine compounds which persist for a long time once released into the environment. However, unlike the pesticides DDT and dieldrin, PCBs were not deliberately released into the environment. PCBs are extremely stable molecules, a characteristic that make them desirable for industrial uses. Their low flammability made them useful as lubricants and as fire retardants in insulating and heat-exchanging fluids used in electrical transformers and capacitors. They have also been used as plasticizers, waterproofing agents, and in inking processes used to produce carbonless copy paper. Since 1977, regulations have been in place in Canada and the United States to ban the import and manufacture of PCBs, and tight restrictions are in place for the storage and destruction of all PCB-containing wastes.

Dieldrin

Dieldrin has been used in parts of the world since 1948 as a soil insecticide and seed dressing to kill fire ants, grubs, wireworms, root maggots, and corn rootworms. Dieldrin is no longer imported or manufactured in Canada. Dieldrin is also the breakdown product of aldrin, another widely used pesticide that has also been banned. In 1993, only one company in Canada had remaining stocks of aldrin and dieldrin. These stocks have since been transferred to a secured landfill site, and dieldrin is no longer used in Ontario.

Dioxin (2, 3, 7, 8-TCDD)

Dioxin is the popular name of a class of chlorinated hydrocarbon compounds known as polychlorinated dibenzo-p-dioxins (PCDDs). PCDDs and polychlorinated dibenzofurans (PCDFs) are formed either as by-products during some types of chemical production that involve chlorine and high temperatures, or during combustion where a source of chlorine is present. Only a few of the 75 different PCDDs and the 135 different PCDFs are highly toxic; others are practically harmless. The most toxic dioxin is 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD), although sensitivity to this compound varies considerably among animal species.

The most serious sources of 2,3,7,8-TCDD in the lower Great Lakes have been linked to industrial effluents and waste dump sites near the Niagara River and Saginaw Bay (Lake Huron). The former Hooker Chemical Company (now Occidental Chemical Company) in Niagara Falls, New York, produced 2,4,5-trichlorophenol (of which 2,3,7,8-TCDD is a by-product). Dow Chemical Company was identified as the primary source of PCDDs and PCDFs on the Tittabawasee River, which flows into the Saginaw River and eventually into the Saginaw Bay. Toxic waste disposal sites associated with this manufacturing, such as Love Canal along the Niagara River, have also been identified as important sources. The factories near Saginaw Bay and Niagara Falls discontinued the production of these chemicals in the mid-1970s.

Atmospheric deposition is also a major source of 2,3,7,8-TCDD, especially in the upper Great Lakes. The sources of atmospheric PCDDs and PCDFs include urban areas where municipal incinerators burn a wide range of chlorinated compounds present in domestic garbage, and engine exhaust when diesel fuel is used. In the past, the use of leaded gasoline in vehicles was

also a significant source of chlorinated compounds. The federal government phased out the use of leaded gasoline in Canada in 1990. A 90% reduction in the generation or release of dioxins and furans by the year 2000 was targeted under the COA objective to "prevent and control pollution."

Heavy metals

Heavy metals of concern in the Great Lakes Network parks include mercury, alkyl-lead, zinc, and cadmium. Mercury is a particularly pervasive and highly toxic heavy metal found in waters across the Network and the globe (for excellent reviews see Evers 2005 and Wiener et al. 2003). Mercury is a naturally occurring element found in rock. Mercury was mined for manufacturing and production of consumer products (fungicides in seed grain, thermometers, lamps, dental fillings) and is also a by-product of coal-burning power generation and solid waste incineration. Growing awareness of its hazards led to discontinuation or reductions in most uses beginning in the 1960s; however, significant anthropogenic releases of mercury still occur (Evers 2005; Hylander and Meili 2005). State and federal regulatory agencies list water bodies as impaired from mercury in eight of nine parks in the Great Lakes Network; this has spurred research in Voyageurs (Ensor Giovengo 1997; Sorensen et al. 2005; Wiener et al. 2006), Isle Royale (Gorski et al. 2003), St. Croix (Christensen et al. 2006), and more recently Apostle Islands (J. G. Wiener, University of Wisconsin-La Crosse, La Crosse, WI, unpublished data).

New and emerging contaminants

Perfluorinated compounds (PFCs), including perfluorooctane sulfonate (PFOS), polycyclic aromatic hydrocarbon (PAH), and polybrominated diphenyl ether (PBDE) are three large groups of chemicals that are emerging as contaminants of concern in the Great Lakes region and around the world (Renner 2000). The 3M Company, stationed in St. Paul, MN near the Mississippi National River and Recreation Area, phased out production of PFOS, the most prevalent form (telomer) of PFC, in 2000 after studies showed that it was highly toxic, persistent, and bioaccumulative in the environment (Auer 2000). PFOS was widely used in Scotchgard™ products that served as water, oil, and grease repellents for garments and other fabrics, as well as use in fire-fighting foams. In February 2006, an employee of the Minnesota Pollution Control Agency released information that fish in the Mississippi River, near the 3M plant, contained the highest levels of PFOS ever recorded (<http://news.minnesota.publicradio.org/projects/2005/02/toxictraces/>). PFOS has been found widely in humans and in wildlife, especially fish-eating birds (Auer 2000). PBDEs are widely used as flame retardants in plastic components of computers and televisions, circuit boards, vehicle upholstery, and many textiles. There is increasing concern that these chemicals are ubiquitous in the environment (human breast milk to marine mammals) and that low-level exposure may be detrimental to human and animal health (Renner 2000).

Nine PBDE congeners and 16 PFC telomers being screened for in this protocol:

PBDE #28

PBDE #47

PBDE #66

PBDE #85

PBDE #99

PBDE #100

PBDE #138
PBDE #153
PBDE #154
PERFLOURO-N-TETRADECANOIC ACID
PERFLOURO-N-TRIDECANOIC ACID
PERFLUORO-1-BUTANESULFONATE
PERFLUORO-1-DECANESULFONATE
PERFLUORO-1-HEPTANESULFONATE
PERFLUORO-1-HEXANESULFONATE
PERFLUORO-1-OCTANESULFONATE
PERFLUORO-N-BUTANOIC ACID
PERFLUORO-N-DECANOIC ACID
PERFLUORO-N-DODECANOIC ACID
PERFLUORO-N-HEPTANOIC ACID
PERFLUORO-N-HEXANOIC ACID
PERFLUORO-N-NONANOIC ACID
PERFLUORO-N-OCTANOIC ACID
PERFLUORO-N-PENTANOIC ACID
PERFLUORO-N-UNDODECANOIC ACID

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